METHODOLOGY FOR PREPARING FUTURE MASTER'S DEGREE STUDENTS IN ADVANCED ENGINEERING SCHOOLS BASED ON INTERNATIONAL EXPERIENCE

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ABSTRACT

This article analyzes the best practices of leading international engineering schools and develops methodological approaches for adapting them to the training process of future master's students in higher education institutions of Uzbekistan. The study emphasizes practice-oriented, innovative, and competency-based teaching methods. Furthermore, the theoretical and practical significance of the CDIO (Conceive–Design–Implement–Operate) framework and project-based learning approaches is explored through in-depth analysis.

Keywords: Engineering education, master's training, international experience, methodology, digital competencies, project-based learning, CDIO, soft skills, simulation, assessment.

INTRODUCTION

In the context of global competition and the digital transformation of industry, the preparation of highly qualified specialists within the higher engineering education system has become one of the most urgent challenges. Presidential decrees of the Republic of Uzbekistan emphasize the need to improve the quality of master's training in engineering fields, assimilate international experience, and implement innovative educational technologies. Therefore, studying advanced foreign practices and adapting them to national conditions is regarded as a critical task for developing an effective training methodology.

An analysis of international experience shows that engineering schools in developed countries such as the USA, Germany, Japan, South Korea, and others prepare master's students based on the following core principles:

- competency-based approach: integration of theoretical knowledge with practical skills. For example, the CDIO (Conceive, Design, Implement, Operate) model;
- practice-oriented teaching: project-based learning in collaboration with companies, aimed at solving real-world industrial problems;
- innovative educational technologies: use of digital platforms, simulators, and AR/VR technologies;
- multidisciplinarity: combining knowledge of engineering, economics, management, and information technology;
- personalized learning paths: supporting individual student development through advisory and mentoring systems.

For example, in Germany, a dual education system enables students to simultaneously study at a university and gain work experience in enterprises. In the United States, project-based courses are an essential component of engineering education, where students are directly engaged with industry. In Uzbekistan, the Cabinet of Ministers' Resolution №14, dated January 16, 2025, titled "On Measures to Implement Dual Education in the Higher Education System", serves as a foundational step toward radically reforming engineering education through the application of international experience.

In the context of Industry 4.0 and digital transformation, the training of specialists in engineering fields is entering a new phase in terms of both quality and demand. Preparing students for admission to advanced engineering schools requires the integration of digital technologies, the development of creativity and problem-solving skills, and the formation of international competencies. To achieve these goals, it is essential to develop systematic mechanisms aimed at modernizing the educational process. In particular, one of the pressing challenges in education today is to design a comprehensive mechanism for preparing students for admission to advanced engineering schools. This mechanism must focus on enhancing students' digital literacy, critical and systems thinking, and the ability to solve real-world practical problems.

Opportunities for Implementing Engineering Education in the Context of Uzbekistan

In the context of Uzbekistan, it is not the direct transfer of foreign experiences that is required, but rather their careful adaptation to national conditions. Advanced engineering schools in Uzbekistan can implement international best practices in the following key areas:

- development of project-based learning courses: designing courses based on practical tasks in collaboration with industrial enterprises;
- implementation of the CDIO model: aligning course design, delivery, and assessment with the CDIO (Conceive–Design–Implement–Operate) framework;
- extension and enrichment of industrial internships: engaging students in solving real-world engineering problems within companies;
- introduction of innovative technologies: applying remote laboratories, AR/VR-based simulation training, and digital learning platforms;
- creation of multidisciplinary modules: offering additional courses that combine engineering with economic analysis, management, and information technology.

Model for the Methodology of Training Future Master's Students

The methodology proposed in this article consists of several key stages aimed at systematically preparing future master's degree students in engineering education. The curriculum design process is central to this model and includes the following components:

- integration of cdio principles
- defining competencies in consultation with employers
- incorporation of multidisciplinary courses.

Stages of Organizing the Educational Process for Training Future Master's Students

- project-based learning;
- strengthening internships and practical training;
- use of simulation and digital technologies.

Assessment System for Training Future Master's Students

Competency-based assessment;
Combination of formative and summative assessments;
Final assessment based on employer feedback.

In the context of digital transformation, applying core principles to the preparation of students entering advanced engineering schools is essential for ensuring the quality and consistency of education. These principles include:

- ➢ competency-based learning
- ➢ practice-oriented education
- ➢ integration of innovative and digital technologies
- ➢ personalized learning pathways

- collaboration and teamwork development

The outcomes of this stage help define individual development trajectories, allowing educators to design personalized and targeted learning experiences for each student.

Developing Digital Competencies

- working with ict tools and digital platforms;
- utilizing remote learning resources;
- basic coding skills (if applicable).

tools for developing digital competencies: learning management systems (LMS), video lectures, interactive exercises.

Practice-Oriented Education Focused on Solving Real-World Problems

- project-Based Learning (PBL)
- modeling of Real Industrial Problems
- elements of the CDIO Approach

Outcome: This model fosters innovative and creative thinking

Development of Soft Skills and Teamwork Abilities

- communication and presentation skills,
- collaborative project work,
- leadership development.

Tools used: Online and offline group activities.

Teaching through Simulation and AR/VR Technologies

- these tools enhance students' understanding of complex systems by enabling hands-on practice in a controlled virtual environment.
- studying engineering processes in virtual environment
- utilization of digital models for laboratory work

Advantage: These technologies offer practical experience in a safe and cost-effective setting.

Assessment and Monitoring

Formative Assessment.
Summative Assessment.
Portfolio and Project-Based Assessment.
Tools used: Electronic assessment systems.

The CDIO Model in Engineering Education

The CDIO model is an internationally recognized approach developed to modernize engineering education. The acronym CDIO stands for four key stages of the engineering process:
C — Conceive: generating ideas, identifying needs, and planning solutions;
D — Design: designing systems, components, and processes based on specified requirements;
I — Implement: constructing, testing, and integrating the design into a functioning product or system;
O — Operate: deploying and maintaining the product in real operational settings.
The core idea of the CDIO model is to ensure that students progressively learn and apply real-world engineering practices during their studies, mirroring the professional environment they will encounter in their future careers.

Key Characteristics of the CDIO Model
Engagement with Real-World Problems: Students are challenged to solve authentic industrial problems, fostering relevance and applicability of their learning.

Project-based and experiential learning: the curriculum combines theory with hands-on practice.

Competency-based education: focus extends beyond theoretical knowledge to include practical skills, problem-solving abilities, and professional competencies.

Teamwork and Collaboration: Students participate in group projects, developing communication, leadership, and collaboration skills essential for engineering practice.

Innovation and Creativity: Learners are encouraged to propose novel solutions and think creatively, nurturing entrepreneurial and design thinking.

In essence, the CDIO model is an integrated approach in engineering education that prepares students to conceive, design, implement, and operate complex systems and processes — just as they would in their future professional careers.

The integrated mechanism for preparing engineers in the digital age consists of interconnected components that form a continuous and adaptive educational process. These components ensure the development of both technical and transversal skills necessary for success in modern engineering careers. The model includes the following stages:

Diagnostic Phase – development of digital competencies – practice- and project-based learning – soft skills development – AR/VR simulation – assessment and monitoring.

Project-Based Learning (PBL) is a student-centered, inquiry-driven instructional method that engages learners in the active exploration and resolution of real-life problems through the design and implementation of complex, goal-oriented projects. This approach encourages students to take ownership of their learning by participating in meaningful tasks that reflect authentic challenges in professional and social contexts.

The Project-Based Learning (PBL) approach aims to develop a comprehensive set of academic, professional, and personal skills in students by engaging them in meaningful, real-world tasks. Its core objectives include: fostering self-directed learning and problem-solving skills, applying knowledge in real-life contexts, developing critical and creative thinking, improving collaboration and communication skills, encouraging responsible and goal-oriented behavior.

Key Characteristics of the Project-Based Learning Method: At the core lies a project or problem-based task, students work both independently and collaboratively, the teacher acts as a guide and facilitator, the learning process is built around real-world and complex problems, a final product or solution is created and presented.

Stages of the Project-Based Learning (PBL) Method:
problem identification and formulation of the driving question: the project begins with selecting a topic based on a real-life problem or an engaging,

planning and project design stage: at this stage, students define goals and tasks, develop a timeline, research and practical implementation stage: students gather and analyze information, conduct investigations or experiments,

product development stage: a tangible outcome is created—this may include a practical solution, a model, a written report, a presentation, or another form of deliverable.

presentation and evaluation stage: students present their final product to peers, instructors, and possibly external stakeholders. feedback is collected, and performance is assessed.

reflection stage: learners critically reflect on their learning process, evaluate what they have achieved, identify challenges faced, and extract lessons from mistakes and successes.

The advantages of project-based learning: it encourages active student participation, develops practical knowledge and skills, strengthens teamwork and communication abilities, and fosters innovative and creative thinking, teaches independent learning.

Disadvantages of the project-based learning method:

it takes a lot of time, requires resources and teacher preparation, and can also be challenging to adapt to each student.

Levels and assessment criteria in the project-based learning method:

during the process — formative assessment

final product — summative assessment methods of peer assessment

self-assessment

assessment criteria — relevance, creativity, scientific rigor, quality of presentation

Applications of the project-based learning method: in schools and higher education institutions across various subjects (natural sciences, social sciences, engineering, art), in small groups or large teams, in traditional and digital environments (online projects).

Examples of Project Topics

1. “Project for Ensuring the Cleanliness of Local Water Resources”
2. “New Technologies for Sustainable Agriculture”
3. “Development of an Automated Irrigation System”
4. “Initiative to Improve Digital Literacy Among Local Youth”

Conclusion

Preparing students for admission to advanced engineering schools in a digital environment requires a distinct, integrated, and phased approach. The proposed mechanism is aimed at developing core competencies — from digital literacy to problem-solving abilities and innovative thinking. This foundation enables the training of globally competitive professionals who meet the demands of industrial digital transformation. Studying advanced international experiences and adapting them to local realities is a crucial task for higher engineering institutions in Uzbekistan. Rather than direct replication, thoughtful adaptation ensures the relevance and effectiveness of applied practices. The proposed methodological model supports the formation of future master’s degree candidates as competitive, innovation-oriented, and practice-ready specialists. Through this approach, it becomes possible to systematically train a new generation of leading engineers who will play a key role in the ongoing digital transformation of industry.

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