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Transformation and Reinvention: A Comprehensive Analysis of Frontiers and Trends in AI-Empowered Medical Education by 2025

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Abstract: In 2025, the rapid iteration of generative artificial intelligence (AI) and large language models (LLMs) has profoundly reshaped the ecosystem of medical education. This review systematically synthesizes the latest advances in AI-enabled medical education through an analysis of more than 150 core articles published in 2025 and indexed in the PubMed database. The paper first evaluates the current state of AI literacy among medical students and educators worldwide, revealing a pervasive "cognition – practice" misalignment. It then examines innovative application models of AI in curriculum integration, the development of intelligent educational tools (e.g., virtual patients and personalized tutoring systems), and AI-enhanced assessment and feedback mechanisms. Ultimately, the review examines key ethical challenges, including algorithmic bias, academic integrity, and data privacy. The findings suggest that future medical education should establish a human-centered framework of human – AI collaboration, with particular emphasis on cultivating physicians' critical thinking and humanistic values. This review aims to provide both theoretical foundations and practical guidance for the development of a new paradigm in intelligent medical education.

Keywords: intelligent teaching, artificial intelligence, medical education, smart classroom, digitalized teaching

1. Introduction

The year 2025 has witnessed the rapid iteration and advancement of generative artificial intelligence (AI) and large language models (LLMs). AI is increasingly being integrated across the healthcare continuum, demonstrating broad application prospects in clinical decision support, medical imaging diagnostics, novel drug development, and precision medicine (Maity & Saikia, 2025; Yu et al., 2025; Mizna et al., 2025). Transformations at the level of diagnostic and therapeutic technologies inevitably necessitate corresponding adjustments in medical education models (Khakpaki, 2025; Cheng & Zhu, 2025). In the face of a highly intelligent healthcare environment, traditional medical education is under considerable pressure with regard to the pace of knowledge renewal, the specificity of skills training, and the adaptability of its pedagogical philosophy (Tucker, 2025; Miguez-Pinto et al., 2025).

To ensure that future healthcare professionals can safely, ethically, and effectively utilize AI tools, the current medical education system must undergo systematic reform (Cho Kwan et al., 2025). Such reform requires not only innovation in curriculum design and assessment strategies, but also proactive engagement with the ethical dilemmas and practical barriers arising from technological integration (Boscardin et al., 2025). Encouragingly, preliminary achievements have emerged in AI-enabled medical education. Applications such as adaptive learning pathway design, immersive virtual simulation training, and automated feedback systems are gradually being implemented (Turner et al., 2025; Seneviratne & Manathunga, 2025; Wang et al., 2025).

However, during the process of technological deployment, substantial heterogeneity persists among faculty and students with respect to AI literacy, acceptance, and readiness, warranting objective evaluation (Clement David-Olawade et al., 2025; Yazdi et al., 2025). Moreover, algorithmic bias, risks to academic integrity, data privacy concerns, and regulatory lag constitute major bottlenecks limiting equitable and widespread adoption (Stern et al., 2025; Liu et al., 2025; Sun et al., 2025). Against this issue,

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the present review synthesizes studies published throughout 2025 to examine the current state of AI literacy among medical students and educators, analyze the effectiveness of emerging application models, and critically evaluate the associated ethical and implementation challenges. The ultimate aim is to provide theoretical grounding and practical guidance for constructing a future-oriented, human－AI collaborative framework in medical education.

2. Methods

This review employed an interdisciplinary literature retrieval and qualitative synthesis approach to ensure scientific rigor and forward-looking relevance. A structured search of the PubMed database was conducted, covering the entire year of 2025. The search strategy combined the keywords "intelligent teaching," "artificial intelligence," "medical education," "smart classroom," and "digitalized teaching."

The initial search yielded 157 relevant publications. Articles were screened rigorously based on their relevance to medical education application contexts. Inclusion criteria focused on studies addressing large language model integration, clinical simulation training, intelligent educational assessment, and educational ethics and policy. Purely technical algorithm-development studies and commentary articles lacking empirical evidence were excluded. Ultimately, 70 representative high-quality studies were selected for in-depth analysis and thematic synthesis.

3. Current Status of AI Awareness, Acceptance and Readiness in Medical Education

3.1 Assessment of AI awareness and knowledge among medical students and educators

As AI applications become increasingly embedded in clinical settings, AI literacy among medical students and faculty has emerged as a key indicator of the adaptability of medical education systems. However, multiple empirical studies have revealed a concerning phenomenon of "competency misalignment."

For example, a survey of 551 medical students in Nigeria found that although approximately 60% of respondents self-reported possessing substantial AI knowledge, objective assessments painted a markedly different picture: up to 92% demonstrated insufficient actual knowledge, and only 12% could accurately define foundational concepts such as "machine learning" (Clement David-Olawade et al., 2025). This disconnect between perceived and actual competence is not an isolated finding.

In Saudi Arabia, medical students widely acknowledged the clinical value of AI but lacked practical operational knowledge (Alsultan et al., 2025). Data from Pakistan similarly indicated that although undergraduates expressed interest in AI, only 11.8% had received formal, systematic training (Syeda et al., 2025). Research conducted in Oman further dissected this deficit, showing that even at the clinical stage of training, students' theoretical foundations remained weak, particularly in core domains such as AI terminology, computational logic, and data science (AlZaabi & Masters, 2025).

More concerningly, this knowledge gap extends to faculty members. A survey among dental practitioners revealed that even as educators, many possessed limited understanding of advanced concepts such as machine learning and deep learning (Abdullah et al., 2025). Collectively, cross-regional and cross-disciplinary evidence converges on a shared reality: within the current medical education ecosystem, both educators and learners exhibit significant AI literacy gaps, rendering existing talent reserves insufficient to meet the demands of future intelligent healthcare systems.

3.2 Attitudes and expectations toward AI integration in clinical practice and teaching

In stark contrast to the insufficiency of objective knowledge, the global medical education community has demonstrated remarkable openness and consensus regarding the integration of AI technologies. From the strong expectation for AI-driven efficiency gains and training demand among over 90% of Nigerian students (Clement David-Olawade et al., 2025), to the high level of clinical endorsement among Saudi physicians (AlGoraini et al., 2025), and to the support for curricular reform and future applications expressed by students in Pakistan (Syeda et al., 2025) and China (Hu et al., 2025), multi-source data consistently indicate a positive orientation toward AI adoption (Hu et al., 2025).

Importantly, this enthusiasm does not reflect uncritical technological optimism. Rather, it reveals a dynamic process of "rational recalibration" accompanying deeper understanding. A multinational study spanning 48 countries reported that systematic AI education simultaneously improved knowledge levels and moderated unreflective enthusiasm, prompting students to adopt more critical perspectives grounded in ethical and professional considerations (Zheng & Xiao, 2025). Conversely, when the tangible benefits of AI tools such as

ChatGPT were directly demonstrated, user acceptance increased significantly (Gigola et al., 2025).

These findings suggest that the medical community is gradually cultivating a mature technological outlook — one characterized by both high expectations and pragmatic caution.

3.3 Differential readiness across populations

AI literacy and attitudes are not uniformly distributed within the medical education ecosystem; rather, they are shaped by the interaction of disciplinary background, professional seniority, and regional context.

From a disciplinary perspective, fields such as dentistry and radiology exhibit relatively stronger knowledge reserves or research engagement (Syeda et al., 2025; Verghese et al., 2025), while in some contexts non-pharmacy students have demonstrated higher readiness than pharmacy students (Alsultan et al., 2025). In terms of professional maturity, senior students, postgraduate trainees, and individuals with clinical experience tend to hold more informed and positive perspectives toward AI (Shishehgar et al., 2025; Chen et al., 2025a). In contrast, junior students—owing to limited clinical exposure—often struggle to fully appreciate the limitations and real-world complexities of AI applications (Clement David-Olawade et al., 2025).

Regional disparities further confer distinct educational meanings upon AI. In developing countries such as Palestine and Nigeria, AI is often perceived as a strategic solution to resource constraints, and students in these settings demonstrate particularly significant knowledge gains following training interventions (Clement David-Olawade et al., 2025; Zheng & Xiao, 2025; Yousef et al., 2025). Notably, students do not invariably lead in technological readiness. Evidence from Iran indicates that faculty members may, in fact, exhibit higher readiness levels than students (Yazdi et al., 2025), underscoring the indispensable leadership and modeling role of educators in the process of technological integration.

4. Innovative Applications of AI-Enabled Models in Medical Education

4.1 Curriculum integration and competency framework development

In response to the disruptive impact of AI technologies, a broad consensus has emerged within the global medical education community regarding the urgent need to systematically integrate AI literacy and digital competencies into existing curricula (Cho Kwan et al., 2025; Clement David-Olawade et al., 2025; Acosta, 2025). Educators increasingly recognize that future physicians must not only master biomedical knowledge, but also acquire the core competencies required to evaluate, apply, and regulate AI tools (Howley & Whelan, 2025; Jiang, 2025). Accordingly, a range of innovative curricular pathways is being implemented.

A representative example is the “Data-Augmented, Technology-Assisted Medical Decision-Making (DATA-MD)” program developed at the University of Michigan, which comprises four modules: AI fundamentals, epidemiology and biostatistics, diagnostic decision-making applications, and ethical – legal considerations. Pilot evaluations have demonstrated significant improvements in residents’ knowledge acquisition and practical confidence (Wong et al., 2025). Beyond formal curricula, extracurricular initiatives have also proven effective. Research on student-led organizations (e.g., AI in Medicine societies) indicates that even a four-week intervention can meaningfully compensate for curricular gaps, enhancing both AI knowledge and pathology-related competencies (Hopson et al., 2025).

From a pedagogical perspective, statistics is widely regarded as foundational for cultivating AI literacy, particularly in strengthening students’ abilities to interpret research findings and mitigate cognitive bias (Huang & Huang, 2025). Interactive approaches, such as video-based case discussions, have been adopted to facilitate perspective shifting and dialectical reasoning, thereby fostering critical thinking skills among future physicians (Lee et al., 2025). Collectively, these initiatives contribute to the development of structured, multi-tiered AI education systems.

More fundamentally, the rise of AI is reshaping the very definition of an “outstanding physician,” compelling medical educators to reconceptualize core competency frameworks (Tucker, 2025). Given that traditional emphases on knowledge memorization and pattern recognition represent areas of AI strength, scholars have cautioned that without transformative reform, physicians trained under existing models may struggle to thrive within human – AI collaborative ecosystems (Tucker, 2025). Consequently, cultivating higher-order cognitive capacities and humanistic values that transcend algorithmic processing has become imperative. Philosophical reasoning and ethical deliberation training have thus been proposed to equip future physicians with the critical thinking, interpersonal competence, and humanistic sensitivity required to navigate complex moral dilemmas (Tucker, 2025).

To provide systematic guidance for this transformation, researchers have begun constructing forward-looking competency maps. A Delphi study conducted in China developed a digital competency framework for medical students comprising three domains, nine primary indicators, and 27 secondary indicators, offering quantitative guidance for curriculum development and professional growth (Chen et al., 2025b). Other scholars have proposed macro-level prospective frameworks emphasizing the integration of advanced technological literacy, robust humanistic values, and global perspectives to cultivate adaptive, empathetic, and innovative physicians (Miguez-Pinto et al., 2025). Alongside calls from international nursing organizations such as Sigma to revise core competencies and curricula (Cho Kwan et al., 2025), these efforts converge on a shared objective: ensuring that future physicians serve not merely as technology users, but as stewards of medical wisdom and humanistic care.

4.2 Transformation of teaching and learning tools

The introduction of generative AI—particularly large language models—has begun to reconstruct the mechanisms through which medical knowledge is acquired and transmitted by offering real-time responses and highly personalized learning support. These technologies aim to address the long-standing challenge of scalable one-to-one tutoring in medical education.

The “2-Sigma” platform developed at the University of Cincinnati College of Medicine exemplifies this approach. Grounded in Benjamin Bloom’s mastery learning theory, the platform leverages simulated virtual patient encounters and real-time feedback to replicate the educational gains associated with individualized tutoring within large-scale instructional settings (Turner et al., 2025). Systematic reviews confirm that such AI technologies substantively support core learning processes, including practice, inquiry, production, and knowledge acquisition (Pham et al., 2025). Students are already widely utilizing tools such as ChatGPT to assist with information retrieval and academic tasks (Hu et al., 2025).

Beyond tutoring, AI functions as a “knowledge translator.” It can convert complex radiology reports into patient-friendly language (Stephan et al., 2025) and transform cutting-edge research into accessible podcast formats (Khoury et al., 2026), thereby lowering cognitive barriers. Targeted health education tools developed for specific diseases (e.g., asthma, stroke) or populations (e.g., bilingual individuals) further demonstrate AI’s capacity to deliver precise, customized information, supporting both patient self-management and focused student learning (Liu et al., 2025a; Qiang et al., 2025; Adhikary et al., 2025).

Virtual patients and immersive simulation training represent among the most promising domains of AI-enabled medical education, providing risk-free environments for clinical skill refinement. Compared with traditional role-play methods, GPT-based simulated patients have demonstrated significant advantages in history-taking training. Empirical evidence indicates that students exposed to such technologies achieve higher clinical assessment scores and exhibit greater learning motivation and autonomy (Wang et al., 2025).

To optimize implementation, scholars have proposed 12 practical strategies for leveraging generative AI in the creation of virtual patient simulations (VPS), highlighting AI’s efficiency in case generation, report drafting, and assessment design. This efficiency enables clinical experts to focus on overarching pedagogical objectives and quality assurance, thereby substantially enhancing development efficiency and simulation fidelity (Moser et al., 2025). Applications have extended to specialized domains such as mental health. For instance, an AI-driven simulator for suicide intervention (QPR) training significantly improved professionals’ intervention self-efficacy (Levkovich et al., 2025).

At a broader level, the integration of AI with mixed reality technologies has been identified as a key direction for the future of simulation-based medical education (Mawyin-Muñoz et al., 2025). Emerging concepts such as embodied AI suggest that future systems will emphasize the organic integration of perception, reasoning, and action, constructing clinical decision-making scenarios that closely approximate real-world practice (Qiu et al., 2025).

AI applications have also demonstrated strong discipline-specific empowerment across medical specialties. In radiology, generative AI has been used to synthesize high-quality images for teaching datasets that include rare diseases (Khosravi et al., 2025), and ChatGPT has generated training questions comparable in quality to those authored by attending physicians (Zheng et al., 2025). In dentomaxillofacial radiology, AI has facilitated a shift from static instruction to adaptive, competency-based interactive education (Negrete et al., 2025).

In surgical education, AI-based real-time phase recognition during cataract surgery has improved procedural efficiency while providing objective benchmarks for training evaluation (Shah et al., 2025). Reviews in hepatobiliary oncology surgery indicate that AI applications now span the entire educational continuum — from diagnosis and decision-making to postoperative monitoring (Bai et al., 2025). Similar explorations are underway in pediatric surgery (Gigola et al., 2025) and bronchoscopy training (Cold et al., 2025), focusing on AI-assisted skill assessment and navigational guidance. In mental health education, AI is being employed to analyze therapeutic process markers to optimize clinical supervision (Lee et al., 2025).

Innovative applications have likewise emerged in anesthesiology and critical care (Daccache et al., 2025), nephrology (Tong et al., 2025), endodontics (Azim & Azim, 2025), cardiology (Zheng et al., 2025a; Ugoala et al., 2025), oncology (Panzuto et al., 2025), and pharmacy (Chen et al., 2025a; Gharib et al., 2025), collectively demonstrating the extensive adaptability and developmental potential of AI across vertically specialized domains.

4.3 Intelligent transformation of assessment and feedback

AI is catalyzing technological transformation within medical education assessment systems, particularly through intelligent item generation and automated scoring. Empirical findings reveal a differentiated landscape of application for large language model - assisted examination design.

In periodontology, AI-generated examinations demonstrated superior content coverage compared with human-designed tests, although item discrimination indices require further refinement (Ma et al., 2025). In radiology, multiple-choice questions generated by ChatGPT have achieved quality and difficulty levels comparable to those produced by experienced physicians, validating its utility as an auxiliary item-writing tool (Zheng et al., 2025).

In automated scoring, AI technologies exhibit remarkable precision and reliability. Evaluation of an Automated Short-Answer Scoring Tool (ASST) revealed high correlations with two human raters (0.93 and 0.96, respectively) and an internal consistency coefficient of 0.94, indicating that machine-based scoring can reliably adhere to established rubrics (Seneviratne & Manathunga, 2025). A report by the Macy Foundation further emphasized that automated scoring and advanced analytics not only reduce faculty administrative burden but also enhance assessment efficiency and instructional quality through timely, targeted feedback loops (Boscardin et al., 2025).

Beyond conventional knowledge testing, AI is expanding into the evaluation of deeper competencies such as clinical reasoning and implicit professional attitudes. The aforementioned 2-Sigma platform demonstrates the capacity to process unstructured data by analyzing complete dialogue transcripts between students and virtual patients, thereby capturing clinical reasoning patterns that are difficult to quantify using traditional methods (Turner et al., 2025).

In clinical documentation analysis, random forest models applied to students' medical records have successfully predicted New York Heart Association (NYHA) classifications of heart failure, offering a novel paradigm for inferring diagnostic logic and keyword utilization from documentation practices (Perera et al., 2025). In complex intensive care diagnostic scenarios, AI assistance significantly improved residents' diagnostic accuracy and reduced decision-making time (Wu et al., 2025).

More advanced explorations involve the detection of implicit attitudes. A study employing ChatGPT to analyze interview transcripts concerning doctor - patient relationships demonstrated high concordance with human expert judgments, with accuracy and F1 scores exceeding 0.8, highlighting the potential of LLMs to interpret semantically nuanced texts (Geng et al., 2026). Additionally, efforts to integrate facial expression recognition technologies for real-time monitoring of learning-related emotions (Zhu & Juanatas, 2025) further suggest that future medical assessments will evolve toward more comprehensive, nuanced, and personalized paradigms.

5. Ethical, Bias and Implementation Challenges in AI Integration

5.1 Algorithmic bias and educational equity

Despite its promise, AI integration in medical education is constrained by embedded algorithmic bias, which poses a substantial threat to educational equity. Such bias originates from the absorption, reinforcement, and amplification of societal prejudices present in training data.

Empirical research has illustrated this risk. A systematic evaluation of Chinese large language models revealed significant imbalances in generated medical education cases across gender, ethnicity, income, and insurance status dimensions. Specifically, cases disproportionately represented male, high-income, and highly educated populations, while minority and uninsured low-income patients were associated with higher referral rates—implicitly suggesting a tendency toward service denial (Liu et al., 2025).

A similar "performance – bias trade-off" has been observed in synthetic electronic health record (EHR) generation: although larger model scales improved data completeness, they simultaneously intensified gender and racial bias, systematically underestimating disease prevalence among Hispanic and Asian populations (Huang et al. 2025). If such biases are embedded uncritically into teaching materials or assessment tools, they risk distorting students' understanding of disease epidemiology and reinforcing stereotypes, thereby undermining fairness in clinical decision-making (Sun et al., 2025). Mitigating algorithmic bias has therefore evolved from a technical concern into a central ethical imperative directly linked to the equity of future healthcare delivery (Maity & Saikia, 2025; Khakpaki, 2025).

5.2 Academic integrity, data privacy and regulatory gaps

While AI technologies enhance efficiency, they also introduce multidimensional challenges to academic integrity, data privacy, and regulatory governance. In the domain of academic integrity, widespread LLM usage has blurred the boundary between originality and plagiarism. Empirical evidence indicates that since the release of ChatGPT, the proportion of AI-generated text in personal statements for adult joint reconstruction fellowship applications has increased significantly—particularly among international medical graduates — undermining the reliability of admissions evaluations of applicants' personal attributes and writing competencies (Stern et al., 2025). Chinese medical students have likewise expressed concerns regarding the potential escalation of academic misconduct (Hu et al., 2025).

Data privacy constitutes another core challenge. Given that AI model training and operation depend on large-scale data aggregation, balancing the extraction of educational value with the protection of student and (virtual) patient privacy has become a pressing issue (Khakpaki, 2025; Cheng & Zhu, 2025; Khosravi et al., 2025; Chang et al., 2025). Preventing data misuse while safeguarding confidentiality is critical to ethical implementation.

In light of the current global lack of targeted regulatory frameworks and standardized ethical guidelines in medical education and healthcare, scholars and institutions have collectively called for the urgent establishment of governance mechanisms to ensure responsible AI development and deployment within transparent, safe, and ethically sound parameters (Cho Kwan et al., 2025; AlGoraini et al., 2025; Howley & Whelan, 2025).

5.3 The digital divide and equitable resource distribution

The broader adoption of AI in medical education is constrained by a dual challenge: technological disparities and inequitable distribution of educational resources. These disparities are particularly pronounced in infrastructure, funding, and faculty capacity.

In developing countries such as Nigeria, infrastructural limitations significantly hinder AI implementation (Clement David-Olawade et al., 2025). Although China possesses extensive online educational resources, large-scale life-education MOOCs exhibit pronounced regional imbalances, with high-quality offerings concentrated in economically developed eastern regions (Xu et al., 2025). Without policy intervention, such asymmetries risk exacerbating the digital divide, enabling resource-rich institutions to further consolidate advantages through AI adoption while marginalizing under-resourced counterparts.

However, AI also holds potential to mitigate inequities. In endodontics — where global training standards and resources are unevenly distributed — digital learning platforms and AI tools may promote decentralization of educational access, benefiting students in resource-limited regions (Azim & Azim, 2025). In constrained environments such as Palestine, AI has been shown to enhance academic productivity and research efficiency, partially alleviating educational challenges (Yousef et al., 2025).

Accordingly, the formulation of scientifically grounded policy strategies to ensure accessibility and fairness in AI deployment — preventing its transformation into an instrument of educational stratification — must be prioritized in future implementation agendas (Khakpaki, 2025).

6. Conclusion and Future Directions

Artificial intelligence is reshaping the ecosystem of medical education in profound ways. Through systematic synthesis of the current literature, this review identifies both the defining characteristics and the inherent dualities shaping the field's contemporary development. On the one hand, although the global medical education community generally maintains a positive stance toward AI integration, substantial "perception – knowledge" gaps persist among both students and faculty, necessitating structured educational interventions to bridge these disparities (Clement David-Olawade et al., 2025; Alsultan et al., 2025; AlZaabi & Masters, 2025). On the other hand, transformative applications have already been implemented at multiple levels. These include the establishment of AI competency frameworks through initiatives such as the DATA-MD curriculum (Wong et al., 2025), the deployment of personalized simulation-based instruction via the 2-Sigma platform (Turner et al., 2025), and the use of automated tools for efficient and precise assessment of clinical skills and professional attitudes (Seneviratne & Manathunga, 2025; Geng et al., 2026). Collectively, these developments substantiate the capacity of AI to enhance both the efficiency and quality of medical education.

Nevertheless, the deepening integration of AI is accompanied by structural challenges that cannot be overlooked. Algorithmic bias threatens educational equity (Liu et al., 2025; Huang et al., 2025); misuse of AI tools raises concerns regarding academic integrity (Stern et al., 2025); and deficiencies in data privacy protection, regulatory governance, and equitable technological access further constrain large-scale implementation (Cho Kwan et al., 2025; Azim & Azim, 2025). Together, these factors constitute substantive barriers that must be addressed to enable responsible and sustainable advancement.

Looking ahead, the sustainable development of AI in medical education requires the adoption of a prudent, human-centered framework of human–AI collaboration. The core objective should be to leverage AI to enrich educational experiences and relieve educators of repetitive administrative burdens, thereby enabling them to focus on cultivating students' critical thinking, clinical judgment, and humanistic competencies — rather than pursuing technological substitution for its own sake (Khakpaki, 2025; Ma et al., 2025).

Future efforts should prioritize four key dimensions. First, standardized AI competency frameworks and curricular systems should be constructed and disseminated, encompassing technical application skills, ethical literacy, and critical appraisal capabilities (Howley & Whelan, 2025; Chen et al., 2025b). Second, faculty development must be strengthened through sustained professional training initiatives to enhance educators' confidence and effectiveness in guiding students' responsible AI use (Abdullah et al., 2025; Sockolow et al., 2025). Third, robust ethical governance mechanisms should be established to clarify the boundaries of AI development and application, with particular emphasis on safeguarding data privacy and systematically mitigating algorithmic bias (Sun et al., 2025; Huang et al., 2025). Fourth, research paradigms should shift from short-term outcome evaluations toward longitudinal impact assessments, alongside the development of standardized evaluation frameworks to ensure safety, validity, and educational effectiveness (Yu et al., 2025; Urda-Cîmpean et al., 2025).

Ultimately, the mission of medical education is to prepare physicians capable of navigating an increasingly complex future. Through the judicious integration of AI technologies, the goal is not merely to cultivate technically proficient experts, but to nurture compassionate, ethically grounded, and humanistically oriented physicians who embody both clinical excellence and moral discernment (Tucker, 2025; Miguez-Pinto et al., 2025).

Conflict of Interest

The authors declare that they have no conflicts of interest in this work.

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References

Abdullah, S., Hasan, S. R., Asim, M. A., Khurshid, A., & Qureshi, A. W. (2025). Exploring dental faculty awareness, knowledge, and attitudes toward AI integration in education and practice: A mixed-method study. *BMC Medical Education, 25*(1), 691. https://doi.org/10.1186/s12909-025-07259-8

Acosta, J. A. (2025). Perspective: Advancing public health education by embedding AI literacy. *Frontiers in Digital Health, 7,* 1584883. https://doi.org/10.3389/fdgth.2025.1584883

Adhikary, P. K., Motiyani, I., Oke, G., et al. (2025). Menstrual health education using a specialized large language model in India: Development and evaluation study of MenstLLaMA. *Journal* *of Medical Internet Research, 27,* e71977. https://doi.org/10.2196/71977

AlGoraini, Y., Alsayyali, M., Alotaibi, O., Almeshawi, I., Alaifan, F., & Alrashed, R. (2025). Perceptions of large language models in medical education and clinical practice among pediatric emergency physicians in Saudi Arabia: A multiregional cross-sectional study. *Frontiers in Public Health, 13,* 1634638. https://doi.org/10.3389/fpubh.2025.1634638

Alsultan, M. M., Baraka, M. A., Alhajri, L. H., et al. (2025). Knowledge and perception of artificial intelligence education among undergraduate healthcare students. *BMC Medical Education, 25*(1), 1066. https://doi.org/10.1186/s12909-025-07577-x

AlZaabi, A., & Masters, K. (2025). Assessing medical students' readiness for artificial intelligence after pre-clinical training. *BMC Medical Education, 25*(1), 824. https://doi.org/10.1186/s12909-025-07008-x

Azim, A. A., & Azim, K. A. (2025). Innovation in endodontic education—cliché or necessity? A perspective on post-graduate training. *International Endodontic Journal. Advance online publication.* https://doi.org/10.1111/iej.14259

Bai, X., Huang, R., Liu, Q., et al. (2025). A technological convergence in hepatobiliary oncology: Evolving roles of smart surgical systems. *Bioscience Trends, 19*(4), 410–420. https://doi.org/10.5582/bst.2025.01047

Boscardin, C. K., Abdulnour, R. E. E., & Gin, B. C. (2025). Macy Foundation Innovation Report Part I: Current landscape of artificial intelligence in medical education. *Academic Medicine, 100*(9 Suppl. 1), S15–S21. https://doi.org/10.1097/ACM.0000000000006107

Chang, L. C., Huang, C. H., Yu, H. Y., et al. (2025). Enhancing work efficiency with generative artificial intelligence: Experience and training insights from school nurses through focus groups and surveys. *International Nursing Review, 72*(3), e70076. https://doi.org/10.1111/inr.70076

Chen, J., Hou, X., Lv, Y., et al. (2025). What digital competencies should medical students in China possess in the AI era? *International Journal of Medical Informatics, 203,* 106043. https://doi.org/10.1016/j.ijmedinf.2025.106043

Chen, J., Zhao, X., Li, J., Chen, W., Jiang, C., & Wang, X. (2025). Core competencies in pharmaceutical education: A Chinese student perspective. *BMC Medical Education, 25*(1), 1096. https://doi.org/10.1186/s12909-025-07686-7

Cheng, Y., & Zhu, L. (2025). A review of ChatGPT in medical education: Exploring advantages and limitations. *International Journal of Surgery, 111*(7), 4586–4602. https://doi.org/10.1097/JS9.0000000000002505

Cho Kwan, R. Y., Yan Tang, A. C., Ha Wong, J. Y., et al. (2025). Navigating the integration of artificial intelligence in nursing: Opportunities, challenges, and strategic actions. *International Journal of Nursing Sciences, 12*(3), 241–245. https://doi.org/10.1016/j.ijnss.2025.04.009

Clement David-Olawade, A., Wada, O. Z., Adeniji, Y. J., Aderupoko, I. V., & Olawade, D. B. (2025). Artificial intelligence readiness among healthcare students in Nigeria: A cross-sectional study assessing knowledge gaps, exposure, and adoption willingness. *International Journal of Medical Informatics, 204,* 106085. https://doi.org/10.1016/j.ijmedinf.2025.106085

Cold, K. M., Vamadevan, A., Laursen, C. B., Bjerrum, F., Singh, S., & Konge, L. (2025). Artificial intelligence in bronchoscopy: A systematic review. *European Respiratory Review, 34*(176), 240274. https://doi.org/10.1183/16000617.0274-2024

Daccache, N., Zako, J., Morisson, L., & Laferrière-Langlois, P. (2025). The applications of ChatGPT and other large language models in anesthesiology and critical care: A systematic review. *Canadian Journal of Anesthesia, 72*(6), 904–922. https://doi.org/10.1007/s12630-025-02973-9

Geng, W., Jiang, Y., Zhai, W., et al. (2026). Can artificial intelligence read between the lines: Utilizing ChatGPT to evaluate medical students' implicit attitudes towards doctor–patient relationship. *Medical Teacher, 48*(1), 85–92. https://doi.org/10.1080/0142159X.2025.2515971

Gharib, A. M., Bindoff, I. K., Peterson, G. M., & Salahudeen, M. S. (2025). Educators' and academic leaders' insights on incorporating computer-based simulation in pharmacy education: A global qualitative study. *American Journal of Pharmaceutical Education, 89*(8), 101433. https://doi.org/10.1016/j.ajpe.2025.101433

Gigola, F., Amato, T., Del Riccio, M., Raffaele, A., Morabito, A., & Coletta, R. (2025). Artificial intelligence in clinical practice: A cross-sectional survey of paediatric surgery residents' perspectives. *BMJ Health & Care Informatics, 32*(1), e101456. https://doi.org/10.1136/bmjhci-2025-101456

Hopson, S., Mildon, C., Hassard, K., et al. (2025). Enhancing AI literacy in undergraduate pre-medical education through student associations: An educational intervention. *BMC Medical Education, 25*(1), 999. https://doi.org/10.1186/s12909-025-07556-2

Howley, L. D., & Whelan, A. J. (2025). From the World Wide Web to AI: Why we must learn from our past to transform the future of medical education. *Academic Medicine, 100*(9 Suppl. 1), S30–S33. https://doi.org/10.1097/ACM.0000000000006103

Hu, N., Jiang, X. Q., Wang, Y. D., et al. (2025). Status and perceptions of ChatGPT utilization among medical students: A survey-based study. *BMC Medical Education, 25*(1), 831. https://doi.org/10.1186/s12909-025-07438-7

Huang, A. A., & Huang, S. Y. (2025). Enhancing medical education through statistics: Bridging quantitative literacy and sports supplementation research for improved clinical practice. *Nutrients, 17*(15), 2463. https://doi.org/10.3390/nu17152463

Huang, R., Wu, H., Yuan, Y., et al. (2025). Evaluation and bias analysis of large language models in generating synthetic electronic health records: Comparative study. *Journal of Medical Internet Research, 27,* e65317. https://doi.org/10.2196/65317

Jiang, J. (2025). Marathon without a finish line: A learner's perspective on AI in medical education. *Academic Medicine, 100*(9 Suppl. 1), S43–S45. https://doi.org/10.1097/ACM.0000000000006100

Khakpaki, A. (2025). Advancements in artificial intelligence transforming medical education: A comprehensive overview. *Medical Education Online, 30*(1), 2542807. https://doi.org/10.1080/10872981.2025.2542807

Khosravi, B., Purkayastha, S., Erickson, B. J., Trivedi, H. M., & Gichoya, J. W. (2025). Exploring the potential of generative artificial intelligence in medical image synthesis: Opportunities, challenges, and future directions. *The Lancet Digital Health.* Advance online publication. https://doi.org/10.1016/j.landig.2025.100890

Khoury, Z. H., Sultan, M. S., Tavares, T., Jessri, M., & Sultan, A. S. (2026). AI-generated podcasts for health education. *Medical Teacher, 48*(1), 158–163. https://doi.org/10.1080/0142159X.2025.2513421

Lee, Y., Hunter, E., McLaughlin, A. T., et al. (2025). Cultural opportunities involving spiritual, existential, religious, or theological (SERT) themes: Three practical approaches. *Psychotherapy.* Advance online publication. https://doi.org/10.1037/pst0000599

Levkovich, I., Haber, Y., Levi-Belz, Y., & Elyoseph, Z. (2025). A step toward the future? Evaluating GenAI QPR simulation training for mental health gatekeepers. *Frontiers in Medicine, 12,* 1599900. https://doi.org/10.3389/fmed.2025.1599900

Liu, C., Zheng, J., Liu, Y., et al. (2025). Potential to perpetuate social biases in health care by Chinese large language models: A model evaluation study. *International Journal for Equity in Health, 24*(1), 206. https://doi.org/10.1186/s12939-025-02581-5

Liu, Y., Yu, F., Zhang, X., et al. (2025). Assessing the role of large language models between ChatGPT and DeepSeek in asthma education for bilingual individuals: Comparative study. *JMIR Medical Informatics, 13, e65365.* https://doi.org/10.2196/65365

Ma, X., Pan, W., & Yu, X. N. (2025). Evaluating AI-generated examination papers in periodontology: A comparative study with human-designed counterparts. *BMC Medical Education, 25*(1), 1099. https://doi.org/10.1186/s12909-025-07706-6

Maity, S., & Saikia, M. J. (2025). Large language models in healthcare and medical applications: A review. *Bioengineering, 12*(6), 631. https://doi.org/10.3390/bioengineering12060631

Mawyin-Muñoz, C. E., Salmerón-Escobar, F. J., Hidalgo-Acosta, J. A., & Calderon-León, M. F. (2025). Medical simulation: An essential tool for training, diagnosis, and treatment in the 21st century. *BMC Medical Education, 25*(1), 1019. https://doi.org/10.1186/s12909-025-07610-z

Miguez-Pinto, J. P., Garcia-Rosa, B., Maggitti-Bezerril, M., et al. (2025). The medical student of the future: Redefining competencies in a transformative era. *Frontiers in Medicine, 12,* 1593685. https://doi.org/10.3389/fmed.2025.1593685

Mizna, S., Arora, S., Saluja, P., Das, G., & Alanesi, W. A. (2025). An analytic research and review of the literature on practice of artificial intelligence in healthcare. *European Journal of Medical Research, 30*(1), 382. https://doi.org/10.1186/s40001-025-02603-6

Moser, M., Posel, N., Ganescu, O., & Fleiszer, D. (2025). Twelve tips: Using generative AI to create and optimize content for virtual patient simulations. *Medical Teacher, 47*(11), 1745–1751. https://doi.org/10.1080/0142159X.2025.2501252

Negrete, D., Lopes, S. L. P. de C., Barretto, M. D. de A., Moura, N. B. de, Nahás, A. C. R., & Costa, A. L. F. (2025). Artificial intelligence and dentomaxillofacial radiology education: Innovations and perspectives. *Dentistry Journal, 13*(6), 245. https://doi.org/10.3390/dj13060245

Panzuto, F., Barbi, S., Trama, A., & Fazio, N. (2025). The importance of education and training in neuroendocrine neoplasms: Challenges and opportunities for multidisciplinary management. *Cancer Treatment Reviews, 139,* 102998. https://doi.org/10.1016/j.ctrv.2025.102998

Perera, I. R., Daniels, T., Looney, J., Gittings, K., & Rawlins, F. A. (2025). Predicting New York Heart Association (NYHA) heart failure classification from medical student notes following simulated patient encounters. *Scientific Reports, 15*(1), 25491. https://doi.org/10.1038/s41598-025-10179-8

Pham, T. D., Karunaratne, N., Exintaris, B., et al. (2025). The impact of generative AI on health professional education: A systematic review in the context of student learning. *Medical Education, 59*(12), 1280–1289. https://doi.org/10.1111/medu.15746

Qiang, S., Zhang, H., Liao, Y., et al. (2025). Application of large language models in stroke rehabilitation health education: 2-phase study. *Journal of Medical Internet Research, 27,* e73226. https://doi.org/10.2196/73226

Qiu, Y., Chen, X., Wu, X., et al. (2025). Embodied artificial intelligence in ophthalmology. *NPJ Digital Medicine, 8*(1), 351. https://doi.org/10.1038/s41746-025-01754-4

Seneviratne, H. M. T. W., & Manathunga, S. S. (2025). Artificial intelligence assisted automated short answer question scoring tool shows high correlation with human examiner markings. *BMC Medical Education, 25*(1), 1146. https://doi.org/10.1186/s12909-025-07718-2

Shah, N., Wawrzynski, J., Hussain, R., et al. (2025). Application of real-time artificial intelligence to cataract surgery. *British Journal of Ophthalmology, 109*(12), 1338–1344. https://doi.org/10.1136/bjo-2024-326111

Shishehgar, S., Murray-Parahi, P., Alsharaydeh, E., Mills, S., & Liu, X. (2025). Artificial intelligence in health education and practice: A systematic review of health students' and academics' knowledge, perceptions and experiences. *International Nursing Review, 72*(2), e70045. https://doi.org/10.1111/inr.70045

Sockolow, P., Michalowski, M., Peltonen, L. M., Pruinelli, L., & Topaz, M. (2025). Advancing AI initiatives in nursing academics: Case studies and insights from thought leaders. *Nursing Outlook, 73*(5), 102527. https://doi.org/10.1016/j.outlook.2025.102527

Stephan, D., Bertsch, A. S., Schumacher, S., et al. (2025). Improving patient communication by simplifying AI-generated dental radiology reports with ChatGPT: Comparative study. *Journal of Medical Internet Research, 27,* e73337. https://doi.org/10.2196/73337

Stern, J. M., Fernandez-Perez, A. M., Cruz-Ossa, N., Hernandez, V. H., McNamara, C. A., & D'Apuzzo, M. R. (2025). Detecting artificial intelligence-generated text in personal statements of adult reconstruction fellowship applicants. *The Journal of Arthroplasty.* Advance online publication. https://doi.org/10.1016/j.arth.2025.07.072

Sun, Q. W., Miller, J., & Hull, S. C. (2025). Charting the ethical landscape of generative AI-augmented clinical documentation. *Journal of Medical Ethics.* Advance online publication. https://doi.org/10.1136/jme-2024-110656

Syeda, L. H., Batool, Z., Hayder, Z., & Ali, S. (2025). Medical undergraduate students' awareness and perspectives on artificial intelligence: A developing nation's context. *BMC Medical Education, 25*(1), 1060. https://doi.org/10.1186/s12909-025-07223-6

Tong, X., Hu, Y., Long, Y., et al. (2025). The application of problem-based learning (PBL) guided by ChatGPT in clinical education in the department of nephrology. *BMC Medical Education, 25*(1), 1048. https://doi.org/10.1186/s12909-025-07427-w

Tucker, F. (2025). Doing philosophy and the future of the "good doctor" paradigm. *Medicine, Health Care and Philosophy, 28*(4), 669–677. https://doi.org/10.1007/s11019-025-10294-3

Turner, L., Kelleher, M., Overla, S., et al. (2025). Harnessing the generative power of AI to move closer to personalized medical education. *Academic Medicine, 100*(12), 1447–1451. https://doi.org/10.1097/ACM.0000000000006185

Ugoala, O., Ebubechukwu, U., Mares, A. C., et al. (2025). Visual art and representation in cardiology: Past, present, and future. *American Heart Journal, 290,* 201–215. https://doi.org/10.1016/j.ahj.2025.06.016

Urda-Cîmpean, A. E., Leucuța, D. C., Drugan, C., Duțu, A. G., Călinici, T., & Drugan, T. (2025). Assessing the accuracy of diagnostic capabilities of large language models. *Diagnostics, 15*(13), 1657. https://doi.org/10.3390/diagnostics15131657

Verghese, B. G., Iyer, C., Borse, T., Cooper, S., White, J., & Sheehy, R. (2025). Modern artificial intelligence and large language models in graduate medical education: A scoping review of attitudes, applications & practice. *BMC Medical Education, 25*(1), 730. https://doi.org/10.1186/s12909-025-07321-5

Wang, Z., Fan, T. T., Li, M. L., Zhu, N. J., & Wang, X. C. (2025). Feasibility study of using GPT for history-taking training in medical education: A randomized clinical trial. *BMC Medical Education, 25*(1), 1030. https://doi.org/10.1186/s12909-025-07614-9

Wong, A., Sussman, J., Price, N., et al. (2025). The data-augmented, technology-assisted medical decision making (DATA-MD) curriculum: A machine learning and artificial intelligence curriculum for clinical trainees. *Academic Medicine, 100*(9), 1035–1039. https://doi.org/10.1097/ACM.0000000000006089

Wu, X., Huang, Y., & He, Q. (2025). A large language model improves clinicians' diagnostic performance in complex critical illness cases. *Critical Care, 29*(1), 230. https://doi.org/10.1186/s13054-025-05468-7

Xu, F., Zhang, J., Zhou, Q., & Mou, S. (2025). MOOC construction for life education in Chinese universities: An analytical study. *Frontiers in Public Health, 13,* 1569881. https://doi.org/10.3389/fpubh.2025.1569881

Yazdi, N. A., Zamaniahari, U., KhadiviMaleki, H., & Hasanabadi, P. (2025). Readiness to use artificial intelligence: A comparative study among dental faculty members and students. *BMC Medical Education, 25*(1), 1006. https://doi.org/10.1186/s12909-025-07621-w

Yousef, M., Deeb, S., & Alhashlamon, K. (2025). AI usage among medical students in Palestine: A cross-sectional study and demonstration of AI-assisted research workflows. *BMC Medical Education, 25*(1), 693. https://doi.org/10.1186/s12909-025-07272-x

Yu, E., Chu, X., Zhang, W., et al. (2025). Large language models in medicine: Applications, challenges, and future directions. *International Journal of Medical Sciences, 22*(11), 2792–2801. https://doi.org/10.7150/ijms.111780

Zheng, A., Barker, C. J., Ferrante, S. S., Squires, J. H., Branstetter, B. F., & Hughes, M. A. (2025). Leveraging ChatGPT for enhancing learning in radiology resident education. *Academic Radiology, 32*(9), 5635–5642. https://doi.org/10.1016/j.acra.2025.06.019

Zheng, L., & Xiao, Y. (2025). Refining AI perspectives: Assessing the impact of AI curricula on medical students' attitudes towards artificial intelligence. *BMC Medical Education, 25*(1), 1115. https://doi.org/10.1186/s12909-025-07669-8

Zheng, X., Zou, H., Wu, L., Dong, P., Yuan, W., & Chen, Y. (2025). Generative artificial intelligence in cardiovascular specialty care: A scoping review. *BMC Nursing, 24*(1), 947. https://doi.org/10.1186/s12912-025-03594-9

Zhu, X., & Juanatas, R. A. (2025). Auxiliary teaching and student evaluation methods based on facial expression recognition in medical education. *JMIR Human Factors, 12,* e72838. https://doi.org/10.2196/72838

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