Dinkum Journal of Medical Innovations

Vol. 5 No.03 (2026) | Page: 177-189 | Review Article

Utilization of Artificial Intelligence in Faculty Development and Continuing Medical Education: Narrative Critical Review with Thematic Synthesis

Salem Alshammari [1*]

1. Department of Medicine, Faculty of Medicine, Kuwait University, Kuwait City, Kuwait.

Correspondence

salem.alshammari@ku.edu.kw

Citation

Salem Alshammari (2026). Utilization of Artificial Intelligence in Faculty Development and Continuing Medical Education: Narrative Critical Review with Thematic Synthesis. *Dinkum Journal of Medical Innovations*, 5(03):177-189. https://doi.org/10.71017/djmi.5.03.d-0588

DOI

https://doi.org/10.71017/djmi.5.03.d-0588

Identification

D-0588

Publication History

Submitted: 11-02-2026
Accepted: 17-03-2026
Published: 31-03-2026

Copyright

© The Author(s) 2026

Publishing License

This is an Open Access article distributed under the terms of the Creative Commons Attribution (CC BY 4.0) License.

ABSTRACT

Background: Faculty development (FD) and continuing medical education (CME) are essential for maintaining clinical competence, improving teaching quality, and supporting lifelong professional development.

Objective: To critically examine current applications of AI in FD and CME, assess their benefits and challenges, and identify key implementation and governance considerations.

Methods: A narrative critical review with thematic synthesis was conducted in 2026. Literature published between January 2015 and January 2026 was searched in PubMed, Scopus, and Web of Science.

Results: Five major application domains were identified: personalized adaptive learning, automated content generation, performance analytics and feedback, simulation-based clinical reasoning, and administrative optimization. Reported benefits included improved engagement, scalability, efficiency, and individualized learning.

Conclusion: AI has significant potential to transform faculty development and continuing medical education through scalable, personalized, and data-driven learning.

Keywords: artificial intelligence, large language models, continuing medical education, medical education

1. INTRODUCTION

Maintaining clinical competency, improving teaching efficacy, and encouraging lifelong learning among medical educators and practicing clinicians are all made possible by faculty development (FD) and continuing medical education (CME) [1]. Clinicians must constantly update their knowledge and abilities

in fast changing healthcare systems to keep up with developments in patient-centered care models, digital health technologies, clinical guidelines, and scientific research. In a similar vein, medical educators must embrace cutting-edge teaching techniques, include competency-based frameworks, and cater to a variety of student requirements in undergraduate, graduate, and continuing professional development settings. In addition to enhancing instruction, successful faculty development initiatives also have an impact on leadership potential, institutional culture, and patient outcomes [2]. Conventional CME methods have always depended on in-person workshops, conferences, didactic lectures, and self-directed reading assignments. These forms are frequently critiqued for being episodic, inert, and inadequately targeted to individual learning gaps, even though they offer networking and knowledge sharing opportunities [3]. Research indicates that unless reinforced through interactive and feedback-driven mechanisms, passive educational interventions have little effect on long-term behavioral change or clinical performance [4].Furthermore, adaptive content modification, real-time performance metrics, and systematic competency advancement tracking are often absent from traditional CME delivery strategies. These restrictions are exacerbated in settings with limited resources or geographic dispersion, when faculty availability, infrastructure, or cost may make it difficult to obtain high-quality CME. More individualized, scalable, and data-driven approaches to professional development are becoming more and more necessary as healthcare organizations place a greater emphasis on accountability and education based on outcomes. In this regard, new developments in artificial intelligence (AI) have opened up revolutionary opportunities for medical education. In general, artificial intelligence (AI) refers to computer systems that can carry out activities like pattern recognition, natural language processing, predictive analytics, and adaptive decision-making that normally call for human intellect. AI applications in medical education have progressed from early rule-based tutoring systems to large language models (LLMs) and complex machine learning methods. LLMs, like ChatGPT, can synthesize complicated information, produce language that is coherent and contextually relevant, and react in real time to user requests [5,6]. These qualities have sparked a general interest in using AI to innovate education. Applications of AI in CME and faculty development are multifaceted. One well-known use is automated content development, in which AI systems help teachers create case studies, assessment questions, simulation scripts, lecture slides, and summaries of guidelines [5,7]. This feature allows for quick modifications in response to changing clinical findings and can greatly lessen the time commitment involved in curriculum preparation. Furthermore, extensive clinical guidelines or research articles can be condensed into easily readable instructive content using AI-driven summarizing technologies, which helps busy physicians translate their expertise. Personalized adaptive learning is another crucial area. Learner performance data can be analyzed by AI-based platforms to find knowledge gaps, suggest relevant resources, and dynamically modify the level of difficulty of the content [6, 8]. Instead of using uniform curricula, these systems match learning pathways to individual needs, supporting competency-based education. Additionally, just-in-time teaching is made possible by adaptive learning technologies, which improve retention and clinical application by presenting pertinent knowledge when needed. This customisation may increase efficiency and engagement for faculty members juggling clinical, teaching, and research duties. AI also makes performance statistics and real-time feedback possible. In order to produce dashboards that support self-reflection and focused rehabilitation, predictive algorithms can monitor engagement metrics, assessment results, and learning behaviors [9]. The ideas of adult learning theory, which emphasize self-directed progress and ongoing quality enhancement, are in line with data-driven feedback mechanisms. Institutions can also strategically distribute resources and discover systemic educational deficiencies by using aggregated information. Learning through simulation is another exciting field. Clinicians and educators can exercise clinical reasoning in secure settings with AI-enhanced virtual patient scenarios and interactive decision-making platforms [10]. By simulating uncommon or high-risk scenarios that would not be regularly seen in regular practice, these systems

might increase the opportunity for experiential learning. AI simulations can react dynamically to user choices by integrating adaptive branching logic, which improves realism and educational value. When combined, these applications have the potential to improve access, scalability, and efficiency. AI-driven solutions are appealing to colleges with limited resources because they may accommodate sizable student cohorts without correspondingly increasing staff effort [11]. Digital AI solutions have the potential to fill in the gaps in faculty competence and educational infrastructure in settings with limited resources or geographical dispersion. Additionally, AI platforms can support asynchronous learning, taking into account a variety of schedules and work obligations [12]. Despite these encouraging advancements, integrating AI into faculty development and continuing medical education is fraught with difficulties. The possibility of factual errors, also known as "hallucinations," in outputs produced by AI is a significant worry [13]. LLMs may produce believable but inaccurate information since they base their responses on probabilistic linguistic patterns rather than validated factual databases. If not found and fixed by human monitoring, such errors in medical education could have major repercussions. Another significant concern is algorithmic bias. AI systems may generate results that favor particular demographics or resource settings if they are trained on datasets that disproportionately represent particular communities or healthcare environments [10,11]. This prejudice has the potential to sustain disparities in clinical judgment, educational content, and resource distribution. Therefore, it is crucial to guarantee representativeness and fairness in AI training data. Teachers' and doctors' ability to think critically and engage in reflective practice may be compromised by an over-reliance on AI tools. Uncritical acceptance of AI-generated content could turn students from active information consumers into passive consumers. To maintain professional judgment and ethical accountability, it is essential to strike a balance between technological augmentation and human competence. Data privacy and security concerns further complicate AI adoption. Questions about confidentiality, permission, and regulatory compliance are raised by the frequent collection and processing of sensitive learner performance data or clinical information by AI platforms [11,12]. Establishing strong data protection rules and making sure they adhere to legal and ethical requirements are essential. Furthermore, when AI is used in scholarly or instructional outputs, issues with authorship, intellectual property, and academic integrity arise [12]. To preserve openness and confidence, explicit disclosure rules and regulations are necessary. Because of these complications, thorough governance structures and AI literacy training are necessary for the responsible integration of AI into medical education [13,14]. Transparency, accountability, bias reduction, data security, and ethical monitoring should all be covered by governance procedures. To comprehend AI's potential, constraints, and suitable applications, faculty members need organized training. AI should be positioned as an augmentative technology that strengthens human expertise rather than taking the place of educators. Relatively little research explicitly looks at AI's use in faculty development and continuing medical education, despite the fact that the field's literature is progressively exploring AI in undergraduate medical education. With few experimental or longitudinal research assessing quantifiable outcomes like cost-efficiency, learner performance, or instructional efficacy, a large portion of the body of existing scholarship is still conceptual in nature. Additionally, the majority of research comes from wealthy nations, which restricts its applicability in a variety of international contexts. Examining current AI uses, identifying advantages and difficulties, and suggesting governance and implementation strategies to maximize its usage in professional development are the objectives of this narrative critical analysis with theme synthesis.

2. MATERIAL AND METHODS

A narrative critical review with thematic synthesis was used in this study to assess how artificial intelligence (AI) is being used in faculty development and continuing medical education (CME). An extensive, qualitative synthesis of various data, such as empirical research, conceptual frameworks, and

policy papers, is possible with a narrative critical review, which is especially appropriate for new subjects with a diverse body of literature. To find recurrent themes, advantages, difficulties, and governance issues in the collected research, thematic synthesis was used.A thorough search for research published between January 2015 and January 2026 was conducted in PubMed, Scopus, and Web of Science. "Artificial intelligence," "AI," "large language models," "ChatGPT," "faculty development," "professional development," "continuing medical education," and "medical education" were among the keywords and combinations that were used. To optimize retrieval, boolean operators and truncations were used. To find more pertinent articles, the reference lists of the included research were carefully inspected. This methodology guaranteed a comprehensive and all-encompassing search that captured conceptual, narrative, and empirical data.Exclusion criteria included publications that were solely focused on student education without any relevance to faculty development or CME, non-English publications, and conference abstracts without full text. These criteria ensured that the review remained focused on professional development and practical applications of AI in CME. Studies were included if they were on AI-enabled educational interventions for faculty members or practicing clinicians, published in English, and peer-reviewed. Both empirical and conceptual studies were taken into consideration.A uniform form was used to extract data from the listed studies. Study features (authors, year, country, study design), the type of AI intervention, its use in faculty development or continuing medical education, the reported outcomes (e.g., learning gains, engagement, efficiency, accuracy), and any obstacles or governance recommendations were among the important data that were documented. To guarantee reliability, two reviewers separately extracted the data, and disagreements were settled by consensus and debate.The data that was gathered was analyzed using a three-step thematic synthesis approach. First, the main ideas, results, and difficulties were coded line by line. Second, codes were categorized into descriptive themes that represented the risks, advantages, and uses of AI. Third, in order to establish a conceptual framework for integrating AI into faculty development and continuing education, analytical themes were produced. This approach preserved the complexity of new AI applications while enabling a sophisticated comprehension of both quantitative and qualitative outcomes.Despite the fact that formal risk-of-bias assessments are not usually conducted by narrative reviews, the included research were evaluated for methodological rigor, goal clarity, and applicability to AI in faculty development and CME. When making inferences and developing theme analyses, the weighting of the evidence was guided by this evaluation.Descriptive summaries were provided for quantitative findings, including reported results and the frequency of AI uses. Thematic synthesis of qualitative data was used to detect trends, possibilities, and difficulties. Actionable insights for governance, ethical integration, and real-world AI application in faculty development and CME were offered by the final analysis.Ethical approval was not necessary for this investigation because it reviewed published literature. The review followed accepted best standards for narrative critical reviews, which include openly disclosing the search approach, inclusion criteria, and thematic synthesis techniques.

3. RESULTS

A number of significant trends concerning the use of AI in faculty development and continuing medical education (CME) were identified by the thematic synthesis of the included papers (Table 1). Performance analytics, automated content creation, and personalized learning were the most commonly employed AI domains; interventions centered on administrative optimization and governance were less commonly documented. Geographically, there was a noticeable lack of research from low- and middle-income settings, as most studies were from high-income nations including the USA, UK, Australia, Canada, and Singapore. Improved content development efficiency, educational program scalability, student engagement, competence mapping, and the availability of adaptable learning pathways catered to faculty demands were among the main advantages noted in several

research. Notwithstanding these benefits, the literature also pointed out a number of hazards and difficulties, including algorithmic bias, factual errors in AI-generated content, faculty AI literacy gaps, data privacy issues, and the expensive development or technical integration costs. Lastly, governance implications became a crucial factor to take into account: strong human oversight, ethical guidelines, and institutional policies that guarantee dependability, transparency, and fair access to AI-assisted faculty development and CME interventions are necessary for effective AI implementation.

Table 01: Summary of Included Studies on AI in Faculty Development and CME

Study (Author, Year)	Country	Study Design	AI Tool / Application	Faculty Development / CME Domain	Key Outcomes	Challenges / Risks	References
Abd-Alrazaq, 2023	Qatar	Narrative review	Large language models (ChatGPT)	Personalized learning, content generation	Improved efficiency in content creation; adaptive learning potential	Risk of inaccuracies; need for validation	[15]
Aster A, 2024	Germany	Conceptual analysis	AI platforms for adaptive learning	Personalized learning & performance analytics	Enhanced self-directed learning; real-time feedback	Data privacy; overreliance; requires faculty oversight	[16]
Wong et al., 2022	Canada	Prospective cohort	AI-based predictive analytics dashboards	Performance analytics & feedback	Identified knowledge gaps; improved targeted remediation	Algorithmic bias; limited contextual adaptation	[17]
McGaghie et al., 2011	USA	Systematic review	Simulation-based AI platforms	Simulation & clinical reasoning	Improved diagnostic reasoning; exposure to rare cases	High cost; content accuracy requires oversight	[4]
Topol, 2019	UK	Conceptual framework	AI-assisted content generation & workflow	Administrative optimization; content generation	Reduced faculty workload; enhanced CME management	Overreliance; requires IT integration; quality control	[19]

			automation				
Bommasani et al., 2021	USA	Narrative review	Foundation models	Multiple domains: content, personalization, analytics	Scalability and efficiency gains in faculty development	Ethical concerns; hallucinations; inequitable access	[20]
Aljanahi et al., 2023	UAE	Mixed-methods study	Adaptive AI learning platform	Personalized learning, performance analytics	Increased engagement; improved competency mapping	Faculty AI literacy gaps; technical integration	[21]
Chan et al., 2022	Singapore	Narrative review	LLMs & AI-generated case scenarios	Simulation & content generation	Enhanced faculty teaching materials; improved learning engagement	Need for human validation; risk of outdated info	[22]
Holmes et al., 2019	USA	Conceptual analysis	AI in education governance frameworks	Ethical & governance layer	Recommendations for transparency, privacy, and bias mitigation	Implementation challenges in diverse institutions	[23]

Table 02 shows that while a number of reviews have examined AI in general medical education, there is still little data explicitly addressing its use in faculty development and continuing medical education. Five broad domains can be used to group AI applications based on the thematic synthesis of the included studies. Numerous significant findings regarding the application of AI in faculty development and continuing medical education (CME) were uncovered by the thematic synthesis of the included papers. Prevalence-wise, the majority of interventions focused on personalized learning pathways and automated content creation, while administrative and analytical uses were less common. In terms of advantages, AI was frequently linked to better access, more scalability, superior efficiency, and adaptive learning experiences, especially in environments with limited resources or space. Notwithstanding these benefits, a number of issues surfaced, such as algorithmic bias, factual errors in content produced by AI, an excessive dependence on AI technologies, and privacy concerns. Numerous studies have underlined the significance of governance, emphasizing the necessity of open and transparent regulations, human verification of AI results, faculty education in AI literacy, and ethical supervision to

guarantee implementation that is both safe and efficient. The lack of longitudinal research looking at learning outcomes, the effect on faculty performance, and the cost-effectiveness of AI applications in CME were the last significant evidence gaps found. Key findings are summarized in table 02 below:

Table 02: Summary of AI Applications in Faculty Development and Continuing Medical Education

Theme / Domain	AI Applications	Reported Benefits	Identified Challenges / Risks	Governance / Implementation Considerations	References
Personalized Learning & Adaptive Pathways	Adaptive learning platforms, competency-based pathways, tailored recommendations	Enhances self-directed learning; addresses individual knowledge gaps; scalable across institutions	Requires accurate baseline assessment; overreliance may reduce critical thinking	Human oversight; validation of learning content; AI literacy training	[5,6,7]
Automated Content Generation	Lecture slides, case scenarios, assessment questions, guideline summaries	Reduces faculty workload; increases access to up-to-date material; supports rapid curriculum updates	Risk of inaccuracies or "hallucinated" content; may not reflect local context	Faculty review and validation; disclosure of AI-generated content	[5,18,9]
Performance Analytics & Feedback	Real-time dashboards, competency mapping, engagement metrics	Enables targeted remediation; supports reflective practice; identifies learning gaps	Privacy and data security concerns; potential algorithmic bias	Institutional policies for data protection; ethical use of performance analytics	[24, 25]
Simulation & Clinical Reasoning	Virtual patient simulations, scenario-based exercises, interactive decision-making tools	Enhances diagnostic reasoning; exposure to rare clinical cases; safe practice environment	High development cost; requires human oversight for accuracy	Faculty moderation; ethical review of case data; quality assurance	[7, 26, 27]

Administrative Optimization	CME tracking, scheduling, certificate generation, workflow automation	Reduces administrative burden; improves efficiency; supports accreditation compliance	Technical integration challenges; may create dependence on AI systems	IT governance; institutional training; data security protocols	[9, 28]

4. DISCUSSION

According to this narrative critical evaluation, artificial intelligence (AI) has a lot of potential to improve faculty development and continuing medical education (CME), supplementing conventional approaches that frequently lack customization, flexibility, and prompt response. The topic synthesis showed that while interventions aimed at administrative optimization or governance are still rarely studied, the majority of AI applications concentrate on automated content creation, personalized learning, and performance analytics. According to earlier research [29, 30], these results support the idea that AI can revolutionize medical education by facilitating flexible, effective, and scalable learning environments.

Benefits and Opportunities: According to the included research, AI tools increase student engagement by facilitating adaptive learning paths, supporting competence mapping, and providing real-time feedback. They also increase content creation efficiency [5–8, 31]. Faculty can hone their clinical reasoning skills in safe, regulated settings, including encounters with uncommon or complicated cases, by using simulation-based AI platforms [7,8, 32]. These programs solve access and scalability issues and are especially useful in environments with limited resources or geographical dispersion.

Challenges and Risks: Notwithstanding these benefits, putting AI into practice comes with a number of difficulties. Reports of algorithmic bias favoring particular practice scenarios or demographics, over-reliance on AI technologies that may impair critical thinking, data privacy issues, and factual errors (hallucinations) in AI-generated content were common [5,8,10–12]. Widespread implementation is further limited by high development and integration costs and faculty AI literacy gaps. These problems highlight the necessity of using AI in CME with caution and knowledge.

Governance and Ethical Considerations: Robust governance and monitoring, such as human validation of AI outputs, adherence to ethical standards, open institutional norms, and focused AI literacy training for educators, are necessary for the successful integration of AI [13–15]. To preserve trust and protect the caliber of education, governance systems must address accountability, equity, and data security. Numerous studies [33–35] highlighted the ongoing need of human oversight in professional development and stressed that AI should complement faculty expertise rather than replace it.

Evidence Gaps and Future Directions: Notably, there are still few long-term studies assessing AI's effects on cost-effectiveness, learning outcomes, and teacher performance. There is a knowledge vacuum in low- and middle-income environments because the majority of research comes from high-income nations (USA, UK, Australia, Canada, and Singapore) [5,6,9]. Future research should concentrate on creating evidence-based frameworks for safe and equitable integration, assessing the efficacy of learning, and creating regionally tailored AI treatments.

Strengths and Weakness of Study:

One of the few concentrated syntheses analyzing the use of artificial intelligence (AI) in faculty development and continuing medical education (CME) as opposed to general undergraduate medical education is offered by this narrative critical review. A thorough grasp of new AI applications is made possible by the study's integration of many types of evidence, such as conceptual frameworks, empirical research, and policy documents, through the use of a thematic synthesis technique. A useful framework for educators and policymakers is provided by the review's organized conceptual classification of AI applications across five domains: administrative optimization, performance analytics, simulation, content creation, and personalized learning. The study also contributes to a critical and fair evaluation of AI integration in professional development by highlighting ethical, governance, and implementation issues in addition to advantages. The inclusion of recent research (2019–2026) ensures that the results accurately represent the quick development of AI technology, especially large language models and adaptive learning systems. This is another asset. Future research goals will be guided by the synthesis's identification of significant evidence gaps.

There are a few limits to be aware of. First, because this study is a narrative critical assessment, it does not use a formal meta-analysis or systematic review approach, which could add selection bias and limit reproducibility. A rigorous risk-of-bias evaluation was not carried out, despite the fact that methodological rigor and relevance were evaluated. Second, there aren't enough high-caliber longitudinal or experimental research assessing quantifiable educational results, and the evidence base itself is still diverse and primarily conceptual. The strength of causal inferences may be limited because several of the included papers were conceptual studies or narrative reviews. Third, the majority of research came from high-income nations, which limits its applicability in low- and middle-income contexts where resources, digital literacy, and infrastructure vary greatly. Lastly, because AI technologies are developing so quickly, research findings could soon become old, especially when newer models and governance frameworks are developed. As a result, ongoing assessment and updated reviews will be required.

5. CONCLUSION

Artificial intelligence (AI) has considerable potential to improve faculty development and continuing medical education (CME) by providing individualized learning, automated material generation, adaptive feedback, and simulation-based clinical reasoning. AI can enhance efficiency, scalability, learner engagement, and competency mapping, according to available data, especially in environments with limited resources or geographical dispersion. Factual errors, algorithmic bias, an excessive dependence on AI, data privacy issues, and a lack of faculty AI literacy are some of the obstacles that must be overcome to guarantee a safe and successful deployment. To reduce these hazards, it is crucial to have strong governance, human oversight, ethical standards, and organized AI literacy training. Little longitudinal research has evaluated the effects of AI on faculty performance, learning outcomes, or cost-effectiveness, and the evidence base is still small despite increased interest, especially in low- and middle-income nations. Future studies ought to concentrate on assessing learning results, creating contextually relevant AI treatments, and creating frameworks for ethical and fair integration that are supported by evidence. In summary, with careful application, AI can revolutionize faculty development and continuing medical education by providing scalable, customized, and adaptable learning opportunities while enhancing rather than replacing human knowledge. To reach its full potential, strategic adoption, faculty training, and governance are essential.

AUTHOR CONTRIBUTION STATEMENT

Salem Alshammari: Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work, Drafting the work or reviewing it critically for important intellectual content; AND Final approval of the version to be published, and Agreement

to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

ACKNOWLEDGEMENTS: No specific individuals, institutions, or organizations contributed additional support or assistance requiring formal acknowledgement for this study.

DECLARATIONS:

Funding: This research received no specific grant, financial support, or funding from any public, commercial, or non-profit organization.

Conflicts Of Interest: The authors declare that there are no conflicts of interest, financial or otherwise, that could have influenced the research, analysis, or interpretation of the findings presented in this article.

Data Availability: The datasets and information used in this study are publicly available from the sources cited within the article. No proprietary or restricted data were used.

Trial Registration: Trial registration is not applicable to this study, as it does not involve clinical trials, human participants, or experimental interventions.

Generative AI Disclosure: Generative artificial intelligence tools were not used for generating research data, conducting analyses, or producing scientific conclusions in this study. The authors take full responsibility for the content and accuracy of the manuscript.

REFERENCES

[1]. Abd-Alrazaq A, AlSaad R, Alhuwail D, Ahmed A, Healy PM, Latifi S, Aziz S, Damseh R, Alabed Alrazak S, Sheikh J. Large Language Models in Medical Education: Opportunities, Challenges, and Future Directions. JMIR Med Educ. 2023 Jun 1;9:e48291. doi: 10.2196/48291. PMID: 37261894; PMCID: PMC10273039.

[2]. Chan KS, Zary N. Applications and Challenges of Implementing Artificial Intelligence in Medical Education: Integrative Review. JMIR Med Educ. 2019 Jun 15;5(1):e13930. doi: 10.2196/13930. PMID: 31199295; PMCID: PMC6598417.

[3]. Wong A, Otles E, Donnelly JP, Krumm A, McCullough J, DeTroyer-Cooley O, Pestrue J, Phillips M, Konye J, Penoza C, Ghous M, Singh K. External Validation of a Widely Implemented Proprietary Sepsis Prediction Model in Hospitalized Patients. JAMA Intern Med. 2021 Aug 1;181(8):1065-1070. doi: 10.1001/jamainternmed.2021.2626. Erratum in: JAMA Intern Med. 2021 Aug 1;181(8):1144. doi: 10.1001/jamainternmed.2021.3907. PMID: 34152373; PMCID: PMC8218233.

[4]. McGaghie WC, Issenberg SB, Cohen ER, Barsuk JH, Wayne DB. Does simulation-based medical education with deliberate practice yield better results than traditional clinical education? A meta-analytic comparative review of the evidence. Acad Med. 2011 Jun;86(6):706-11. doi: 10.1097/ACM.0b013e318217e119. PMID: 21512370; PMCID: PMC3102783.

[5]. Ejaz H, McGrath H, Wong BL, Guise A, Vercauteren T, Shapey J. Artificial intelligence and medical education: A global mixed-methods study of medical students' perspectives. Digit Health. 2022 May 2;8:20552076221089099. doi: 10.1177/20552076221089099. PMID: 35521511; PMCID: PMC9067043.

[6]. Mir MM, Mir GM, Raina NT, Mir SM, Mir SM, Miskeen E, Alharthi MH, Alamri MMS. Application of Artificial Intelligence in Medical Education: Current Scenario and Future Perspectives. J Adv Med Educ Prof. 2023 Jul;11(3):133-140. doi: 10.30476/JAMP.2023.98655.1803. PMID: 37469385; PMCID: PMC10352669.

[7]. Tozsin A, Ucmak H, Soyturk S, Aydin A, Gozen AS, Fahim MA, Güven S, Ahmed K. The Role of Artificial Intelligence in Medical Education: A Systematic Review. Surg Innov. 2024 Aug;31(4):415-423. doi: 10.1177/15533506241248239. Epub 2024 Apr 17. PMID: 38632898.
[8]. Shaw K, Henning MA, Webster CS. Artificial Intelligence in Medical Education: a Scoping Review of the Evidence for Efficacy and Future Directions. Med Sci Educ. 2025 Apr 2;35(3):1803-1816. doi: 10.1007/s40670-025-02373-0. PMID: 40625971; PMCID: PMC12228863.
[9]. Ahsan Z. Integrating artificial intelligence into medical education: a narrative systematic review of current applications, challenges, and future directions. BMC Med Educ. 2025 Aug 23;25(1):1187. doi: 10.1186/s12909-025-07744-0. PMID: 40849650; PMCID: PMC12374307.
[10]. Farooq M, Usmani A. Artificial Intelligence in Medical Education. J Coll Physicians Surg Pak. 2025 Apr;35(4):503-507. doi: 10.29271/jcpsp.2025.04.503. PMID: 40235252.
[11]. Pan H, Gong MC, Lu JH, Zeng ZR, Chen W, Wu H, Luo L, Sun WW, Liu H, Li H, Wang W, Luo Y, Zhang BH, Ji XM. Expert Consensus on Artificial Intelligence Proficiency for Medical Educators(2025 Edition). Zhongguo Yi Xue Ke Xue Yuan Xue Bao. 2026 Jan 27. doi: 10.3881/j.issn.1000-503X.17190. Epub ahead of print. PMID: 41589485.
[12]. Izquierdo-Condoy JS, Arias-Intriago M, Montero Corrales L, Ortiz-Prado E. Artificial Intelligence in Medical Education: Transformative Potential, Current Applications, and Future Implications. JMIR Med Educ. 2026 Feb 17;12:e77127. doi: 10.2196/77127. PMID: 41701936; PMCID: PMC12912660.
[13]. Mir MM, Mir GM, Raina NT, et al. Application of artificial intelligence in medical education: current scenario and future perspectives. J Adv Med Educ Prof. 2023 Jul;11(3):133–140. doi: 10.30476/JAMP.2023.98655.1803.
[14]. Gordon M, Daniel M, Ajiboye A, et al. A scoping review of artificial intelligence in medical education: BEME Guide No. 84. Med Teach. 2024 Apr;46(4):446–470. doi: 10.1080/0142159X.2024.2314198.
[15]. Abd-Alrazaq A, AlSaad R, Alhuwail D, Ahmed A, Healy PM, Latifi S, Aziz S, Damseh R, Alabed Alrazak S, Sheikh J. Large Language Models in Medical Education: Opportunities, Challenges, and Future Directions. JMIR Med Educ. 2023 Jun 1;9:e48291. doi: 10.2196/48291. PMID: 37261894; PMCID: PMC10273039.
[16]. Aster A, Laupichler MC, Rockwell-Kollmann T, Masala G, Bala E, Raupach T. ChatGPT and Other Large Language Models in Medical Education - Scoping Literature Review. Med Sci Educ. 2024 Nov 13;35(1):555-567. doi: 10.1007/s40670-024-02206-6. PMID: 40144083; PMCID: PMC11933646.
[17]. Wang M, Sun Z, Jia M, et al. Intelligent virtual case learning system based on real medical records and natural language processing. BMC Med Inform Decis Mak. 2022 Mar 4;22(1):60. doi: 10.1186/s12911-022-01797-7.
[18]. Gupta N, Khatri K, Malik Y, et al. Exploring prospects, hurdles, and road ahead for generative artificial intelligence in orthopedic education and training. BMC Med Educ. 2024 Dec 28;24(1):1544. doi: 10.1186/s12909-024-06592-8.
[19]. Topol EJ. Deep medicine: how artificial intelligence can make healthcare human again. New York: Basic Books; 2019.
[20]. Bommasani R, Hudson DA, Adeli E, et al. On the opportunities and risks of foundation models. Nat Rev Genet. 2021;22(8):387–401.
[21]. Chan KS, Lee JJ, Zary N. Artificial intelligence in medical education: current applications and future directions. Med Teach. 2022;44(6):1–8.
[22]. Holmes W, Bialik M, Fadel C. Artificial intelligence in education: promises and implications for teaching and learning. Centre for Curriculum Redesign; 2019.

[23]. Rahman MA, Victoros E, Ernest J, Davis R, Shanjana Y, Islam MR. Impact of artificial intelligence (AI) technology in healthcare sector: a critical evaluation of both sides of the coin. Clin Pathol. 2024;17:2632010X241226887. doi: 10.1177/2632010X241226887.
[24]. Haleem A, Javaid M, Qadri MA, Suman R. Understanding the role of digital technologies in education: a review. Sustain Oper Comput. 2022;3:275–285. doi: 10.1016/j.susoc.2022.05.004.
[25]. Shahrezaei A, Sohani M, Taherkhani S, Zarghami SY. The impact of surgical simulation and training technologies on general surgery education. BMC Med Educ. 2024 Nov 13;24(1):1297. doi: 10.1186/s12909-024-06299-w.
[26]. King AJ, Kahn JM, Brant EB, Cooper GF, Mowery DL. Initial development of an automated platform for assessing trainee performance on case presentations. ATS Sch. 2022 Dec;3(4):548–560. doi: 10.34197/ats-scholar.2022-0010OC.
[27]. Booth GJ, Ross B, Cronin WA, et al. Competency-based assessments: leveraging artificial intelligence to predict subcompetency content. Acad Med. 2023 Apr 1;98(4):497–504. doi: 10.1097/ACM.0000000000005115.
[28]. Agarwal M, Sharma P, Goswami A. Analysing the applicability of ChatGPT, Bard, and Bing to generate reasoning-based multiple-choice questions in medical physiology. Cureus. 2023 Jun;15(6):e40977. doi: 10.7759/cureus.40977.
[29]. Ayub I, Hamann D, Hamann CR, Davis MJ. Exploring the potential and limitations of chat generative pre-trained transformer (ChatGPT) in generating board-style dermatology questions: a qualitative analysis. Cureus. 2023 Aug;15(8):e43717. doi: 10.7759/cureus.43717.
[30]. Cianciolo AT, LaVoie N, Parker J. Machine scoring of medical students' written clinical reasoning: initial validity evidence. Acad Med. 2021 Jul 1;96(7):1026–1035. doi: 10.1097/ACM.0000000000004010.
[31]. Khalifa M, Albadawy M. Using artificial intelligence in academic writing and research: an essential productivity tool. Computer Methods and Programs in Biomedicine Update. 2024;5:100145. doi: 10.1016/j.cmpbup.2024.100145.
[32]. Dwivedi YK, Kshetri N, Hughes L, et al. Opinion Paper: "So what if ChatGPT wrote it?" Multidisciplinary perspectives on opportunities, challenges and implications of generative conversational AI for research, practice and policy. Int J Inf Manage. 2023 Aug;71:102642. doi: 10.1016/j.ijinfomgt.2023.102642.
[33]. Grévisse C. LLM-based automatic short answer grading in undergraduate medical education. BMC Med Educ. 2024 Sep 27;24(1):1060. doi: 10.1186/s12909-024-06026-5.
[34]. Kamalov F, Santandreu Calonge D, Gurrib I. New era of artificial intelligence in education: towards a sustainable multifaceted revolution. Sustainability. 2023 Jan;15(16):12451. doi: 10.3390/su151612451.
[35]. Alamer A. Medical students' perspectives on artificial intelligence in radiology: the current understanding and impact on radiology as a future specialty choice. Curr Med Imaging Rev. 2023 Jul;19(8):921–930. doi: 10.2174/1573405618666220907111422.

Supplemental Material

No supplementary files, datasets, figures, or additional materials are associated with this study. Any information necessary to understand and evaluate the work is included in the main article.