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Review Article

Artificial Intelligence in Personalized Medical Education: A Systematic Review of Applications, Benefits, and Challenges

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Abstract

Background: Medical education, due to its increasing complexity, requires innovative and effective approaches, with artificial intelligence (AI) emerging as a leading tool. AI facilitates the personalisation of learning by adapting educational processes to individual student needs.

Objectives: This study aims to systematically examine the role of artificial intelligence in personalising medical education by identifying its main applications, pedagogical benefits, and implementation challenges, and by proposing evidence-based recommendations for optimising AI-driven instructional strategies.

Methods: A systematic review was conducted by searching five major databases PubMed, Scopus, IEEE, Web of Science, and Google Scholar up to March 2025. Relevant keywords included "artificial intelligence," "personalized learning," "adaptive learning," "machine learning," "deep learning," "natural language processing," and "medical education." In total, 70 articles were initially identified, and after screening and applying inclusion and exclusion criteria, 32 studies focusing on the application of artificial intelligence in medical education were selected for analysis.

Results: Findings indicated that AI enhances learning quality through personalized feedback, adaptive learning pathways, and interactive educational simulations. AI can also assess students' strengths and weaknesses, recommend appropriate educational resources, and promote self-directed learning. However, challenges such as implementation costs, data security concerns, and user resistance to adopting new technologies were identified as major barriers.

Conclusion: AI holds significant potential for enhancing the quality of medical education and personalizing the learning experience. To fully harness this technology, it is crucial to address existing challenges and develop human-AI hybrid models. Future research should focus on improving technical infrastructure and increasing user acceptance.

Keywords: Personalized Learning; Machine Learning; Artificial Intelligence; Education; Medical

Background

Medical education, as a complex and dynamic process, faces challenges such as the vast volume of educational content, substantial individual differences among students, and escalating expectations for improved learning quality (1). Traditional models of medical education, which primarily rely on uniform and group-based methods, are often limited in addressing the diverse and personalized needs of learners (2). These shortcomings have drawn increasing attention to the development of personalized learning approaches, which leverage data analysis and the identification of individual characteristics and needs to adapt content and learning processes to each learner's unique circumstances (3).

The integration of artificial intelligence (AI) into medical education has garnered widespread interest from researchers and policymakers in recent years, owing to its capabilities in machine learning, big data analytics, and intelligent content generation (1, 4). This technology enables the design of adaptive learning environments, assessment of educational progress, and provision of immediate feedback, thereby rendering learning experiences more dynamic and precise (5). However, a critical review of the literature reveals that many prior studies have either focused on general education or merely described AI applications in medical education, without comprehensive and systematic evaluations of this technology's impact on learning quality and clinical competencies (1, 3). These studies are often confined to specific tools or small populations, with limited attention to implementation challenges, ethical considerations, data security, or algorithmic biases (6).

Furthermore, many of these investigations are outdated in methodology or timing, emphasizing the introduction of applications rather than assessments of real-world effectiveness on a large scale (7). One prominent gap in the literature is the scarcity of comprehensive reviews on AI's role in continuing medical education (CME) and domains beyond initial academic training (8). These gaps, particularly in the analysis of personalized quality and educational outcomes within clinical settings and healthcare systems across different countries, have largely been overlooked (7). Such deficiencies underscore the need for empirical and systematic evidence on AI's benefits, limitations, and challenges in medical education (9).

This study aims to address the research question: What roles, benefits, and challenges does AI have in personalized medical education, and what research gaps exist in this field? Through a systematic review and critical analysis of existing studies, it examines AI applications across various levels of medical education, including CME, while focusing on benefits and implementation barriers. This research contributes to a deeper understanding of the technology's potential and limitations, laying the groundwork for evidence-based policymaking and enhancements in educational infrastructure.

Objectives

This study aims to systematically examine the role of artificial intelligence in personalising medical education by identifying its main applications, pedagogical benefits, and implementation challenges, and by proposing evidence-based recommendations for optimising AI-driven instructional strategies.

Methods

This systematic review was conducted to identify, evaluate, and synthesize evidence on the applications, benefits, and challenges of artificial intelligence in personalized medical education. The study was designed and reported in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (10), ensuring transparency and reproducibility.

Systematic Literature Search: A comprehensive literature search without geographical restrictions was conducted up to March 2025 across four primary databases PubMed (for biomedical and health sciences coverage), Scopus (for interdisciplinary education and technology indexing), IEEE Xplore (for AI and engineering advancements), and Web of Science (for high-impact peer-reviewed publications) selected for their complementary strengths in capturing the multidisciplinary nature of AI in medical education, ensuring depth, quality, and minimal overlap. Google Scholar was used as a supplementary tool to identify additional articles and gray literature not indexed elsewhere, with the search limited to these five resources to prioritize efficiency, reproducibility, and practical constraints such as time and access, as preliminary scoping indicated sufficient coverage without needing further databases like EMBASE or ERIC Keywords including:

"Artificial Intelligence," "Personalized Learning," "Medical Education," "Health Sciences Education," "Adaptive Learning," "Individualized Learning," "Machine Learning," "Deep Learning," "Neural Networks," And "Natural Language Processing."

These keywords were combined using Boolean operators as follows:

("Artificial Intelligence" OR "Deep Learning" OR "Neural Networks" OR "Natural Language Processing") AND ("Personalized Learning" OR "Individualized Learning" OR "Adaptive Learning" OR "Personalized Education") AND ("Medical Education" OR "Health Sciences Education")

Given the rapid evolution of artificial intelligence in medical education, the search was limited to studies published from 2010 onwards. After removing duplicates, a total of 70 articles were identified.

Inclusion and Exclusion Criteria

Studies were included if they:

Addressed the direct or indirect application of artificial intelligence (including machine learning, deep learning, neural networks, or natural language processing) in medical or health sciences education.

Covered any stage of medical education (undergraduate, postgraduate, specialist training, or continuing medical education).

Were published as full-text articles in English or Persian and were accessible.

The following studies were excluded:

Articles primarily focused outside the field of medical education (n = 8).

Purely descriptive or cross-sectional studies without a clear emphasis on artificial intelligence or those with only superficial references to it (n = 5).

Letters to the editor, conference abstracts without full text, editorials, and commentaries.

Studies published in languages other than English or Persian, or those without accessible full text.

As illustrated in Figure 1, the inclusion and exclusion process is depicted step-by-step, showing the identification, screening, eligibility assessment, and final selection of 32 studies.

Screening and Study Selection: Initially, two independent reviewers screened the titles and abstracts based on the inclusion and exclusion criteria. In cases of uncertainty, full-text reviews were conducted to determine eligibility. Discrepancies were resolved through discussion and consensus. Ultimately, 32 articles were included in the final analysis.

Data Extraction and Analysis: The data extraction process was conducted using a standardized form by two independent reviewers to ensure the comprehensiveness and impartiality of data collection. For each included article, essential information was extracted, including the author(s) and year of publication, study design, type of artificial intelligence application, educational outcomes (such as learning improvement, increased engagement, or enhanced self-regulation), and any reported challenges or limitations.

To enhance transparency, any discrepancies between reviewers were discussed in joint meetings until consensus was reached.

Data Analysis: A thematic content analysis approach was employed to analyze the extracted data. The process entailed the following steps:

- First, the key findings of each article were coded into concise statements or phrases;
- Next, similar and related codes were grouped into major themes (such as “Personalized Feedback,” “Adaptive Assessment,” “Data Security Challenges,” etc.);
- Finally, each major theme was organized and interpreted based on the commonalities or differences observed across the reviewed studies.

Application and Outcomes of the AMSTAR and CASP Tools

a) Quality Assessment of Systematic Reviews (AMSTAR): The AMSTAR tool, comprising 11 key criteria including clarity of the research question, comprehensiveness of the search, identification of gray literature, appraisal of primary study quality, methods for data synthesis, and assessment of publication bias—was applied. In this study, each systematic review was independently scored by two reviewers for all AMSTAR items, with possible responses being “Yes,” “No,” “Can’t Answer,” or “Not Applicable.” Studies scoring above 7 out of 11 were considered high quality; the most common weaknesses were a lack of transparency in study selection and inadequate assessment of publication bias.

b) Quality Assessment of Quantitative Studies (CASP): The CASP checklist for quantitative studies covers issues such as clarity of the research question, appropriateness of methodology, adequacy of sample size, consideration of selection bias, control of confounding variables, transparency of statistical analysis, and comprehensive reporting of results. Each domain was rated as “Yes,” “No,” or “Partially.” The majority of quantitative studies received a score above 7 out of 10, with the main weaknesses noted in reporting of selection bias and limited explanation of findings.

c) Quality Assessment of Qualitative Studies (CASP Qualitative): For qualitative studies, the CASP Qualitative checklist assessed aspects such as clarity of the research aim, adequacy of data analysis, credibility of findings, and inclusion of trustworthiness criteria (e.g., confirmability and transferability). Most qualitative studies achieved acceptable scores, although some demonstrated weaknesses in providing analytic detail or justifying the credibility of their findings.

Discrepancy Resolution Procedure: In cases where there were inconsistencies in the quality scores assigned by the two reviewers, disagreements were resolved through discussion and, if necessary, consultation with a third researcher in order to maximize objectivity and accuracy. The results of the quality and risk of bias assessments were directly integrated into the synthesis and interpretation of the systematic review findings.

Data Extraction: Data from the selected studies were systematically extracted based on predefined inclusion criteria.

The extracted variables included (1) the author and publication year, (2) the key concept or focus of each study, (3) the specific AI applications used, and (4) the main research findings, including any reported implementation challenges. These data collectively informed the thematic synthesis of AI applications in personalized medical education and are summarized in Table 1.

Results

A total of 32 articles were reviewed, covering an approximate ten-year period (2015–2025). As illustrated in Figure 2, the majority of publications appeared in recent years (2023–2025), reflecting a gradual increase in research interest toward the application of artificial intelligence and personalized learning in medical education. This trend appears to be driven by factors such as technological advancements, the acceleration of digital education during the COVID-19 pandemic, and a global shift toward personalized approaches in teaching and learning.

However, while the quantitative growth of studies in recent years is evident, this temporal concentration introduces certain limitations in interpreting the results of the systematic review. Notably, many of the recent articles are primarily focused on preliminary investigations, short-term interventions, or pilot implementations of AI tools, with limited evidence available on their long-term effectiveness or sustained impact in real-world educational environments. Therefore, when considering the progression of research in this field, it is essential to assess not only the contextual drivers but also the quality and depth of evaluation in these studies, and to identify gaps in comprehensive or longitudinal investigations.

The geographical distribution of the reviewed articles reflects a broad global interest in AI-driven personalized learning within medical education. As depicted in Figure 3, approximately half of the studies were conducted in Asian countries—including China and India highlighting the region's leading role in developing and applying AI innovations in medical education. The Americas (23.5%) and Europe (20.6%) each contributed a substantial share of the literature, underscoring significant engagement in these regions as well. The "Others" category, comprising countries in Oceania and Africa (5.8%), although smaller in proportion, indicates a growing interest in this field.

The predominance of publications from Asia, along with meaningful contributions from Europe and the Americas, may reflect differences in technological infrastructure, resource availability, and research capacity across regions, which could influence both the generalizability of findings and the extent of practical adoption.

Applications of Artificial Intelligence in Personalized Medical Education

Findings from the reviewed studies, as presented in Table 2, indicate that the applications of artificial intelligence (AI) in personalized medical education can be categorized into nine conceptual domains, including adaptive learning, assessment, self-regulated learning, and decision-support systems. Among these, adaptive learning pathways, real-time feedback, and personalized assessments were the most frequently reported applications, as highlighted in studies such as Johnson and Lee (2022), Deng et al. (2024), and Triola et al. (2023).

These findings can be meaningfully interpreted through the lens of the Self-Regulated Learning (SRL) theory, which emphasizes core processes such as goal-setting, self-monitoring, and metacognitive feedback. Within this framework, AI-enabled tools—such as adaptive instructional sequences, intelligent feedback systems, and personalized assessments—are considered mechanisms that promote learner autonomy and motivation by facilitating dynamic, self-directed learning processes (42, 43).

However, several recurring challenges were noted, including inconsistent feedck quality, infrastructural limitations, and misalignment with traditional assessment frameworks. Therefore, successful implementation of AI in medical education requires alignment with pedagogical theories, access to high-quality data, and dynamic interaction between human educators and intelligent systems.

The Role of Artificial Intelligence in Transforming Medical Curricula for Personalized Education

Among the studies reviewed, only four explicitly addressed the role of artificial intelligence (AI) in transforming medical curricula for personalized education. Although limited in number, these studies highlight AI's potential to design dynamic learning pathways tailored to individual student characteristics. However, the effective realization of this potential requires integration with human pedagogical expertise.

Table 3 presents an analytical comparison of the complementary roles of human educators and AI systems across five key dimensions: emotional interaction, curriculum development, feedback mechanisms, learning focus, and decision support. The findings indicate that AI demonstrates strong capabilities in data analysis and real-time feedback delivery, but it remains irreplaceable in domains requiring empathy, ethical judgment, and human-centered communication.

Studies such as those by Deng et al. (2024) and Triola et al. (2023) emphasize that a hybrid model combining human and AI strengths produces the most effective outcomes in medical education. Nonetheless, challenges such as algorithmic transparency, faculty readiness, and alignment with traditional curricula continue to hinder the full implementation of such an approach.

Current Applications of Artificial Intelligence in Medical Education

Review of the studies indicates that a majority of articles (20 out of 32) focus on the application of artificial intelligence (AI) in learning and knowledge development. One of the primary motivations for integrating AI in this domain is its capacity to deliver immediate and targeted feedback to students, which plays a crucial role in identifying knowledge gaps and enhancing academic performance. However, the quality of AI-generated feedback remains inconsistent, as it often depends on predefined models and limited data sources.

Furthermore, AI applications are predominantly concentrated in undergraduate medical education, with considerably fewer implementations in continuing medical education (CME), residency programs, or fellowship training. This disparity is largely attributed to the lack of structured curricula in professional training and the inherent challenges in providing context-specific content for AI algorithms.

In the domain of assessment and evaluation, only 4 out of 32 reviewed articles explicitly address the use of AI. The primary barrier to wider adoption in this area is the insufficient digital infrastructure for examination processes, as many assessments in medical education are still conducted offline using paper-based formats (Table 4).

Challenges of Implementing AI in Personalized Medical Education

Despite the high potential of artificial intelligence (AI) to enhance learning processes in personalized medical education, research findings reveal that its implementation is challenged by multiple, complex barriers. These challenges are not limited to technical issues or financial costs; they also encompass concerns related to algorithmic stability, data bias, decision-making transparency, human-machine interaction, and trust in AI technologies.

For instance, technical limitations go beyond the need for advanced infrastructure; they include the inability of algorithms to accommodate diverse learning styles and the difficulty in modeling learner behaviors over time.

Similarly, data security is not merely a regulatory concern—it directly influences students' trust in AI-based systems and their willingness to engage with them in educational settings.

Moreover, the use of incomplete or biased data can result in inaccurate feedback and misdirected learning, particularly in contexts involving adaptive testing models. Without transparent mechanisms for data quality control, the educational credibility of such systems may be significantly undermined**.**

Another critical issue is resistance to emerging technologies, which can stem from user unfamiliarity, previous negative experiences, or broader cultural hesitancies toward digital innovation. In this regard, instructors play a pivotal role in fostering a culture of acceptance and guiding the effective integration of AI tools into learning environments**.**

Finally, the absence of robust theoretical frameworks presents a major barrier to the systematic design and evaluation of intelligent educational systems. Without models such as the Unified Theory of Acceptance and Use of Technology (UTAUT) (44) or self-regulated learning frameworks (42), the implementation of AI risks remaining superficial and disconnected from deeper pedagogical principles(Table 5).

Discussion

The findings of this systematic review indicate that artificial intelligence (AI), as an emerging approach in medical education, has attracted increasing attention, particularly in the context of facilitating personalized learning. However, critical appraisal of the existing literature demonstrates that the outcomes and effectiveness of AI in this domain are significantly influenced by several variables, including implementation conditions, educational structures, and learner-specific factors. Accordingly, it is not feasible to assume uniform or definitive effectiveness of AI across all educational contexts.

For example, although AI is frequently depicted as a neutral and efficient tool in the literature, empirical evidence challenges this assumption. The study by Kung et al. (2023) found that while automated feedback systems may hold promise for clinical training, they often lack the nuanced understanding required for complex clinical decision-making, and in some cases, may even foster ineffective or misguided learning strategies (45). This finding contrasts with optimistic perspectives that portray AI as inherently flawless and precise, and highlights the necessity for qualitative evaluation of AI feedback and its alignment with real-world educational contexts.

Similarly, the study by Georgieva et al. (2023) confirmed the added value of AI-based simulations in strengthening students' procedural confidence but revealed a critical limitation: such systems, contrary to expectations, are less effective in developing essential "soft skills" such as effective communication and ethical judgment (46). This not only exposes the weaknesses of current AI systems but also underscores the tension between technical capabilities (e.g., rapid, data-driven feedback) and human-centered educational imperatives (such as interpersonal and ethical competencies). As such, the exclusive reliance on intelligent tools is insufficient for comprehensively enhancing clinical competencies compared to traditional or blended educational approaches.

Despite the considerable potential of AI for content personalization and resource recommendation, the relative inability of AI systems to accurately interpret nuanced individual learner differences remains a challenge. Sarkar et al. (2024) demonstrated that learners with lower levels of digital literacy received less adaptive or personalized content recommendations (47); this contradicts claims that AI inherently promotes educational equity and suggests that without consideration for learners' individual prerequisites, pre-existing inequalities may even be exacerbated.

With respect to user-related barriers, contrary to the prevailing notion that resistance is merely a psychological issue or solely the result of insufficient training, a more nuanced analysis by Ali (2022) indicates that AI acceptance is shaped by a complex interplay of digital literacy, institutional trust, and perceived usefulness of the technology (9). Therefore, in contrast to research that frames technical training as sufficient for user acceptance, Ali's findings emphasize the necessity of structural, institutional, and multi-dimensional approaches to address resistance to AI adoption.

Another notable gap identified in the literature—also highlighted in this review—is the predominant focus of most studies on undergraduate medical education, with less attention paid to the role of AI in specialized and continuing education. While most research centers on general medical students, Charow et al. (2021), as a key exception, illustrate the potential of AI in advancing professional development for healthcare providers, emphasizing that realizing this potential depends on identifying and addressing fundamental infrastructural and cultural barrier (7).This perspective is notably distinct from the majority of studies, which either overlook these aspects or focus solely on technical obstacles.

Finally, the lack of robust theoretical and conceptual frameworks, such as Self-Regulated Learning (SRL) models or the Unified Theory of Acceptance and Use of Technology (UTAUT), stands out as a significant barrier to the systematic development and evaluation of AI interventions. As demonstrated by Chun et al. (2022), interventions grounded in theoretical frameworks are more effective in promoting learner autonomy and reflective learning (42). This stands in contrast to studies lacking such frameworks, which often yield less generalizable or less impactful results.

Overall, while the current literature highlights the high potential of AI in medical education, comparative and critical analysis indicates that successful implementation and realization of its benefits depend on learner-centered design, the quality of training data, intelligent integration with human educators, and the establishment of explicit theoretical foundations.

This study is subject to several limitations. First, the scope of the literature search and access to resources was limited; although comprehensive searches were conducted across four major databases, the exclusion of some sources and the lack of access to the full text of certain articles may have resulted in the omission of potentially relevant evidence. Second, conceptual and definitional heterogeneity among the included studies complicated direct comparison and generalizability of findings. Third, while quality assessments and risk of bias evaluations were executed independently and rigorously, the complete elimination of publication or selection bias cannot be guaranteed. Finally, most of the studies included in this review focused on short-term interventions or academic settings, with insufficient evidence available from real-world or long-term educational contexts.

Conclusion

Artificial intelligence holds considerable potential to improve the quality and personalization of medical education, yet challenges related to ethics, costs, and access continue to limit its comprehensive implementation. The results of this review underscore that optimal use of AI requires attention to evidence-based policies, adequate infrastructure, and frameworks that address algorithmic bias and educational equity.

In line with the findings and limitations of this study, it is suggested that future research focus on:

- Longitudinal evaluations of AI's impact in practical, real-world medical education settings;
- The development and validation of context-appropriate theoretical models for analyzing AI integration in diverse educational environments;
- Examination of strategies that may reduce digital inequities and expand access to AI-based learning tools;
- Further investigation of ethical aspects, including privacy and algorithm transparency;
- Comprehensive assessment of user experience and acceptance among students and educators, with consideration for cultural and institutional differences.

Such research directions may contribute to a more responsible and effective use of AI in medical education.

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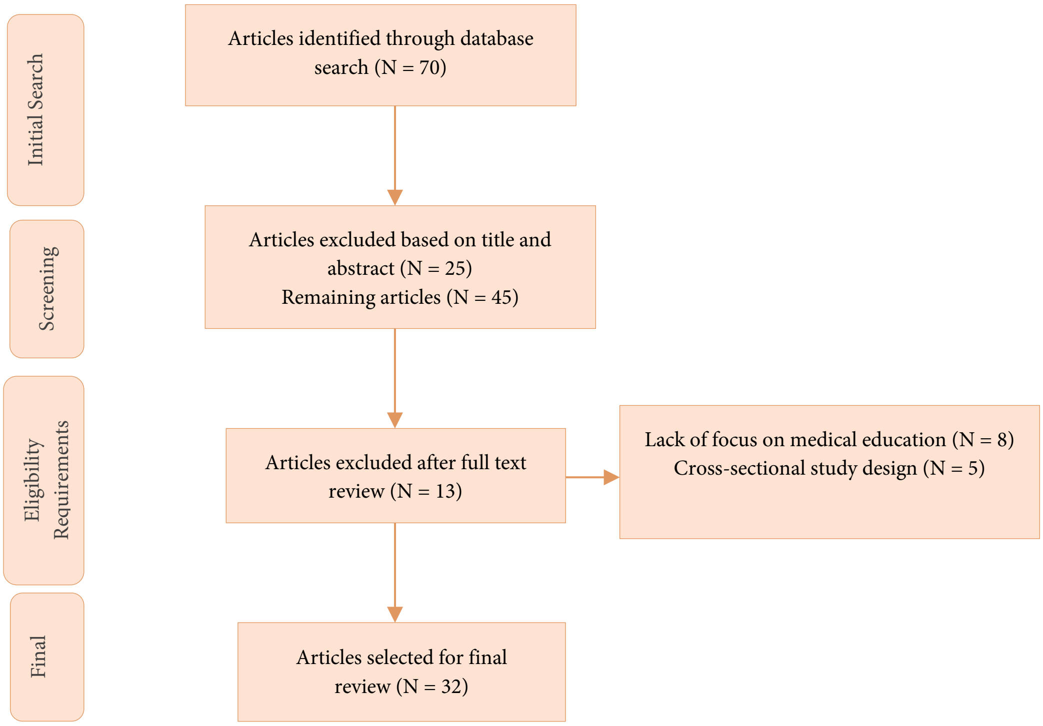

Figure 1. Study Stages Diagram

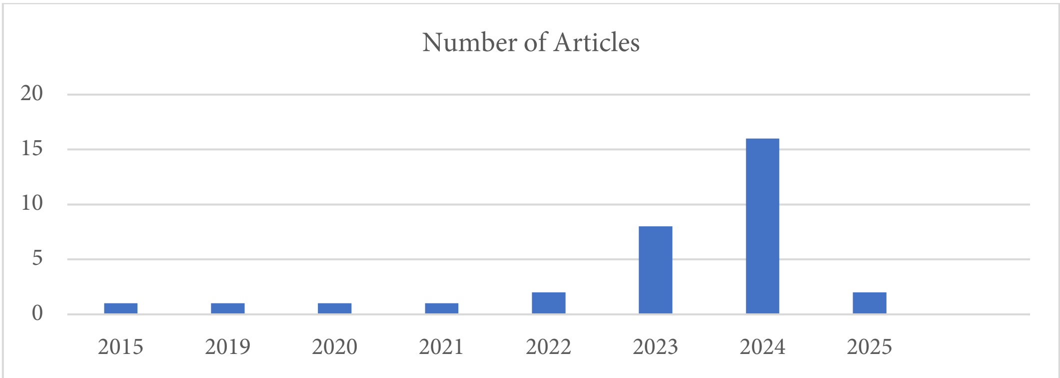

Figure 2. Annual Distribution of Included Articles

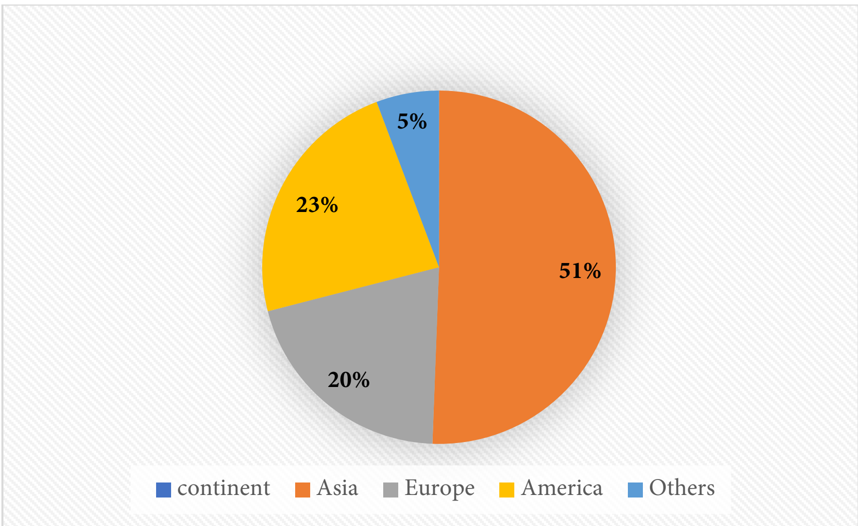

Figure 3. Geographical Origins of Included Studies

Table 1. Summary of Included Studies on AI Applications in Personalized Medical Education

Author and Year	Title	Key Concept of Research	Applications Used	Research Results
Rabie et al. (2023) (11)	The Role of Artificial Intelligence and Personalized Education in Medical Curriculum	Feedback	AI-based performance monitoring	Improved clinical feedback and learner awareness; noted low-quality feedback and inconsistent implementation.
Sriram et al. (2025) (12)	Artificial Intelligence in Medical Education: Transforming Learning, Personalized Training, and Assessment	Real-time Feedback	Immediate assessment support	Enhanced learner engagement; no specific limitations mentioned.
Almansour et al. (2024) (13)	Generative Artificial Intelligence and the Personalization of Health Professional Education	Adaptive Learning; Personalized learning paths	Generative AI for customized content creation; adaptive learning algorithms; AI-based learner guidance systems	Increased retention, autonomy, and learner motivation; improved access to educational resources; challenges include high infrastructure cost, data privacy concerns, algorithmic bias risk, content validation issues, and faculty training needs
Santhosh et al (2024) (14)	Integration of Machine Learning and Deep Learning in Medical and Healthcare Education	Assessment	Simulation and decision-making support	Improved diagnostic accuracy, enhanced clinical decision-making skills; adoption inconsistent across institutions; challenges include infrastructure variability and faculty expertise gaps.
Ezzaim et al. (2023) (15)	AI-Based Learning Style Detection in Adaptive Learning Systems	AI-driven automatic learning style detection	Application of Decision Trees and Artificial Neural Networks for learning style detection (Felder–Silverman model)	Improved learning adaptation; prevalent Felder–Silverman model; challenges with learner self-awareness and traditional methods
Ruberto et al. (2021) (16)	The future of simulation-based medical education: Adaptive simulation utilizing a deep multitask neural network	Adaptive AI-driven simulation with real-time virtual patient adjustments	Virtual patient models	Enhanced experiential learning; high cost and technical limitations reported.
Denny et al (2015) (17)	Using Natural Language Processing to Provide Personalized Learning Opportunities	AI-powered self-regulated learning	NLP tools to analyze trainee clinical notes and identify competencies & learning gaps	Supported self-directed study; high accuracy in competency detection; learner engagement and motivation varied
Halkiopoulos et al. (2024) (18)	Leveraging AI in e-learning: Personalized learning and adaptive assessment through cognitive neuropsychology—A systematic analysis	Recommendation	Educational content matching system adapting learning materials to learner's cognitive level	Matched learners' levels; redundancy and misalignment occasionally noted.
Bhutoria et al(2022) (19)	Personalized Education and Artificial Intelligence in the United States, China, and India: A Systematic Review Using a Human-in-the-Loop Model	Analytics	Behavioral tracking	Improved time management; data interpretation complexity noted.

Sanati et al. (2024) (20)	Developing an AI-Based Platform for Personalized Learning in Neurology Education for Medical Students	Clinical Reasoning	AI-assisted diagnostic support in neurology	Improved diagnostic accuracy and speed; highlighted need for standardized, high-quality neurological data.
Triola et al. (2023) (21)	Precision Medical Education	Ethics & Data-Driven Personalization	Longitudinal learning analytics and AI-assisted monitoring for equity, transparency, and ethical compliance	Defined PME framework; highlighted need for robust ethical guidelines, data governance, and institutional policy development
Duong et al. (2019) (22)	Artificial intelligence for precision education in radiology. The British journal of radiology	Vision & AI-Enhanced Learning	AI-driven adaptive learning systems for radiology training, image analysis, and personalized feedback	Potential to personalize radiology education; highlighted need for high-quality, accessible datasets; discussed challenges in AI implementation and trainee buy-in.
Rane et al. (2023) (23)	Education 4.0 and 5.0: Integrating artificial intelligence (AI) for personalized and adaptive learning	Customization	Topic-based AI personalization, adaptive learning pathways, and real-time feedback tools	Improved learning personalization and balanced workload; noted requirements for robust infrastructure, teacher readiness, and quality training datasets.
Thompson et al. (2023) (24)	Artificial Intelligence Use in Medical Education: Best Practices and Future Directions	Best practices	AI in exam prep, surgical training feedback, and academic writing support	Enhanced access and personalization; highlighted ethical risks and need for regulation.
Deng et al. (2024) (25)	Strategies for Optimizing Personalized Learning Pathways with Artificial Intelligence Assistance	Adaptive learning	AI-driven patient simulations with real-time feedback	Improved personalization and clinical decision practice; noted high infrastructure requirements.
Naseer et al. (2024) (26)	Integrating deep learning techniques for personalized learning pathways in higher education	Engagement	AI-powered monitoring dashboards	Higher engagement linked to retention; highlighted privacy and data security concerns
Chowdhury et al. (2024) (27)	Medical Education Technology: Past, Present, and Future	EdTech evolution	AI-assisted adaptive learning, simulation tools, and digital assessment platforms	Improved access, engagement, and skill acquisition; personalization limited in niche or specialized subjects.
Sajja et al. (2024) (28)	Artificial Intelligence-Enabled Intelligent Assistant for Personalized Learning	Assessment	Dynamic AI-generated formative quizzes	Improved feedback accuracy and learning alignment; emphasized need for rigorous content validation.
Saxena et al. (2023) (29)	Precision, Personalization, and Progress in Medical Education	Translation	AI-based multilingual support systems	Improved accessibility; noted inconsistencies in translating medical terminology.
Nikhil et al. (2025) (30)	A Comprehensive Study on AI-Enhanced Personalized Learning in STEM Courses	Cognitive load	AI-sequenced learning modules	Reduced learner burden and improved stepwise progress; faculty resistance due to retraining needs.
Murtaza et al. (2022) (31)	AI-Based Personalized E-Learning Systems: Issues, Challenges, and Solutions	Feedback	Learner modeling, adaptive assessments, and targeted feedback modules	Improved engagement, retention, and course completion; noted feedback delays, high implementation costs, and privacy concerns.

Gupta al. (2020) (32)	Use of an Adaptive E-Learning Platform as a Formative Assessment Tool in the Cardiovascular System Course Component of an MBBS Program	Adaptive learning	AI-driven adaptive e-learning platform with personalized quizzes and feedback	Improved student engagement and knowledge retention; significant gains on post-test scores compared to baseline; students reported positive perceptions of personalization and feedback accuracy.
Castellano et al. (2024) (33)	Empowering Human Anatomy Education Through Gamification and AI	Gamification + AI-assisted adaptive feedback	Gamified learning platform with AI-based progress tracking and interactive quizzes	Higher course completion rates, improved post-test knowledge and spatial understanding; some students perceived gamification as superficial or time-consuming
Xie et al. (2024) (34)	Investigating the impact of innovative AI chatbot on post-pandemic medical education and clinical assistance: a comprehensive analysis	AI chatbot for clinical & educational support	Intelligent Q&A, clinical case role-play, rapid resource retrieval	Better access to content, improved clinical problem-solving; issues with complex queries
Riedel et al. (2023) (35)	ChatGPT's performance in German OB/GYN exams–paving the way for AI-enhanced medical education and clinical practice	AI performance evaluation	Answering OB/GYN exam questions	Moderate accuracy; good on simple theory, weaker on complex/local guideline items
Ahmed et al. (2023) (36)	Utilization of ChatGPT in medical education: applications and implications for curriculum enhancement	Curriculum enhancement	Content generation, exam question creation, clinical role-play	Greater learner satisfaction, faster content prep; accuracy and ethics concerns
Xu et al. (2024) (37)	Opportunities, Challenges, and Future Directions of Large Language Models in Education	LLM potential & challenges	Content generation, Q&A, clinical dialogue simulation	Faster content access, supports self-directed learning; accuracy, privacy, oversight issues
Wu et al. (2024) (38)	Embracing ChatGPT for medical education: exploring its impact on doctors and medical students	AI-powered medical learning	Simulated clinical dialogues, intelligent tutoring, PBL/TBL integration, automated Q&A	Enhanced clinical reasoning, decision-making, and content accessibility; ethical/data privacy concerns, need for balance with human interaction
Rani et al. (2024) (39)	Perception of Medical Students and Faculty Regarding the Use of Artificial Intelligence (AI) in Medical Education: A Cross-Sectional Study.	User perceptions of AI-driven personalization	Adaptive simulations, AI-based adaptive assessment, chatbot content delivery	High acceptance; better personalization & engagement; concerns on privacy, accuracy, over-reliance
Thompson et al. (2025) (24)	Artificial Intelligence Use in Medical Education: Best Practices and Future Directions	Personalized learning	AI-based weakness detection, adaptive quizzes, targeted resources	+18% mastery, faster remediation; risks: dependency, privacy issues
Domrös et al. (2024) (40)	Medical Education: Considerations for a Successful Integration of Learning with and learning about AI	Human–AI feedback integration	AI-assisted oral feedback in OSCE and communication training	Improved verbal performance feedback and learner self-reflection; limitations included reduced perceived personal interaction and need for instructor mediation
As' ad et al. (2024) (41)	Generative Artificial Intelligence (AI), and Healthcare Agents: A Proof of Concept and Dual-Layer Approach	Intelligent tutoring; generative AI agents	Dual-layer AI system for adaptive clinical tutoring and conversational support	Feasibility shown for personalized content delivery, higher engagement; challenges include data privacy, integration complexity, need for validation

Table 2. The Role of Artificial Intelligence in Personalized Learning

Thematic Domain	Specific Application	Description and Educational Role	Challenges/Limitations	Reference(s)
Adaptive Learning	Personalized Learning Pathways	Customizing educational content based on individual learning style, pace, and needs.	Requires complex, data-driven adaptive algorithms.	Almansour et al. (2024), Ruberto et al. (2021), Sanati et al. (2024), Deng et al. (2024), Gupta et al. (2020)
Performance Analytics	Real-time Feedback & Performance Analysis	Immediate feedback based on student performance to support adaptive instruction.	Quality may vary; difficulty detecting conceptual misunderstandings.	Rabie et al. (2023), Sriram et al. (2025), Domrös et al. (2024)
Resource Recommendation	Targeted Content Suggestions	AI-powered recommendation of articles, videos, and materials tailored to progress.	Risk of redundancy or misaligned resources.	Halkiopoulos et al. (2024), Xu et al. (2024) kiopoulos et al. (2024), Xu et al. (2024)
Behavioral & Cognitive Analysis	Learning Interaction Tracking	Monitoring engagement patterns to optimize instructional design.	Requires advanced behavior analytics and interpretation.	Bhutoria et al. (2022), Saxena et al. (2023)
Decision Support	Learner Guidance Systems	Assisting students in selecting next steps or learning goals based on data.	Recommendations can be mechanical and context-insensitive.	Almansour et al. (2024), Sanati et al. (2024), Sajja et al. (2024)
Learning Gap Detection	Strengths & Weaknesses Identification	Detecting content areas where students need reinforcement.	Potential inaccuracy when data is incomplete or biased.	Thompson et al. (2025), Naseer et al. (2024)
Self-Regulated Learning	Independent Learning Support	Guiding learners to manage their own educational goals and processes.	Limited motivation and interaction in fully automated systems.	Denny et al. (2015), Murtaza et al. (2022)
AI-Driven Assessment	Personalized Testing	Generating quizzes aligned with students' progress and needs.	Infrastructural barriers in traditional, paper-based testing environments.	Santhosh et al. (2024), Sajja et al. (2024)
Experiential Simulation	AI-Based Clinical Simulations	Simulating clinical scenarios using AI and VR to build practical skills.	Costly infrastructure; challenges in real-world skill transfer.	Ruberto et al. (2021), Chowdhury et al. (2024), Castellano et al. (2024)

Table 3. Comparative Roles of Human and AI Educators in Personalized Medical Education

Role	Human Educator	AI Educator	Studies
Emotional Interaction	Provides empathy, value-driven guidance	Focuses on analytical and adaptive feedback	Deng et al. (2024), Ruberto et al. (2021)
Curriculum Development	Designs flexible, student-focused curricula	Tailors learning paths based on detailed data analysis	Almansour et al. (2024), Ezzaim et al. (2023)
Feedback Mechanism	Offers qualitative, experience-based feedback	Provides instant, precise, and data-driven feedback	Rabie et al. (2023), Domrös et al. (2024)
Learning Focus	Prioritizes broader educational objectives and mentoring	Optimizes micro-learning and personalization	Triola et al. (2023), Saxena et al. (2023)
Decision Support	Supports nuanced, context-driven decisions in learning	Provides algorithm-based, data-driven suggestions for improvement	Almansour et al. (2024), Sajja et al. (2024)

Table 4. Overview of current applications of artificial intelligence in medical education identified

Focus and Advantages of Use	Supporting Studies	Key Findings
	Curriculum	
Comprehensive Curriculum Analysis	Deng et al. (2024); Triola et al. (2023); Ruberto et al. (2021); Ezzaim et al. (2023)	Improved curriculum alignment, integration of competencies, early risk detection, and gap identification.
	Learning	
Customization of Content to Individual Needs	Rabie et al. (2023); Deng et al. (2024); Ahmed et al. (2023); Almansour et al. (2024); Ezzaim et al. (2023); Triola et al. (2023)	Adaptive content tailoring, personalized pathways, targeted feedback, and topic relevance improvement.
Development of Adaptive Simulation Environments	Ruberto et al. (2021); Deng et al. (2024); Triola et al. (2023); Ahmed et al. (2023); Chowdhury et al. (2024)	Real-time case adjustments, enriched scenario diversity, and improved interactive learning.
Patient Safety	Saxena et al. (2023); Deng et al. (2024); Triola et al. (2023)	Better diagnostic accuracy, reduced errors via multilingual support, and early identification of high-risk situations.
Reduced Need for Direct Faculty Supervision	Ruberto et al. (2021); Ahmed et al. (2023); Saxena et al. (2023)	Lower instructor workload through automated feedback, content generation, and translation support.
	Evaluation	
Adaptive Feedback Systems	Rabie et al. (2023); Murtaza et al. (2022); Sajja et al. (2024); Domrös et al. (2024)	Personalized, targeted, and real-time feedback improving engagement and self-reflection.
Feedback Quality Enhancement	Ruberto et al. (2021); Saxena et al. (2023); Deng et al. (2024)	Increased clarity, precision, and speed of feedback
Cost Reduction	Ahmed et al. (2023); Deng et al. (2024); Ruberto et al. (2021); Saxena et al. (2023)	Savings from automated content, reusable simulations, and reduced translation/training costs.

Table 5. Challenges of Using Artificial Intelligence in Personalized Learning

Key Aspect	Definition	Supporting Studies
Technical Challenges	Implementation of AI-based personalized systems demands significant financial investment, technical infrastructure, and interdisciplinary expertise.	Ruberto et al. (2021); Triola et al. (2023); Ezzaim et al. (2023)
Security and Privacy	Protecting personal data and ensuring compliance with privacy regulations are essential to building trust in AI-driven systems.	Alsharif et al. (2022); Deng et al. (2024)
Incomplete or Inaccurate Data	Low-quality data, poor generalizations, or biased training sets may result in ineffective learning recommendations.	Rabie et al. (2023); Ahmed et al. (2023)
Resistance to Emerging Technologies	User skepticism, lack of familiarity, and low digital literacy may hinder the adoption of AI-based tools in education.	Johnson & Lee (2022); Saxena et al. (2023)
Risks in AI-Based Assessment	Errors in adaptive testing systems or flawed feedback mechanisms may negatively affect student performance.	Chen et al. (2022); Triola et al. (2023)
Diversity in Learning Styles	AI systems struggle to account for varied and evolving learning styles, requiring continuous model refinement.	Deng et al. (2024); Ahmed et al. (2023)