Journal of Informatics Education and Research
ISSN: 1526-4726
Vol 5 Issue 2 (2025)

Integrating Large Language Models and Personalized Learning in Medical Education: Potential, Challenges, and the Path Ahead – A Systematic Review

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Abstract:
The use of large language models (LLMs) in medical education, particularly for personalized learning, has gained significant interest in the past five years. We conducted a systematic literature review (2019–present) following PRISMA guidelines to assess how LLMs (e.g., GPT-based models) are applied in adaptive medical training. Searches of PubMed, Scopus, IEEE Xplore, and Web of Science identified relevant peer-reviewed articles, prioritizing systematic reviews, meta-analyses, and qualitative studies. LLMs have the potential to transform medical education through adaptive quizzes, on-demand tutoring, and customized study plans. However, challenges such as misinformation, algorithmic biases, and privacy concerns must be addressed. We outline guidelines to leverage LLM benefits while ensuring faculty oversight to maintain accuracy. If responsibly integrated, LLMs can significantly enhance personalized learning in medical education. Collaboration among educators, AI developers, and policymakers is essential to establish safe, effective practices. This review synthesizes current evidence, identifies innovation opportunities, and highlights necessary safeguards for AI-driven medical education.

Keywords: Large Language Models, Personalized Learning, AI-driven Medical Education, Medical Training

1. Introduction

The advancement of educational technology, encompassing learning management systems, big data, and analytics, is transforming higher education institutions and propelling digital change (Kustitskaya et al., 2023). This shift has led to the development of innovative teaching methods and greater flexibility in education, offering cost-effective access to limitless educational resources, irrespective of geographical boundaries (Yuan, 2025). The emergence of personalized adaptive learning has greatly altered higher education by merging the principles of personalized learning with adaptive learning technologies. This combination has resulted in educational experiences that are more effective, efficient, and engaging, tailored to meet the unique needs of each learner. Medical education is evolving with AI advancements, personalised learning including large language models (LLMs) like GPT-3 and GPT-4 (ChatGPT) (Larson et al., 2023). Leveraging intricate neural network structures, particularly those rooted in transformer models, LLMs are adept at recognizing and mimicking subtle language nuances. Their abilities go beyond mere text creation; they can also generate related images or even videos from text prompts, thus tackling a broad spectrum of linguistic tasks. Significantly, the application of LLMs in medical education is increasingly becoming a central theme in global research and discourse. LLM models enable personalized learning by tailoring educational content to individual needs, addressing challenges like information

overload and varied learning paces (Da Silva et al., 2024). Unlike traditional teaching methods, LLMs can serve as scalable, 24/7 personal tutors.
Early applications in general education, such as Duolingo and Khan Academy, highlight their potential (Li and Bonk, 2023),(Munday, 2015) . In medical training, LLMs could generate custom study plans, simplify complex topics, create practice questions, and provide instant feedback (Lucas et al., 2024), (Gordon et al., 2024). This could enhance knowledge retention and self-directed learning while allowing educators to focus on mentorship and clinical skills (Sevgi et al., 2024). However, concerns exist regarding accuracy, overreliance, algorithmic bias, and ethical risks like plagiarism and privacy breaches. Effective integration requires mitigating these challenges to ensure AI augments rather than undermines medical training. Given the rapid adoption of LLMs and limited consolidated evidence, this review systematically examines their role in personalized medical education. We summarize current applications, benefits, challenges, and ethical considerations, providing insights for educators, AI researchers, and policymakers.

This paper conducts a systematic review of the literature concerning Large Language Models and personalized e-learning in medical education, with the goal of assessing the current state of knowledge and identifying gaps in the existing research. This research paper contributes to overview of E-learning in SME and various findings on E-learning benefits, challenges and trends in SMEs are presented. In addition, this paper, in its systematic review of the literature, sheds light on this study's limitations and opportunities for further future research in this field. The systematic review research questions help researchers narrow the scope and concentrate on specific research details. This systematic review encourages research on Large Language Models and personalized learning in medical education, and it suggests three research questions:

- RQ1. What are the benefits and applications of Large Language Models and Personalised Learning in Medical Education?
- RQ2. Do the Large Language Models promote or improve learning outcome?
- RQ3. What are the perspectives of educators, learners and associated challenges or ethical issues?

The structure of the paper is outlined as follows: it starts with a discussion of the research methodology, including protocol development, search strategy, data extraction, synthesis, and quality appraisal. Further, key findings are discussed with focus on research questions. Finally, the research paper concludes with future directions and limitation on research on large language models and personalised learning.

2. Research Methodology

This systematic review follows PRISMA 2020 guidelines. The PRISMA 2020 statement replaces the 2009 statement and includes new reporting guidance that reflects advances in methods to identify, select, appraise, and synthesise studies (Parums, 2021). A predefined protocol outlined the search strategy, inclusion/exclusion criteria, and data extraction methods. Given the evolving role of LLMs in education, we included both quantitative and qualitative

2.1. Protocol Development

We included peer-reviewed studies (2019–2025) that:

- Focused on medical education (undergraduate, graduate, or continuing education).

- Involved LLMs (e.g., GPT-3, GPT-4) in an educational setting.
- Addressed personalized or adaptive learning (e.g., AI-driven tutoring, tailored feedback).

Excluded: Non-peer-reviewed articles, non-English papers, and studies unrelated to education or personalization.

2.2. Search Strategy & Study Selection

We searched PubMed, Scopus, Web of Science, and IEEE Xplore using MeSH and keywords related to LLMs, medical education, and personalized learning. We used a combination of Medical Subject Headings (MeSH) and keywords related to: "large language model*" OR "generative AI" OR "GPT-3" OR "ChatGPT" OR "transformer model" AND "medical education" OR "health professions education" OR "medical training" AND "personalized learning" OR "adaptive learning" OR "individuali*ed instruction" OR "tutor" OR "education technology". After removing duplicates, two reviewers independently screened and assessed studies, resolving disagreements through discussion. A PRISMA flow diagram tracked the selection process.

2.3. Data Extraction & Synthesis

Key data points extracted included study design, sample, setting, LLM applications, personalization aspects, and outcomes. Given study heterogeneity, we conducted a narrative synthesis, categorizing findings by LLM applications, learning impact, user perceptions, and challenges.

2.4. Quality Appraisal

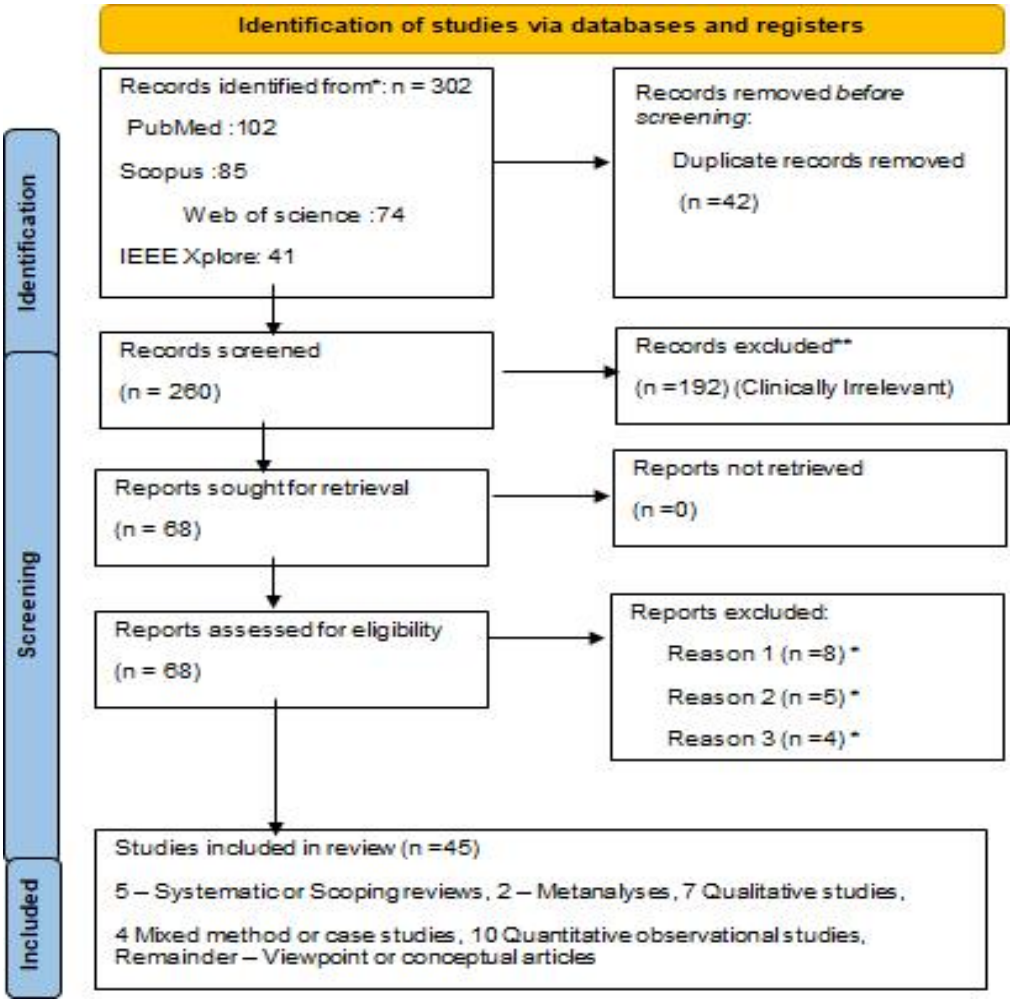
Study quality was assessed using appropriate tools (AMSTAR 2, AMSTAR)(De Santis and Kaplan, 2020). Biases were considered, particularly in descriptive studies. Only peer-reviewed sources were included.

Results Summary

- **Records identified:** 302 (PubMed: 102; Scopus: 85; Web of Science: 74; IEEE Xplore: 41).
- **Screening:** 260 unique records reviewed; 192 excluded as irrelevant.(De Santis and Kaplan, 2020)
- **Eligibility:** 68 full texts reviewed, 23 excluded.
- **Final inclusion:** 45 studies (5 reviews, 2 meta-analyses, 7 qualitative, 4 mixed-method, 10 quantitative, and conceptual articles).

This review provides a structured synthesis of LLM applications in personalized medical education and depicted in Fig 1.

Figure 1. PRISMA Flow Diagram of Study Selection



*Reason 1: Did not actually utilize LLMs, *Reason 2: Did not address personalized/adaptive learning, *Reason 3: Conference papers or non-peer-reviewed pieces *Reason 4: Not in English, *Reason 5: Duplicate reports or superseded by later studies

3. Findings, Review Questions and Discussions

Early reviews on LLMs in medical education exist, but interventional trials remain limited. Studies mainly originate from the US, Middle East, and Europe, with a few from Asia. Research focuses on medical students and faculty, assessing ChatGPT's role in learning. Key themes include LLM applications, learning outcomes, user perceptions, and challenges.

Table 1: Key Studies on LLMs and Personalized Learning in Medical Education (2019–2025)

Study (Year) & Design	**Context & Participants**	**LLM Focus**	**Key Findings**	**Limitations**
Lucas et al. (2024) - Systematic Review	40 studies on LLMs in medical education (global)	Personalized learning, exam prep, Q&A	LLMs improve education by addressing information overload; ~42% of studies show near-human performance in medical tasks.	Mostly commentary-based; lacks long-term outcome studies.
Temsah et al. (2025) - Qualitative (Focus Groups)	Medical faculty & students (Saudi university)*	Initial perceptions of ChatGPT	Benefits: quick info access, summarization, study time reduction. Concerns: reduced critical thinking, fake references, ethical issues. Cautious optimism.	Single-institution, early reactions, no objective learning impact measures.
Elhassan et al. (2025) - Cross-sectional Survey	Medical students (Alfaisal Univ., n=293)	Usage patterns, AI attitudes	~94% familiarity, ~80% use AI. ~46% see AI as ethical, 24% disagree. Positive attitudes, but need for guidance.	Self-selection bias, self-reported data, evolving ethics views.
Abd-Alrazaq et al. (2023) - Perspective (Expert Opinion)	Medical educators & AI experts	AI's role in med ed	LLMs enable personalized plans, quizzes, tutoring. Challenges: bias, misinformation, plagiarism, privacy issues. Calls for best-practice guidelines.	Theoretical, lacks empirical data.
Gordon et al. (2024) - Scoping Review	117 AI-in-med-ed studies (various AI forms)	AI-driven learning tools	AI supports adaptive learning, virtual simulations, and personalized platforms. Concludes AI can scale education but needs better evaluation.	Broad scope, not specific to LLMs, focus on categorization.

Alkhaaldi et al. (2023) - Cross-sectional Survey	Residency applicants (UAE, n=265)	AI/ChatGPT use in training	~20% used ChatGPT in med school; ~63% plan to use AI in residency. Positive AI outlook, but structured guidance needed.	Single location, early data, potential social desirability bias.

3.1. RQ1. What are the benefits and applications of Large Language Models and Personalised Learning in Medical Education?

LLMs offer personalized, self-paced learning in medical education through:

- **Intelligent Tutoring**: Acts as an AI tutor, answering questions, simplifying concepts, and adapting explanations based on student needs (Garugu et al., 2025).
- **Customized Study Plans**: Generates tailored learning schedules based on student performance and knowledge gaps (Alshatnawi et al., 2025),(Elhassan et al., 2025)
- **Adaptive Assessments**: Creates and evaluates quizzes, providing instant feedback and targeted review.
- **Content Summarization**: Condenses medical texts, adjusting complexity based on learner expertise (Abouammoh et al., 2025).
- **Simulated Role-Play**: Acts as a virtual patient or examiner for skill training and interactive learning (Yow, 2022).
- **Administrative Support**: Automates grading and feedback, allowing instructors to focus on mentorship.

These tools enhance competency-based education, enabling struggling students to catch up and advanced learners to progress faster. While most benefits remain theoretical, early studies suggest LLMs could revolutionize medical training.

3.2. RQ2. Do the Large Language Models promote or improve learning outcome?

Evidence on LLMs improving learning outcomes is still emerging, with no RCTs yet available. However, some findings suggest potential benefits:

- **Exam Performance**: Studies show LLMs like GPT-4 can pass USMLE-style questions (~70% accuracy), implying their utility for practice and explanations (Brin et al., 2023).
- **Efficiency & Perception**: Students report AI helps summarize information, clarify doubts, and streamline study processes, though impact on grades remains unproven (Rajbanshi et al., 2024).
- **Ongoing Research**: Planned trials, like Veras et al.'s, aim to measure AI-driven learning gains formally.
- **Adaptive Learning**: AI-powered systems have shown improved efficiency in education, hinting at potential benefits if LLMs are used adaptively (Li et al., 2024).
- **Clinical Reasoning**: LLMs could aid reasoning by simulating cases and providing feedback, though empirical data is lacking (Bany Abdelnabi et al., 2025).
- **Challenges**: Over-reliance on AI may hinder deep understanding and critical thinking, necessitating balanced use guided by educators (Salim et al., 2023).

More rigorous studies are needed to quantify the true impact of LLMs on medical education.

3.3. RQ3. What are the perspectives of educators, learners and associated challenges or ethical issues?

Current Evidence & Impact

Hard evidence on improved exam scores or skills due to LLMs is lacking, but students find them useful for learning. While LLMs enhance knowledge acquisition and efficiency, concerns remain about their effect on critical thinking and reliance on AI-generated content.

Learner & Educator Perspectives

- **Students**: Enthusiastic but cautious. Benefits include quick access to information, simplified explanations, and personalized study aids. Concerns include accuracy, over-reliance, and ethical issues (e.g., plagiarism) (Papadopoulos, 2024).
- **Educators**: See potential for AI to assist teaching but worry about misinformation, academic integrity, and the impact on critical thinking. Many feel unprepared for AI integration and advocate for structured guidance (Alshehri, 2023).

Challenges & Ethical Issues

- **Accuracy & Hallucinations**: AI can produce incorrect or outdated information, requiring verification(Thorne, 2024).
- **Bias & Fairness**: AI models may reflect biases from training data (Zhai et al., 2023).
- **Privacy & Integrity**: Risks include data breaches and unethical use in assessments (Fan et al., 2024).
- **Technical Barriers**: Access limitations and lack of AI literacy affect usage (Krüger, 2023).

3.4 Discussion

Potential Benefits: LLMs can personalize learning, provide virtual tutors, and support active learning through interactive quizzes and simulations. They assist faculty by generating teaching materials, grading assessments, and optimizing curriculum design, allowing educators to focus on mentorship and skill-based training (Alkhaaldi et al., 2023).

Challenges & Solutions

- **AI Literacy**: Training students and faculty on AI usage, prompt strategies, and ethical considerations is essential (Gao et al., 2024).
- **Policy & Ethics**: Institutions must establish guidelines on AI use, academic integrity, and data privacy(Marcel and Kang, 2024) .
- **Assessment Reforms**: Evaluations should emphasize application-based learning (e.g., OSCEs, case discussions) rather than rote memorization (Jiang and Ferraro, 2024).
- **Technical Advancements**: Collaboration with AI developers can enhance reliability, ensuring medical AI tools are evidence-based and citation-backed (Xivuri and Twinomurinzi, 2023).
- **Faculty Roles**: AI may shift educators' focus from content delivery to moderation, mentorship, and quality control (Jenks, 2024).

Overall, LLMs have immense potential, but careful implementation, oversight, and ethical frameworks are necessary for effective integration into medical education (Zhu et al., 2024) .

4. Future Directions in Research

Our review highlights key gaps that future studies must address:

- **Efficacy Studies**: Controlled trials should compare LLM-based personalized learning with traditional methods to assess improvements in exam scores, skill retention, and clinical reasoning (Abd-Alrazaq et al., 2023).
- **Implementation Strategies**: Research should explore AI-augmented self-study vs. AI-integrated classrooms, and the impact of AI literacy training on learning outcomes (Kehinde-Awoyele et al., 2024).
- **Cognitive Impact**: Studies should analyze how AI changes problem-solving, critical thinking, and metacognition, ensuring that reliance on AI does not compromise deep understanding (Goyal, 2025).
- **Long-term & Clinical Impact**: Longitudinal studies should examine whether AI-trained doctors demonstrate better competence, decision-making, and confidence in residency and practice (Conrado et al., 2023).
- **Equity & Diversity**: Research should monitor AI's effect on different student groups, ensuring inclusive adoption and mitigating disparities based on learning styles or tech proficiency (Yamijala et al., 2024).
- **AI Behavior & Improvement**: Ongoing refinements should ensure AI reliability, integrating feedback from medical students to enhance model accuracy and educational value (Hansen et al., 2025).

5. Ethical & Policy Considerations

- **Guidelines & Accreditation**: Institutions may integrate AI literacy into medical curricula, shaping future board exam structures and competency standards.
- **Faculty Roles & Mentorship**: AI should enhance—not replace—human mentorship, allowing educators to focus on professional identity formation, ethics, and empathy.
- **Privacy & Integrity**: Policies must ensure responsible AI use, maintaining academic integrity and safeguarding student data.

6. Limitations

While this literature review on the subject has yielded numerous valuable insights, it is important to acknowledge certain limitations. This study was limited to articles from just four databases— PubMed, Scopus, Web of Science, and IEEE Xplore —which may not have encompassed all relevant research on the topic. This review is constrained by the evolving nature of AI in education, a mix of study designs, and potential optimism bias in the literature. While broad, our scope prioritized personalized learning, leaving other AI applications less explored. Secondly, the review focused solely on articles written in English, which may have led to the omission of relevant studies published in other languages. This limitation could have excluded certain research findings from countries where English is not the primary language, such as India, where numerous regional languages are spoken. Even though we have made every effort to carry out a comprehensive and impartial systematic literature review by employing stringent search methods and criteria for inclusion and exclusion to reduce bias, the possibility of selection bias cannot be completely eradicated. Moreover, our review might have unintentionally overlooked pertinent studies due to constraints in our search methodology or the scope of the databases used.

7. Conclusion

Large language models (LLMs) have emerged as transformative tools in medical education, offering personalized learning, adaptive tutoring, and instant feedback. This review highlights their potential to enhance medical training by addressing knowledge gaps and improving efficiency. However, challenges such as accuracy, ethical concerns, and AI over-reliance must be managed through structured integration, AI literacy training, and regulatory oversight. To maximize benefits, educators should pilot AI-assisted learning, policymakers must establish guidelines, and AI developers should refine models for educational accuracy. Thoughtful adoption can ensure LLMs enhance—not replace—human mentorship, ultimately fostering competent, critical-thinking physicians for the modern healthcare era.

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