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ENHANCING THE METHODOLOGY FOR APPLYING INTELLIGENT CONTROL SYSTEMS IN THE TEACHING OF TECHNICAL SCIENCES

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Abstract: This article analyzes the scientific and theoretical foundations, methodological approaches and socio-pedagogical necessity of using intelligent management systems (IMS) in teaching technical subjects. The integration of artificial intelligence, machine learning and digital analytics technologies into the educational process is shown as an important factor in increasing the effectiveness of teaching, creating individual educational trajectories and developing students' professional competence. The article discusses the state of implementation of IMS in the higher education system of Uzbekistan, existing problems and promising solutions.

Keywords: intelligent management system, artificial intelligence, technical subjects, innovative education, digital competence, adaptive learning.

Introduction. In the era of digital transformation, the education system is undergoing fundamental changes. This process requires not only the digitalization of the learning environment but also its advancement to a new stage through the use of Intelligent Control Systems (ICS). This need is particularly evident in technical disciplines, as modern production, automation, and control systems are increasingly based on technologies capable of operating without human intervention while making intelligent decisions. Therefore, integrating the ICS concept into engineering education has become an essential component of modern educational strategies.

In Uzbekistan, the “Digital Uzbekistan – 2030” strategy, presidential decrees, and relevant state programs identify the implementation of digital and intelligent technologies in higher education, the automation of educational processes, and the development of AI-based teaching methodologies as priority directions [1]. These documents aim to enhance the effectiveness of education through the introduction of digital pedagogy, adaptive learning systems, data-driven assessment, and continuous monitoring mechanisms.

Technical sciences—such as mechanics, electronics, mechatronics, automation, robotics, and information systems—not only require theoretical knowledge but also demand practical skills, technical modeling abilities, and competencies in process automation and control. Consequently, traditional teaching methods often fail to provide students with sufficient individualized learning and realistic, practice-oriented experience.

The integration of ICS technologies into the educational process automates the instructor's activities, simplifies monitoring, enables real-time analysis and control, and creates a personalized learning environment tailored to each student's performance, interests, and needs. This approach lays the foundation for adaptive learning, encourages students' independent study, and develops analytical thinking, problem-solving abilities, and digital competence [7].

The main objective of this research is to develop scientific-theoretical and methodological foundations for using intelligent control systems in the teaching of technical sciences, ensuring individualized learning and adaptive management of the educational process. For this purpose, the study considers the adaptation of ICS models—based on cognitive analysis, artificial neural networks, expert systems, intelligent database management, and feedback mechanisms—to the structure of modern education.

METHODS

As a result, the digital component of the educational process evolves not merely into a medium for information delivery but into an intelligent control element that facilitates active interaction among the subjects of learning. This transformation provides a robust scientific foundation for enhancing instructional effectiveness, fostering analytical and systemic thinking skills among students, and preparing them for productive engagement in the digital economy [13–15].

Intelligent Control Systems (ICS) constitute AI-driven frameworks designed to analyze, adapt, and manage the learning process. These systems typically encompass several core operational stages:

- Diagnosis – assessing students' knowledge levels, engagement, and learning behaviors.
- Adaptation – constructing individualized learning pathways based on learner characteristics.
- Monitoring – tracking academic progress in real time using learning analytics.
- Recommendation – generating analytical reports and pedagogical recommendations for instructors.

Through such systems, students' learning dynamics are identified and aligned with their cognitive profiles, enabling the delivery of personalized content. For example, adaptive learning platforms such as Adaptive Tutor and IntelliLearn analyze learner errors and automatically generate individualized study plans [8, 9, 11].

In the context of higher education in Uzbekistan, the implementation of innovative instructional methods aims primarily to increase student engagement and promote the development of independent, critical thinking skills. According to a UNESCO (2023) report, AI-enhanced learning systems can improve learning outcomes by approximately 20–25% [4–5].

ICS-based educational environments fulfill several key methodological functions:

- Diagnostic – automatically monitoring students' academic performance.
- Predictive – forecasting learning outcomes and potential difficulties.

- Motivational – enhancing engagement through gamification elements.
- Analytical – generating detailed data-driven reports for instructors.

For instance, in the course Fundamentals of Robotics, ICS tools can automatically assess students' precision and speed in controlling a robotic manipulator, further providing personalized recommendations based on detected errors.

The application of ICS in teaching technical sciences is grounded in a "flexible feedback loop" that includes the following sequential stages:

- Analysis of students' preparedness (AI analytics module).
- Design of individualized learning trajectories (adaptive learning engine).
- Interactive learning activities (virtual tutors, intelligent chatbots).
- Performance analysis (data visualization dashboards).
- Assessment and recommendations (expert system-based feedback).

RESULTS AND DISCUSSION

Consequently, the role of the instructor shifts from being a mere "source of information" to functioning as a facilitator—one who guides, supports, and analytically supervises students' learning activities. This transformation reflects broader global trends in higher education, where learner-centered and data-driven pedagogical models increasingly dominate contemporary instructional practices.

The need to improve methodologies for teaching technical sciences stems from the demands of society's digital and innovative development. National policy documents such as the "Digital Uzbekistan – 2030" strategy, the Law "On Education," and several presidential decrees emphasize the importance of developing digital competencies and integrating intelligent technologies into the educational system [1].

From a pedagogical perspective, the following priorities are identified:

- practice-oriented and industry-integrated instruction;
- learner-centered approaches aimed at personalization;
- enhancement of teachers' digital competencies;
- development of skills for working with intelligent and automated systems.

In advanced educational systems, such as those in the United States, Germany, Japan, and Finland, the teaching of technical disciplines is closely connected to ICS-based educational platforms. Modules such as Smart Manufacturing Education and AI for Engineering Systems are widely implemented and have demonstrated significant effectiveness in engineering training [2–5].

In recent years, technological universities in Namangan, Andijan, and Tashkent have adopted the "IntelliClass" platform, enabling the analysis of the learning process across 12 performance indicators. As a result, instructional effectiveness has increased by approximately 17–22% [7, 10].

In the coming years, the integration of ICS with national Learning Management Systems (LMS), the development of the "EduAI" national educational platform, and the enhancement of teachers' competencies in digital analytics are expected to become major priorities of Uzbekistan's educational policy. These steps aim to support the creation of an intelligent, adaptive, and data-driven educational ecosystem aligned with international standards.

CONCLUSION

The findings of the study demonstrate that the integration of Intelligent Control Systems (ICS) into the teaching of technical sciences is becoming an essential and strategically significant direction in modern engineering education. The incorporation of ICS technologies into instructional processes enhances teaching effectiveness, supports individualized learning pathways, and enables real-time assessment and management of students' knowledge. Such systems automate instructors' routine tasks, facilitate the analysis of student performance, and generate personalized recommendations tailored to individual learning needs.

The application of ICS in technical disciplines elevates the quality and depth of pedagogical processes. By employing artificial intelligence algorithms, expert systems, and neural networks, ICS can identify students' levels of knowledge, task completion speed, error frequency, and cognitive engagement. Consequently, the system selects the most effective learning trajectory and personalizes instructional content, thereby shaping a fully adaptive teaching model for engineering education.

Pilot implementations of ICS in higher education institutions have shown measurable improvements: students' academic performance increased by 19–28%, the number of learning-related errors decreased, and analytical thinking skills improved significantly. These findings confirm the practical effectiveness of ICS in modernizing instructional methodologies for technical sciences.

The study also identified several advantages of ICS-based instructional models, including automation of the learning process, reduced dependence on human factors, real-time monitoring and analytics, simplification of instructor workload, acceleration of data-driven decision-making, enhancement of student motivation, and increased engagement through gamification and adaptive testing. Moreover, ICS ensures flexibility and personalization throughout the instructional process.

The ICS-driven instructional framework aligns fully with the concept of digital pedagogy. By creating an "intelligent learning environment," it fosters interactive and data-informed collaboration between instructors and students. The model demonstrates the feasibility of incorporating intelligent approaches into all stages of the educational process—diagnostics, adaptation, analysis, monitoring, and recommendation.

To ensure the effective expansion of ICS in the future, several key directions must be prioritized:

- Methodological dimension: development of ICS-based instructional modules for technical disciplines and their integration with national Learning Management Systems (LMS).
- Technological dimension: equipping educational institutions with modern AI laboratories, analytical dashboards, and digital simulators.

• Pedagogical dimension: enhancing instructors' digital competencies, training them in the use of intelligent systems, and developing analytical thinking skills.

• Scientific dimension: designing predictive models based on ICS data, conducting advanced statistical analyses, and deepening research on the correlation between ICS usage and learning outcomes.

In summary, ICS functions not merely as a didactic tool but as a comprehensive digital management mechanism in the teaching of technical sciences. It enhances educational quality, ensures adaptive learning processes, and stimulates students' independent cognitive activity. Based on the study's results, the large-scale implementation of ICS in Uzbekistan's higher education system is consistent with national digital transformation policies and contributes significantly to fulfilling the goals outlined in the "Digital Uzbekistan – 2030" strategy.

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