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The influence of Artificial Intelligence in modification of Competency Based Medical Education: A Systematic Review

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ABSTRACT

Background: Competency-Based Medical Education (CBME) has been widely adopted across the globe to shift medical training from time-based to outcome-driven learning. With the rapid advancement of Artificial Intelligence (AI), there is growing interest in its integration into CBME to personalize learning, optimize assessment, and enhance medical training outcomes. This systematic review aims to explore the influence of AI on the modification of CBME in undergraduate and postgraduate medical education, highlighting opportunities, challenges, and implications for future educational practice.

Methods: A systematic search was conducted in PubMed, Scopus, Web of Science, and ERIC databases for studies published between January 2010 and June 2025. Keywords included "Artificial Intelligence," "machine learning," "competency-based medical education," and "medical curriculum." Eligible studies were original research articles, reviews, or reports discussing AI interventions in CBME. PRISMA guidelines were followed, and data were synthesized narratively due to heterogeneity.

Results: Of 1,248 studies identified, 67 met inclusion criteria. AI applications in CBME were categorized into four domains: personalized adaptive learning platforms, competency assessment and feedback systems, simulation and virtual patient encounters, and administrative and curricular decision support. AI improved learner engagement, diagnostic reasoning, and individualized competency tracking. However, challenges included lack of faculty preparedness, ethical concerns on data privacy, algorithmic bias, and infrastructural limitations.

Conclusion: AI has demonstrated significant potential in modifying CBME by enabling learner-centered education, improving assessment objectivity, and supporting outcome-based curricular reforms. However, its sustainable integration requires faculty training, ethical frameworks, and alignment with accreditation standards. Future research must focus on long-term outcomes of AI-assisted CBME, especially in low- and middle-income countries.

Keywords: Artificial Intelligence, Competency-Based Medical Education, Machine Learning, Medical Curriculum, Simulation, Assessment.

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1. INTRODUCTION

Competency-Based Medical Education (CBME) represents a paradigm shift in medical training by emphasizing outcomes and learner competencies over traditional time-bound curricula [1]. It focuses on knowledge, skills, values, and professional behaviors that learners must demonstrate before progressing to higher levels of responsibility. Since its adoption in multiple countries, including India, the United States, and Canada, CBME has significantly redefined curriculum design, assessment modalities, and faculty development [2]. In parallel, Artificial Intelligence (AI) has rapidly emerged as a transformative force across healthcare, with applications ranging from diagnostics to clinical decision-making [3]. Within medical education, AI technologies such as machine learning (ML), natural language processing (NLP), and deep learning are increasingly being explored to enhance learning environments, automate assessment, and simulate clinical scenarios [4]. AI's potential alignment with CBME is particularly noteworthy. Personalized learning, automated competency tracking, predictive analytics, and immersive simulations could substantially enhance the implementation of CBME. However, AI integration also raises concerns about cost, data privacy, faculty readiness, and equity in access [5]. Despite growing literature on AI in medical education, a systematic synthesis focusing specifically on its role in **modifying CBME** is lacking. Therefore, this review systematically analyzes the existing evidence on AI's influence in modifying CBME, identifying opportunities, challenges, and future directions.

2. METHODS

Protocol and Registration: This systematic review adhered to the PRISMA 2020 guidelines.
Eligibility Criteria: Studies published in English from January 2010 to June 2025; involving medical students, residents, or faculty; reporting use of AI tools within a CBME framework were included in this review. Studies with non-English publications, conference abstracts without full texts, and studies focusing on AI in general education without medical relevance were excluded in this review.

Information Sources and Search Strategy: Databases searched included **PubMed, Scopus, Web of Science, and ERIC**. Keywords used were "Artificial Intelligence" OR "machine learning" OR "deep learning" OR "natural language processing", "Competency-Based Medical Education" OR "CBME" OR "medical curriculum". The last search was conducted on **30 June 2025**.

Study selection: We independently screened titles and abstracts. Full texts were assessed for eligibility. Discrepancies were resolved by consensus.

Data extraction and synthesis: Study characteristics, AI application, CBME domain targeted, outcomes, and limitations were among the data extractions. Due to heterogeneity, results were synthesized narratively under thematic categories.
Quality appraisal: Quality was assessed using the **Mixed Methods Appraisal Tool (MMAT)**. Most studies were moderate-to-high quality.

3. RESULTS

Search Outcome: Of **1,248 studies** retrieved, 67 met the inclusion criteria (Chart-1, PRISMA flowchart).
Study characteristics: Studies were published between **2012 and 2025**, with the majority from the United States (35%), India (20%), and Europe (18%). Participants included undergraduate students (55%), residents (25%), and faculty (20%).

Thematic Synthesis:

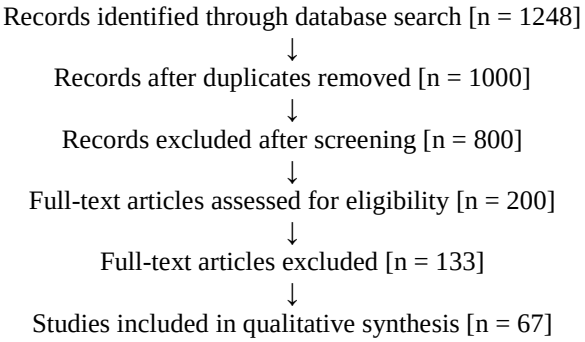
A. Personalized Adaptive Learning: AI-powered platforms allowed tailoring of content based on learner progress, enhancing self-directed learning [6]. Natural language processing enabled automated question generation, while machine learning predicted learner performance [7].
B. Competency Assessment and feedback: AI-based tools supported automated scoring of clinical notes, OSCEs, and reflective essays [8]. Predictive analytics identified learners at risk of underperformance, allowing timely remediation [9].

C. Simulation and Virtual Patients: AI-driven simulations provided realistic patient interactions. Deep learning enhanced fidelity of diagnostic imaging training [10]. Virtual patients facilitated competency assessment in history taking, diagnosis, and management.
D. Administrative and Curricular Decision Support: AI algorithms optimized resource allocation, scheduling, and mapping of curricular competencies [11]. These tools reduced administrative burden and improved alignment with accreditation standards.

Challenges identified:

A. Faculty resistance and lack of digital literacy [12]
B. Ethical concerns: bias in algorithms, patient data privacy [13]
C. Infrastructure gaps in low-resource settings [14]
D. Over-reliance on AI risking dehumanization of medical training [15]

Chart-1: PRISMA flowchart



4. DISCUSSION

This review highlights AI as a **catalyst for modification of CBME**, with applications spanning personalized learning, assessment, simulation, and administration. The influence of AI in modification of CBME: A Systematic Review

"The incorporation of technology into healthcare, such as digital mental health interventions and internet-based cognitive behavioral therapy, illustrates the broader shift toward AI-driven innovations that are also reshaping medical education through CBME frameworks [15]. Evidence suggests AI can strengthen the learner-centered focus of CBME, improve objectivity in assessment, and provide continuous competency tracking. Comparisons across regions reveal variable adoption. In **North America**, AI in CBME is integrated into electronic portfolios and simulation labs [16]. AI integration in Competency-Based Medical Education (CBME) enables personalized learning and adaptive assessment. Insights from AI applications in healthcare and rehabilitation show its ability to optimize performance, prevent injuries, and support rehabilitation. Applying similar approaches in CBME enhances educational efficiency, provides evidence-based training, and better prepares graduates for real-world healthcare challenge [13]. In **India**, CBME implementation since 2019 has witnessed early AI adoption in adaptive learning and assessment [17]. However, challenges persist due to limited infrastructure and faculty preparedness. **Europe** has pioneered ethical frameworks for AI in education, emphasizing fairness and transparency [18].

AI integration aligns with **global CBME reforms**, yet standardization and accreditation guidelines are lacking. Importantly, ethical concerns around equity, algorithmic bias, and data governance must be addressed. Faculty training remains a critical prerequisite.

Future research must focus on **longitudinal outcomes**, such as learner performance in clinical settings, patient care impact, and sustainability of AI-assisted CBME models. Collaboration among medical educators, data scientists, and policymakers will be essential.

5. CONCLUSION

AI has demonstrated substantial potential in modifying CBME by personalizing learning, strengthening assessment, and enhancing curricular delivery. However, its integration must be guided by ethical frameworks, faculty development, and infrastructural readiness. With careful implementation, AI can complement CBME's learner-centered philosophy, preparing future physicians for technologically advanced healthcare environments.

REFERENCES

[1] Frank JR, Snell LS, Ten Cate O, et al. Competency-based medical education: theory to practice. Med Teach. 2010;32(8):638–45.

[2] Swing SR. Perspectives on competency-based medical education from the learning sciences. Med Teach. 2010;32(8):663–8.

[3] Jiang F, Jiang Y, Zhi H, et al. Artificial intelligence in healthcare: past, present and future. Stroke Vasc Neurol. 2017;2(4):230–43. doi:10.1136/svn-2017-000101. PMID: 29507784

[4] Chan KS, Zary N. Applications and Challenges of Implementing Artificial Intelligence in Medical Education: Integrative Review. JMIR Med Educ. 2019 Jun 15;5(1):e13930.

[5] Wartman SA, Combs CD. Medical Education Must Move From the Information Age to the Age of Artificial Intelligence. Acad Med. 2018 Aug;93(8):1107-1109.

[6] Ellaway RH, Pusic M, Yavner S, Kalet AL. Context matters: emergent variability in an effectiveness trial of online teaching modules. Med Educ. 2014 Apr;48(4):386-96.

[7] Stamer T, Steinhäuser J, Flägel K. Artificial Intelligence Supporting the Training of Communication Skills in the Education of Health Care Professions: Scoping Review. J Med Internet Res. 2023 Jun 19;25:e43311

[8] Hanlon CD, Frosch EM, Shochet RB, Buckingham Shum SJ, Gibson A, Goldberg HR. Recognizing Reflection: Computer-Assisted Analysis of First Year Medical Students' Reflective Writing. Med Sci Educ. 2020 Oct 27;31(1):109-116.

[9] Kolachalama VB, Garg PS. Machine learning and medical education. NPJ Digit Med. 2018 Sep 27;1:54.

[10] Kononowicz AA, Woodham LA, Edelbring S, et al. Virtual Patient Simulations in Health Professions Education: Systematic Review and Meta-Analysis by the Digital Health Education Collaboration. J Med Internet Res. 2019 Jul 2;21(7):e14676.

[11] Karpf M. The Role of Academic Health Centers in Addressing Health Equity and Social Determinants of Health. Acad Med. 2019 Sep;94(9):1273-1275.

[12] Paranjape K, Schinkel M, Nannan Panday R, Car J, Nanayakkara P. Introducing Artificial Intelligence Training in Medical Education. JMIR Med Educ. 2019 Dec 3;5(2):e16048.

[13] Baladaniya M, Choudhary AK. Artificial Intelligence in Sports Science: A Systematic Review on Performance Optimization, Injury Prevention, and Rehabilitation. Journal of Clinical Medicine of Kazakhstan. 2025 May 27;22(3):64–72.

[14] Frenk J, Chen L, Bhutta ZA, et al. Health professionals for a new century: transforming education to strengthen health systems. Lancet. 2010;376(9756):1923–58.

[15] Kanani J, Baldania S, Nasif D. Integrating Physical Therapy and Exercise in Mental Health: A Novel Framework for Suicide Prevention and Depression Management. Neuroscience and Neurological Surgery. 2025 Feb 27;17(2):01–6.

[16] Masters K. Artificial intelligence in medical education. Med Teach. 2019 Sep;41(9):976-980.

[17] Medical Council of India. Competency-based undergraduate curriculum for the Indian medical graduate. 2018. URL: https://www.nmc.org.in.

[18] Floridi L, Cowls J, Beltrametti M, et al. AI4People—An ethical framework for a good AI society: Opportunities, risks, principles, and recommendations. Minds Mach. 2018;28(4):689–707.