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Artificial Intelligence in Medical Education: Current Applications and a Proposed Comprehensive Integration Framework

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Abstract

Artificial intelligence (AI) is rapidly transforming healthcare, yet its integration into medical education remains inconsistent and lacks standardization across training levels. This comprehensive review synthesizes current research on AI applications within medical education, highlighting significant gaps between the growing clinical role of AI and its representation in undergraduate and postgraduate curricula. The review identifies disparities in AI awareness and utilization, with postgraduate trainees demonstrating greater familiarity than undergraduates, and notes that most existing educational efforts are concentrated in specialty training and continuing education, particularly in fields such as radiology, pathology, surgery, cardiology, and dentistry. While medical trainees generally express positive attitudes toward acquiring AI competencies, barriers such as the absence of standardized frameworks and AI taxonomy, limited faculty expertise, curricular constraints, and ethical considerations impede broader adoption. Drawing on examples of pioneering programs and a systematic analysis of curricular approaches, we propose a novel, tiered framework for comprehensive AI integration across the medical education continuum. This framework emphasizes universal AI literacy, critical evaluation skills, ethical awareness, and experiential learning at the undergraduate level, with extensions for specialty-specific training and advanced technical or leadership tracks. Recommendations include phased implementation strategies, faculty development initiatives, including "teach the teacher", and competency-based assessment methods. The review concludes that adequate preparation of future physicians requires a shift from isolated AI initiatives to coordinated, longitudinal integration efforts supported by collaboration among educational institutions, professional societies, and technology experts. Future research should focus on evaluating educational outcomes, developing robust assessment tools for AI competencies, and examining the long-term clinical impact of AI training.

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1. Introduction

There is an evolving landscape of artificial intelligence in medical education with significant potential, yet uneven implementation across training levels. This comprehensive review synthesizes the current research on AI applications in medical education and proposes a novel framework for integrating AI across the continuum of medical training. Medical education has struggled to keep pace with the rapid advancements in AI technologies that are transforming healthcare delivery. Despite numerous calls to action, the adoption of AI teaching in undergraduate medical education (UME) remains limited and lacks standardization. Recent reviews have identified significant gaps between AI's growing role in clinical practice and its representation in medical curricula [1,2]. Research shows notable disparities in AI awareness and utilization between educational levels, with postgraduate students demonstrating higher levels of awareness in using medical AI than

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undergraduates [3]. This discrepancy highlights the need for a systematic approach to education on medical AI beginning at the undergraduate level. The integration of AI into medical curricula is currently focused predominantly on clinical specialty training and continuing education, with radiology, pathology, surgery, cardiology, and dentistry reflecting the primary clinical areas of the AI applications [4].

Ngo and co-authors emphasized the need to incorporate AI into medical school curricula, recognizing its future impact on medicine. Key concepts included the benefits of introducing AI at both the preclinical and clinical levels, developing AI literacy, understanding ethical implications through the creation of AI educational modules and electives, and integrating AI discussions into clinical rotations [5].

Tolentino and colleagues emphasized the necessity for medical education to adapt in response to the integration of artificial intelligence (AI) into the curriculum. They recommended developing general AI courses for undergraduate medical education (UME) and specific courses for graduate medical education (GME), as well as extending these concepts to continuing medical education [6].

Another article discussed the idea of incorporating AI education into medical school curricula to develop essential medical competencies. The authors identified 82 key AI competencies and proposed methods for their integration, emphasizing the importance of AI literacy and application skills. Their recommendations include incorporating AI into biostatistics, using case-based learning, implementing clinical rotations, and inviting guest lecturers to enhance the learning experience [7].

Medical trainees generally hold positive attitudes toward AI integration in their education and future practice. A study of radiology residents found that 72.8% believe AI improves disease diagnosis, and 78.18% feel radiologists should embrace AI [8]. Similarly, most medical students express interest in acquiring AI-related competencies during their training [4]. Factors positively associated with the intention to use medical AI include performance expectancy, habit formation, perceived benefits, and trust in the technology [3].

2. Existing Educational Frameworks and Programs

2.1. Undergraduate Medical Education Initiatives

Several pioneering institutions have implemented AI curricula at the undergraduate level:

- The University of Illinois College of Medicine developed a curriculum that introduces AI fundamentals in the preclinical years and transitions to applied clinical scenarios in later years [9].
- The University of Münster integrated AI and data science into its “Medical Informatics” block, covering neural network foundations, AI evaluation, regulation, and hands-on sessions [10].

However, a systematic analysis reveals little consensus on content and methods to teach AI in undergraduate medical education, with considerable heterogeneity across existing programs [2].

2.2. Postgraduate (GME) and Continuing Education

At the postgraduate level, specialized AI training programs have emerged:

- Northwestern University’s Feinberg School of Medicine offers an in-depth fellowship to cardiology, cardiac surgery, and internal medicine trainees, beginning with computational fundamentals before advancing to AI applications [11].
- The University of Pennsylvania’s Radiology Imaging Informatics Fellowship provides specialized training for fourth-year residents and clinical fellows through lectures, discussions, and hands-on sessions [12].

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- The Radiological Society of North America Imaging AI Foundational Certificate course has demonstrated effectiveness in enhancing radiology residents' knowledge and skills in AI applications. Participants showed significant improvement in assessment scores after completion [13].
- Neither the Society of Breast Imaging (SBI) nor the American College of Radiology (ACR) has issued a formal policy requiring the inclusion of artificial intelligence (AI) in breast imaging fellowship curricula. However, both organizations recognize the increasing importance of AI in radiology and have begun efforts to integrate AI education into their training programs [14].

3. Applications of AI in Medical Education

3.1. Clinical Skills Development and Assessment

AI tools have demonstrated effectiveness in improving practical skills, diagnosing diseases, and evaluating student performance. Support vector machines (SVMs) have shown high accuracy (>92%) in assessing students' experiences, diagnosing acute abdominal pain, classifying skilled versus novice participants, and evaluating surgical training levels [15].

3.2. Personalized Learning and Assessment

AI-powered adaptive learning systems analyze learners' performance and generate personalized study plans, potentially optimizing educational efficiency. In assessment, AI tools are utilized to plan instructional methods, identify themes for test blueprinting, generate test items, and guide test standard-setting [16,17].

3.3. Teaching Laboratory Applications

The majority of AI applications in medical education are found in training laboratories, where AI technologies create realistic simulations and provide immediate feedback on performance, allowing students to practice in safe, controlled environments [18].

3.4. Innovative Teaching Methods

Datathons have become valuable educational experiences for medical trainees to develop AI skills in healthcare contexts. These collaborative events enable participants to work with real healthcare data under expert guidance, developing practical AI competencies [19].

4. Challenges in AI Integration

The well-documented 17-year delay between clinical trials and the integration of new practices into routine healthcare is increasingly unacceptable in an era of rapidly advancing artificial intelligence. With AI's ability to analyze vast datasets, predict outcomes, and optimize clinical decision-making in real-time, there is a pressing need to accelerate the translation of research into practice. The traditional lag not only limits patient access to the latest treatments but also undermines the potential for AI to improve healthcare outcomes. To keep pace with innovation, medical schools and healthcare systems must adapt more quickly, leveraging technology to streamline the adoption of evidence-based care [20,21].

There is a notable lack of standardized AI curriculum frameworks and significant global discrepancies in implementation approaches. The absence of consensus on core competencies complicates consistent integration across programs. Many medical educators lack sufficient training and expertise in AI technologies, creating a significant barrier to effective curriculum implementation [22].

Medical educational programs may require additional faculty who are equipped with the expertise to create, oversee, and deliver content. Further resources and funding may be necessary,

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such as institutional access to applications, software, or licensing, all of which may create cost barriers to implementation.

Additional barriers may include the placement of AI integration into already limited curricular time. Some workarounds include creating 4th-year medical student electives in AI and establishing University-wide access to AI in Medicine Clubs led by first-year medical students as officers. In addition, meeting accreditation standards, the inclusion of licensing examination content, and other competing priorities are considered challenges to incorporating innovative content.

Ethical challenges remain regarding data collection, anonymity, consent, and ownership of provided data in AI-based educational tools. Additionally, practical concerns about resource allocation and infrastructure requirements present implementation challenges [17].

Recently, the AAMC provided guidance based on the work of 11 key subject matter experts regarding the Principles for the Responsible Use of Artificial Intelligence (AI) in medical education. This framework consists of two main pillars. The first pillar focuses on integrating AI into medical education to support learners along their developmental journey in a responsible manner. The second pillar emphasizes the development and incorporation of AI into various tasks, processes, and systems within medical education [23].

5. Proposed Framework for AI Integration in Medical Education

Based on the review of current evidence, we propose a comprehensive tiered framework for integrating AI across the medical education continuum:

Tier 1: Universal AI Competencies (All Medical Trainees)

Undergraduate Medical Education Focus:

AI Literacy and Foundation

- Basic AI taxonomy and concepts creating a living glossary
- Types of machine learning, deep learning, large language models, foundational models and their applications in medical education and clinical healthcare
- Data science fundamentals relevant to clinical practice
- Critical and Analytic Evaluation of AI Tools
- Understanding AI limitations and potential biases
- Evaluating the quality of AI-generated information
- Rubric evaluating Medical Student and Resident and Fellowship Trainees usage and interaction with AI
- Recognizing appropriate contexts for AI utilization

Ethical Dimensions

- Patient privacy in the AI era
- Informed consent with AI-assisted decisions
- Equity and access considerations

Implementation through Experiential Learning

- Case-based discussions incorporating AI tools
- Simulation exercises with AI-augmented clinical scenarios
- Reflective practice on AI's role in clinical reasoning

Residency Training Extensions:

Specialty-Specific AI Applications

- Targeted learning about AI tools relevant to the chosen specialty
- Supervised incorporation of AI into clinical decision-making
- Quality improvement projects leveraging AI technologies

Implementation through Practice-Based Learning

- Journal clubs focused on AI applications in specialty domains
- Structured reflection on AI integration in clinical rotations

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- Collaborative projects with AI experts may involve Clinical Quality Measures (CQMs), where medical students are tasked with identifying 50 to 100 cohort data points and applying an AI algorithm while critically evaluating the significance of the output.

Tier 2: Advanced AI Competencies (Interested Trainees)

Technical Proficiency Track

- Optional certificate programs in healthcare AI to include a Certificate of Completion by attending AI Course material and Certificate of Competency by completing a third party administered exam
- Hackathon and datathon participation opportunities
- Research electives in AI application development

AI Leadership Track

- Policy development for AI governance in healthcare
- Quality oversight of AI implementation
- Interprofessional collaboration models with data scientists

Implementation through Enhanced Opportunities

- Dedicated AI fellowships post-residency
- Cross-disciplinary mentorship with computer science departments
- Protected time for AI-focused scholarly activities

Tier 3: AI Integration Infrastructure

Faculty Development

- Train-the-trainer programs for medical educators
- Regular updates on evolving AI applications
- Collaborative teaching models with informatics specialists

Curriculum Integration Strategies

- Embedding AI as a tool within patient-centered frameworks
- Interdisciplinary teaching approaches
- Longitudinal exposure throughout training

Assessment Methods

- Competency-based evaluation of AI knowledge and skills (Certification of Competency)
- Portfolio assessments of AI applications in practice
- Objective structured clinical examinations incorporating AI elements

6. AI Framework Implementation Strategy

This framework should be implemented through a phased approach:

Phase 1: Foundation Building (Years 1-2)

- Establish AI curriculum committees with multidisciplinary representation
- Conduct needs assessments across training programs
- Develop core educational materials and faculty training modules including AI taxonomies and living glossaries

Phase 2: Pilot Implementation (Years 2-3)

- Launch Tier 1 competencies in selected programs
- Evaluate effectiveness through mixed-methods assessment
- Refine the curriculum based on feedback and outcomes

Phase 3: Comprehensive Integration (Years 3-5)

- Scale implementation across training levels
- Develop Tier 2 specialized tracks
- Establish continuous quality improvement mechanisms

7. Conclusion

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Integrating AI in medical education represents a significant challenge and opportunity for preparing future physicians. Current evidence demonstrates growing recognition of AI's importance in medical training, with emerging programs showing promising results in enhancing trainees' knowledge and skills. The proposed tiered framework addresses the need for standardized yet flexible approaches to AI education across the continuum of medical training. To effectively prepare the next generation of physicians, medical education must evolve from isolated AI initiatives to comprehensive integration that balances technical competency with ethical awareness. This requires collaborative efforts between medical schools, residency programs, professional societies, and technology experts to develop curricula that equip healthcare professionals with the knowledge and skills needed to leverage AI as a powerful tool in improving patient care. Future research should focus on evaluating the effectiveness of different educational approaches, developing valid assessment methods for AI competencies, and understanding the long-term impact of AI training on clinical practice and patient outcomes.

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References

1. Gordon M, Daniel M, Ajiboye A, et al. A scoping review of artificial intelligence in medical education: BEME Guide No. 84. *Med Teach*. 2024;46(4):446-470. doi:10.1080/0142159X.2024.2314198
2. Lee J, Wu AS, Li D, Kulasegaram K (Mahan). Artificial Intelligence in Undergraduate Medical Education: A Scoping Review. *Acad Med*. 2021;96(11S):S62-S70. doi:10.1097/ACM.0000000000004291
3. Li Q, Qin Y. AI in medical education: medical student perception, curriculum recommendations and design suggestions. *BMC Med Educ*. 2023;23(1):852. doi:10.1186/s12909-023-04700-8
4. Sun L, Yin C, Xu Q, Zhao W. Artificial intelligence for healthcare and medical education: a systematic review. *Artif Intell*.
5. Ngo B, Nguyen D, vanSonnenberg E. The Cases for and against Artificial Intelligence in the Medical School Curriculum. *Radiol Artif Intell*. 2022;4(5):e220074. doi:10.1148/ryai.220074
6. Tolentino R, Baradaran A, Gore G, Pluye P, Abbasgholizadeh-Rahimi S. Curriculum Frameworks and Educational Programs in AI for Medical Students, Residents, and Practicing Physicians: Scoping Review. *JMIR Med Educ*. 2024;10(1):e54793. doi:10.2196/54793
7. Singla R, Pupic N, Ghaffarizadeh SA, et al. Developing a Canadian artificial intelligence medical curriculum using a Delphi study. *Npj Digit Med*. 2024;7(1):323. doi:10.1038/s41746-024-01307-1
8. Chen Y, Wu Z, Wang P, et al. Radiology Residents' Perceptions of Artificial Intelligence: Nationwide Cross-Sectional Survey Study. *J Med Internet Res*. 2023;25:e48249. doi:10.2196/48249
9. Krive J, Isola M, Chang L, Patel T, Anderson M, Sreedhar R. Grounded in reality: artificial intelligence in medical education. *JAMIA Open*. 2023;6(2):ooad037. doi:10.1093/jamiaopen/ooad037
10. Brandt J, Frey N. Digitale Transformation in der medizinischen Ausbildung.
11. Artificial Intelligence (AI) Fellowship in Cardiovascular Disease. Accessed May 31, 2025. https://www.medicine.northwestern.edu/divisions/cardiology/education/fellowships/ai-fellowship-cardiovascular-disease.html
12. Informatics Fellowship | Radiology | Penn Medicine. Accessed May 31, 2025. https://www3.pennmedicine.org/departments-and-centers/department-of-radiology/education-and-training/residency-programs/special-resident-programs/imaging-informatics-fellowship
13. Finkelstein M, Ludwig K, Kamath A, Halton KP, Mendelson DS. The Impact of an Artificial Intelligence Certificate Program on Radiology Resident Education. *Acad Radiol*. 2024;31(11):4709-4714. doi:10.1016/j.acra.2024.05.041
14. Katzen JT, Grimm LJ, Brem RF. The American College of Radiology/Society of Breast Imaging Updated Fellowship Training Curriculum for Breast Imaging. *J Breast Imaging*. 2021;3(4):498-501. doi:10.1093/jbi/wbaa112

 doi:10.20944/preprints202507.0171.v2

15. Tozsin A, Ucmak H, Soyturk S, et al. The Role of Artificial Intelligence in Medical Education: A Systematic Review. *Surg Innov*. 2024;31(4):415-423. doi:10.1177/15533506241248239
16. Ensign D, Nisly SA, Pardo CO. The Future of Generative AI in Continuing Professional Development (CPD): Crowdsourcing the Alliance Community. *J CME*. 2024;13(1):2437288. doi:10.1080/28338073.2024.2437288
17. Sridharan K, Sequeira RP. Artificial intelligence and medical education: application in classroom instruction and student assessment using a pharmacology & therapeutics case study. *BMC Med Educ*. 2024;24(1):431. doi:10.1186/s12909-024-05365-7
18. Nagi F, Salih R, Alzubaidi M, et al. Applications of Artificial Intelligence (AI) in Medical Education: A Scoping Review. In: Mantas J, Gallos P, Zoulias E, et al., eds. *Studies in Health Technology and Informatics*. IOS Press; 2023. doi:10.3233/SHTI230581
19. Yao MS, Huang L, Leventhal E, Sun C, Stephen SJ, Liou L. Leveraging Datathons to Teach AI in Undergraduate Medical Education: Case Study. *JMIR Med Educ*. 2025;11:e63602-e63602. doi:10.2196/63602
20. Rubin R. It Takes an Average of 17 Years for Evidence to Change Practice—the Burgeoning Field of Implementation Science Seeks to Speed Things Up. *JAMA*. 2023;329(16):1333-1336. doi:10.1001/jama.2023.4387
21. Balas EA, Elkin PL. Technology Transfer From Biomedical Research to Clinical Practice: Measuring Innovation Performance. *Eval Health Prof*. 2013;36(4):505-517. doi:10.1177/0163278713508135
22. Rincón EHH, Jimenez D, Aguilar LAC, Flórez JMP, Tapia ÁER, Peñuela CLJ. Mapping the use of artificial intelligence in medical education: a scoping review. *BMC Med Educ*. 2025;25(1):526. doi:10.1186/s12909-025-07089-8
23. Principles for the Responsible Use of AI in and for Medical Education Review Committee. AAMC. Accessed June 29, 2025. https://www.aamc.org/about-us/mission-areas/medical-education/principles-ai-use/review-committee