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Letter to the Editor

Improving medical education through the integration of artificial intelligence

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Dear Editor,

The prospects of artificial intelligence (AI) in medical education are manifold, influencing various aspects of medical training, and having significance for medical universities, as well as medical teachers. In the context of significant advancements in AI and its influence on medical education, there seems to be a transition from traditional pedagogical approaches to those that incorporate AI technologies. However, it is essential to address the challenges associated with AI to improve its effectiveness and relevance for medical students.

Benefits of AI

The use of AI in medical education is revolutionizing the pedagogical approaches employed in the teaching and learning process of medical students.[1] AI tools in the field of medical education can not only facilitate individualized learning experiences and provide immediate feedback[2] but also enhance student assessment.[1] For instance, Chanysheva et al indicated that machine learning and data analytics technologies facilitate the development of customized educational programs tailored to the distinct objectives and requirements of individual students.[3] Alonso-Silverio et al developed a laparoscopic box trainer based on open-source hardware and AI for objective assessment of surgical psychomotor skills of medical students and residents. Their findings showed that the AI tool had the potential to increase the self-confidence of trainees and augment their learning.[4] In this vein, the resultatnt of AI application in the medical education field would be heightened student engagement, enhanced learning, and superior retention of knowledge as well as advanced psychomotor skills in comparison to conventional teaching methods. In addition, AI can facilitate the integration of theoretical knowledge with practical application during pre-clinical experiences, while also enhancing clinical reasoning, decision-making, and critical thinking skills during the clinical years. Consequently, this advancement is likely to result in improved patient outcomes and more efficient healthcare delivery.[5] Moreover, in the field of emergency medicine, AI plays a significant role in predicting patient outcomes, analyzing clinical images, and detecting early signs of deterioration.[6]

The transition to AI-enhanced medical education enables medical universities to address the lack of the workforce and improve resource distribution, thereby augmenting the training of medical students. Furthermore, the effective incorporation of AI-enhanced medical education enables medical universities to remain abreast of contemporary advancements and technological innovations. This approach promotes a culture of ongoing learning and enhancement, while simultaneously catering to the varied needs of students, thereby improving student engagement and motivation.[7] Medical universities by using AI-driven virtual simulations can replicate authentic clinical situations, and provide students with opportunities to practice and hone their diagnostic, surgical, and communication skills within a secure learning setting.[5] Al simulation technology can enhance students' self-assurance and reduce the likelihood of medical errors in practical clinical environments, where accuracy is of paramount importance.

By the same token, medical teachers can obtain valuable information regarding student performance, pinpoint areas of insufficient knowledge, provide administrative support, and develop targeted interventions to support those who are experiencing difficulties with particular concepts.[8] In a similar line, they can gain a comprehensive understanding of the learning landscape, enabling them to refine their teaching strategies. They can also tailor their teaching to meet the unique needs of individual students

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and foster a more collaborative and effective learning environment.[9] Given the significance of AI in medical education, in the following section we elaborate on (*a*) the impact of AI in medical education in comparison to traditional pedagogical approaches, and (*b*) the challenges and limitations associated with AI application.

AI versus conventional methods

Recent research on the application of AI technology in student learning indicates that its benefits are numerous, and student satisfaction with such technology is notably high.[10] Indeed, AI is rapidly transforming the educational landscape for medical students. For instance, as previously noted, AI-driven personalized learning experiences significantly enhance the learning process for students by tailoring content to individual needs, allowing for a more engaging and effective educational experience. It is important to acknowledge that traditional teaching methods have also been effective in developing medical students' competencies, providing foundational knowledge and skills that are essential for practice. However, in light of the rapid advancements in technology and the evolving perspectives of medical students, medical universities and educators must integrate AI technology into their curricula to the greatest extent possible. One notable advancement in the field is the development of machines that can perform radiological diagnoses with a success rate comparable to, or even exceeding, that of highly qualified specialists in the respective speciality.[11] It seems that numerous skills and areas of knowledge are more effectively developed through the utilization of AI-driven tools, which surpass the capabilities of traditional teaching methods. In this regard, AI-based tools can offer valuable feedback, assist medical students in their educational journeys, and facilitate simulation-based learning experiences. For example, chatbots can provide instant answers to student queries, intelligent tutoring systems can adaptively guide students through complex topics, and natural language processing applications can analyze student responses to enhance understanding. McFadden and Crim provided evidence for the efficacy of an AI-driven simulator, which resulted in a statistically significant enhancement in diagnostic accuracy of 22% following training. In contrast, a multimedia-based training program led by experts yielded a non-significant improvement of 8%.[12] These innovations surpass conventional teaching methods, which often fall short in addressing the complexities inherent in medical education, such as the need for immediate feedback and the ability to practice clinical scenarios in a risk-free environment.[5,13]

A systematic review and meta-analysis examining the application of AI tools in medicine and healthcare have demonstrated that the utilization of ChatGPT has the potential to transform medical practices, enhance patient care, and improve interactions among healthcare professionals, patients, and data.[14] This highlights the imperative for medical education to progress in tandem with technological advancements, thereby ensuring that future healthcare professionals are adequately prepared to utilize these technologies proficiently. By integrating AI into the curriculum, medical education can not only align with contemporary technological developments but also equip students for a future in which these tools are essential components of patient care and medical practice. Table 1 presents various dimensions of student performance in traditional educational settings versus those utilizing AI methodologies. The table highlights the potential of AI-based approaches to enhance decision-making processes, improve diagnostic accuracy, foster communication skills, facilitate knowledge retention, and bolster overall confidence in clinical competencies.

Challenges and limitations

The challenges associated with the utilization of AI continue to be a prominent area of interest among researchers and are subject to ongoing research. To the best of our knowledge, a significant obstacle in the application of AI within medical education is the disparity in access to educational resources. This inequity can severely disrupt learning opportunities and result in insufficient support systems, particularly for students hailing from underserved communities. To address this issue effectively, it is imperative to adopt a strategic approach that prioritizes investment in AI-driven solutions aimed at enhancing the accessibility and personalization of medical education while

Table 1. Comparison of student performance concerning AI-enhanced educational methods versus traditional methods

AI-based education	Traditional-based education	Aspect of performance
Real-time feedback with AI-powered analytics; exposure to diverse simulated scenarios enhances decision-making.	Limited ability to analyze complex cases; relies on traditional practice in limited scenarios.	Clinical decision making
Immediate diagnostic feedback with AI simulations leads to higher diagnostic accuracy.	Depending on the frequency of hands-on experience and instructor feedback, often delayed.	Diagnostic accuracy
AI simulations allow students to practice communication in various scenarios, improving response time and empathy.	Developed through in-person interactions and practice; limited to scheduled interactions.	Communication skills
Adaptive repetition based on AI analysis helps reinforce learning and retain knowledge over time.	Knowledge decays without consistent review; students often require refreshers.	Knowledge retention
Increases as students engage in controlled yet realistic virtual scenarios, reducing anxiety in real-world settings.	Varies by individual exposure and practice opportunities.	Confidence in clinical skills

simultaneously fostering equity and inclusivity. Another prominent issue in the use of AI in medical education has a connection with its ethical considerations. In this regard, research findings underscore the significance of patient privacy, transparency, and the involvement of physicians in the decision-making process.[6] Although AI has the potential to enhance the accuracy of disease diagnosis and the development of treatment protocols through machine learning techniques,[15] its implementation must prioritize the safeguarding of patient confidentiality. Ensuring transparency in the methodologies employed for training AI algorithms and in their performance is essential to achieve unbiased results. Furthermore, AI systems should be designed to augment the interactions between patients and physicians. Ultimately, while AI can provide valuable support in clinical decision-making, the ultimate responsibility for judgment must remain with the physician, thereby ensuring that human oversight is a fundamental aspect of patient care. Last but not least, the absence of a well-defined curriculum in certain areas of medical science, coupled with the lack of a digital medical education framework, undermines the potential for curriculum evaluation and presents obstacles to the attainment of educational objectives.[12,16]

In summary, the incorporation of AI into medical education offers significant potential for revolutionizing training methodologies, enhancing student engagement, and improving overall educational outcomes. AI technologies enable personalized learning experiences, deliver immediate feedback, and refine assessment techniques, thereby promoting essential competencies such as clinical reasoning and decision-making. The transition from conventional pedagogical methods to AI-enhanced learning not only equips students to confront contemporary healthcare challenges but also addresses workforce shortages through innovative virtual education strategies. Nonetheless, it is crucial to address the challenges that accompany this integration, including ensuring equitable access to resources, considering ethical implications related to patient privacy, and maintaining transparency in AI applications. By emphasizing these considerations, medical institutions can effectively leverage AI as a valuable instrument in cultivating proficient healthcare professionals. Ultimately, the successful integration of AI into medical education is likely to improve both student performance and patient care, thereby contributing to a more effective and efficient healthcare system. Future research endeavors may elucidate the role of AI in the domains of organ donation and trauma management, as these two areas are of considerable significance within global healthcare systems.[17,18]

Authors' Contribution

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Competing Interests

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