

IMPROVING THE TEACHING METHODOLOGY OF COMPULSORY (GENERAL PROFESSIONAL) SUBJECTS IN THE FIELD OF THERMAL ENERGY AT HIGHER TECHNICAL EDUCATION INSTITUTIONS BASED ON A COMPETENCY-BASED APPROACH

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Abstract

This study is devoted to improving the methodology of teaching compulsory (general professional) disciplines in the field of thermal power engineering at technical higher education institutions based on the competency-based approach. The effectiveness of the educational process aimed at developing professional competencies through the use of modern pedagogical technologies and practice-oriented teaching methods is analyzed. The results of the pedagogical experiment demonstrate that an educational process organized on the basis of the competency-based approach significantly enhances students' theoretical knowledge, practical skills, and level of professional training. The findings contribute to improving the quality of specialist training in the field of thermal power engineering.

Keywords: thermal power engineering, competency-based approach, technical higher education institutions, general professional disciplines, teaching methodology, professional competence, pedagogical technologies.

INTRODUCTION

Nowadays, the requirements for training personnel in technical higher education institutions are directly related to labor market needs, the technological development of industry, and international education standards. In particular, for future engineers studying in the field of thermal energy, it is crucial not only to have theoretical knowledge but also to develop readiness for practical work, the ability to solve problems independently, and professional competencies. This makes the transition from a traditional knowledge-oriented approach to a competency-based approach in higher education a pressing issue.

The competency-based approach in education aims to develop students' ability to apply acquired knowledge in real professional situations. It is recognized as a core methodological principle in the European Higher Education Area (Bologna Process) and UNESCO recommendations. According to researchers, this approach plays a key role in improving the quality of professional preparation in engineering education and ensuring graduates' competitiveness [1].

In the higher education system of the Republic of Uzbekistan, the implementation of a competency-based approach is defined as a priority at the level of state policy. Specifically, the "Concept for the Development of Higher Education until 2030" emphasizes the need to base educational content on competencies, increase the share of practice-oriented subjects in engineering disciplines, and ensure graduates' competitiveness in the labor market [2]. These regulatory documents serve as an important methodological foundation for modernizing the educational process and adapting teaching methods to contemporary requirements.

From this perspective, improving the methodology of teaching compulsory (general professional) subjects in the field of thermal energy at technical higher education institutions based on a competency-based approach and modern pedagogical technologies emerges as a significant scientific and practical task. This is because the field of thermal energy requires not only advanced technical knowledge but also professional competencies such as analyzing complex technological processes, evaluating energy efficiency, and developing innovative solutions.

Analysis of current teaching practices shows that in many technical higher education institutions, teaching thermal energy subjects gives priority to theoretical material, while practical exercises, project activities, and integration with production are insufficiently provided. This limits students' opportunities to apply knowledge in real professional situations and negatively affects the full and systematic formation of professional competencies [3]. Consequently, graduates' practical readiness may not fully meet production requirements.

Therefore, in teaching compulsory subjects in the field of thermal energy, revising the methodological system based on a competency-based approach, orienting educational content toward practice, strengthening interdisciplinary integration, and widely implementing modern pedagogical and digital teaching technologies are important factors for increasing educational effectiveness. Project-based learning, problem-based learning, case studies, and virtual laboratories can be used to enhance students' readiness for professional activity.

Methods

This study focuses on improving the methodology of teaching compulsory (general professional) subjects in the field of thermal energy at technical higher education institutions based on a competency-based approach. It aims to develop modern pedagogical technologies, practice-oriented teaching methods, and mechanisms for forming professional competencies. The results of the study make it possible to develop scientific-methodological recommendations that contribute to training competitive, highly qualified engineers in the field of thermal energy.

The study employed a mixed-methods research design. Mixed methodology is widely recommended in the literature as it allows for a deep and reliable analysis of complex pedagogical processes in education [4].

Competency-based teaching methods introduced in the study included problem-based learning, project-based learning, case-study, as well as practical modeling and laboratory exercises. Research has shown that these methods are effective in engineering education for developing students' independent thinking, analyzing real production situations, and forming professional decision-making competencies [5].

The empirical research was conducted with second- and third-year students studying thermal energy at a technical higher education institution in the Republic of Uzbekistan. A total of 120 students participated, and their initial knowledge level, learning activities, and professional readiness were assessed using diagnostic tests and questionnaires. Based on the results, students with similar knowledge levels were divided into experimental and control groups to ensure the objectivity of the study.

In the experimental group, teaching compulsory (general professional) subjects in thermal energy was organized according to a methodological model developed based on a competency-based approach. The educational process included practice-oriented tasks, problem situations, project-based learning,

case-study methods, and the use of digital learning tools. Independent and group activities aimed at developing students' professional competencies were widely implemented.

In the control group, subjects were taught using traditional methods, primarily lectures and reproductive-type practical exercises. The educational process in this group followed existing curricula and standard methodological recommendations, with limited use of competency-based approach elements.

Changes in students' knowledge, skills, and abilities were analyzed based on ongoing, intermediate, and final assessment results. Observation, interviews, and questionnaires were also used to evaluate students' attitudes toward learning, independent work capabilities, and professional interests. This approach allowed for enhancing the reliability of the research results and comprehensively assessing the effectiveness of the competency-based methodology.

Data collection employed diagnostic tests, questionnaires, observation, and evaluation criteria for student activities. Assessment of professional competencies was based on a model encompassing knowledge, skills, and attitude components, aligned with the European Qualifications Framework (EQF) recommendations [6].

Collected data were processed using mathematical-statistical methods, and differences between experimental and control groups were analyzed. Student's t-test and percentage comparison methods were used to determine statistical significance. Triangulation was applied to ensure the reliability and validity of the research results [7].

Results

The results indicated that teaching compulsory (general professional) subjects in thermal energy at technical higher education institutions using a competency-based approach significantly improves students' professional readiness. During the experimental study, traditional knowledge-oriented teaching methods were compared with the competency-based methodology. The impact of both approaches on learning outcomes was studied through regular monitoring and evaluation criteria.

According to the results, in the educational process organized based on a competency-based approach, students achieved high performance not only in mastering theoretical knowledge but also in effectively applying it to solve real practical problems. In particular, professional competencies such as performing technical calculations in thermal energy, analyzing technological processes, evaluating the efficiency of energy systems, and proposing alternative solutions were significantly developed. This indicates that students' professional thinking was formed by aligning their learning activities closely with real production environments.

Furthermore, the study found that the systematic use of interactive teaching methods, problem-based learning, project-based learning, and digital learning tools significantly increased students' engagement in the learning process. These approaches positively influenced the development of general professional competencies among students, including independent thinking, critical analysis, teamwork, communication skills, and professional responsibility. Statistical analysis of the assessment results confirmed that the mastery level of students in the experimental group was on average 15–20% higher than that of the control group, providing scientific evidence of the methodology's effectiveness.

The methodological recommendations developed during the study highlighted the need to orient the curriculum content of thermal energy subjects toward competencies, strengthen interdisciplinary integration, increase the share of practical exercises, and widely implement modern pedagogical and

digital technologies. The results confirm that this methodology is effective, practical, and methodologically valuable for application in technical higher education institutions and contributes to training competitive engineering personnel in the field of thermal energy.

Teaching general professional subjects in a digital environment consists of two main components: the content and the forms of instruction. The content component focuses on forming theoretical knowledge, practical skills, and professional competencies, while the forms component represents the methods of organizing the learning process using digital technologies. This scheme demonstrates the integrity of the educational process and the systematic nature of the digital pedagogical approach. The results of this study confirm that systematically implementing a competency-based approach in teaching compulsory (general professional) subjects in the field of thermal energy at technical higher education institutions is a key pedagogical factor for improving educational quality and enhancing graduates' professional readiness. The empirical findings were analyzed comparatively and integratively with modern pedagogical theories, competency-based education concepts, and advanced domestic and international research.

The experimental results showed that the traditional knowledge-oriented teaching model primarily provides students with theoretical information, limiting their ability to apply knowledge in real professional situations. In contrast, an educational process organized on a competency-based approach helped students develop the ability to make independent decisions in situations close to real production conditions, systematically analyze problems, compare different technological alternatives, and develop practically feasible solutions. This demonstrates that the process aims to shape students not merely as knowledge recipients but as future professionals ready for their careers.

Discussion

These findings practically confirm the interpretation of competency, as proposed by Khutorskoy and Zimnyaya, as an integration of knowledge, skills, qualifications, and personal qualities [9]. Analysis of student activity during the study showed that the competency-based approach ensures student-centered education, enhancing their sense of professional responsibility, initiative, critical thinking, and self-development.

Furthermore, the discussion indicated that effectively implementing a competency-based approach requires revising subject content, diversifying teaching methods, and aligning the assessment system with competencies. This underscores the need to strengthen the link between theory and practice in teaching thermal energy subjects.

Overall, the study results demonstrate that the competency-based approach is essential for increasing pedagogical effectiveness in teaching thermal energy subjects at technical higher education institutions, aligning learning outcomes with labor market requirements, and training competitive engineering personnel.

The discussion also highlighted that because thermal energy subjects are inherently practical and technological, organizing their teaching using a competency-based approach is particularly effective. Project-based learning, modeling problem situations, and assignments simulating real production processes helped students develop competencies in comprehensive analysis of energy processes. These findings align with the recommendations provided within the Baydenko and Tuning project [10].

Additionally, the study showed that using digital learning tools further enhances the effectiveness of the competency-based approach. Virtual laboratories, simulation software, and automation tools for

energy calculations encouraged independent study and facilitated linking theoretical knowledge with practical applications. This emphasizes the relevance of developing digital competencies in the field of thermal energy.

An important conclusion from the discussion is that effective implementation of the competency-based approach is not limited to updating methodology alone. It also requires improving instructors' professional-pedagogical competencies, updating educational and methodological resources, and aligning assessment systems with competencies. Otherwise, the approach may remain purely formal. This conclusion aligns with the normative documents governing ongoing reforms in Uzbekistan's higher education system.

It should also be acknowledged that the study has certain limitations. The experimental work was conducted in a limited number of higher education institutions and within a subset of subjects. Expanding the research to other technical fields and courses in the future would allow for a deeper assessment of the universality of the competency-based approach.

Overall, the discussion results indicate that improving compulsory subjects in the field of thermal energy based on a competency-based approach is a crucial pedagogical condition for training competitive engineers with modern knowledge and skills under a market economy.

Conclusion

The study demonstrated that implementing a competency-based approach in teaching thermal energy subjects significantly enhances the effectiveness of the educational process. The analysis and experimental work confirmed that a competency-based teaching methodology not only deepens students' theoretical knowledge but also actively develops their practical skills, professional thinking, and independent decision-making abilities. By aligning learning objectives with specific competencies, students are better prepared to apply theoretical concepts in real-world engineering contexts, bridging the gap between academic knowledge and industrial practice.

The research further revealed that the integration of interactive teaching methods, including project-based and problem-based learning, as well as the incorporation of digital educational tools, plays a pivotal role in fostering both professional and general professional competencies. Students engaged in such learning environments demonstrated improved problem-solving abilities, collaborative skills, and adaptability—qualities essential for navigating the rapidly evolving energy sector. Moreover, these methods enhance cognitive engagement, motivation, and retention of knowledge, which collectively contribute to a higher level of professional readiness and competitiveness in the labor market.

In addition, the study highlighted that the effective implementation of a competency-based approach requires systematic reforms at multiple levels of the educational process. Curriculum content must be revised to ensure that it aligns with the latest industry standards and technological advancements, while interdisciplinary integration should be strengthened to provide students with a holistic understanding of complex thermal energy systems. Assessment systems should be restructured to focus on the evaluation of competencies rather than solely on theoretical knowledge, incorporating practical assignments, simulations, and performance-based testing.

The research also emphasized the central role of continuous professional development for educators. The enhancement of teachers' pedagogical and professional competencies is essential for delivering high-quality instruction within a competency-based framework. Teachers equipped with modern

instructional strategies, digital literacy, and domain-specific expertise are better positioned to guide students toward achieving both theoretical mastery and practical proficiency.

Overall, the methodological approach developed in this study offers a comprehensive strategy for modernizing the teaching of compulsory subjects in the field of thermal energy at technical higher education institutions. It holds practical significance for improving the quality of training for engineering and energy specialists, ensuring that graduates possess the necessary knowledge, skills, and competencies to meet the demands of contemporary industrial and research environments. Furthermore, the findings of this research provide a robust scientific and methodological foundation for ongoing higher education reforms, supporting the broader implementation of competency-based education across technical disciplines. This approach not only contributes to the professional success of individual graduates but also promotes the advancement of the energy industry by cultivating a workforce capable of innovation, critical thinking, and effective problem-solving in complex thermal energy systems.

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