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# SCIENTIFIC-RESEARCH COMPETENCE OF PROSPECTIVE ENGINEER: FORMS, EXPERIENCE, PERSPECTIVES

**N. O. Romanchuk***

*The article examines the issue of forming scientific-research competencies in prospective engineers as a component of the general professional competence of a prospective specialist of a technical sphere. The implementation of a competency-based approach is determined by the conceptual vector of modernizing the training of engineering specialists for their effective activity in industrial production at the level of world standards.*

*Based on the analysis of the experience of training specialists in the technical field, the features and purpose of professional training of prospective engineers in institutions of higher technical education are established. The professional competence of a prospective specialist in the technical field is characterized by a creative thinking, scientific-research skills, initiative in solving production tasks, the ability to organize teamwork, and a conscious understanding of personal responsibility for work results.*

*The humanitarian, engineering, project-technological, managerial, informational, scientific-research, economic, legal-economic, and ecological components of the professional competence of a prospective engineer are substantiated, which determine the professionalism of a modern specialist in the industry.*

*Scientific-research competence is singled out as an important component of the professional competence of a specialist in the technical field. Scientific-research competence is defined as an integrated quality of the personality of a prospective engineer capable of purposeful scientific-research activity in the field of industrial production based on formed knowledge, skills, experience, and a valuable attitude towards the profession, colleagues, and state natural resources.*

*The target, motivational, cognitive, activity, and reflexive aspects of the scientific-research competence of a prospective specialist in the technical field are characterized. The effectiveness of forming the scientific-research competence of prospective engineers is proved in order to prepare highly qualified technical specialists in institutions of higher technical education.*

***Keywords:*** *institutions of higher technical education, professional training, prospective engineers of engineering profile, competency-based approach in education, professional competence, scientific-research competence.*

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# НАУКОВО-ДОСЛІДНИЦЬКА КОМПЕТЕНТНІСТЬ МАЙБУТНЬОГО ІНЖЕНЕРА: ФОРМИ, ДОСВІД, ПЕРСПЕКТИВИ

**Н. О. Романчук**

*У статті досліджується проблема формування науково-дослідницьких компетентностей майбутніх інженерів як складової загальної професійної компетентності майбутнього фахівця технічної галузі. Реалізація компетентнісного підходу визначається концептуальним вектором модернізації підготовки інженерних фахівців з метою їх ефективної діяльності в галузі промислового виробництва на рівні світових стандартів.*

*На основі аналізу досвіду підготовки фахівців технічної галузі встановлюються особливості та мета професійної підготовки майбутніх інженерів в закладах вищої технічної освіти. Професійна компетентність майбутнього фахівця технічної галузі характеризується через творчий характер мислення, науково-дослідницькі вміння, виявлення ініціативи у розв'язанні виробничих завдань, здатність організовувати роботу колективу та усвідомлене розуміння особистої відповідальності за результати праці.*

*Обґрунтовуються гуманітарна, інженерна, проектно-технологічна, управлінська, інформаційна, науково-дослідницька, економічна, господарсько-правова та екологічна компоненти професійної компетентності майбутнього інженера, які визначають професіоналізм сучасного фахівця в галузевій сфері.*

*Виокремлюється науково-дослідницька компетентність як важлива складова професійної компетентності фахівця технічної сфери. Науково-дослідницька компетентність визначається як інтегрована якість особистості майбутнього інженера, здатної до здійснення цілеспрямованої наукової, дослідницької діяльності в галузі промислового виробництва на основі сформованих знань, умінь, досвіду та ціннісного ставлення до професії, колег, державних природних ресурсів.*

***Ключові слова:*** *заклади вищої технічної освіти, професійна підготовка, майбутні фахівці інженерного профілю, компетентнісний підхід в освіті, професійна компетентність, науково-дослідницька компетентність.*

**Introduction of the issue.** Modern socio-economic challenges, globalization processes, which are the main trend in the development of modern information society, define education as one of the factors of production, relying on its productivity. Society requires a conscious, socially active citizen-patriot of the state, a responsible leader, a competent, competitive specialist in the technical field. The implementation of a competency-based approach, which has become a key trend in the development of world educational practice, ensures the formation of important personal qualities of prospective engineers: innovation, initiative, social and professional mobility, creativity, and others.

Contemporary professional activity of an engineering specialist involves organizing production processes based on the implementation of new technologies and equipment, requiring the engineer to be aware of operation specifics as well as to be able to ensure the team work with new mechanisms and devices. Such phenomena of the contemporary world highlight the necessity of preparing competent engineers capable of conducting research activities.

The professional competence of a graduate of an institution of higher technical education is considered a significant indicator of readiness for professional activity in the field of industrial production and an active role in society. Successful acquisition of professional competencies by engineering specialists, a high level of self-organization of professional activities, is ensured by the unity of fundamental and subject training and involves a combination of theoretical knowledge, practical skills, significant personal qualities, and life experience.

The relevance of studying the formation of scientific-research skills as an important component of the professional competence of engineering professionals is determined by the need for prospective engineers to perform professional research

tasks in the field of industrial production and to conduct scientific research aimed at improving both existing technical means and developing new ones.

**Current state of the issue.** Researchers of modern technologies and the content of engineering education I. Bendera, N. Golub, K. Gomoyunov, P. Darvall, J. Martin, A. Melecinek, O. Padalka, S. Sysoeva, V. Tyurina and others emphasize the multifaceted nature of the engineering profession, which requires making correct technical decisions, designing and setting up devices, being a conscious citizen of the state, a responsible leader, and an organizer of teamwork.

According to the conclusions of contemporary researchers on the theoretical and practical aspects of preparing future specialists in the technical field S. Artyukh, O. Baranets, N. Bryukhanova, E. Zeer, O. Kovalenko, A. Nizovtsev, Yu. Pazynich, N. Tymkiv and others, engineers should not only be able to adjust the operation of technical devices but also conduct scientific activities, be researchers, and implement their own ideas in practice. Currently, in Ukraine, there is a stable trend towards the activation of scientific-research activities of engineering students based on a competency-based approach.

The necessity of implementing a competency-based approach in education is justified by researchers such as N. Bibik, O. Yeremenko, O. Lokshyna, V. Lugovyi, O. Lyashenko, O. Ovcharuk, O. Pometun, O. Savchenko, O. Topuzov, V. Khymynets, K. Khoruzhy, and others, whose works define the competence of a prospective specialist in the technical field as the ability to engage in socially valuable activities, and a competent professional is characterized by their readiness to solve tasks in professional activities using innovations to achieve goals based on their knowledge in the field of industrial production.

Modern researchers such as N. Bordovska, L. Kovalenko, V. Petruk, V. Raievskyi, A. Rean, S. Sisoyeva, V. Fedina define professional competence as the ability of prospective engineering professionals to particularly structure scientific and practical knowledge in order to better solve professional tasks and their personal qualities that ensure a high level of self-organization of professional activities.

In contemporary pedagogical science, issues related to organizing research activities of students are actively studied. Specifically, researchers such as S. Belkin, I. Butsik, S. Vitvitska, I. Haydaenko, I. Yermakova, O. Kopus, O. Krushelnytska, N. Kushnarenko, L. Ruskulis, Z. Slepkan, H. Tsekhmistrova, V. Sheiko, and others examine the scientific-research activities of students as an integral component of professional competence, which ensures the integration of scientific, educational, and production activities in the process of professional training of prospective specialists.

**Outline of unresolved issues brought up in the article.** The new conditions of society development set new priorities and tasks for the higher education system, among which the primary one is to ensure a qualitatively new level of training for professionals who possess their own thinking style and an original approach to solving professional tasks [4].

The current realities of the professional activity of prospective engineers in the field of industrial production require the development of skills in scientific problem perception, creative search for unconventional solutions, and the enhancement of research skills. Solving the problem formulated above requires prospective engineers to acquire a scientific-research component of professional competence during their training in institutions of higher technical education.

Despite the increasing intensity of research into the theoretical and methodological foundations of training prospective engineering professionals, the problem of forming scientific-research competence in the process of their training in institutions of higher technical education remains relevant and debatable.

**Aim of the research.** To explore, based on the analysis of modern approaches and experience in organizing scientific and

research activities of students, the principles, methods, forms, and means of forming the scientific-research component of professional competence of prospective engineers.

**Results and discussion.** According to the analysis of the experience in training technical specialists, the competency-based approach has become a socially significant phenomenon and a priority in shaping state policy in the field of education, with its implementation being a primary task in the training of engineering professionals. The foundation of the contemporary understanding of the competency-based approach lies in the notions of knowledge efficiency and the personal attitude towards acquired knowledge as the basis for self-realization. The implementation of the competency-based approach in the training of prospective engineers entails the acquisition by individuals of a comprehensive experience in solving life problems, performing key functions, social roles, and demonstrating competencies.

The implementation of the competency-based approach in the training of prospective engineers entails a shift of emphasis from accumulating normatively defined knowledge, skills, and abilities to forming the ability of technical specialists to creatively apply acquired knowledge and experience in the practice of production processes. Another important aspect of preparing students in institutions of higher technical education lies in their ability to self-organize and reflect, meaning students should comprehend the educational material and feel the need for it. Therefore, the aim of professional training is the development of activity-based skills as a priority characteristic of the value-oriented personality of the prospective technical specialist based on the realization of the competency-based approach.

The engineering profession is unique in its communicative-subject essence and the nature of actions performed in the field of industrial production, as it combines interdisciplinary knowledge, innovative concepts, and environmental features with the ability to synthesize various information to create new subject reality. For effective professional activity, a well-prepared engineer must be able to design and construct, utilize means of production, management practice, constructive-technological, and research activities. Engineering professionals are organizers of the production process and thus must be able to regulate and manage the work of a team, utilize normative-reference, scientific-technical, and production information to ensure the implementation of scientific and technological advances in modern production. Important professional skills of an engineer include the development of scientific-technical documentation, implementation of techno-technological projects, plans, and regulations, and conducting measures to improve production efficiency [8].

According to the Law of Ukraine "On Higher Education", the competency of prospective professionals is defined as a dynamic combination of knowledge, skills, practical abilities, ways of thinking, professional, ideological, social qualities, moral-ethical values, which determine the individual's ability to successfully carry out professional and further educational activities [5].

Thus, competence is understood as a specified requirement, a norm of educational preparation, while competency – as formed personal qualities, the result, and experience of activity, the personal acquisition of the prospective engineer. Competency is the possession by a professional of the necessary knowledge and skills in a specific field of professional activity; familiarity, awareness, breadth of intellect, general professional readiness; synthesis of cognitive, subject-practical, and personal experience.

According to international norms and standards for the training of engineering professionals, competencies have the following composition:

- knowledge and understanding of engineering analysis, design, research; engineering practice, personal competencies (UR-ACE agency standard for engineering programs);

- knowledge and understanding, intellectual abilities, practical skills, personal competencies (UK-SPEC standard);
- technical knowledge and thinking, personal and professional competencies; interpersonal competencies, work and communication in a team; design, implementation, and management of systems in the enterprise and in society (CDIO Syllabus international higher education reform project in engineering and technology) [13].

The professional competence of a prospective technical specialist reflects the level of knowledge, skills, and experience for the purpose of carrying out effective activities in the field of industrial production, thus being an integrative characteristic of their professional and personal qualities. The competence of a technical specialist includes professional knowledge; the ability to analyze and predict work results; using modern information, conducting scientific-research activities in the relevant production sector; social-communicative and individual abilities of the prospective engineer, work experience in the production sector, ensuring independence in carrying out professional activities. The professional competence of a prospective technical specialist involves: the ability to evaluate professional situations; creative thinking; research skills; showing initiative in solving production tasks; the ability to organize teamwork; a conscious understanding of personal responsibility for work results.

The necessity to develop skills and abilities in engineering professionals to forecast social, economic, and environmental consequences of their decisions, according to researchers O. Romanovsky and L. Tovazhnyansky, is associated with the need to solve complex organizational, managerial, technical, and scientific tasks in professional activities in industrial production. Therefore, the structure of professionalism for a modern technical specialist is determined by competency in industry-specific areas (design-construction, operational-technological, organizational-management, scientific-research); psychological-pedagogical, legal, economic, and special managerial competence [10].

The formation of professional competence of prospective engineers is achieved through a combination of scientific-theoretical training and experience in applying acquired knowledge in the field of industrial production. Thus, professional competence combines a system of knowledge and skills that prospective engineers master in the process of scientific-theoretical and practical training to solve basic production tasks with the experience of applying acquired competencies to solve typical and non-standard tasks of professional activity.

The effectiveness of professional training for prospective technical specialists is ensured by the formation of components of professional competence, including humanitarian, engineering, project-technological, managerial, informational, scientific-research, economic, legal-economic, and environmental competencies.

The formation of an intelligent technical specialist who is knowledgeable about the peculiarities of personality development, establishing their place in the national and global cultural environment, and who respects and considers the opinions, rights, and freedoms of others, is ensured by humanitarian competence. Understanding the basic principles, regularities, and models of the industrial production sector ensures the formation of engineering competence of prospective engineers.

Project-technological competence involves the knowledge of engineering professionals in the technologies of industrial processing of materials and products, mastery of the peculiarities of designing and organizing technological processes in industrial production to create competitive goods.

The managerial component of professional competence of prospective engineers involves the formation of skills in team management, solving strategic and tactical engineering-technological tasks in the field of industrial production,

social organization of labor, adequate to market relations based on competition of ideas, goods, and services.

Acquiring scientific-research competencies involves fostering a scientific culture by engaging students in fundamental industry research and developing skills to implement innovative engineering science and technology. Studying modern information technologies, computer equipment, search tools, data processing, storage, and visualization methods are necessary for effectively forming the informational component of professional competence.

The economic competence of prospective engineering professionals entails cultivating an economic culture where their engineering decisions are substantiated by economic feasibility and supported by the development of adaptive skills for professional activities in market economies. In the process of forming the economic-legal component, the legal and legal culture of the engineer's future activities is developed based on the study of the system of state legal norms, laws, and regulations. Knowledge of the impact of technical systems and production technologies on human health, the environment, is essential for a professional in the "human-machine-environment" system, the acquisition of which ensures the formation of the environmental component of professional competence.

The foundation of high-quality training for prospective engineering professionals in institutions of higher technical education is the scientific-research component of their professional competence. Based on the organic unity of education and science, we consider science as a systematic, rational basis for the education of technical specialists. Thus, education becomes the primary mechanism for individuals to acquire professional competencies and experience their practical implementation in future professional activities.

We define *scientific-research competence* as an integrated quality of the prospective engineer's personality, manifested in the readiness and ability to conduct purposeful scientific and research activities in the field of industrial production based on acquired knowledge, skills, experience in organizing such activities, formed personal and professionally significant qualities of the prospective technical specialist's personality, and a values-based attitude toward the engineering profession, colleagues, work results, and the natural resources of the country.

The goal of developing scientific-research competence is to cultivate in the individual of the prospective engineering professional the ability to perform professional research tasks in organizing the production process and conducting scientific research aimed at improving existing and developing new means of production.

According to the formulated purpose, the main tasks facing institutions of higher technical education in the formation of scientific-research competence include the development of the scientific worldview of prospective technical specialists; expanding the scope of their scientific erudition, theoretical readiness for conducting research activities; mastering the methodology and methods of scientific cognition; fostering creative thinking, developing individual abilities of engineering students to solve both typical and non-standard situations in the field of industrial production.

The leading ways to implement the outlined tasks are: orienting the activities of institutions of higher technical education towards developing research skills, shaping the experience of scientific work for prospective engineers; encouraging students to solve scientific problems by involving them in the activities of university research associations (schools, clubs, laboratories, etc.); acknowledging the results of scientific-research activities through participation in scientific seminars, round tables, conferences, symposiums; publishing the results of research work in collections of scientific papers.

The scientific-research competence of prospective engineers is characterized by: the level of professional education; individual abilities for scientific research;

experience in conducting research activities; motivated pursuit of continuous self-education, self-development; a creative approach to professional activities; skills to act in atypical, non-standard situations.

Important principles ensuring the effectiveness of forming scientific-research competence include: a creative attitude towards the engineering profession; the professional focus of scientific-research activities; the personal activity in this process.

The formation of scientific-research competency of prospective engineering professionals is influenced by target, motivational, cognitive, activity, and reflexive aspects.

*The target aspect* directs the scientific-research activities of prospective engineers, delineating their achievements at a certain stage of work.

*The motivational aspect* stimulates the research activities of students. It is important to interest, explain the role, shape attitudes towards scientific work, and demonstrate the necessity of an engineer's scientific activity.

*The cognitive aspect* provides students of engineering specialties with knowledge of the methods, forms of scientific-research work.

*The activity aspect* ensures the involvement of students in the scientific work of the university, participation in events (clubs, conferences, symposiums), writing reports, articles; participation in competitions of scientific works, etc.

*The reflexive aspect* involves the development of students' ability to analyze, evaluate their own scientific achievements; habits of engaging in scientific work in their professional activities; self-improvement.

According to the evidence of the analysis of the training experience of engineering students of Admiral Makarov National University of Shipbuilding, the effective forms for shaping the scientific-research component of professional competence are such special academic disciplines as: "Fundamentals of Scientific Research", specialized courses, and seminars. The activities of student research associations (clubs, problem groups, student laboratories) foster interest in conducting scientific research, engaging in inventive activities; they provide prospective engineers with opportunities for in-depth study of certain disciplines and mastery of research methodology.

The effective formation of scientific-research competence of prospective technical professionals is ensured by the infrastructure activities for planning and conducting research, which include: the scientific-expert council of the Admiral Makarov National University of Shipbuilding, scientific-technical councils for research directions, and 30 scientific schools, including: "Research on Seakeeping Qualities and Design of New Types of Vessels", "Brazing and Pressure Welding in Vacuum", "Environmental Safety and Energy Conservation", and so on.

Based on the activities of branch laboratories and scientific-technical centers of the university, prospective directions for scientific research have been identified:

1. Shipbuilding, ship design, and oceanographic research equipment.
2. Physical-technical problems of materials science (metal structural, ceramic, composite, monocrystalline materials).
3. Interdisciplinary problems and systemic research in energy (energy efficiency and energy conservation).
4. Information and communication technologies for project management, analysis and synthesis of control systems for technical and environmental processes.
5. Energy and energy efficiency, research on seakeeping qualities of vessels and other floating structures.

An important indicator of the level of formation of research skills, as well as a means of gaining experience in solving current scientific problems, discussing the results of scientific research is the preparation and presentation of reports by engineering students at the annual scientific-practical conference "Innovations in Shipbuilding".

To implement the provisions of the Law of Ukraine "On Higher Education" in conditions of limited time and material resources, an effective resource for integration into the European educational space is proclaimed by the Association Agreement between Ukraine and the EU, which activates cooperation in higher education, reform, and modernization of the state higher education system towards increasing mobility of teachers and students, particularly in the field of implementing research projects.

Therefore, a promising direction for scientific-research activity at the Admiral Makarov National University of Shipbuilding is defined as expanding cooperation between the institution's scientists and international research centers and foundations; intensifying their participation in international research projects; expanding academic mobility of teachers, graduate students, and engineering students; establishing an expert center at the university for scientific and methodological consulting.

The functioning of the International Cooperation Educational and Scientific Center (ICESC) established at the Admiral Makarov National University of Shipbuilding has proven its effectiveness in shaping the scientific-research competencies of future engineering professionals. Prospective activities, aimed at expanding opportunities and gaining experience in scientific-research activities for engineering students at the university, include implementing joint international research projects with strategic partners of the university, such as the German Academic Exchange Service (DAAD), the Alexander von Humboldt Foundation, the Fulbright Program, the International Research & Exchanges Board (IREX) (USA), the Education for Democracy Foundation (Poland), etc.

Engaging prospective engineers in scientific-research activities of student scientific associations (clubs, problem groups, laboratories, research schools, international cooperation centers) at the Admiral Makarov National University of Shipbuilding has demonstrated positive results in executing research tasks related to utilizing acquired skills in developing rational proposals, inventions during analytical, exploratory, design, and engineering tasks.

The implementation of a competency-based approach in the training of prospective engineers has strengthened the professional-applied orientation of the educational process, increased the competitiveness of prospective technical specialists by shaping an individual style of professional activity, and a sustainable need for conducting science-research activities in industrial production.

**Conclusions and research perspectives.** As a conclusion, the implementation of a competency-based approach is a logical step towards modernizing the content of professional training for prospective engineering specialists in institutions of higher technical education, responding to societal and social challenges and demands.

The scientific-research activity of students in the process of their training in institutions of higher technical education is considered an integral component of their overall professional competence.

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