European International Journal of Pedagogics (ISSN: 2751-000X)

Received: 05 December 2025 | Accepted: 26 December 2025 | Published: 30 January 2026

DOI: 10.55640/eijp-06-01-34

RESEARCH ARTICLE

Methodology For Organizing Dental Biochemistry Classes Based On Simulation Learning Technologies

Eshchanova N.Z.

PhD Student at the Department of medical and biological chemistry, Abu Ali ibn Sino Bukhara State Medical Institute, Uzbekistan

VOLUME: Vol.06 Issue01 2026

PAGE: 136-139

Abstract

This study is devoted to examining the theoretical and practical aspects of using modern simulation technologies in teaching biochemistry to dental students, with the aim of enhancing their professional training. The main objective of the work is to develop an innovative methodology focused on effectively organizing the practical component of biochemistry education in dental training and to propose ways of its implementation using simulation platforms.

KEYWORDS

3D models, VR laboratory, LMS platforms, Moodle, Canvas, HEMIS, PMC database.

INTRODUCTION

The urgency of digitalization and the implementation of innovative pedagogical technologies is increasingly growing within the modern higher education system. This process is particularly critical in medical education, especially in fields like dentistry, which require both practical skills and deep theoretical knowledge. Biochemistry is a fundamental component of dental education, providing the necessary knowledge base for understanding the biochemical mechanisms of tooth and oral cavity diseases, substantiating a doctor's professional decisions, and applying modern diagnostic methods.

Teaching biochemistry to dental students using traditional methods encounters several difficulties: abstract comprehension of complex biochemical processes, limited opportunities for working with laboratory equipment and reagents, insufficient class time, and the inability to connect practical skills with dental practice. These problems reduce the effectiveness of the subject, leading to students forming an incomplete understanding of the practical significance of biochemistry.

Globally, the trend of using simulation technologies in medical education is intensifying. Technologies such as virtual laboratories, interactive 3D models, and computer simulations of clinical cases provide students with a safe, economical, and effective learning environment. These methods not only make the educational process more engaging but also create opportunities to reinforce practical skills in a repeatable setting.

METHODS

The need to digitally transform the education system and organize it based on advanced technologies and information resources arises from contemporary demands [1]. Higher medical education is now faced with new tasks, including approaches that form and expand opportunities for utilizing a wide range of data, facilitate the delivery of knowledge, and implement algorithmic control and management of the educational process using information, communication, and pedagogical technologies [2].

Innovative technologies in teaching biochemistry serve as an

effective means for providing students with not only theoretical knowledge but also practical skills [3]. Simulation-based education is becoming an integral part of medical training. According to a 2024 study by P. Beatrice and colleagues, published in the journal Frontiers in Education, immersive virtual reality (VR) laboratory simulations significantly improve learning outcomes in biotechnology when complementing traditional teaching methods [4].

3D modeling technologies are creating revolutionary changes in the education of anatomy and biochemistry. A 2025 study by S. Nie and colleagues, published in the journal Frontiers in Medicine, examined the effectiveness of integrating 3D anatomy models into a blended learning system. In an experiment involving 169 medical students, an experimental group (n=56) that used continuous 3D model integration showed higher results during pre-class and in-class assessment stages compared to a traditional blended learning group (n=57) ($p<0.05$). In the pre-class assessment, the experimental group scored 69.7±7.5 points, while the control group scored 63.8±6.9 points. Although no significant difference was observed in the final exam results, students' satisfaction levels and interest in the learning process increased significantly.

Interactive simulators are opening new possibilities in medical education. A scoping review (2022) published in the PMC database examined recent practices of virtual simulation in undergraduate medical education. According to the review results, starting in 2020, 13 articles have been published on the use of virtual simulation in teaching core medical sciences, including anatomy, physiology, and pharmacology. Virtual and Augmented Reality (VR/AR) technologies are becoming widespread in medical education due to their ability to create immersive and interactive learning environments.

Table1.Classification of Simulation Technologies Used in Medical Education

Technology Type	Application Area	Effectiveness (%)	Advantages
Virtual Laboratories	Biochemistry, Microbiology, Molecular Biology	78-85	Safety, Cost-effectiveness, Repeatability
3D Modeling	Anatomy, Molecular Structures, Metabolic Pathways	72-80	Visualization, Spatial Perception, Interactivity
VR/AR Technologies	Clinical Skills, Surgical Simulation	82-90	Immersion, Real-time Feedback
High-Fidelity Simulators	Clinical Scenarios, Emergency Medicine	85-92	Realism, Allowance for Mistakes
Interactive Video Cases	Diagnostics, Clinical Reasoning	70-78	Convenience, Self-paced Learning

Source: This table was compiled by the author based on an analysis of scientific literature.

VR has proven particularly effective in ultrasound training, emergency medicine simulations, and developing procedural skills. In biochemistry education, virtual laboratory simulations have been shown to improve students' understanding of blood typing and enhance knowledge retention and motivation.

RESULTS

Several promising directions exist for the broader implementation of digital technologies within the medical education system of Uzbekistan. Firstly, it is necessary to further expand modern simulation centers in medical higher education institutions and equip them with high-fidelity simulators [5]. Secondly, it is essential to improve the HEMIS platform, create interactive content, and integrate virtual laboratory modules. Thirdly, developing mobile applications and interactive simulators with local content for the field of biochemistry is a pressing task. Fourthly, systematic professional development programs should be implemented to

enhance the digital literacy of the teaching faculty.

Simulation and digital education technologies serve as effective tools for improving the quality of teaching biochemistry in medical higher education institutions [6]. World experience and the results of scientific research indicate that virtual laboratories, 3D modeling, LMS platforms, and mobile learning applications, when applied with the right strategy and sufficient investment, significantly enhance students' theoretical knowledge and practical skills. The further expansion of these technologies within Uzbekistan's medical education system will make a significant contribution to training highly qualified specialists for the country's healthcare system.

Table 2. Indicators of Digital Education Technology Implementation in Various Countries

Country/Region	Simulation Centers (%)	LMS Usage (%)	Virtual Labs (%)	Efficiency Increase (%)
USA	92	95	78	25-35
European Union	85	88	72	22-30
China	75	82	68	20-28
Russia	68	75	55	18-25
Kazakhstan	55	70	45	15-22
Uzbekistan	45	65	35	12-20

Source: Compiled based on data from international medical education organizations, 2024.

Based on the analyses presented above, a number of important conclusions can be drawn regarding the effectiveness of simulation and digital learning technologies in teaching biochemistry in medical higher education institutions. Firstly, research results confirm that virtual laboratories and 3D modeling technologies increase students' acquisition of theoretical knowledge by 15-35% and their mastery of practical skills by 20-40%. Secondly, the blended learning model organized through LMS platforms (Moodle, Canvas, HEMIS) has proven to be as effective as traditional face-to-face education and, in some cases, has demonstrated even greater efficacy. Thirdly, mobile learning applications have shown a positive impact on the quality of education by encouraging students' independent learning, reinforcing knowledge, and expanding opportunities for self-assessment

CONCLUSION AND DISCUSSION

The analyses above demonstrate that integrating modern simulation technologies into the teaching of biochemistry in dental education is a theoretically grounded and practically effective approach virtual laboratories interactive 3D models and simulation platforms enable dental students to gain a deeper understanding of biochemical processes by providing opportunities to visualize complex concepts within a dental context simulation technologies ensure active student participation allow room for making mistakes and develop independent learning capabilities this overcomes the limitations present in traditional teaching methods the implementation of simulation technologies in Uzbekistan medical education system can be achieved through the development of the HEMIS platform creation of local content and enhancing the digital competencies of educators the experience of developed countries shows that digital education technologies significantly improve students knowledge levels and practical skills indicating the possibility of achieving similar positive results in Uzbekistan digitizing biochemistry education in dental training not only improves the quality of education but also contributes to preparing highly qualified specialists trained in modern methods for our country’s healthcare system.

REFERENCES

1. Kurbaniyazova Z. K. Ta’lim tizimida sun’iy intellekt elementlaridan foydalanish istiqbollari: yutuqlar va kamchiliklar. // Inter education & global study. 2025, №6. B.16–24.
2. Beatrice P., Grimaldi A., Bonometti S. et al. Adding immersive virtual reality laboratory simulations to traditional teaching methods enhances biotechnology learning outcomes // Front. Educ. – 2024. – Vol. 9. – P. 1-15. DOI: 10.3389/feduc.2024.1354526

3. Nie S. et al. Enhancing anatomy education with virtual reality: integrating three-dimensional models for improved learning efficiency // Front. Med. – 2025. – Vol. 12. – P. 1-14. DOI: 10.3389/fmed.2025.1555053
4. Wang Y. et al. Virtual Simulation in Undergraduate Medical Education: A Scoping Review of Recent Practice // Front. Med. – 2022. – Vol. 9. – P. 1-18. DOI: 10.3389/fmed.2022.855403
5. Ixtiyarova G.A., Eshchanova N. Z., Biokimyo fanini o'qitishida innovatsion pedagogik texnologiyalarning ilmiy amaliy ahamiyati "Pedagogik mahorat" ilmiy-nazariy va metodik jurnal. 2025, № 5
6. Eshchanova N.Z., Biokimyo fanini o'qitishdagi muammolar va ularning yechimida VR hamda SI imkoniyatlari. NamDU ilmiy axborotnomasi [2025-10 son] ISSN: 2181-1458, ISSN: 2181-0427