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CREATING AND IMPLEMENTING AN INTEGRATIVE EDUCATIONAL ENVIRONMENT IN TECHNICAL UNIVERSITIES BASED ON CDIO PRINCIPLES

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Annotation. This article addresses the creation and implementation of an integrative educational environment in technical higher education institutions based on the CDIO (Conceive, Design, Implement, Operate) principles. It analyzes methods for ensuring the harmony of theoretical knowledge, practical training, and project-based activities in the educational process. Each stage of the CDIO cycle (Conceive, Design, Implement, Operate) is substantiated in connection with pedagogical and technological approaches to develop students' professional competencies. Furthermore, the stages of implementing the integrative educational environment into practice and criteria for its effectiveness are proposed.

Keywords: CDIO, integrative educational environment, engineering education, professional competence, project-based learning, practice-oriented education, innovative pedagogy.

СОЗДАНИЕ И ВНЕДРЕНИЕ ИНТЕГРАТИВНОЙ ОБРАЗОВАТЕЛЬНОЙ СРЕДЫ В ТЕХНИЧЕСКИХ ВУЗАХ НА ОСНОВЕ ПРИНЦИПОВ CDIO

Аннотация. В данной статье рассматриваются вопросы создания и внедрения интегративной образовательной среды в технических высших учебных заведениях на основе принципов CDIO (Conceive, Design, Implement, Operate). Анализируются методы обеспечения гармонии теоретических знаний, практических занятий и проектной деятельности в образовательном процессе. Обосновываются возможности каждого этапа цикла CDIO (осмысление, проектирование, реализация, управление) в развитии профессиональных компетенций студентов во взаимосвязи с педагогическими и технологическими подходами. Также предлагаются этапы внедрения интегративной образовательной среды в практику и критерии её эффективности.

Ключевые слова: CDIO, интегративная образовательная среда, инженерное образование, профессиональная компетенция, проектное обучение, практико-ориентированное образование, инновационная педагогика.

Introduction. In the current context of globalization and digital transformation, one of the most pressing tasks is to train highly qualified engineering personnel with modern knowledge and practical skills in technical higher education institutions. The rapid development of industry, construction, energy, transport, and other technical fields requires the education system not only to provide theoretical knowledge but also to equip students with practice-oriented competencies that are closely aligned with real production conditions. From this perspective, traditional educational approaches can no longer fully meet today's demands, necessitating the introduction of modern pedagogical models.

In recent years, the CDIO approach has gained wide recognition worldwide as one of the key frameworks for improving engineering education. The CDIO model is based on organizing the educational process through four main stages: Conceive (idea formulation), Design (planning), Implement (execution), and Operate (operation and maintenance). This approach serves to develop not only knowledge but also essential competencies in students, including engineering thinking, systematic approach, teamwork, problem-solving, and innovative thinking.

The issue of forming an integrative educational environment in technical universities is closely linked to the CDIO approach. An integrative educational environment refers to a system that ensures interdisciplinary connections, the integration of theory and practice, and the approximation of the learning process to real engineering activities. In such an environment,

students learn to solve complex problems by understanding the interrelationships between different disciplines rather than studying them in isolation. This significantly enhances their level of professional preparedness.

Today, in many technical higher education institutions, the educational process is often focused primarily on the acquisition of theoretical knowledge, while the development of practical skills is insufficiently addressed. As a result, graduates face difficulties in adapting to work in industrial enterprises. Therefore, integrating the educational process with production and introducing teaching methods based on real engineering projects is of great importance.

The CDIO approach is specifically aimed at solving this problem. It enables the organization of education through project-based learning, bringing students closer to real-life situations, and gradually preparing them for complex engineering activities. In an educational process organized on the basis of this model, students first learn to identify and analyze a problem, then design solutions, subsequently implement them in practice, and finally acquire the skills to operate and evaluate the results.

Furthermore, the role of digital technologies and innovative tools in modern education is steadily increasing. E-learning platforms, virtual laboratories, simulation programs, and other digital resources serve as important instruments for creating an integrative educational environment. This, in turn, creates additional opportunities for the effective implementation of the CDIO model.

Main part. The formation of an integrative educational environment based on the CDIO approach in technical higher education institutions is currently one of the key directions for modernizing engineering education. This approach is aimed at the systematic organization of the educational process, ensuring a close link between theory and practice, as well as preparing students for real engineering activities.

By its very nature, the CDIO model covers the complete cycle of engineering activity and divides the educational process into four main stages: Conceive (idea formulation), Design (planning), Implement (execution), and Operate (operation and maintenance). An educational process organized around these stages equips students not only with theoretical knowledge but also with practical competencies focused on solving real-world problems.

CDIO Stage	Educational Tasks	Integrative Environment Elements
Conceive	**Identifying and analyzing problems, defining project goals**	**Interdisciplinary connections, real production challenges**
Design	**Planning solutions, engineering design**	**Project-based learning, mentoring, advanced pedagogical methods**
Implement	**Developing and realizing the project**	**Virtual labs, simulation tools, internships at industrial enterprises**
Operate	**Evaluating results, system management**	**Digital platforms, teamwork, professional adaptation**

The integrative educational environment is one of the main factors ensuring the effective functioning of the CDIO model. In such an environment, academic disciplines are organized not in isolation but as an interconnected system. This helps students perceive knowledge as a coherent system and apply it in practice. Through an integrative approach, curricula, course programs, and practical exercises are harmonized with one another.

The professional development of teachers is also a crucial factor in an integrative educational environment. The CDIO approach requires teachers not only to have deep subject knowledge but also to possess skills in project management, pedagogical design, and mentoring. Therefore, it is necessary to organize special training sessions, professional development courses, and methodological seminars for teachers.

Research shows that when the level of interaction between teachers and students in an integrative educational environment is high, learning outcomes improve significantly. This demonstrates the need to make the educational process interactive and student-centered.

Moreover, collaboration with industrial enterprises is of particular importance in forming an integrative educational environment. Conducting internships at real enterprises, familiarizing students with production problems, and involving them in real projects enhance their professional preparedness.

Digital technologies also play a significant role in the effective implementation of an integrative educational environment. Through e-learning platforms, virtual laboratories, and simulation programs, students have the opportunity to visually study complex technical processes. This contributes to the effective implementation of all stages of the CDIO model.

At the same time, the role of teachers changes significantly. Unlike the traditional role of a "lecturer," in the CDIO model, the teacher acts as a mentor, guide, and project manager. The teacher encourages students to think independently, helps them solve problems, and manages their activities.

Another important finding of the research is that the integrative educational environment increases student motivation. Working on real projects, achieving practical results, and engaging in team activities enhance students' interest in the learning process.

Conclusion. The formation of an integrative educational environment based on the CDIO approach in technical higher education institutions is one of the most pressing and strategic directions of modern engineering education. This approach requires viewing the educational process not merely as a means of transmitting theoretical knowledge but as a system aimed at the comprehensive development of students' professional competencies. From this perspective, the following final conclusions have been formulated based on the analyses and summarized results.

An integrative educational environment is a goal-oriented system in which various disciplines, methods, technologies, and practical activities are harmoniously integrated. In such an environment, the student is not a passive recipient of knowledge confined within individual subjects but an active participant in solving engineering problems. The CDIO approach enables the systematic organization of this process, its gradual development, and its close integration with practice.

Through the four stages of the CDIO model – Conceive, Design, Implement, and Operate – the educational process covers the complete cycle of real engineering activity. This develops in students not only technical knowledge but also essential skills such as problem analysis, solution development, practical application, and result evaluation. At the same time, this approach teaches students teamwork, develops their communicative competencies, and fosters project-based thinking.

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