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FORMATION OF PROFESSIONAL QUALITIES OF FUTURE ENGINEERS IN A DIGITAL EDUCATIONAL ENVIRONMENT: SCIENTIFIC AND ANALYTICAL RESEARCH BASED ON FOREIGN EXPERIENCE

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Abstract

In this article, the issue of forming the professional qualities of future engineers in a digitalized educational environment is scientifically and analytically investigated based on foreign experience. The main goal of the research is to determine the influence of digital pedagogical models, project-based learning, blended learning, and industry-oriented approaches used in the practice of international engineering education on the development of professional competencies of future engineers. The research was conducted on the basis of mixed methods, using the methods of theoretical analysis, empirical observation, questionnaires, and comparison.

Keywords: Digital educational environment, engineering education, professional qualities, foreign experience, project-based learning, blended learning, digital educational ecosystem, engineering competence, professional development.

Аннотация:

В данной статье на основе зарубежного опыта научно-аналитически исследуется вопрос формирования профессиональных качеств будущих

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инженеров в цифровой образовательной среде. Основная цель исследования - определить влияние цифровых педагогических моделей, проектного обучения, смешанного обучения и отраслевых подходов, используемых в практике международного инженерного образования, на развитие профессиональных компетенций будущих инженеров. Исследование проводилось на основе смешанных методов, с использованием методов теоретического анализа, эмпирического наблюдения, анкетирования и сравнения.

Ключевые слова: Цифровая образовательная среда, инженерное образование, профессиональные качества, зарубежный опыт, проектное обучение, смешанное обучение, цифровая образовательная экосистема, инженерная компетентность, профессиональное развитие.

Annotatsiya:

V dannyoy state na osnove zarubejnogo opita nauchno-analiticheski issledovan vopros formirovaniya professionalnix kachestv budushix injenerov v sifrovoy obrazovatelnoy srede. Tadqiqotning maqsadi xalqaro muhandislik ta'limi amaliyotida qo'llanilayotgan raqamli pedagogik modellar, loyihaviy ta'lim, aralash ta'lim va tarmoqli yondashuvlarning bo'lajak muhandislarning kasbiy kompetensiyalarini rivojlantirishga ta'sirini aniqlashdan iborat. Tadqiqot aralash usullar asosida, nazariy tahlil, empirik kuzatuv, so'rovnoma va taqqoslash usullaridan foydalangan holda amalga oshirildi.

Tayanch iboralar: Raqamli ta'lim muhiti, muhandislik ta'limi, kasbiy sifatlar, xorijiy tajriba, loyihaviy ta'lim, aralash ta'lim, raqamli ta'lim ekotizimi, muhandislik kompetensiyasi, kasbiy rivojlanish.

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Introduction

In the context of global digital transformations, engineering activity is acquiring an interdisciplinary and systemic character, which significantly changes the requirements for the professional training of future engineers. A modern engineer must possess not only fundamental knowledge, but also developed engineering thinking, digital competence, design culture, teamwork skills, and a responsible approach to the application of digital technologies.

Foreign studies show that the digitalization of the educational environment manifests itself not as a set of individual technological solutions, but as a holistic pedagogical mechanism that influences the formation of professional qualities of students. However, with the partial introduction of digital technologies, their impact on professional development is limited. Therefore, a scientific and analytical assessment of foreign experience in the formation of professional qualities of future engineers in the context of a digital educational environment is relevant.

The purpose of this study is to analyze international experience and identify pedagogical mechanisms that ensure the effective formation of professional qualities of future engineers.

Methods

The study was conducted based on a mixed-methods approach, combining qualitative and quantitative analysis.

At the theoretical stage, the framework of international competencies and content analysis of regulatory and analytical documents (OECD, UNESCO, CDIO, European Commission) were used. The empirical-analytical stage was based on a secondary analysis of the data of foreign studies, in which the results of the implementation of digital educational environments in engineering programs were considered.

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The following indicators were used to compare effectiveness:

- relative growth of professional competencies (%);
- influence values (Cohen's d);
- level of statistical significance ($p < 0.05$);
- reduction of the dispersion of learning outcomes.

The method of comparative analysis was used to compare traditional and digital integrated models of engineering education.

Results

The results of the analysis of foreign studies show that digital-integrated models of engineering education provide a statistically significant improvement in the professional qualities of students.

Table 1. Comparative results of the formation of professional qualities

Indicator	Traditional model (%)	Digital-integrated model (%)
Engineering thinking	56-60	80-88
Design competence	50-58	78-85.
Spatial thinking	52-60	75-82.
Digital competence	60-65	85-90

Generalized data show an average increase in professional indicators in the range of 25-40%, while the value of influence varies from $d = 0.48$ to $d = 0.82$, which corresponds to a medium and high level of pedagogical influence.

Discussion

The results obtained confirm the conclusions of foreign researchers that the digitalization of the educational environment is a means of enhancing the formation of professional qualities of future engineers in the context of pedagogical harmony of content, methods, and assessment.

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Within the framework of the CDIO approach, digital technologies are integrated into the full life cycle of engineering activity, which contributes to the development of systemic thinking and professional identity. In European models based on DigComp, the focus is on the critical and ethical use of digital technologies.

At the same time, the analysis revealed the danger of technological determinism, in which digital tools are used without methodological justification, which reduces their educational effectiveness. This confirms the need for systematic design of the digital educational environment.

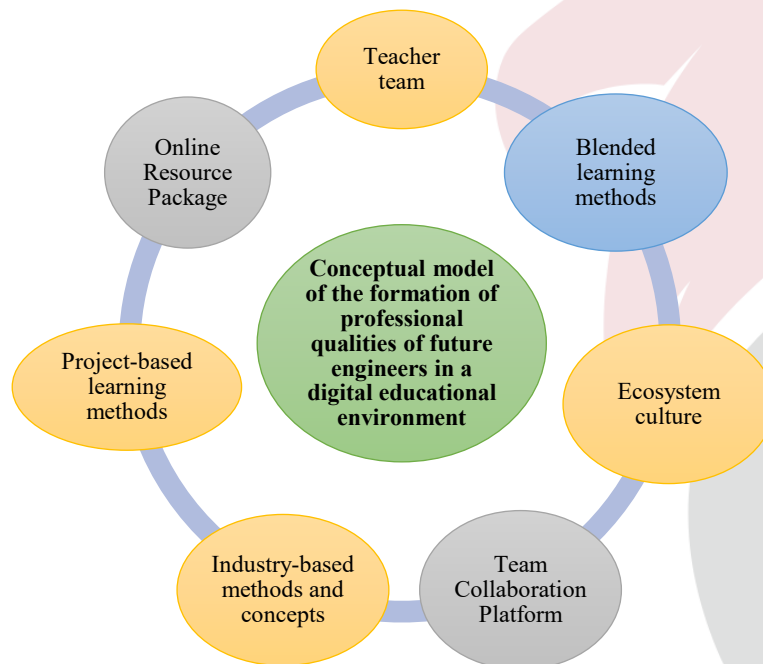


Figure 1. Conceptual model of the formation of professional qualities of future engineers in a digital educational environment

Industry-based methods and concepts - Applying industry-based methods and concepts to implement an industry-based methodological and technological set to ensure validity and achieve a solution.

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Team Collaboration Platform - Create a community platform for open communication and trust, contributing to a critical thinking environment.

Stakeholder Collaboration - Engaging all stakeholders in collaboration to address the request, create a professional network, and develop comprehensive competencies.

Ecosystem culture - Creating a culture of professional sharing and trust based on the sharing of ecosystem knowledge, information, and learning among peers in an environment of cooperation and trust.

Blended learning methods - Applying blended learning methods using virtual and digital delivery channels, tools, and collaboration while ensuring laboratory competencies and students' needs for social interaction.

Teacher team - Create a teaching team to manage the dynamics of comprehensive integration, community learning, and assessment.

Online Resource Package - Creating an online resource base for diverse learning, providing useful materials, critical thinking, and lifelong learning.

Project-based learning methods - Applying project-based learning methods using real industry-based problems as project tasks within the integrated curriculum to activate critical thinking and problem-solving skills.

Conclusion

The conducted scientific and analytical research shows that the formation of professional qualities of future engineers in the context of digitalization is most effective when using integrated pedagogical models based on learning outcomes, design activities, and evidence-based assessment.

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Foreign experience confirms that digital technologies become a factor of professional development only in conditions of systematic integration into the educational process. The obtained conclusions can be used in the modernization of national programs of engineering education.

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