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Application Of Artificial Intelligence For The Development Of Clinical Thinking In Students Of Dental Faculties

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ABSTRACT:

Modern medical education is developing under conditions of digitalization and active implementation of artificial intelligence (AI). One of the main tasks in dental education is the development of clinical thinking, including the ability to analyze clinical data, interpret diagnostic results, and make informed decisions.

According to the World Health Organization, many diagnostic errors are associated with insufficient clinical thinking among young specialists. Therefore, increasing attention is being paid to digital educational technologies, including virtual patients, intelligent learning platforms, and clinical decision support systems [1].

Studies show that AI in medical education improves educational quality, analytical skills, and clinical reasoning [2]. Schwendicke et al. reported that AI technologies in dentistry improve interpretation of diagnostic images and enhance professional training of students [6].

In addition, virtual simulators and adaptive learning systems increase student engagement and bring education closer to real clinical practice [9].

At the same time, excessive dependence on AI systems may reduce independent clinical analysis and critical thinking skills. Current data confirm the potential of AI technologies in dental education when implemented rationally and under appropriate supervision.



Keywords: artificial intelligence, clinical thinking, dental education, virtual patients, simulation-based learning, digital educational technologies.

INTRODUCTION

In recent years, artificial intelligence (AI) has become one of the most rapidly developing areas of digital transformation in healthcare and medical education. Machine learning technologies, neural networks, and generative language models are increasingly used for medical image analysis, clinical decision support, data processing automation, and personalization of the educational process [1, 3].

The development of digital technologies has significantly changed approaches to the training of future physicians and dentists. Traditional educational methods based mainly on memorization of theoretical material are gradually being supplemented by interactive digital platforms, virtual patients, and simulation technologies [8]. In the context of the growing volume of medical information, the ability of students to analyze clinical data, formulate diagnostic hypotheses, and make informed decisions is becoming increasingly important.

Modern medical education faces the challenge of preparing specialists to work under conditions of rapidly increasing amounts of medical information. According to current studies, the volume of clinical data and scientific publications continues to grow annually, making the exclusive use of traditional educational approaches less effective [3]. Therefore, artificial intelligence is considered a tool capable of optimizing the educational process, improving access to clinical information, and enhancing the quality of student training.

Artificial intelligence technologies have become especially relevant following the widespread development of generative language models. Such systems can simulate clinical dialogues, generate diagnostic scenarios, and be used for interactive training of medical students [5]. This promotes greater student engagement and supports the development of clinical thinking skills.

Dental education is of particular interest for the implementation of AI technologies because the diagnosis of dental diseases requires comprehensive analysis of clinical, visual, and radiographic data [6]. Modern AI systems can identify pathological changes on radiographic images, analyze clinical



parameters, and serve as supportive tools in teaching students diagnostic reasoning.

Furthermore, the rapid development of generative AI models, including ChatGPT and other language systems, opens new possibilities for adaptive learning, automated assessment, and clinical scenario simulation [5]. At the same time, the integration of AI into education is associated with ethical, organizational, and methodological issues that require further investigation [10, 14].

AIM OF THE STUDY

To investigate the possibilities of applying artificial intelligence technologies for the development of clinical thinking in students of medical and dental faculties.

MATERIALS AND METHODS

An analysis of domestic and foreign scientific publications devoted to the use of artificial intelligence, virtual patients, and digital educational platforms in medical education was conducted.

The study included data from systematic reviews, pedagogical experiments, and comparative studies evaluating the effectiveness of traditional and digital teaching methods for students of medical and dental faculties.

RESULTS

The analysis of scientific literature demonstrated that the implementation of artificial intelligence technologies positively affects the development of clinical thinking in students of medical and dental faculties. According to Chan et al., AI-oriented educational platforms improve clinical situation analysis skills, interpretation of diagnostic data, and student engagement in the educational process [2]. Zhao et al. found that the use of virtual patients and digital simulators improves practical skills and clinical analysis compared to traditional educational approaches [9].

According to Schwendicke et al., artificial intelligence systems in dentistry demonstrate high efficiency in the analysis of radiographic images and



identification of pathological changes, allowing them to be used as tools for the development of students' diagnostic thinking [6].

Several studies emphasize that AI technologies improve the objectivity of student assessment and the quality of feedback in the educational process [2, 4]. Intelligent platforms can automatically analyze testing results, identify the most difficult topics, and adapt educational content according to the level of student preparation.

An additional advantage of digital technologies is the possibility of repeated simulation of clinical situations of varying complexity. Unlike traditional learning, virtual simulators allow students to repeatedly analyze diagnostic cases, practice decision-making algorithms, and correct mistakes without risk to patients [9].

Studies also show that the use of AI contributes to the development of an interdisciplinary approach in medical education. Students are able to simultaneously analyze clinical symptoms, radiographic findings, and digital patient data, contributing to a more comprehensive development of clinical thinking [6].

Wartman and Combs noted that the integration of AI into medical education promotes a shift from memorization of information toward the development of analytical approaches to solving clinical problems [8]. According to Masters, intelligent educational systems improve the individualization of the educational process and enhance the understanding of clinical material [4].

Several studies report a tendency toward improved academic performance and practical training of students using digital simulators and artificial intelligence technologies [3, 5].

Additional studies indicate that adaptive educational systems can account for individual student characteristics and adjust the complexity of educational tasks according to students' learning outcomes [4]. Such an approach improves the effectiveness of independent work and contributes to the development of more stable clinical analysis skills.



According to Topol, the integration of artificial intelligence technologies into medical education contributes to the transition toward personalized learning models in which AI is used to evaluate student progress and identify knowledge gaps [7]. This is particularly relevant in dental education, where practical skills and clinical thinking are formed through repeated analysis of clinical cases.

At the same time, studies indicate several potential problems associated with excessive use of AI in the educational environment. According to El-Hakim et al., excessive dependence on artificial intelligence may reduce independent clinical analysis and weaken students' critical thinking skills [11]. Similar findings were reported by Németh et al., who noted that constant use of AI assistants may encourage passive learning behavior and reduce students' ability to make independent clinical decisions [12].

Some studies indicate the risk of excessive trust in artificial intelligence algorithms. In particular, Hosseini et al. reported that generative AI systems may reduce the depth of independent material analysis and negatively affect students' problem-solving skills [13].

According to recent publications, generative language models can also be used by students for automated generation of answers and academic assignments without sufficient independent analysis of educational material [5]. This creates a risk of reduced academic independence and requires the development of new approaches to assessing knowledge and practical skills of medical students.

The scientific literature also discusses ethical and organizational issues related to AI implementation in medical education. The main limitations include concerns regarding medical data confidentiality, algorithmic bias, insufficient transparency of AI systems, and the absence of unified educational standards for their application [10, 11]. Quinn et al. emphasized that errors of medical AI systems may reduce trust in both technologies and healthcare systems overall [14]. Another problem is the possibility of generating inaccurate diagnostic recommendations. Recent studies show that language models may demonstrate a high level of errors when analyzing incomplete clinical data, limiting their autonomous use in clinical thinking education [15].



Thus, modern studies confirm the significant potential of artificial intelligence in the development of clinical thinking among dental students, while emphasizing the need for rational and controlled implementation of these technologies in the educational process.

DISCUSSION

The obtained data confirm the promising potential of implementing artificial intelligence technologies in medical and dental education. The use of virtual patients and intelligent educational systems contributes to the development of analytical thinking, improvement of clinical analysis skills, and formation of practical competencies [2, 4, 9].

AI has particular importance in dental education, where diagnosis requires comprehensive analysis of clinical and radiographic data. Digital technologies allow simulation of real clinical situations and provide a safe educational environment for students [6]. The use of digital platforms also makes the educational process more adaptive and closer to real clinical practice.

At the same time, the effectiveness of AI directly depends on the manner of its implementation in the educational environment. Excessive dependence on intelligent systems may limit the development of independent clinical analysis and critical thinking among students [11–13]. In addition, the limitations of generative models and the possibility of diagnostic errors require mandatory supervision by educators [14, 15].

Despite its advantages, the implementation of AI requires the development of unified methodological approaches, improvement of digital infrastructure, and training of educators in the use of new educational technologies.

A promising direction for the future development of medical education is the integration of artificial intelligence with virtual and augmented reality technologies. Such systems may improve the realism of simulation-based learning and contribute to more effective practical skills training for dental students [1, 7]. However, the effectiveness of these technologies will depend on the quality of methodological support and the degree of integration into traditional educational environments.



An additional task of modern medical pedagogy is the development of students' skills in critically evaluating AI-generated results. Under conditions of active implementation of digital technologies, future specialists must be able not only to use intelligent algorithms but also to assess the reliability of obtained data, identify possible errors, and make final clinical decisions based on professional analysis [7, 14].

CONCLUSION

The application of artificial intelligence technologies in medical education is a promising direction in the development of modern educational environments. The use of virtual patients, intelligent educational platforms, and digital simulators contributes to the development of clinical thinking, formation of professional competencies, and improvement of training quality among dental students.

The integration of AI into the educational process makes learning more adaptive, interactive, and closer to real clinical practice, thereby increasing students' readiness for clinical practice.

At the same time, existing limitations of AI systems, including the risk of reduced independent clinical analysis, possible diagnostic errors, and concerns regarding algorithm reliability, require rational and controlled implementation of these technologies in the educational process [11–15].

Thus, artificial intelligence should be considered a supplementary educational tool complementing traditional methods of training future dental specialists.

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