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Digitalization-Based Pedagogical Problems in Teaching Mechanics in Uzbekistan and Ways to Overcome Them

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Abstract:
This article analyzes the current state of teaching mechanics within the education system of Uzbekistan and identifies the main pedagogical problems arising in this process. The study examines the compliance of existing curricula in mechanics with modern educational requirements, the level of professional and digital pedagogical preparedness of faculty members, as well as the state of material and technical support of educational institutions.
Furthermore, methodological and organizational issues that arise during the usage of digital educational technologies, such as virtual laboratories and interactive learning tools, are examined. The analysis made it possible to form scientifically grounded and practically proven proposals for raising the efficiency of the educational process in mechanics in the conditions of digitalization, which are accompanied by methodological recommendations for the implementation of these proposals in educational practice.

Keywords: Teaching mechanics, digital pedagogy, improvement of the educational process, virtual laboratories, pedagogical problems, quality of education, education system of Uzbekistan.

Introduction

In today's context of accelerated globalization and the deep penetration of digital transformation into all spheres, including the education system, it has become necessary to fundamentally reconsider the content and methodology of teaching natural sciences in higher and general education institutions. In particular, improving the teaching of mechanics based on modern didactic approaches is emerging as an important condition for enhancing the quality and effectiveness of education [1]. The theory and practice of mechanics are closely linked with the engineering field, technology and other natural sciences, therefore, the solid knowledge and skills in this area are crucial for the professional training of future specialists.

As a fundamental science, mechanics not only reveals the basic laws of natural phenomena but also develops students' logical and critical thinking, problem analysis skills, and the ability to apply theoretical knowledge in practical activities [2]. Therefore, the teaching of mechanics should not be limited to traditional lectures and reproductive methods but should require pedagogical approaches integrated with interactive, experiment-based, and digital technologies.

Despite large-scale reforms implemented in Uzbekistan's education system in recent years, including curriculum updates, competency-based education, and the development of a digital learning environment, a number of systemic problems remain in teaching mechanics [3]. In particular, curricula do not fully meet the requirements of modern scientific and technological development; the digital pedagogical competencies of faculty members are insufficiently developed; and material and technical resources necessary for laboratory and experimental work are limited, which negatively affects the effectiveness of the educational process.

These circumstances necessitate a scientific analysis of existing pedagogical approaches in teaching mechanics, the improvement of the learning process by considering the potential of digital technologies, and the development of new methodological solutions aimed at enhancing educational quality.

Methodology

A mixed qualitative and quantitative research design was used in this study to investigate digitalization based pedagogical issues related to teaching mechanics in Uzbekistan, and to discover beneficial practices to mitigate the problems. A methodological framework based on a systematic analysis of regulatory documents, national education standards, and current curricula for mechanics in general secondary and higher education institutions formed the basis of this work [4]. Documentary analysis conducted regarding the congruency of mechanics content with requirements of current science, technology, and digital ludic education.

Inputs for analysis were made out of surveys, diagnostic tests, and semi-unstructured observations. Research goal: In order to determine the level of professional development, digital pedagogical competence and frequency of using virtual laboratories, simulations and digital measurement tools, questionnaires were administered to mechanics instructors. Conceptual diagnostic assessments were administered to first year university students covering core mechanics topics such as Newton's laws, force analysis, and motion on inclined planes. The methodology based on a classroom and laboratory observations of instructional practices, theoretical versus practical activities balance, and the state of material and technical resources.

Quantitative data were analysed through descriptive statistics to identify obvious trends, percentages, and performance differences, and qualitative data from observations and open ended responses in the survey were analysed using thematic analysis. The researchers compared conventional versus digital-enhanced teaching degrees of freedom with respect to student achievement [5]. This triangulation of methods has provided reliable and valid findings and allows for a holistic assessment of pedagogical, methodological and technical dimensions that inform the effectiveness of teaching mechanics in the digitalized context.

Results and Discussion

Analysis of the teaching process of mechanics based on real educational practice shows that most problems are associated with insufficient continuity between educational stages. In particular, in grades 7–9 of general secondary schools, fundamental mechanical concepts such as "motion," "force," "acceleration," and "impulse" are often taught through formula-based approaches, while their experimental and practical interpretations are not sufficiently developed (Table 1)

Table 1. Status of Professional Development and Laboratory Provision in Teaching Mechanics

Analysis Area	Indicator	Share (%)
Predominance of theoretical training in professional development courses	Theoretical sessions occupy the main portion	60–65
Practical and subject-oriented training in professional development courses	Insufficient level	55–60
Availability of specialized modules on digital laboratories	Almost nonexistent	70–75
Teachers engaged in scientific research	Actively use innovative teaching methods	40–45
Student achievement in groups taught by research-active instructors	Average increase in performance	+15–20
Availability of digital measurement tools in mechanics laboratories	Absent or very limited	40–50
Duration of use of analog laboratory equipment	Manufactured 15–20 years ago	65–70

According to practical observations, in diagnostic assessments conducted among first-year university students, approximately 50% failed to independently solve problems related to Newton's laws, and nearly 60% made serious mistakes in correctly drawing free-body diagrams. A common example is problems related to "motion on an inclined plane", where the students confused the direction of force, or ignored friction forces [6]. It reflects a lack of depth and systematic development or formation of mechanical concepts.

The second big problem is the inflexibility of current curricula for mechanics. Curricular analyses reveal that 70–75% of the total instructional load assigned for mechanics is comprised of theoretical classes, with only 25–30% allocated to lab and practical work [7]. Therefore, students experience mechanical phenomena not in real experiments but at the level of abstract formulas.

As an example, many school laboratories when examining the gravitational acceleration is to a desk with a calculator without any physical mechanism or digital sensor. What results is an inadequate formation of skill in the interpretation of experimental data, error calculation, and scientific conclusion.

Fourth-based on the Shiow-Chen Hsu in 2012 paper, the actual teaching methods, is directly related to the digital pedagogy preparedness of faculty members. According to the survey results, only about, 35–40% of the mechanics instructors regularly use the virtual laboratories, computer simulations, or the digital measurement programs.

In contrast, although there are simulation tools to be used, such as PhET, Algodoo, or Crocodile Physics, some professors prefer only to use blackboard explanation without providing any other means of learning [8]. As a result, students miss an opportunity to see and dynamically comprehend complex mechanical systems.

Important problems may also be found in the analysis of professional development courses. Over 60 % of trainers have stated that the training sessions are more theoretical than practical & course-based. More specifically, there are almost no dedicated modules designed specifically for creating digital laboratories for mechanics or lesson plans for virtual experiments [9].

Simultaneously, teachers actively involved in scientific work are inclined to use innovative methods in the classroom more. Small essay-style background box As a result, empirical studies reveal that student understanding levels are about 15–20% higher on average in classes taught by research-oriented faculty than those taught by yeoman instructors. This is because of the use of contemporary scientific enigmas, authentic technical processes, active problem-solving tasks.

Laboratory and experimental activities hold one of the most important didactics in mechanics teaching by either reinforcing theoretical knowledge, by making it possible to understand physical laws using real processes, or by promoting practical knowledge and skills.

However, observations indicate that in many general and higher education institutions, laboratory equipment for mechanics is outdated or insufficient, leading to a decline in educational quality.

In most institutions, a significant portion of mechanics laboratory equipment consists of analog devices manufactured 15–20 years ago, which do not meet modern accuracy and functionality requirements [10]. For example, in laboratory works such as "determination of gravitational acceleration," "law of conservation of momentum," and "determination of friction coefficient," digital timers, motion sensors, or computer-connected measurement systems are often unavailable. As a result, experiments are conducted manually, reducing the accuracy of results.

Practical analysis suggests that 40–50% of educational institutes with mechanics labs do not receive digital measurement capabilities for their instruction (motion sensors, force sensors, video analysis software, etc). This does not allow students to properly develop their skills in treating experimental data, analyzing the errors, and carrying out the scientific conclusions, and instead, it is a process that is overloaded with memorizing instead of practicing [11].

The rapid spread of distance and blended learning formats has opened new pedagogical possibilities for mechanics instruction. Using computer simulations, virtual laboratories and web-based platforms helps to visualize and dynamically explain mechanical processes [12]. But, an appropriate integration of these technologies in education practice is still a challenge.

Evidence suggests that these digital platforms are frequently used merely for the dissemination of lectures or video lessons, whereas systematic utilization of virtual laboratories and interactive assignments is scarce. This is mainly because of lack of methodology and few prepared teachers with digital tools.

Also, the assessment systems in the teaching of mechanics are based on traditional systems. Less commonly used assessment forms for distance and blended learning environments include interactive tests, virtual experiment based assessments, and project-based tasks [13]. As a result, those practical activities from students and independent research efforts are never fully accounted for, undermining the didactic possibility of digital education.

The conducted analysis and presented examples demonstrate that the problems in teaching mechanics are interconnected rather than isolated. Insufficient material and technical resources limit effective digitalization, while underdeveloped methodological and digital competencies of instructors prevent full utilization of available technologies [14].

Therefore, improving the effectiveness of teaching mechanics requires a comprehensive approach. This includes enriching curricula with digital and practical competencies, ensuring continuous professional development of faculty members, and gradually equipping laboratories with modern digital tools. Such an approach ensures coherence between theoretical knowledge and practical skills in teaching mechanics [15].

Conclusion

In conclusion, the pedagogical problems identified in teaching mechanics in Uzbekistan under conditions of digitalization directly affect the quality and effectiveness of education. The analysis highlights insufficient continuity between educational stages, limited material and technical support for laboratory work, and underdeveloped methodologies for implementing digital educational technologies as key issues.

The results confirm that systematic and targeted use of digital technologies, virtual laboratories, and interactive methods significantly enhances the transformation of theoretical knowledge into practical skills. Digital measurement tools and simulations foster students' abilities to analyze mechanical phenomena, process experimental data, and draw scientific conclusions.

At the same time, improving the effectiveness of teaching mechanics requires not only the introduction of technical tools but also the enrichment of curricula with practical and digital competencies, continuous professional development of faculty members, and modernization of assessment systems. Scientific and comprehensive approaches in these areas contribute to improving the quality of mechanics education, ensuring competitive professional training of students, and supporting sustainable development of the education system.

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