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Application of AI in Anatomy Learning: A Good or Bad Thing?

Mohd Asnizam Asari, Siti Fatimah Mukhtar

Department of Anatomy, School of Medical Sciences, Universiti Sains Malaysia, Kelantan, MALAYSIA

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ABSTRACT

Anatomy has been a pillar of medical education for centuries. The emergence of artificial intelligence (AI) technology has sparked significant interest among educators, especially regarding its application in anatomy learning. This article explores the current application of AI technology, such as AI-powered chatbots tailored for anatomy education. This short commentary examines the potential benefits of AI, such as personalised learning experiences, enhanced learning efficiency, enhanced visualisation, and interactivity. Conversely, it also examines challenges and drawbacks, including issues of accuracy in AI models, potential for over-reliance on technology, and fair access to AI technology.

Keywords: *Artificial intelligence, AI, Medical education, Anatomy, Personalised learning*

CORRESPONDING AUTHOR

Mohd Asnizam Asari, Department of Anatomy, School of Medical Sciences, Health Campus, Universiti Sains Malaysia, 16150 Kubang Kerian, Kota Bharu, Kelantan, Malaysia

Email: asnizam@usm.my

INTRODUCTION

Anatomy is the foundation of clinical medical science and is widely recognised as a cornerstone of medical education (1). Knowledge of anatomy is vital for understanding the pathophysiology of various diseases. Clinicians need to acquire knowledge of anatomy before examining patients, making accurate diagnoses, and performing surgical procedures. A deep understanding of human anatomy is essential for ensuring competent clinical practice, particularly in surgical contexts (2).

Over the last century, anatomy education has faced several challenges that have adversely affected student learning. These include limited learning resources, particularly limited access to cadavers, resulting in restricted hands-on learning experience essential for mastering anatomical concepts. Additionally, progressively reducing time devoted to teaching and learning anatomy in the modern medical curriculum has reduced the anatomical knowledge of medical graduates (1, 3). Furthermore, traditional teaching methods such as rote memorisation and lectures are rapidly becoming obsolete for the younger generation (3). Therefore, adopting innovative teaching strategies, such as the use of digital technologies including artificial intelligence (AI), to enhance student engagement and understanding of complex subjects like anatomy is warranted.

WHAT IS AI?

AI is a science that focuses on the development of computer-intelligent systems capable of performing tasks such as decision-making, which typically require human intelligence (2). In literature, AI is also referred to as "algorithmic data processing" or simply "machine learning." Applications based on AI are now utilised across diverse sectors such as automotive engineering, finance, education, and healthcare (4). Self-driving cars, web searches, automatic language translation, and online product recommendations are a few examples of AI applications that are currently in use (5). AI applications are currently utilised in the field of medicine and healthcare for several purposes, which include matching patient-physician preferences, assisting in patient diagnosis, drug discovery, transcription of the physicians' notes, and organising medical files (5). This commentary aims to provide a brief overview of how AI is being integrated into anatomy education, exploring both its potential benefits and drawbacks.

CURRENT APPLICATION OF AI IN ANATOMY

Chabot are among the rapidly growing AI-powered tools in medical education. Chatbots are AI-powered software applications designed to simulate conversation with users, typically through text or voice interactions, by comprehending natural language inputs and providing relevant responses or actions (6). Chat Generative Pre-Trained Transformer (ChatGPT), an AI model developed by OpenAI, is a notable example of chatbots. Chatbots provide an interactive and engaging learning experience to students and can play a pivotal role in medical education. The availability of chatbots enables students to learn comfortably at their own pace. Students can quickly review specific anatomical structures by entering keywords such as the arteries of the heart into ChatGPT on their electronic devices. ChatGPT then provides an instant, detailed description of the requested structure (2). Interestingly, a chatbot prototype that aims to offer students an individualised and interactive learning experience in anatomy education is currently being developed specifically for anatomy education (7, 8). Looking ahead, specially programmed anatomy-specific chatbots can offer detailed explanations and visual aids to help students understand complex anatomical subjects such as embryology and neuroanatomy (7). Integration of these anatomy chatbots into computer software, mobile applications, and virtual reality platforms can enhance the accessibility and effectiveness of anatomy education (8). A more advanced mode of AI-integrated educational software is the intelligent tutoring system (ITS), a computer-based learning system that utilises AI to deliver instructions and immediate feedback to students without direct human assistance (9). ITS has been used for training students to acquire certain surgical skills, such as suturing, along with intraoperative and history-taking skills. For instance, an ITS known as the virtual operative assistant was developed for training resident doctors in specific neurosurgical procedures. This innovative tool enables trainees to practice and refine their surgical skills before performing operations on real patients since it provides automatic feedback on performance and accuracy (10). However, this system is still in its infancy in the field of anatomy education (9).

ADVANTAGES OF THE AI APPLICATION IN ANATOMY

The integration of AI into anatomy education denotes a significant advancement in teaching methods. One clear advantage of AI is that it can provide personalised learning experiences, which is very important for self-directed learning. AI technologies can adapt to individual

needs, preferences and learning paces, and thus have a clear advantage over the traditional one-size-fits-all approaches (11). AI-powered instructional software provides students with access to learning resources and support around the clock, thereby enabling them to study at their convenience. Furthermore, more advanced AI systems can analyse students' learning behaviours and preferences to recommend specific resources, pacing, and content delivery methods which can help enhance their ability to comprehend and retain complex anatomy concepts (2). Another significant benefit of AI in anatomy education is that it can autonomously handle administrative tasks such as grade marking, scheduling teaching activities, and managing record-keeping processes, thereby enhancing the students' learning efficiency (11). This automation feature reduces the workload on educators, which allows them to dedicate more time to instructional activities and student engagement. Moreover, AI is capable of analysing large datasets, which enables it to identify patterns in student performance, predict outcomes, and recommend interventions to enhance the students' academic progress (2, 11). Another significant benefit of AI is that it is capable of providing enhanced visualisation and user interactivity. AI-powered anatomy software enables students to access interactive 3D models and simulations that provide a more immersive and detailed view of anatomical structures. For example, a radiation department has previously used AI algorithms to create 3D images of anatomical structures (e.g., lung, liver) using magnetic resonance imaging (MRI) and computed tomography (CT) scan images obtained from real patients (12). This immersive experience enhances the understanding and retention, especially of complex anatomical concepts (2). Moreover, the ability of AI-integrated applications to simulate surgical procedures or specific pathological conditions provides students with realistic learning experiences.

LIMITATIONS OF THE AI APPLICATION IN ANATOMY

The application of AI in anatomy learning presents promising opportunities, but it raises significant concerns that must be carefully considered. One primary concern regarding AI applications in anatomy education is their ability to accurately recognise the diverse variations in human anatomy. Human anatomy can vary significantly among different individuals, genders, and ethnicities (13). Excessive reliance on AI could potentially foster the misconception of the universal uniformity of human anatomy, disregarding crucial variations. Human anatomy can harbour several different kinds and forms of variations such as blood vessel branching, bone morphology and accessory bones, muscle structure, attachments and innervation, ligament attachments and morphology, nerve patterns and placements, and blood vessel branching (13). Some of these variations can significantly influence clinical presentations, diagnoses, and prognoses. For example, previous studies have demonstrated that individuals who exhibit left coronary artery dominance face higher risks of in-hospital mortality and myocardial reinfarction compared with those who exhibit right coronary artery dominance (14). Concerns have also been expressed regarding the ability of AI to generate inaccurate or biased information, particularly on specialised anatomical topics that are seldom discussed in public and academic circles. This concern can be attributed to the fact that AI relies on diverse and representative training datasets to produce accurate, fair, and relevant outputs across various scenarios and applications. In the event of insufficient, misleading, or outdated training data, AI can inadvertently replicate and amplify these biases in its outputs (15). Therefore, AI models and algorithms need to be rigorously validated to ensure the accuracy and reliability of educational content, particularly concerning anatomical variations.

Another significant concern in anatomy education arises from the potential overdependence on technology. While AI can certainly enrich the learning experience, there is a risk that excessive dependence on AI might reduce hands-on learning opportunities and negatively impact the development of critical thinking skills (11). Direct interaction with anatomical specimens through practical exercises or dissection facilitates the development of tactile abilities, enhances spatial comprehension, and fosters a profound understanding of anatomical structures, and hence is warranted (16). AI simulations might not completely replicate the insights provided by hands-on experiences. Moreover, there is a concern that the excessive reliance of students on AI-generated outputs without actively engaging in problem-solving and decision-making processes could hamper the development of their critical thinking skills. These skills are crucial for medical professionals for analysing complex clinical scenarios and making informed decisions (11). Another critical concern that must be addressed to ensure fair opportunities for individuals and society to benefit without discrimination is equitable access to AI technologies (15). This issue is closely associated with the financial aspect, as acquiring hardware, software, and specialised expertise requires a substantial initial investment. Institutions with limited financial resources could face challenges in affording the initial and ongoing costs associated with AI implementation. This could result in the risk of unequal access to advanced educational tools and opportunities among students across different institutions (15).

CONCLUSION

The integration of AI into anatomy education represents a promising advancement poised to enhance student learning and elevate educational outcomes in anatomy. However, this innovative technology also brings forth significant concerns that require careful consideration. AI technology in anatomy education, which is currently in its early stages, has the potential to mature into a sophisticated instructional tool that can complement traditional teaching methods like face-to-face engagement and cadaveric dissection. Addressing these concerns thoughtfully will be crucial in extracting the maximum benefits of AI while maintaining the integrity and effectiveness of anatomy education.

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