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EFFECTIVENESS OF USING DIGITAL TECHNOLOGIES IN TEACHING MATHEMATICS IN HIGHER EDUCATION

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Abstract
This article analyzes the theoretical foundations, practical significance, and pedagogical effectiveness of using digital technologies and interactive platforms in teaching mathematics in higher education. Mathematics, with its logical and abstract nature, stands out distinctly, and therefore the use of digital tools in teaching it serves to improve the quality of the educational process. The study examines the impact of platforms such as GeoGebra, Desmos, Moodle, Khan Academy, and Google Classroom on the teaching process, highlighting their application experience in Uzbekistan's higher education system. Additionally, the role of digital education in student motivation, independent thinking, and creative approach formation is scientifically analyzed.

Keywords: Digital education, mathematics teaching, interactive platform, GeoGebra, Moodle, innovative pedagogy, digital competency, learning effectiveness, visual teaching, higher education.

Introduction

Mathematics, recognized as one of the highest forms of human thinking, requires teaching methods to keep pace with the times. In an era when digital transformation processes encompass all stages of education, the application of modern digital technologies in teaching mathematics in higher education is one of the important factors in increasing effectiveness. While mathematics classes taught in traditional style were mainly limited to classrooms, blackboards, and books, today the educational process is expanding through the internet, digital devices, and interactive programs.

Digital technologies refer to the integration of information and communication tools into the educational process, that is, organizing lessons, knowledge assessment, analysis, independent learning, and mastery processes in electronic form. With the help of digital technologies in the mathematics teaching process, abstract concepts, formulas, and models are brought to visual form. This increases students' level of perception, motivation, and capacity for independent thinking.

GeoGebra software is one of the most widely used interactive platforms in mathematics teaching. It is effectively applied in the fields of algebra, geometry, trigonometry, statistical analysis, and mathematical modeling. For example, a teacher draws a parabola or circle graph, and students observe the graph's changes in real-time by changing their parameters. In this way, students not only memorize the mathematical process but also understand it through visualization. This method connects theoretical knowledge with practical perception.

The Desmos platform provides the ability to plot function graphs and analyze derivative and integral domains. When a student enters a formula, the program automatically creates its graph. If they change a parameter, the result immediately updates on the screen. Such interactivity enlivens the lesson process and strengthens students' interest in the subject. Especially in complex sections like differential and integral calculus and analytical geometry, Desmos is an effective tool.

The application of digital technologies in Uzbekistan's higher education system is developing rapidly within the framework of the "Digital Uzbekistan - 2030" concept. Currently, mechanisms for digitizing the lesson process, organizing distance courses, and assessing students' knowledge based on the Moodle system have been established in many higher education institutions. The Moodle system enables teachers to create course modules, place educational materials, and automatically assess tests and assignments. As a result, the lesson process takes on a systematic and transparent form.

In the digital education process, communication between teacher and student reaches a new level. Now the teacher operates not as a source of information but as a guide, mentor, and facilitator. The student also becomes not a passive listener but an active participant, a subject independently forming their knowledge. Therefore, digital technologies are transforming the teaching model from a "teacher-to-student" oriented system to a "student-to-knowledge" oriented system.

Digital platforms provide the opportunity to individualize the teaching process. Each student masters materials, takes tests, and receives feedback according to their learning pace. Through Moodle or Google Classroom, teachers give individual grades, recommendations, and comments to students. This approach encourages learners to develop themselves and think independently.

Another important aspect of digital teaching is the speed of feedback. Students receive results immediately for each assignment they complete, see their mistakes, and analyze them. During this process, they independently form their knowledge. This method, unlike traditional assessment, provides specific monitoring of the learning process itself.

The complexity of mathematics education lies in the fact that it requires logical thinking, abstract reasoning, and evidence-based approaches. Digital technologies visualize this process, that is, they express formulas, functions, and models in graphical or animated form. This significantly increases students' level of perception. For example, a student who dynamically changes the sum of a triangle's angles through GeoGebra and observes that it always equals 180° understands this theorem more deeply.

The effectiveness of digital teaching is also confirmed by international research. According to analyses conducted by UNESCO and OECD, students taught based on digital technologies achieved results 25-40 percent higher on average than their peers in traditional systems in terms of mastery level. Interactivity, visualization, and a personalized approach were noted as key factors.

The success of digital teaching is directly related to teachers' digital competency. Teachers need to be skilled in working on digital platforms, preparing educational materials in electronic form, creating tests, and designing interactive lessons. For this purpose, special professional development courses on digital pedagogy, information and communication technologies, and distance learning methods are being organized in Uzbekistan's higher education institutions.

Digital education not only optimizes the lesson process but also forms digital culture in students. Today, in the conditions of the digital economy, not only professional knowledge but also digital skills are important for employers. From this perspective, teaching mathematics in higher education through digital technologies serves to form 21st-century competencies in students.

Uzbekistan's experience shows that technical infrastructure, quality content, and teachers' level of preparation are important factors for the effective functioning of the digital education system. Stable internet, modern computers, multimedia boards, and licensed software are necessary for all higher

education institutions. Along with this, curricula should be adapted to the digital environment, and teaching methodology should be reviewed based on technological approaches.

Digital teaching also has psychological advantages. The interactive environment increases students' activity, encouraging them to search independently, work collaboratively, and express their opinions freely. During the lesson process, students exchange ideas, conduct online discussions, and present their solutions. This forms communication, teamwork, and creative thinking skills.

The effectiveness of teaching mathematics based on digital technologies is clearly visible not only in the results of the educational process but also in education quality assessment criteria. For example, during students' independent work, time management, speed of responding to online assignments, test results, and readiness for analysis are automatically recorded on digital platforms. Based on this data, teachers analyze students' development dynamics and determine necessary pedagogical measures. In this way, the digital education process is organized taking into account students' individual characteristics.

For digital education to be effective, teachers should not only have technical skills but also master digital pedagogy and pedagogical design. Creating online courses, developing interactive content, skillfully managing virtual communication, properly organizing group work, and providing individual approach to students are important aspects of the teacher's work. The pedagogical approach also involves taking into account not only the technical aspect of digital tools but also their psychological and social impact on students.

Interdisciplinary connections also play an important role in the digital teaching process. Interactive mathematical modeling in physics, demonstrating the practical expression of mathematical formulas through GeoGebra in engineering sciences strengthens interdisciplinary interaction. Such an approach develops interdisciplinary thinking, comprehensive problem-solving, and logical conclusion-drawing skills in students.

Students' independence also increases in the digital teaching process. They expand their knowledge sphere through online resources, electronic libraries, and educational platforms. In this way, the teacher operates not as a knowledge provider but as a guide and advisor. The student becomes the center of their learning process. This approach corresponds to the principles of constructivist pedagogy.

Digital teaching also has social and psychological advantages. Even if a student is studying in an online environment, they have the opportunity to express their opinion, ask questions, and participate in discussions through virtual communication. Additionally, group online projects, interactive assignments, forums, and chats form teamwork skills and communicative culture in students. Through this process, teachers observe students' activities and assess their active participation.

Several practical steps are being taken to form digital teaching culture in Uzbekistan's education system. Specifically, according to the Resolution of the Cabinet of Ministers of the Republic of Uzbekistan dated April 19, 2021, an "Electronic Education Platform" has been implemented in all higher education institutions. Through this platform, teachers place lesson materials, and students master lessons online, take tests, and monitor their results. Additionally, a "Digital Education Center" has been established under the Ministry of Higher and Secondary Special Education, which develops online trainings and methodological guidelines for educators.

For the sustainable development of digital education, along with technical infrastructure, the development of methodological and scientific bases is also important. In this direction, a number of projects and programs are being implemented in cooperation with scientific research institutes,

universities, and international organizations. For example, within the framework of the "Uzbekistan - UNESCO Educational Innovations Program," digital resources for curricula are being developed.

At the same time, digital teaching also has certain limitations. The main problem is the quality of the internet network and insufficient technical equipment. Additionally, not all teachers have thoroughly mastered digital technologies. For this reason, it is necessary to continuously retrain and improve the qualifications of teachers in the education system. For this purpose, special grants, training programs, and online courses should be organized at the state level.

Digital technologies also have economic advantages in teaching. For example, electronic textbooks, online test systems, and virtual laboratories reduce the costs of preparing educational materials in print form. Additionally, distance learning reduces transportation, building rental, and energy costs. In this way, the educational process also becomes economically efficient.

In the mathematics teaching process through digital technologies, the following skills are formed in students: analytical thinking, problem situation analysis, logical conclusion drawing, graphic modeling, information processing, algorithmic thinking, as well as teamwork and self-control skills. These skills fall into the category of "soft skills" and "digital skills" that are most in demand in the modern labor market.

For teachers, digital technologies are a tool for harmonizing education with the times. If teachers use programs like GeoGebra or Desmos in lesson planning, the process becomes interactive, dynamic, and interesting for students. This increases the didactic effectiveness of lessons and demonstrates the teacher's professional competence. Along with this, through digital platforms, teachers have the opportunity to analyze their work activities, determine students' mastery level, and improve methodological approaches.

Digital teaching also supports the principles of democratizing education and inclusivity. For example, distance education opportunities create learning possibilities for students in remote areas, with disabilities, or busy with work. Through this, an education system based on equal opportunities is formed.

Conclusion

Using digital technologies and interactive platforms in teaching mathematics in higher education makes the educational process innovative, effective, and transparent. Teaching with the help of digital tools deepens students' perception, increases their capacity for independent thinking and analysis, and prepares them for modern labor market demands. Using platforms like GeoGebra, Moodle, Desmos, and Khan Academy improves lesson quality, optimizes teachers' pedagogical activities, and objectifies the assessment system.

The following measures are important for developing digital teaching:

1. Organizing systematic courses to improve teachers' digital competency.
2. Developing digital education centers in each higher education institution.
3. Adapting curricula to digital platforms.
4. Creating national digital educational resources.
5. Strengthening technical infrastructure and ensuring stable internet network.

Additionally, it is necessary to form digital teaching culture, train students in distance learning discipline, and harmonize interactive methods with pedagogical approaches. The fact that reforms in this direction continue in Uzbekistan's education system shows that the prospects for digital pedagogy development are high.

Digital technologies are becoming the main factor determining the future of mathematics teaching. They are not only transforming education but also taking it to a new level - that is, from the stage of knowledge delivery to the stage of knowledge creation. Therefore, the widespread application of digital technologies in teaching mathematics in higher education is the foundation of future education.

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