

Artificial Intelligence: Crossing a Threshold in Healthcare Education and Simulation

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Abstract

Artificial intelligence (AI) is transformative, irreversible, and integrative, properties that align with the threshold concept in education, fundamentally reshaping how healthcare professionals learn, make decisions, and practice. Despite its vast potential, AI's role in healthcare education remains underexplored, and traditional publishing struggles to keep pace with rapid advancements. The challenge is to bridge disciplines, fostering collaboration between healthcare professionals, AI researchers, data scientists, and healthcare educators to accelerate research dissemination while maintaining academic rigor. Understanding AI as a threshold concept is essential; once grasped, it permanently transforms perspectives on healthcare education and cannot be unlearned. We invite researchers and educators to join this movement to shape the future of AI-driven healthcare education, embracing this shift together as we cross the threshold.

Categories: Accessibility, AI applications, Ethical AI and Responsible Technology

Keywords: threshold concept, healthcare education, healthcare simulation, artificial intelligence, health professions education, health professions, ai and healthcare simulation

Editorial

In an era where technology and healthcare intersect like never before, integrating artificial intelligence into healthcare sets new benchmarks for excellence in healthcare education and simulation, with the ultimate goal of enhancing patient safety. In education, ideas can fundamentally change how we think, learn, and apply knowledge. These are known as threshold concepts, the ideas that, once understood, transform a learner's perspective and cannot be "unlearned" [1]. Threshold concepts are often troublesome, challenging existing ways of thinking, and irreversible, meaning they permanently shift understanding. For example, patient-centered care is considered a threshold concept, as it has essentially reframed the training of healthcare providers since its introduction [2]. They are also integrative, connecting previously unrelated ideas and bounded, redefining the limits of a discipline [1].

Artificial intelligence (AI) in healthcare education and simulation represents one such threshold concept, one that is reshaping how we can prepare healthcare professionals and safeguard patients. Although AI has been around since the 1950s and has been steadily integrated into our daily lives ever since, it is now becoming mainstream in healthcare education, training, and simulation [3-6]. As AI-driven learning systems, intelligent simulations, and data-driven decision-making become embedded in healthcare training, they challenge traditional educational paradigms [5]. For instance, using AI-powered assessment platforms in clinical training introduces a new way of evaluating students, not solely based on predefined rubrics, but on adaptive feedback models. Once educators adopt this approach, returning to traditional assessment methods will become difficult. Considering the evolution of healthcare education, training, and simulation, educators, practitioners, and technologists must cross this threshold to fully realize AI's potential in transforming healthcare learning.

Intersection of expertise: Collaboration of multiple scientific fields

Despite AI's transformative potential, the intersection of AI, healthcare education, and the computational foundations that underpin AI, such as data science, machine learning, and algorithm design, remains underexplored in academic discourse within the healthcare field [7]. AI-driven educational tools, such as intelligent tutoring systems, virtual patients, and machine learning-based assessment platforms, are emerging. For example, some simulation centers now deploy AI-based virtual patients that respond to learner input in real time, adjusting the case complexity based on performance [8]. Generative AI changes how scenarios are written and instructors intervene during sessions, as shown by Liaw et al. [9]. These tools impact learners, faculty, staff, patients, communities, other stakeholders, and the broader learning

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environment.

It is essential to engage with multiple disciplines, particularly health professions education, computer science, and engineering, as they intersect at this threshold because AI integration relies on both technical foundations and domain-specific applications. However, there is a lack of dedicated research venues to examine the pedagogical, ethical, and technological implications. As technology and applications using AI rapidly permeate the patient care environment, collaboration between these areas becomes essential. Healthcare simulation plays a critical role in providing a controlled testing environment where new AI-driven tools can be developed and evaluated before being exposed to patients and their care teams. For example, integrating AI-driven diagnostic systems into patient care requires a team of engineers to research and develop the AI system, clinicians to inform use cases, simulation researchers to test the AI to meet specific needs and applicable ethical standards, and administrators and educators to determine safe implementation.

As the adoption and use of AI in patient care environments continue to increase, simulation-based education will correspondingly evolve and expand to include competencies in digital health, AI literacy, interdisciplinary collaboration, and the ethical use of emerging technologies. It will be key to fostering interdisciplinary collaboration among computer scientists, healthcare educators, AI researchers, and other stakeholders to explore the field, synthesize knowledge, and rapidly disseminate information.

Speed of publication: Keeping pace with publication rate and AI's evolution

The AI field is evolving rapidly, and research is expanding exponentially. The average time from submission to publication in leading journals ranges from 6 to 12 months [10]. By the time findings are published, newer studies may have introduced insights that either reinforce or contradict the original work. Given AI's rapid evolution, the traditional pace of academic publishing risks rendering research outdated before it even reaches its audience.

Concurrently, our institutional culture expects educators to conduct scholarship and publish frequently, sometimes referred to as a "publish or perish" culture [11-14]. This pressure, combined with other factors such as technological advancements, including increased access to digital libraries, has resulted in a surge in publications. In 2022, approximately 2.82 million papers were indexed by major databases, such as Scopus and Web of Science [13]. Moreover, AI-assisted research encompasses automated literature review generation, formulating research questions, refining methodologies, data analysis, and manuscript drafting [15]. The Deloitte Tech Trends 2025 report highlights how AI is shifting research methodologies by enabling real-time data analysis, predictive modeling, and automated content synthesis, reducing the time from conceptualization to publication [15]. Traditional academic publishing has struggled to keep pace with this accelerated research trend, even as AI transforms research workflows. This raises an important question: can AI also help streamline aspects of the publishing process, from peer review to editorial workflows, to match the speed of AI-driven research better?

Accessibility: Democratizing research

Traditional open-access journals often impose high and opaque publication fees, limiting opportunities for researchers with financial constraints [13]. Publishing through this medium ensures that publication costs are clearly stated upfront, allowing researchers from diverse backgrounds to participate in knowledge creation and dissemination without economic barriers.

In addition to financial barriers, many researchers, particularly early-career scholars and those from underrepresented regions, may hesitate to submit their work due to concerns about quality, relevance, and the complexity of the peer review process [16]. This can be especially true when researchers with a primary focus on healthcare education try to integrate AI into their research, which introduces technical complexity. Although many AI tools are freely accessible, a lack of training often prevents researchers from assessing whether these systems are appropriate for their educational contexts.

This emphasis on accessibility reflects the integrative nature of threshold concepts, bridging previously siloed domains such as technology, healthcare, and education [1]. It not only broadens reach and readership but also fosters transdisciplinary peer review and dissemination. Integrating AI into scholarship is not merely the adoption of a technological tool; it represents a pedagogical shift, redefining the relationship between technology, education, and healthcare practice.

Call to action: Owning the irreversible shift

AI is a threshold concept that is irreversible and permanently alters how healthcare education is designed, delivered, assessed, and disseminated. This shift demands shared responsibility and coordinated action across disciplines. Educators, simulationists, computer scientists, AI specialists, instructional designers, ethicists, and journal editors must collaborate to develop practical, evidence-based frameworks to guide

the integration of AI into learning environments and scholarly workflows. This collaborative work should also consider the diverse levels of user expertise and AI adoption.

Build Faculty Readiness Through Structured AI Literacy Programs

Institutions must invest in professional development that goes beyond tool demonstrations. Faculty requires pedagogically grounded training on how AI systems function, where biases can emerge, how to evaluate outputs, and how to use AI to enhance, rather than replace, clinical reasoning. For example, simulation centers can create joint faculty-technologist workshops to test AI-driven debriefing tools using real scenarios, with structured reflection on performance and relevance.

Develop and Validate Representative AI Training Tools

Simulationists should collaborate with AI developers and clinicians to ensure that intelligent agents and virtual patients are validated using representative and diverse datasets. For instance, co-designing a virtual sepsis case with data from multiple healthcare systems, including those serving underserved populations, ensures that learners develop diagnostic reasoning skills applicable to a broader range of clinical realities. Another example would be co-designing a virtual sepsis case using data from multiple healthcare systems, including those serving underserved populations, which can expose learners to a broader range of clinical presentations and healthcare contexts. This approach supports the development of diagnostic reasoning skills that are adaptable to diverse and real-world clinical scenarios.

Redesign Peer Review Processes With AI as a Support Tool, Not as a Replacement

Academic journals and conferences should pilot AI-assisted review systems that support human reviewers, rather than replacing them. A retrieval-augmented generation model, for example, could help identify potential methodological inconsistencies, suggest areas where reporting standards may not be met, or highlight underdeveloped sections within a manuscript. This preliminary AI-assisted human analysis can help reviewers focus on substantive critique while maintaining accountability and scholarly depth. To maintain trust, policies must clearly define acceptable AI use and require disclosure from both reviewers and authors. Transparency is essential, especially as a large language model use becomes more prevalent in both manuscript preparation and review.

Align Institutional Policies With Educational and Ethical Priorities

Educational institutions and publishers must align AI adoption policies with the core values of equity, validity, and learner-centered design. This means not only ensuring access to AI tools but also developing shared rubrics for their evaluation and mechanisms for continual reassessment. Ongoing reassessment is essential to keep pace with the rapid advancements in AI and its evolving role in healthcare education and training. Advisory boards that include educators, technologists, and learners can help guide this evolution.

In conclusion, due to the ongoing rapid technological evolution, AI in healthcare education is not a static threshold, but a dynamic, interdependent phenomenon. Each new application, from virtual patient design to AI-assisted review, reshapes expectations and workflows. Institutions must prepare not just to integrate AI, but to navigate its evolving challenges deliberately and transparently. Resisting this shift delays progress; embracing it responsibly is the only viable path forward. By doing so, the healthcare education community can ensure that AI enhances learning, strengthens assessment, and upholds the integrity of scientific communication. Let us cross this threshold as a unified community, learning, researching, disseminating, and advancing healthcare education together!

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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