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An Innovative Approach To Developing The General Technical Competence Of Prospective Engineers

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ABSTRACT

This article provides a systematic analysis of the key competencies that must be developed in prospective engineers-namely, information, technical, research, and leadership competencies-based on the qualification requirements of their future professional activities. The content and role of each competency within the engineering education process, along with the pedagogical and practical mechanisms for their development, are examined in detail. The study also explores the alignment of these competencies with the demands of modern industry. It is substantiated that the integrated formation of these competencies ensures the professional preparedness of future specialists in accordance with established qualification standards. The article concludes with findings on the comprehensive development of competencies and offers scientific and practical recommendations for improving the educational process.

Keywords: General technical competence, qualification requirements, information competence, technical competence, research competence, leadership competence, innovative educational technologies, integrative approach, practical training, engineering education, competency-based approach.

INTRODUCTION

In the context of rapid technological advancement, increasing complexity of production processes, and ongoing digital transformation, the qualification requirements for future engineers are undergoing significant renewal. National higher education standards, sector-specific regulatory documents, and the demands of modern industrial enterprises emphasize that engineering professionals must be capable of working effectively with information, possess a deep understanding of technical and technological processes, conduct scientific research, and demonstrate leadership within a team.

Therefore, the formation of general technical competence in prospective engineers should not be limited to the transmission of theoretical knowledge; rather, it must ensure the systematic development of information, technical, research, and leadership competencies that correspond to their future professional activities. These competencies constitute key components of the competency model defined in the Qualification Requirements for Higher Education of the Republic of Uzbekistan and in relevant professional standards.

Contemporary qualification requirements expect engineers not only to apply existing technologies but also to improve them, create innovative solutions, and effectively address complex industrial problems. Achieving such outcomes necessitates organizing the educational process on the basis of practice-oriented, integrated, and innovative approaches. From this perspective, the interconnected development of information, technical, research, and leadership competencies in the teaching of general engineering disciplines becomes a fundamental condition for preparing prospective engineers in accordance with qualification standards.

METHODS

Modern technical education requires students not only to

acquire theoretical knowledge but also to develop practical skills, technological literacy, creative thinking, and the ability to solve problematic situations. From this perspective, identifying the most effective educational approach for developing students' general technical competence has become an important scientific and practical issue. Today, education, social spheres, the economy, and nearly all fields are gradually transitioning to a digital economy

[1, 24, 27]. This process requires future engineers to possess competencies such as information management, the ability to operate modern technical tools, the creation of innovative solutions, and the effective organization of teamwork. Therefore, organizing the formation of general technical competence through educational approaches aimed at the integrated development of information, technical, research, and leadership competencies is one of the most essential requirements of contemporary engineering education.

Engineering education is a process implemented based on curriculum and regulatory documents, aimed at preparing competent specialists for industry, where general engineering subjects play a fundamental and central role [2, 25, 26].

In the course of our research, each element (competency) that constitutes general technical competence will be systematically analyzed. The theoretical and practical foundations necessary for the study will be developed, and scientific conclusions will be drawn based on the obtained results.

The first element that constitutes general technical competence is the concept of information competence. As the foundation for improving this component of GTC, it should be noted that the qualification requirements for engineering education programs clearly define information-analytical tasks of professional activity (Figure 1).

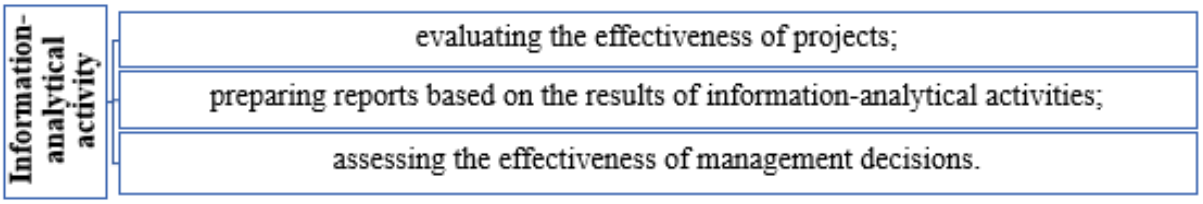


Figure 1. Tasks of engineers in information-analytical professional activities.

According to these requirements, the formation of information competence involves acquiring the following professional competencies:

- knowledge of methods for collecting, storing, processing, and using information, as well as the ability to make independent, well-grounded decisions in professional practice;
- the ability to understand documents and tasks related to professional activity in a foreign language and to use that language sufficiently for professional purposes;
- the ability to present thoughts, opinions, ideas, proposals, descriptions, and conclusions in oral and written forms clearly, logically, accurately, and in accordance with the rules and norms of the state language;
- knowledge of the procedures for planning activities related to commissioning technological equipment, as well as the ability to analyze various types of technological machines and devices.

These requirements outline the essential professional competencies that a future engineer must possess as part of the development of information competence.

Based on the requirements outlined above, the following definition may be proposed: information competence is the individual's ability to search for, collect, store, process, and effectively use information necessary for professional activity; to understand and utilize professional information sources in a foreign language; to logically and accurately express ideas, opinions, and conclusions orally and in writing in the state language; and to analyze information related to technological processes and equipment and apply it in practical activities.

In today's globalized world, it is essential for future specialists in any field to possess well-developed information competence in order to carry out professional activities effectively. Although access to a wide range of

information sources allows us to retrieve data from various platforms, it also raises the challenge of determining the quality and reliability of the information we obtain.

There are various approaches to defining the concept of "information competence," and several of them are presented below.

According to Y.I. Askerko, "information competence is an integral personal characteristic that reflects an individual's desire and ability to effectively search for, collect, analyze, process, and productively use information in educational and cognitive activities" [3].

Based on the research of N.V. Gafurova and A.D. Arnautov, "information competence is the ability to integrate the functional possibilities of various software products and computing devices, and to consciously incorporate information technologies into professional activities for solving professional problems" [4].

M.P. Lapchik emphasizes that "information competence is a feature of a specialist's personal and professional activity, which includes readiness to effectively and diversely use all types of computer tools and technologies" [5].

After analyzing the definitions provided above, a comparative table was developed to examine the conceptual essence of "information competence" as described by different scholars (Table 1).

Information competence may therefore be defined as a set of knowledge, skills, abilities, and personal qualities that enable an individual to search for, receive, analyze, process, present, transmit, systematize, and transform information into knowledge using digital information technologies; to integrate this information into professional activities; and to make effective decisions and solve professional problems in non-standard situations.

Table 1.

No.	Author(s)	Definition Content	Main Emphasis
1	Y.I.Askerko	The desire and ability to effectively search for, collect, analyze, transform, and productively use information in educational and cognitive activities (an integral personal characteristic).	Ability to search for and effectively use information.
2	N.V.Gafurova, A.D.Arnautov	Solving professional problems by consciously integrating the functional capabilities of software products and technical devices into professional activities.	Solving professional problems using technical tools.
3	M.P.Lapchik	A specialist's readiness to effectively use all types of computer tools and technologies.	Readiness to use computer technologies.

Information competence is a set of knowledge, skills, and abilities that enables students to effectively search for, analyze, process, present, and transmit information using modern digital technologies. General technical competence, in turn, encompasses a student's level of preparedness to work with technology and technological systems, the development of engineering thinking, and the ability to solve technical problems.

Thus, information competence is one of the core components of general technical competence, as it provides the ability to search for, process, and apply the necessary information in the technical field.

Information competence plays an important role in the development of general technical competence. In particular, the theoretical foundations, problem-solving activities, and practical tasks covered in the course "Theoretical Mechanics," which is included in the general engineering disciplines, are closely related to real-life processes and technical phenomena encountered in industrial environments, thereby contributing to the development of students' engineering thinking.

The second component of general technical competence is

the concept of technical competence.

As the basis for improving this element of general technical competence, it should be noted that the qualification requirements specify the tasks of design and engineering activities (Figure 2).

Figure 2. Tasks of engineers in design and engineering professional activities.

According to these requirements, the formation of technical competence includes the following professional abilities:

- the ability to use fundamental laws of natural sciences in professional activities, and to apply mathematical analysis, modeling, and methods of theoretical and experimental research;
- skills in designing, manufacturing, operating, and maintaining technological machines and equipment;
- knowledge of technical conditions, standards, and specifications aimed at improving the efficiency of technological equipment within the field of machine and equipment design;
- understanding of the technological characteristics of devices involved in designing, manufacturing, operating, and maintaining technological machines and equipment, as well as the ability to use and repair them;
- the ability to identify and eliminate the causes of existing problems in designing, manufacturing, operating, and maintaining technological machines and equipment, and to develop measures to prevent their recurrence.

Based on these requirements, technical competence can be defined as a specialist's theoretical knowledge and practical skills required to design, manufacture, effectively operate, and maintain technological machines and equipment in accordance with the laws of natural sciences; to understand the technical conditions, standards, and

specifications aimed at improving the performance of technical systems; and to analyze and resolve existing technical problems to enhance production processes.

L.M. Spencer and S.M. Spencer emphasize technical competence as an important factor that enhances job performance. According to them, technical competence is the application of technical knowledge and skills to real work tasks [6].

L.S. Shulman notes that, in addition to technical knowledge, a specialist should also possess pedagogical and organizational skills, which implies that technical competence has a broader and more comprehensive nature [7].

P. Mishra and M.J. Koehler view technical competence as the integration of technological and pedagogical knowledge, highlighting the effective use of technologies in teaching [8].

A comparative Table 2 of the definitions of technical competence is presented below:

Table 2.

Author	Content	Main Emphasis
L.M. Spencer	Application of technical knowledge and skills in real work tasks.	Enhancing performance through the application of knowledge in real tasks.
L.S. Shulman	Integration of technical knowledge with pedagogical and organizational skills.	Importance of pedagogical and organizational skills.
P. Mishra, M.J. Koehler	Integration of technological, pedagogical, and content knowledge.	Integration of knowledge for effective technical competence.

The third element of general technical competence is the concept of research competence.

The basis for improving this element of general technical competence is determined by the scientific-research tasks specified in the qualification requirements (Figure 3).

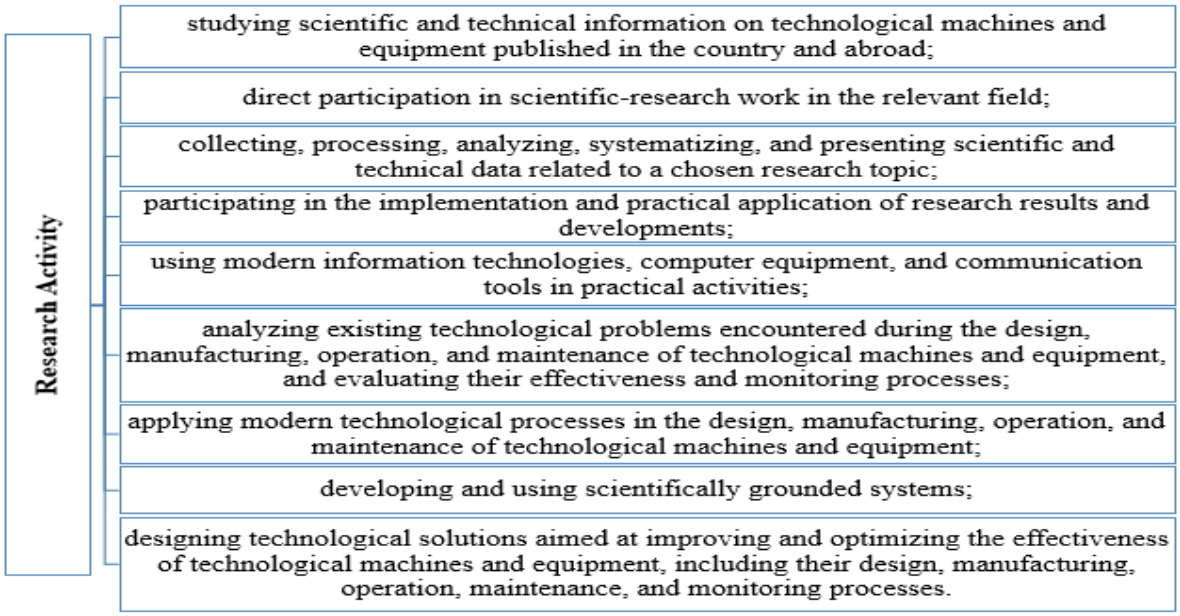


Figure 3. Tasks of engineers in scientific-research professional activities.

According to the qualification requirements, the formation of research competence includes the following professional abilities:

- understanding, analyzing, and using documents and tasks related to professional activity;
- critically evaluating acquired professional experience, engaging in self-development, improving qualifications, and adapting professional abilities to various situations and changing conditions;
- having a clear understanding of potential hazards in the workplace and taking preventive measures to avoid possible accidents;
- knowing the procedures for organizing design work on technological machines and equipment, as well as developing and analyzing design methods;
- possessing skills in evaluating the efficiency of technologies and devices used in designing, manufacturing, operating, and maintaining technological machines and equipment, developing cost-effective measures, and calculating their economic indicators.

Based on these requirements, research competence refers to the ability of a future engineer or specialist to think analytically in the field of technological machines and equipment, conduct research, analyze findings, and apply the results in practice. This competence is closely associated with identifying problems through a scientific approach, collecting, processing, and evaluating scientific data, and developing new technological solutions within the professional activity.

The formation of research competence as one of the key components of future engineers' professional preparedness is among the essential tasks of modern education. Scholars such as O.E. Lebedev, A.A. Ushakov, E.V. Fes'kova, I.I. Kholodtsova, L.A. Chernyaeva, and others have studied research skills within the structure of research competence [9].

An analysis of these authors' works shows that issues related to the formation, emergence, and development of research competence are mostly addressed within the context of the education system, and that no single, universally accepted definition exists in pedagogical theory. This is clearly reflected in the interpretations provided by different researchers: research competence is described as socially significant requirements for independent cognitive activity and mastering ways of acting in non-standard situations [10]; it is interpreted as a set of knowledge, concepts, action programs, value systems, and attitudes manifested during professional activities [11]; it is viewed as an individual's ability to adopt a researcher's position toward the environment, identifying and solving problematic situations using various theoretical and empirical information sources [12]; it is also understood as readiness and ability to independently master new knowledge by shifting the content of activity from a functional level to a creative level based on existing knowledge, skills, and methods [13]; it is assessed as the level of theoretical and practical preparedness necessary for effectively conducting research activities [14, 15]; and it is defined as personally assimilated knowledge, skills, abilities, practical experience, value-oriented criteria, and behavioral models formed in the process of research activity [16]. Additionally, it is explained as a teacher's ability to solve creative pedagogical problems, where the "situation" refers to the psychological-pedagogical environment shaped by mastering the logic of analytical inquiry [17].

According to J.R. Turmatov, "research competence is not only a set of research-related knowledge, skills, and abilities that an educated person must possess, but also a deeper concept that reflects the individual's personal attitude toward the subject of activity" [18].

M.B. Shashkina and A.V. Bagachuk argue that "research competence includes the individual's integrative characteristics, which encompass mastery of methodological knowledge and research technologies and readiness to apply them in professional activities" [19].

Based on the above considerations, the research competence of future engineers can be defined as follows:

Research competence is an integrative quality that reflects an individual's readiness and ability to apply scientific research methods in the search for, creation, and practical application of new knowledge. It is founded on the integration of theoretical knowledge, practical skills, and abilities; encompasses personal attitudes and value systems; fosters creativity in solving problem situations; and supports continuous self-development.

The fourth element of general technical competence is the concept of leadership competence.

The basis for improving this element of general technical

competence is defined by the organizational and managerial tasks specified in the qualification requirements (Figure 4). According to these requirements, the formation of leadership competence involves the ability to:

- clearly express one's opinions, participate in communication, justify proposals and conclusions, and ensure harmony within a team;
- make independent decisions in professional activities, take initiative, and assume responsibility;
- critically evaluate one's own professional performance, identify ways to improve it, and guide others in this process;
- lead efforts to ensure safety and efficiency in production processes and demonstrate initiative in solving problems.

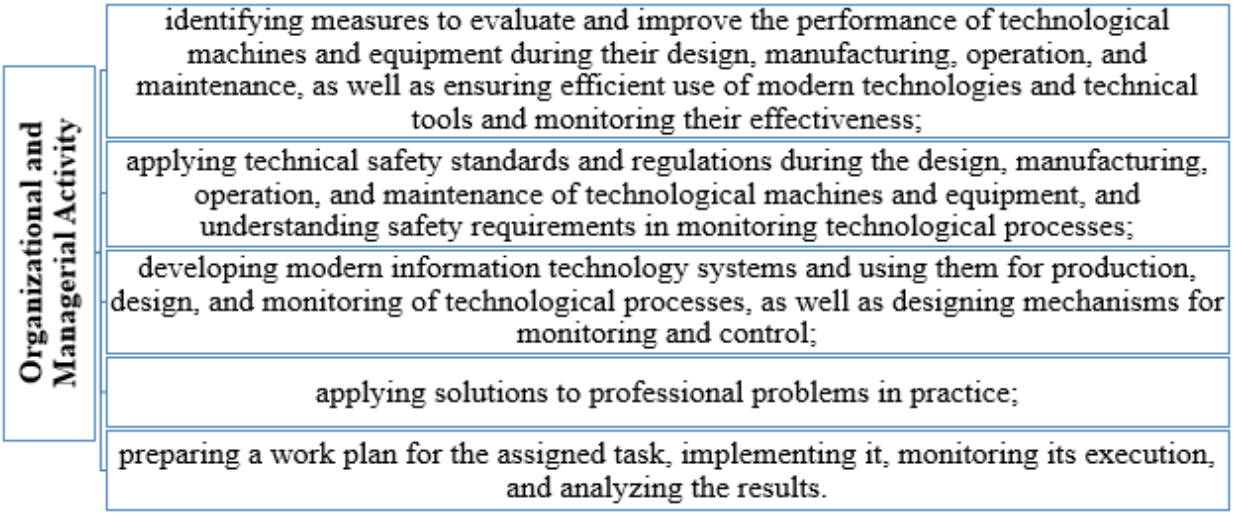


Figure 4. Tasks of engineers in organizational and managerial professional

Based on the above considerations, leadership competence is defined as the ability of a future specialist to demonstrate initiative in production and management processes, guide a team toward common goals, plan activities, supervise implementation, and effectively organize the process of analyzing outcomes.

No group can function effectively without a leader. A leader is a person capable of uniting a group of individuals around a specific goal; their main function is to motivate team members to follow them, facilitate collaboration within the group, and guide them toward achieving shared objectives. In other words, a leader is the key element that regulates the functioning of a system composed of people. Leadership is the individual's ability to influence a group, directing the actions of all members toward the goals of an organization or team. The English word "leader" means "head," "commander," "guide," or "person who leads" [20].

According to F. Drucker, "effective leadership is an activity measured by results, and it is defined not by innate abilities or personality traits but by achieving concrete goals. Leadership is not the art of creating followers; it is the process of giving direction and achieving outcomes" [21].

E.S. Wibbeke describes global leadership competence through seven key dimensions, highlighting intercultural communication, adaptability, strategic thinking, and the ability to collaborate as essential qualities of a modern leader [22].

H.M. Schroder views leadership competence as a critical factor in enhancing both personal managerial effectiveness and collective performance. According to him, competent leaders demonstrate advanced skills in decision-making, analyzing complex situations, and managing resources effectively [23].

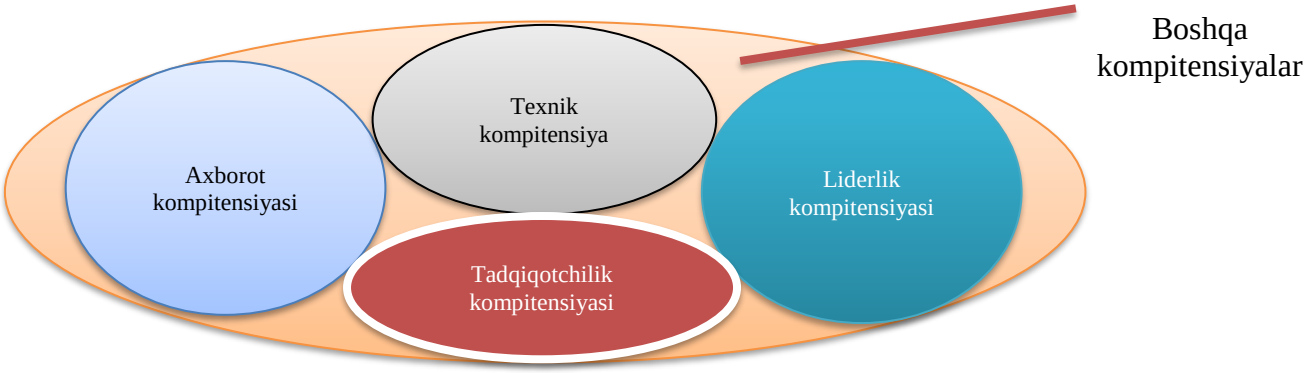
O. Woodward describes leadership as "a process that leaves a positive impact on people's lives and inspires them to achieve personal and collective accomplishments." This

definition emphasizes not only the managerial role of leadership but also its educational and motivational dimensions.

Based on the interpretations above, leadership competence can be defined as a set of knowledge, skills, abilities, and personal qualities that enable an individual to effectively manage group or team activities, provide confidence and motivation, make strategic decisions in attaining shared goals, and unlock the potential of team members.

Applied to the professional activity of future engineers, the leader of an engineering team is an individual capable of effectively managing engineers involved in production, design and engineering, technical maintenance, or scientific research processes; directing them toward common objectives; making timely and well-grounded technical and organizational decisions; supporting innovative ideas; and fully developing the team's professional potential.

Thus, in our research, if the general technical competence of future engineers and its constituent competencies are combined through their mutual interference represented by Euler diagrams, the individual may be considered to possess comprehensive general technical competence (Figure 5).



5-rasm. Umumiy texnik kompitentlik va uning kompitensiyalarining kompitentli yondashuv asosidagi ta'limdagi bog'lanishi.

RESULTS

The study revealed that the formation of general technical competence in future engineers depends on the systematic and interconnected development of four core competencies: information, technical, research, and leadership. The analysis of qualification requirements, professional standards, and engineering education curricula demonstrated that each competency contributes uniquely to students' professional readiness.

The results show that:

Information competence enables students to work effectively with digital technologies, conduct information search, analyze and process data, and apply information resources in technical tasks.

Technical competence equips students with the ability to understand technological processes, design and model engineering systems, operate technical devices, and apply engineering standards and methods.

Research competence enhances students' ability to conduct scientific inquiry, analyze complex problems using scientific methods, propose innovative solutions, and integrate research outcomes into engineering practice.

Leadership competence strengthens students' capabilities in team management, initiative taking, decision-making, communication, and coordination within engineering

environments.

The findings also showed that the integration of these competencies-modeled through an Euler diagram approach-ensures a holistic formation of general technical competence, providing future engineers with a unified and sustainable framework for professional activity.

Furthermore, the study identified that aligning educational content, practical training, and assessment methods with current industry requirements significantly improves the overall quality of engineering education.

DISCUSSION

The results of the study confirm that modern engineering education must adopt an integrative and competence-based approach to adequately prepare future specialists for rapidly changing technological environments. The interconnected development of information, technical, research, and leadership competencies is not only desirable but essential for ensuring that graduates meet the demands of contemporary industrial practice.

The discussion highlights several key observations:

- The increasing digitalization of industrial sectors requires stronger emphasis on *information competence*, particularly the use of digital platforms, simulations, and technological tools in the learning process.
- The complexity of engineering tasks necessitates robust *technical competence*, which can only be achieved through practice-oriented instruction, laboratory work, and exposure to real-world technical challenges.
- Innovation-driven industries demand a high level of *research competence*, reinforcing the need to integrate scientific inquiry, experimental methods, and problem-based tasks into the curriculum.
- Effective participation in engineering teams requires well-developed *leadership competence*, including communication, coordination, and management skills that must be cultivated through social-psychological training and collaborative learning activities.

Additionally, the research suggests that the integration of competencies, as demonstrated by the Euler model, allows for synergy across learning outcomes, resulting in more comprehensive and adaptable engineering graduates. This aligns with global trends emphasizing interdisciplinary approaches, active learning methodologies, and continuous professional development.

Overall, the findings underscore that the quality of engineering education significantly depends on the coherence between qualification requirements, professional standards, industry needs, and pedagogical practices. Therefore, adopting an integrative model for competence development is crucial for enhancing educational effectiveness and producing competitive engineering professionals.

CONCLUSION

The study concludes that the development of general technical competence in future engineers is a fundamental requirement of modern engineering education. The research demonstrates that effective professional preparation can be achieved only through the integrated development of four essential competencies: information, technical, research, and leadership. Each competency contributes to a specific dimension of engineering readiness, while their interconnected formation ensures the holistic development of students' professional capabilities.

The findings indicate that information competence equips students with digital literacy and the ability to work effectively with information resources; technical competence enables them to design, model, and operate technological systems; research competence fosters scientific inquiry, analytical thinking, and innovation; and leadership competence strengthens decision-making, communication, teamwork, and organizational skills necessary for engineering practice.

The integrative model developed in the study—based on the Euler diagram approach—demonstrates that the synergy between these competencies leads to the formation of a unified level of general technical competence. This framework aligns with qualification requirements, professional standards, and the needs of modern industrial production.

Moreover, the study highlights the necessity of aligning educational content, teaching methods, practical activities, and assessment approaches with contemporary industry demands. Competence-based, practice-oriented, and digitally enriched learning environments significantly enhance the effectiveness of engineering education.

Overall, the research confirms that building general

technical competence through an integrative approach is a key factor in improving the quality of engineering training and preparing future engineers to meet the challenges of rapidly evolving technological and industrial environments.

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