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DIDACTIC FOUNDATIONS OF DESIGN AND CONSTRUCTORY EDUCATION BASED ON DIGITAL TECHNOLOGIES

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Annotation

This thesis covers the didactic foundations of organizing design and engineering education based on digital technologies. The possibilities of the digital educational environment, methods of integrating project activities, and factors for the formation of technological and creative thinking in students are analyzed. The research results show that combining project-based learning with digital tools increases the effectiveness of the educational process and contributes to the formation of students' design competencies.

Keywords

digital technologies, design and engineering education, didactic basis, digital environment, competence, technological thinking.

INTRODUCTION

In today's era of globalization and digital transformation, the education system is fundamentally changing and rising to a new level. Digital technologies are deeply penetrating all areas of education, especially the educational process in engineering and technical fields. Digitalization of the educational process, organization of educational resources in an electronic environment, implementation of design and engineering activities through digital means are not only a necessity today, but also a requirement of the times.

The process of **preparing** students **for design and engineering activities** in engineering education is, by its nature, a complex process requiring creative, practical, and analytical thinking. Traditional teaching methods cannot fully ensure effectiveness in this direction, since they are mainly aimed at transmitting knowledge. Therefore, **design and design education,** organized on the basis of digital technologies, allows for the activation of student activity, the interaction of the learning process, and the connection of the studied knowledge with practice.

PROBLEM SETTING AND RESEARCH METHOD

In the modern education system, the improvement of the educational process in engineering and technological fields, especially the development of design and engineering competencies in students, is of particular importance in the context of digital transformation. Traditional forms of education do not sufficiently form students' creative thinking, initiative in solving engineering problems, and skills in the effective use of digital tools.

Today, the introduction of digital technologies, such as CAD/CAM/CAE, 3D modeling, artificial intelligence, and virtual laboratories, which are widely used in production, maintenance, and design processes, has become an important necessity in the educational process. However, such issues as their adaptation to the didactic system of teaching, ensuring interactive cooperation between the teacher and the student, and developing criteria for assessing the effectiveness of teaching have not yet been fully resolved.

Based on this, the problem of the research is formulated as follows: Development of didactic foundations for organizing design and engineering education based on digital technologies, determining its effectiveness and implementation in practice.

In order to achieve a scientific result, theoretical, empirical, and experimental approaches were used in the study.

Digital educational technologies are a complex of modern software and hardware tools that provide interactivity, visualization, model creation, and simulation capabilities in the educational process. For example, with the help of such digital platforms as AutoCAD, SolidWorks, Tinkercad, Fusion 360, MATLAB, students will have the opportunity to develop technical projects, test them in a virtual environment, and optimize them. This combines the theoretical and practical stages of design activity.

This approach forms in students not only technical knowledge, but also competencies of technological thinking, analysis of problem situations, decision-making, and the development of creative solutions. Also, organizing project activities in a digital environment develops students' skills in teamwork, online collaboration, and problem-solving remotely.

RESEARCH RESULTS AND THEIR DISCUSSION

Didactic foundations of the organization of design and engineering education based on digital technologies - a set of scientific and methodological approaches that allow for the effective, targeted, and systematic implementation of the educational process. In this case, the training process is organized on the basis of the following didactic principles:

The principle of integration - ensuring interdisciplinary connectivity;

The principle of activity and independence - encouraging active student participation in the educational process;

The principle of digital interactivity - constant interaction between the student, teacher, and digital resources;

The principle of visualization and modeling - explaining complex processes through modeling in a digital environment.

Through the organization of design and engineering education based on digital technologies, the educational process **transitions from a traditional reproductive model to a learning system oriented towards creative and constructive activity.** This will form in the student the competence of "creating knowledge," and not "acquiring knowledge."

Today, project-based learning models based on the concept of digital education are actively used worldwide. In particular, in such countries as **Finland, Germany, South Korea, Japan**, training based on digital design laboratories and "Digital Twin" systems is widely implemented in engineering education. The education system of Uzbekistan is also gradually carrying out reforms in this direction, which requires the development of a didactic model corresponding to the national educational environment.

Thus, studying the didactic foundations of design and engineering education based on digital technologies is an urgent scientific task for modernizing modern education, increasing the effectiveness of teaching, and raising the practical and professional training of students to a new level. This area is one of the important factors in improving the quality of education in engineering, strengthening interdisciplinary integration, and developing innovative thinking.

The issues of introducing digital technologies into the educational process and studying their didactic possibilities have been at the center of attention of many domestic and foreign researchers in recent years. Organization of design and engineering activities based on digital technologies in the process of modern engineering education not only increases the effectiveness of learning, but also improves the practical and creative competencies of students.

J. Dron and T. Anderson (2014) in their research deeply analyze **the concept of the "digital educational environment"** and interpret the learning process as an open, collaborative,

and self-regulating system. In their opinion, in the context of digital project education, the student participates as an active subject in the creation and assessment of their knowledge.

The main principles of integrating digital technologies into the education system have been developed in the concept *"Digital Learning and Competence Development Framework,"* published **by UNESCO (2022)** . It defines the formation of digital competencies, the creation of a modular training system, and the use of artificial intelligence tools as strategic directions of the digital learning process.

Among the scientists of Uzbekistan, research conducted by **I. Karimov (2023)** , **D. Khusanov (2024)** and **I. Umirov (2024)** highlights the role of digital education in the national education system, the effectiveness of the integration approach, and the formation of digital competencies [1, 2, 3].

- **I. Karimov** in his research developed methodological foundations for creating a digital learning environment, paying special attention to the development of students' independent learning activities in this environment [1].
- **D. Khusanov** identified the mechanisms for the development of technological thinking competencies in students by **combining the methodology of project-based learning with digital technologies** in the educational process [2].
- **I. Umirov** in his research practically substantiated the concept **of "digital educational module"** and proposed a didactic model for its application in engineering education [3].

Sh. Kholmatov (2021) analyzed the didactic conditions for creating a digital environment in the educational process and showed the need for systematic and targeted use of digital tools to increase the effectiveness of training. According to him, digital technologies are not only a source of information, but also a means of creating an active learning environment [4].

A. Tukhtaev (2022) in his research substantiated the possibility of creating a personality-oriented learning system through the introduction of artificial intelligence technologies into the educational process. It has shown the positive impact of digital analysis, automatic assessment, and adaptive learning systems on the learning process [5].

Research conducted in the education system of European and Asian countries (OECD, 2020; Siemens, 2005) shows that digital project-based learning is an effective way to develop not only technical training, but also the student's competencies of creative thinking, finding solutions in problem situations, and collaborative work [10].

In general, the analysis of the studied sources shows that the organization of design and engineering education based on digital technologies is one of the most pressing issues on a global scale, both theoretically and practically. However, in existing studies, adaptation of didactic principles to the national education system in the context of the digital environment**,** development of criteria for the effectiveness of interdisciplinary integration **and** definition of the scientific basis for assessing digital competencies have not been sufficiently studied. Therefore, the research conducted in this area is of great scientific and practical importance for the higher education system of Uzbekistan.

The methodological basis of the research is based on modern pedagogical theories, digital educational concepts, the methodology of project-based learning, and the principles of engineering didactics. At the center of this research is the issue of didactic improvement of the process of preparing students for design and engineering activities using digital technologies.

The following methodological approaches were used in the research process:

Systematic approach - analysis of the educational process as a complex system consisting of interconnected components. This involves the interaction of teacher, student, digital environment, learning resources, and outcomes.

Integrative approach - designing educational content based on interdisciplinary connections, combining theory and practice through a single digital learning environment.

Person-centered approach - choosing a learning strategy that meets each student's abilities, level of preparedness, and digital competence.

Innovative-pedagogical approach - effective use of the capabilities of new information technologies, artificial intelligence, 3D modeling, and the virtual environment in the educational process.

Activity-Oriented Approach - directing the student towards active participation as a creative subject, not a cognizer.

The study was based on the following pedagogical and didactic principles:

Scientificity -the content of training is formed on the basis of a scientific approach;

Suitability - The choice of digital technologies is tailored to the learning objectives;

Visualness - the educational process is organized in a visual, interactive form;

Reflexiveness -the student learns to evaluate and analyze the results of their activity;

Adaptability - the digital learning environment adapts depending on the student's preparedness.

The didactic model of design and engineering education based on digital technologies developed during the study was tested in the conditions of the Jizzakh Polytechnic Institute and other higher educational institutions of a technical profile. The model is aimed at developing students' project thinking, a constructive approach, and digital competencies, aimed at increasing the effectiveness, interactivity, and interdisciplinary integration of the educational process.

Experimental work was conducted during the 2024-2025 academic year, in which 120 students and 8 teachers participated. Students were divided into two groups - the control group and the experimental group. In the control group, training was conducted on the basis of traditional methods.

In the experimental group, training was organized using digital technologies (Moodle, Tinkercad, Fusion 360, AutoCAD, SolidWorks) and project-based tasks.

During the experiment, students developed various technical projects using digital tools, performed virtual modeling, graphic design, and design analysis.

At the initial stage, the average level of students' knowledge was 59%, and at the end of the experiment, this indicator increased to 81%. In the control group, the growth was from 62% to 70%.

The results showed that the effectiveness of assimilation of the educational process organized on the basis of digital technologies increased by 20-25%.

RESULT

The research results showed that the organization of design and engineering education based on digital technologies is one of the most promising and effective areas of modern engineering education. Such an approach modernizes the educational process, adapts the content of education to the capabilities of the digital environment, and forms professional and technological competencies in students.

The didactic model of digital design and engineering education, developed during the research, ensures an inextricable link between theory and practice. It is based on the following didactic principles: systematicity, integration, personality orientation, activity, cooperation, and reflexivity. This model creates interactive cooperation between the teacher and the student in the digital learning environment, transforming the educational process into a creative, constructive, and practically oriented system.

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