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# PROMISES AND PERILS OF ARTIFICIAL INTELLIGENCE IN BASIC SCIENCES MEDICAL EDUCATION

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**ABSTRACT: Background:** Within the realm of artificial intelligence, a notably prominent large language model is ChatGPT, which is employed in the domain of medical education to address challenges associated with teaching, learning and assessment. These models have been utilized in various capacities such as the creation of clinical scenarios, the generation of multiple-choice questions, and the facilitation of research endeavors etc. **Objective:** The aim of this study is to conduct a comprehensive review of ChatGPT capabilities and to analyze the advantages, limitations, existing methodologies and future implications of implementing artificial intelligence within the realm of medical education. **Methodology:** A thorough review of the literature was executed by utilizing databases such as PubMed, Scopus, Web of Science and Google Scholar. The search terms employed included ChatGPT, Artificial Intelligence, Chatbot, Medical Education and large language models. **Results:** The utilization of ChatGPT in the context of medical education presents numerous benefits including an augmented quality of interaction between students and patients, enhanced educational outcomes, increased research opportunities, personalized learning experiences, virtual patient simulations. Nevertheless, there exist significant challenges including ethical and transparency issues, restricted access to dependable databases, limited availability of information post-2021 and insufficient development of critical thinking skills. **Conclusion:** Artificial intelligence has the potential to improve medical education by supporting personalized learning, assessment, and teaching efficiency. At the same time, the use of AI raises important concerns, including data privacy, bias, unequal access, and overdependence on technology. Addressing these challenges through ethical guidelines, faculty training, and ongoing evaluation is essential. AI should be used as a supportive tool not a replacement for human educators to ensure safe, fair and effective medical education.

**INTRODUCTION:** Artificial intelligence (AI), a branch of computer science enables machines to perform tasks that typically require human intelligence.

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A key application of AI is natural language processing (NLP), which underpins conversational AI models such as ChatGPT (Generative Pretrained Transformer). Launched on November 30, 2022 ChatGPT can understand and generate human-like text, interact in multiple languages and respond to follow-up queries thus rapidly gain over 100 million users by January 2023. The pervasive adoption of AI across fields such as finance, engineering, and entertainment has highlighted its potential utility in medical education. ChatGPT offers several applications in this domain including

supporting conversational tasks, clinical scenario design, assessment, small-group learning, personalized education and curriculum development [1]. Its ability to provide instant, context aware responses and summarize large volumes of information makes it particularly suitable as a complementary tool for teaching and learning in medical settings. However ChatGPT has inherent limitations including restricted reasoning ability, dependence on training data, privacy and security concerns and lack of emotional and professional judgment. Given the increasing integration of AI in medical education, this review examines the current utilization of ChatGPT, its benefits and challenges, prospective strategies for optimization and future implications for teaching and learning in the medical field.

**METHODS:** A comprehensive literature search was conducted across PubMed, Scopus, Web of Science and Google Scholar to identify articles on large language models (LLMs), ChatGPT and other chatbots in medical education including their applications, benefits, challenges and advancements. The search used keywords such as ChatGPT, chatbot, artificial intelligence, medical education and LLMs. Two authors independently screened titles and abstracts with a third author resolving any discrepancies through discussion. Irrelevant studies were excluded and the full texts of relevant articles were systematically reviewed, summarized and critically analyzed.

**RESULTS:**

**Learning Anatomy in the Era of Technology:** The evolution of technology enabled the anatomy education to shift from static visualization towards interactive learning, with each modality offering distinct pedagogical strengths and limitations. Three-dimensional interactive anatomy platforms such as Primal Pictures and Netter's Interactive 3D Anatomy enhance visual spatial understanding through layered and rotational views supporting self-directed learning however, their screen based nature and lack of tactile engagement limit their ability to replicate dissection based experiences [2, 3]. Three-dimensional printing represents a transition from visual to tactile anatomy learning by enabling physical interaction and repeated handling without ethical constraints. These models are particularly useful for illustrating complex or minute structures, yet their limited experience in tissue texture and inability to demonstrate dynamic relationships restrict their role to that of an adjunct rather than substitutes for cadaveric dissection [4-7]. Digital dissection platforms notably the Anatomage table bridge traditional and virtual anatomy by allowing layered exploration of real human datasets with higher anatomical realism. Although these systems improve student motivation and understanding but their lack of tactile feedback and high cost and maintainence limits its widespread adoption and equivalence to conventional dissection [8-10].

VR (Virtual Reality) and AR (Augmented Reality) technologies provide engaging, multi-angle visualization of complex spatial relationships, enhancing engagement and experiential learning. However, their educational effectiveness remains difficult to establish due to limited randomized controlled trials, variable outcome measures and challenges related to cognitive load and infrastructure [11-14]. Collectively these technologies are best viewed as complementary components of an integrated anatomy curriculum, where their optimal use depends on alignment with learning objectives, learner level and institutional resources rather than reliance on any single modality.

**How Traditional Method of Teaching Different from New Curriculum:** The National Medical Commission (NMC) established under the National Medical Commission Act of 2019, replaced the Medical Council of India with the objective of improving access to quality and affordable medical education [15]. Despite the expansion to over 500 medical colleges and nearly 83,000 medical graduates annually, India's physician-to-population ratio remains approximately 0.77 per 1000, below the World Health Organization recommendation of 1 per 1000 [16, 17]. There are concerns regarding graduates competence which led to the implementation of Competency-Based Medical Education (CBME) in 2019 and how it is different from traditional curriculum is shown in **Table 1.** CBME emphasizes on outcome-based learning and assessment aligned with Miller's Pyramid, which progresses from knowledge acquisition to skill performance [18]. While lower cognitive levels are commonly assessed through essays and recall based MCQs, higher-order thinking is evaluated using case based questions and well constructed MCQs

that promote comprehension and critical thinking. Consequently, MCQs have become a central assessment tool particularly in postgraduate entrance examinations [1]. With concurrent curricular reforms and technological advancements, the integration of AI into medical education is increasingly viewed as essential to address resource constraints and evolving competence requirements.

**TABLE 1: HOW TRADITIONAL CURRICULUM DIFFERENT FROM COMPETENCY BASED MEDICAL EDUCATION**

| Traditional curriculum | Competency based Medical Education |
|---|---|
| **Curricular approach** | |
| Teacher centric acquisition of knowledge | Student centric with teachers as facilitators |
| Too much syllabus | Curriculum broken into competencies |
| Didactic lectures | Mentions teaching methods |
| No components | Foundation course, ECE, AETCOM components |
| **Educational strategies** | |
| No differentiation between core and non core | Emphasize on core and non core competencies by introducing phrases like know, know how, show, show how |
| Lecture with chalk and board and power point presentations | Lectures, Small group discussions DOAP, SDL |
| Topics taught depend on faculty convenience and experience | Horizontal and vertical integration on the topic being taught |
| **Faculty development** | |
| Faculty were guided by teacher training program with no universal format | Uniform capacity building of faculties by basic and advanced course workshops |
| **Assessment modalities** | |
| Mostly summative | Both summative and formative like OSCEs and OSPEs |
| Giving feedback was on teacher discretion | Constructive feedback |

*ECE- Early clinical exposure, AETCOM- Attitude, ethics and communication, DOAP- Demonstration-observation-Assistance-Performance, SDL- Self directed learning, OSCE- Objective structured clinical examination, OSPE- Objective structured practical examination.

**Benefits of ChatGPT in Anatomy Education:**

**Designing Content Outline for Teaching Sessions and Curriculum Development:** With the guidance of medical education specialists, ChatGPT possesses the capacity to assist in the formulation of educational curriculum across diverse disciplines. It functions as a valuable tool in designing the course framework, establishing educational objectives and methodologies, delineating assessment benchmarks, ascertaining the anticipated outcomes [19].

Given the delicate nature of curriculum development, the utilization of ChatGPT can be advantageous if it is consistently supervised and all recommendations are implemented under the oversight of a qualified professional [20].

**Designing Multiple Choice Questions (MCQs):** ChatGPT, Google Bard and Microsoft Bing were evaluated for their ability to generate valid, difficult and reasoning-based MCQs. ChatGPT produced the highest proportion of valid MCQs, although these were generally of low difficulty [21]. None of the models consistently generated items assessing subject comprehension. Common limitations included the use of negative phrasing and "all of the above" option in Bing and Bard-generated MCQs [22, 23]. Items using terms such as "most important" primarily tested factual recall. ChatGPT showed the lowest text similarity index whereas Bing and Bard demonstrated greater structural similarity across questions [21].

**Clearing Exams:** ChatGPT has demonstrated the ability to perform at or near passing thresholds on several medical examinations including the United States Medical Licensing Examination (USMLE) and the German state licensing progress test, correctly answering approximately two-thirds of questions in the latter [24-26]. Physician led evaluations across multiple specialties have also found that its responses to a range of medical queries were generally accurate and comprehensive [24]. These findings suggest that large language models may have potential applications in medical education and clinical decision support although further validation is required [27].

**Medical Writing:** Research is a key component of medical education. ChatGPT does not independently retrieve or verify scholarly articles and has been reported to generate inaccurate or fictitious citations when prompted as noted in prior studies [28, 29]. However, when provided with the full text of an article, it can generate summaries and

extract key points. In this context, ChatGPT may serve as a supportive tool for organizing information, outlining manuscripts and assisting with research related tasks although human oversight remains essential [30].

**Personalized Learning, Feedback and Assessment:** ChatGPT and related language models have been explored as tools to support educational assessment by providing automated feedback and assisting in the evaluation of written assignments potentially improving efficiency and timeliness [31-34].

These models may also be used to support personalized learning by suggesting resources or generating assessment items aligned with learners' proficiency levels particularly in domains such as language and critical thinking. However, their use in grading and assessment requires careful oversight to ensure validity, fairness and educational appropriateness [33, 35, 36].

**Problem Based Learning and Creating Clinical Scenarios:** ChatGPT has been explored as a tool for generating clinical scenarios to support the development of clinical reasoning and problem solving skills in medical students particularly with student centered approach such as problem based learning and small-group discussions [24, 27, 37].

These scenarios may include elements such as patient history, clinical findings and investigative data [1, 38]. In addition language models have been used to create conversational agents that allow learners to engage with clinical problems through natural language interaction although their educational effectiveness requires further evaluation [39].

**Challenges:** The application of artificial intelligence (AI) models has witnessed a marked increase in the healthcare sector facilitating enhancements in both diagnostic and therapeutic procedures in addition to contributing significantly to medical education. A quick examination of the existing literature shows the proliferation of scholarly articles pertaining to this subject matter. Nonetheless, it is imperative to confront the obstacles that accompany with the use of AI technologies in medical education. ChatGPT is one such AI model and a comprehensive understanding of its associated challenges may foster its efficacious use within the realms of medicine and medical education. The subsequent section briefly discusses the challenges linked to the utilization of ChatGPT in the context of medical education.

**Lack of Access to Certain Database:** The lack of access to key medical databases such as PubMed and Cochrane as well as to up to date literature limits ChatGPT effectiveness in medicine and medical education and may affect the credibility of its outputs [40].

**Lack of Visual Illustrations:** ChatGPT cannot generate visual aids such as diagrams, sketches or flowcharts, limiting its usefulness for visually intensive subjects including Anatomy, Histology, Embryology, Neuroanatomy, Radiologic anatomy, and Biochemistry where visual representations are essential for understanding [1].

**Limitations on Access to Information Published Post-2021:** The restricted availability of information and scholarly content published subsequent to 2021 renders ChatGPT inadequate as a resource for clinical decision making and teaching emerging scientific concepts. The application of this tool in such contexts may lead to misguided decisions or the propagation of inaccurate scientific information there by diminishing its overall utility [41].

**Formation of an ideal MCQs:** Assessment tool play a critical role in driving learning and among the various methods available, MCQs remain a time tested and widely accepted assessment format in national and specialty board examinations. Both CBME and several state university guidelines permit the use of MCQs as valid assessment tool. An effective assessment tool should demonstrate validity, reliability, practicality, sensitivity in discriminating learner performance from nonlearners and alignment with learning objectives while facilitating feedback. Despite the potential of AI chatbots to generate MCQs rapidly several limitations have been identified.

Studies report that AI-generated MCQs frequently contain poorly constructed stems and implausible or non-homogeneous distractors, thereby compromising item validity and reliability as shown in **Table 2** [42, 43].

**TABLE 2: MCQS CREATED BY CHATBOTS WITH IMPLAUSIBLE DISTRACTORS**

| | | |
|---|---|---|
| **Stem of question** | Which cranial nerve innervates the muscles of facial expression and carries taste sensation from the anterior two-thirds of the tongue? | What is the anatomical term for the socket of the pelvic bone that articulates with the femur? |
| **Distractors created by AI** | Cranial nerve III(Oculomotor), Cranial nerve V (Trigeminal), Cranial nerve VII (Facial), Cranial nerve IX (Glossopharyngeal), Cranial nerve X (Vagus) | Acetabulum<br>Glenoidcavity<br>Foramen magnum<br>Fossa ovalis |
| **Nonhomogenous distractor** | Cranial nerve III(Oculomotor | Glenoid cavity, Foramen magnum, Fossa ovalis |
| **Homogenous distractor** | Cranial nerve XII (Hypoglossal nerve) | Obturator foramen, Ischial tuberosity, fovea capitis |

Overall, published literature indicate that AI-generated MCQs predominantly assess recall and lower order cognitive thinking, corresponding to the lower level of Bloom's taxonomy. The generation of higher order clinically oriented MCQs that test application and analysis remains heavily dependent on the quality of user prompts. Additionally, the lack of cited references for AI generated answers limits transparency and reduces confidence in their use for high stakes professional examinations

**Ethical and Copyright Issues:** Several scholars and journals have expressed concerns about the use of ChatGPT in scientific writing citing limitations in critical analysis, logical thinking, and originality [44]. Key concern includes accountability for AI-generated content, as well as ethical, medicolegal and copyright implications, potential methodological bias and the risk of inaccurate or misleading information [45, 46]. While ChatGPT may assist with drafting text when guided by user provided material, evidence suggests it is unable to independently perform comprehensive literature reviews or engage in critical appraisal of scientific studies, reinforcing the need for substantial human oversight [52].

**DISCUSSION:** Artificial intelligence (AI) has increasingly influenced multiple domains including medical education. Large language models (LLMs) such as ChatGPT, Google Bard and Microsoft Bing have drawn attention for their potential to support teaching, learning and research. ChatGPT in particular has been widely studied since its launch with numerous publications evaluating its advantages, limitations and applicability in medical education [22, 43, 47, 48]. Its integration into educational settings reflects a broader trend where AI tools are becoming part of the learning environment offering new opportunities for both students and educators. LLMs are trained on vast amounts of text data, including books, websites and other written content and are subsequently fine-tuned using human feedback to enhance the relevance and accuracy of their responses. When queried, ChatGPT generate answers based on patterns learned during training rather than actual knowledge or reasoning. As a result, outputs can appear plausible but may contain inaccuracies, emphasizing the need for careful human oversight. Evidence suggests that ChatGPT can assist in drafting content, summarizing articles, generating multiple choice questions and supporting basic research tasks, thereby saving time for educators and enabling them to focus on higher order teaching activities [22, 43, 47, 48].

Despite its potential, several limitations constrain its effectiveness. ChatGPT does not have direct access to current biomedical databases such as PubMed or Cochrane, nor can it reliably incorporate literature published after 2021, which reduces its utility for teaching emerging concepts or supporting clinical decision-making [45, 46]. Additionally, it cannot generate visual aids, diagrams or flowcharts which are crucial for understanding visually intensive subjects [43]. These limitations mean that while ChatGPT can assist with text-based tasks, it cannot replace traditional teaching methods or hands-on learning experiences.

Ethical, academic, and practical considerations further influence its integration into medical education. Concerns include accountability for AI-generated content, potential for plagiarism, methodological bias, data privacy, and the risk of disseminating inaccurate or misleading information [44-46]. Clear guidelines and institutional policies are needed to define responsible use, specify the extent to which AI can support learning and assessment

and delineate areas where human expertise remains essential. Such oversight ensures that AI is used as a complementary tool rather than a replacement for evidence-based teaching and professional judgment.

Despite these challenges, ChatGPT offers opportunities to enhance educational efficiency and personalization. It can provide rapid access to information, support self-directed learning, assist in formative assessment, and facilitate problem based or case-based learning activities. Its multilingual capabilities and consistency in responding to repeated prompts allow for standardized support across diverse student populations, which may be particularly useful in resource-limited settings. Integrating ChatGPT alongside traditional pedagogical methods allows educators to leverage its strengths while mitigating limitations, ultimately contributing to more effective, student-centered learning experiences.

Moving forward, continuous evaluation, feedback from educators and students, and collaboration with AI developers will be essential to optimize ChatGPT's role in medical education. By combining AI-generated outputs with human expertise and critical appraisal, it is possible to harness its potential while maintaining the rigor, accuracy and integrity of medical teaching and research. In this way, ChatGPT may serve as a valuable complementary tool that enhances rather than replaces conventional approaches to medical education.

**CONCLUSION:** The evolution of anatomy education reflects a progressive shift from purely traditional cadaver based instruction toward an integrated technology enabled learning environment. Advances such as 3D visualization, virtual and augmented reality, digital dissection platforms and artificial intelligence have expanded educational possibilities by enhancing spatial understanding, learner engagement and accessibility. Within the framework of Competency-Based Medical Education, these tools align well with outcome oriented learning and assessment, supporting self-directed learning, formative feedback and clinical reasoning. ChatGPT and other large language models demonstrate particular promise in curriculum planning, content organization, assessment support, and problem based learning especially in resource constrained settings. However, their limitations including lack of tactile experience, restricted access to current literature, absence of visual outputs and ethical concerns underscore the necessity of human oversight. Collectively, emerging technologies and AI should be viewed as complementary to rather than replacements for traditional teaching methods.

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