DHR Proceedings

Special Edition: Junior Commentary
https://doi.org/10.47488/dhrp.v3iS1.94

COMMENTARY

Bridging the Gap: Integrating Artificial Intelligence into Medical Education

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Received: August 15, 2023
Accepted for publication: September 26, 2023
Published: October 10, 2023

Introduction

Artificial intelligence (AI) is rapidly becoming an integral part of our lives (1), seamlessly integrated into numerous technologies in use today (2). Its presence spans from the smartphones we carry to the algorithms driving our social media streams. Take, for instance, Google Maps, a remarkable AI-driven tool adeptly guiding us to different destinations, showcasing its exceptional navigational prowess in our daily experiences. These AI capabilities, when integrated with our technologies, make our lives more efficient and seamless. This can also be seen in medical settings, where AI-enhanced systems augment the capabilities of medical personnel in diagnosing and treating an extensive array of medical conditions. Moreover, AI solutions play a significant role in optimizing operational efficiency with healthcare institutions, encompassing both medicinal functions and administrative responsibilities within hospitals (3).

With AI growing rapidly, it is increasingly finding its place in medical educational systems. Aspiring medical professionals engage in activities such as patient interaction and research, where AI subtly and visibly enriches the educational journey (4). However, this profound integration prompts multifaceted discussions within the medical education community (5). While advocates commend AI for its potential to enhance learning outcomes by offering adaptive and tailored educational pathways (6), concerns also arise about striking the right balance between AI-assisted learning and the acquisition of hands-on clinical skills (7). This paper delves deeper into the role AI plays in the current medical education system.

Current Applications of AI in Medical Education

Given the expanding scope of medical knowledge, integrating technologies like AI into medical education is imperative, especially considering its transformative potential in medical imaging, diagnosis, and treatment (Figure 1). This integration offers a pivotal avenue for healthcare professionals to apply evolving medical insights in their practices. Consequently, cultivating a profound understanding of this emerging technology becomes indispensable for medical experts in the present context. Specifically, in the field of medical education, this comprehensive training encompasses not only mastering the technology itself but also delving into its current merits, which include benefits related to cost-efficiency, enhanced healthcare quality, and improved accessibility (8).

In the current environment, AI's role in medical education predominantly revolves around its capacity to deliver personalized feedback, thereby providing tailored learning support (9). However, there is limited emphasis on refining curricula and effectively assessing student progress in academic settings. This limitation is intricately linked to ongoing challenges stemming from incomplete digitalization within education and the intricate nature of assessments, both of which demand astute management. A study by Lee et al. introduces a

https://doi.org/10.47488/dhrp.v3iS1.94

holistic curriculum and professional development framework meticulously tailored for educators (10).

This curriculum focuses on specific categorizations under AI methods in Data Science. Specifically, it aims to expose learners to numerous AI methods through a structured curriculum divided into five distinct units: Data Analytics, Logic Systems (using human-readable rules), Machine Learning (experienced-based model building), Supervised Learning (utilizing neural networks), and Transfer Learning (using K Nearest Neighbor algorithm). Each unit consists of five lessons carefully designed to guide learners through various stages of understanding. Starting with hands-on experiential learning, these lessons gradually lead to the clarification of key concepts including statistical analysis, creating AI models, and visualizing data. They also include practical exercises conducted in Google Colab. This proactive approach, precisely attuned to its respective context, aims to empower instructors with a nuanced grasp of AI intricacies, heightening their sensitivity to the multifaceted ethical dimensions inherent in AI, ranging from bias to accountability. Impressively, this study underscores the successful infusion of AI into STEM classrooms, as validated by the enthusiastic endorsement of educators who actively engaged with modular curriculum units.

In another study, it was observed that four distinct AI techniques (including Machine Learning, Deep Learning, Robotic Skills Training, and Virtual Reality) are currently employed across various medical education domains, with a notable focus within training laboratory environments (11). Specifically, these techniques were utilized in behavioral health, ophthalmology, orthopedics, surgery, surgery/medicine, and training labs. This shows the diverse areas of implementation in current medical education—demonstrating AI's potential to further develop and refine certain medical practices (including surgical skills). Letting students practice their abilities in simulated situations provides them with the perfect avenue to better understand what patients might be feeling emotionally and mentally, while also fostering effective communication and listening skills. For instance, in ophthalmology, the integration of Machine Learning and Deep Learning proved to be instrumental in aiding students with the recognition of numerous eye-associated diseases, primarily through medical imaging analysis. This helps students identify patterns and improve their decision-making abilities, ultimately improving medicinal diagnostic precision. Therefore, amid ongoing technological evolution, integrating AI into medical education offers transformative potential, shaping the learning journey for future healthcare practitioners.

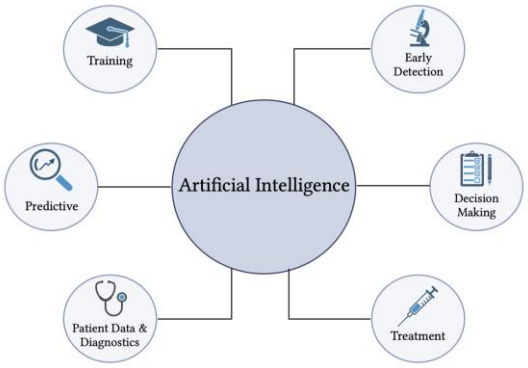

Figure 1: Various applications of Artificial Intelligence in medicine. Created with BioRender.com

Benefits and Challenges of AI in Medical Education

Benefits

Positioning the upcoming generation of medical practitioners to participate in the evolving data science revolution by acquiring pertinent Machine Learning techniques stands as one of the notable benefits of AI in medical education (12). Some of these techniques include essential tools such as predictive analytics and image detection. Specifically, students may initially encounter Machine Learning through specialized courses in population health and evidence-based medicine. In such contexts, Machine Learning serves as a supplementary tool for clinicians, enhancing their healthcare delivery. Furthermore, technology's adoption opens new opportunities for specific student groups, expanding accessibility and engagement for part-time students and offering tailored programs for gifted or talented students (13). Highlighting AI's transformative role in education, another study emphasizes its potential to provide personalized learning assistance, aligning with individual preferences and progress (14). Moreover, this examination supports the notion that enhancing healthcare quality is achievable by empowering medical professionals to reach their full potential (7). By incorporating AI-based applications into medical education and training, this empowerment journey for numerous medical workers can be further facilitated. In fact, after implementing AI-based training, noticeable enhancements in practical skills were observed among medical students (11).

https://doi.org/10.47488/dhrp.v3iS1.94

Challenges

Integrating AI into medical education presents several challenges. Many instructors may require additional training to adeptly employ technology and enrich the educational experience (15). The development of nascent technology, particularly when intended for educational purposes, often entails substantial expenses and demands a diverse range of expertise (13). This expertise includes AI algorithm development (designing algorithms tailored to medical content), data analytics (collecting, processing, and interpreting AI-generated medical education data), educational technology integration (seamlessly integrating AI into existing curricula), and instructional design (creating engaging learning experiences). Additionally, embedding AI into education can pose difficulties given its interdisciplinary nature and reliance on technology (14). Among these challenges, as evidenced by 17 studies, six indicated the presence of early-stage prototypes with technical constraints requiring refinement to enhance the user experience (16). These constraints include aspects such as performance enhancement, efficacy validation, and AI computational processes. Regarding the efficacy of AI applications in medical education, a study emphasized the importance of diverse evaluation methods and ample sample sizes to validate replicability. This is crucial due to the challenges surrounding effective AI implementational methods, constraints related to available curriculum hours, and limited faculty expertise (17). Furthermore, complications arise in training AI algorithms due to constraints such as limited sample sizes, data integrity, and privacy considerations (18). Moreover, concerns have been brought up regarding the interpretability, generalizability, and potential overfitting of AI algorithms (18). Navigating these challenges underscores the significance of a comprehensive understanding of AI's potential and limitations is vital for effective integration in medical education.

Future Prospects and Considerations

Significant changes are reshaping medical practice due to the progress of cutting-edge technologies and Artificial Intelligence (AI). This swift and ground-breaking evolution has underscored the growing necessity for a comprehensive educational curriculum that effectively imparts insights to medical students about the possibilities and capabilities of AI in the healthcare domain (19). In medical education, it's crucial to prioritize essential skills such as statistical competence and empathy. Aspiring medical students must prepare themselves for an innovative educational paradigm driven by AI and Machine Learning (20). Leveraging advanced technology for student-directed learning involves active participation through customization, social engagement, and easy access to resources (5). While technology holds the potential to transform medical education, it's vital to acknowledge that AI cannot replace human proficiency and discernment (21). The guidance of experienced practitioners remains indispensable for medical students to develop clinical skills and gain profound subject comprehension (22).

Recommendations for Effective AI Integration

Even though AI has rapidly progressed, there is a scarcity of readily available literature to help medical students grasp its concepts. Existing AI resources often assume technical expertise, leaving medical students without essential fundamental knowledge (23). Therefore, to facilitate the seamless integration of AI in the medical field, it is imperative to implement strategies that incorporate AI into the medical school syllabus (9). This proactive step will equip medical professionals with a foundational understanding of AI algorithms, enabling them to optimize the use of this transformative technology. In the context of enhancing patient care through adept information technology use, integrating Machine Learning-related material can be seamlessly woven into a comprehensive curriculum (12). This strategic approach ensures a holistic framework that emphasizes competence and skill development. Additionally, it's crucial to highlight that while AI offers diverse advantages, its integration into healthcare raises ethical considerations concerning data privacy, automation, and telehealth (24). The lack of well-defined guidelines can result in challenges during implementation, emphasizing the importance of establishing a set of rules to be followed.

Conclusion and Discussion

Artificial Intelligence (AI) has profoundly permeated various aspects of our lives, revolutionizing technologies and offering unparalleled advantages. This transformative impact extends to medical education, where AI-enhanced systems are reshaping how medical professionals diagnose, treat, and optimize healthcare operations. However, as AI's role expands in medical education, discussions arise about balancing its benefits with cultivating hands-on clinical skills. This calls for an integrated approach that harmonizes AI-driven advancements with traditional curricula, ensuring that students gain both

technical proficiency and practical expertise. Challenges, including the presence of immature prototypes, varying evaluation methods, and ethical concerns, underscore the complexity of AI integration. To harness AI's full potential, effective integration strategies are crucial, equipping future medical practitioners with the proficiency needed to navigate the evolving healthcare landscape. Within these challenges lies a transformative opportunity to redefine medical education, enhancing healthcare professionals' capabilities and elevating patient care to new heights. As AI continues to evolve, the journey towards comprehensive AI integration in medical education is set to shape the future of healthcare.

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