Review Article

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Application of Artificial Intelligence in Medical Education: Current Scenario and Future Perspectives

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Abstract

Introduction: Medical education is a lifetime learning process stretching from undergraduate to postgraduate, specialty training, and beyond. It also applies to various healthcare professionals, including doctors, nurses, and other allied healthcare professionals. Therefore, it is essential to acknowledge the immense role of artificial intelligence in medical education in the current era of rapidly growing technology.

Methods: High-quality data that met the study objectives were included. In addition, comprehensive investigations on articles available in reputable databases such as PubMed, Research Gate, PubMed central, Web of Science, and Google Scholar were considered for literature review.

Results: Artificial intelligence has fixed various issues in education during the last decade, including language processing, reasoning, planning, and cognitive modelling.

Conclusion: It can be used in medical education in the following forms: Virtual Inquiry System, Medical Distance Learning and Management, and Recording teaching videos in medical schools. It can also enhance the value of the non-analytical humanistic aspects of medicine. The goal of this review article was to present the implications of AI in medical education, now and in the coming years.

Keywords: Medical education; Artificial intelligence; Machine learning; Digital technology

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Introduction

Artificial intelligence (AI) is a new field of study that originated in the mid-twentieth century. It is a technology that primarily employs computer systems to imitate human thought processes. AI is primarily associated with computer science, but it also incorporates languages, psychology, philosophy, mathematics, and other fields. Since the invention of AI in 1955, its applications have grown in a quickly changing digital ecosystem where public expectations are rising and fuelled by social media, industrial leaders, and medical practitioners. Artificial intelligence has had fixed various issues in education during the last decade, including language processing, reasoning, planning, and cognitive modelling (1). The first search in Web of Science for AI in medical education revealed an increasing interest in the subject. A rise in the total number of publications and the number of times the papers were cited

during the last two decades indicates a recent surge in the application of AI in research and development in medical education (2). It can be used in medical education in the following ways: virtual inquiry system, medical distance learning and management, and recording teaching videos in medical schools (1).

Medical education is a lifetime learning process stretching from undergraduate to postgraduate and specialty training and beyond. It also applies to various healthcare professionals, including doctors, nurses, and other allied healthcare professionals. Therefore, it is crucial to admit that new works must be built on the existing materials in order to advance the subject of AI in medical education in the current period of rapidly advancing technology (2).

AI can enhance the value of the non-analytical humanistic aspects of medicine. From a plethora of possibilities, a healthcare professional has to be abstract and make sense of the information while making a medical judgment in an age where medical knowledge is growing exponentially. Physicians' attempts towards understanding digital data will be reduced by artificial intelligence, which will improve their diagnostic and problem-solving capabilities (3).

Learners in the digital age are different from past generations. They are growing in a digital world and highly value social connections. This generation of learners prefers to work in groups and share the details of their activity with their fellow learners using different software applications. They appreciate the positive feedback on their accomplishments and need one-on-one intellectual support.

Educators must discover and use appropriate instructional tactics to engage and hold the learners' attention and engagement. For example, the Institute of Medicine (US) held a multidisciplinary summit to incorporate a core set of competencies into health professional education and suggested a mix of approaches involving oversight processes, training environments, research, public reporting, and leadership (4). "Training Tomorrow's Doctors" illustrated the issues facing the educational mission and offered suggestions for health institutions, accrediting agencies, and other comparable institutions, as well as public policy (5).

In a highly connected world, medical training must evolve to the changing healthcare scenarios, including digitalization and a new generation of students in healthcare (3).

Curriculum development and analysis, learning, and assessment are the areas in which AI can be used in medical education. AI can minimize the time it takes to review various curricula, solve multidimensional problems, improve classification accuracy, and indicate a relationship between the parameters in curriculum assessment. For example, AI can assess the "effectiveness of curriculum" and the "overall happiness" of medical students with the course curriculum, which is critical in preparing future doctors. In the learning process, AI can assist students in receiving adaptive and tailored instructional content enhanced by student feedback, allowing students to detect their knowledge gaps and respond appropriately. Moreover, AI can make the assessment process more accurate, rapid and cost-effective, and efficiently provide detailed, customized feedback (6).

Wartman *et al.* believe that emphasizing communication, teamwork, risk management, and patient safety to reform the medical education system is necessary but not sufficient. They conclude that to teach the students "medical practice" in a world revolutionized by AI, the following changes are required (7).

- Authorities need to emphasize invention and research apart from the conventional strategy of fact-based memorization and clinical internship.
- The educational institute must emphasize skills like statistical expertise and compassion.
- A medical student in the future needs to adapt to a new approach to education based on rapidly growing technologies like AI and machine learning.
- Medical students will need to make a transition to a value-based payment system in the future, where buyers of healthcare services can hold the healthcare system accountable for both quality and cost.

This article aimed to highlight the necessity of integrating AI technology in medical education in order to fulfil the changing expectations of learners and the expanding digital ecosystem. Additionally, it emphasizes the advantages AI can have for medical education, including strengthening diagnostic and problem-solving skills, improving curriculum development and analysis, enabling personalized learning, and expediting the evaluation procedures. The article also emphasizes the necessity of emphasising research, skills beyond memorization, and a value-based approach to medical practise, as well as the significance of equipping future healthcare workers to adapt to breakthroughs in AI and machine learning. The aim of this review was to promote AI integration in medical education as a way to meet the opportunities and difficulties of the digital age and guarantee the provision of high-quality healthcare services.

Methods

The aim of this review article was to present the implications of AI in medical education from the past twenty years, its present scenario, and its future applications. Thus, high-quality data that met the study objectives were included. In addition, comprehensive investigations on articles available in reputable databases such as PubMed, ResearchGate, PubMed Central, Web of Science, and Google Scholar were considered for literature review.

The key index words or phrases used during the literature search were artificial intelligence, healthcare and AI, artificial intelligence and medical education, AI in medical science, doctors and AI, new dimensions in medical education, medical doctors, postgraduate medical courses, and AI.

Inclusion criteria were scientific articles which addressed the study objectives and were written in the English language.

Exclusion criteria were the studies published in languages other than English, literature that did not address the application of AI in medical education, and literature dated before 2002.

Artificial Intelligence in medical education in the existing scenario

At its annual conference in 2018, the American Medical Association (AMA) adopted its first policy on augmented intelligence. It supported studies that highlighted how AI should be undertaken in medical education. Medical students at Duke Institute for Health Innovation work with data experts to build care-enhanced technologies for doctors. Similarly, Stanford University Centre for AI in Medicine and Imaging engages graduate and postgraduate students in using machine learning to solve healthcare problems. The residents of the radiology department of the University of Florida collaborated with a technology firm to develop computer-aided detection for mammography. Carle Illinois College of Medicine offers a course taught by a scientist, clinical scientist, and engineer to learn about new technologies. In addition, the Sharon Lund Medical Intelligence and Innovation Institute offers a course on the latest healthcare technology, which is open to medical students. The University of Virginia Centre for Engineering in Medicine places medical students in engineering labs to develop new healthcare innovations (8).

AI can provide knowledge to physicians as clinical issues come up, saving time spent reviewing what they already know or skimming stuff that isn't relevant to their practices. Similarly, at Johns Hopkins University School of Medicine, informatics is tailored to what and how students are taught (9).

Another example of an innovative AI-enabled healthcare system is the "Human Diagnosis Project," or "Human Dx," as it is called in short. "Human Dx" aims to provide better, accurate, inexpensive, and accessible care for everyone by merging the collective intellect of physicians with machine learning. Its use in clinical decision-making is now being researched in collaboration with some of the world's finest medical institutions, including Harvard, Stanford, Yale, and other stakeholders (10, 11).

Similarly, Innovations like MedAware technology developed in collaboration with Harvard University by analysing large-scale electronic medical records (EMRs) data using big data analytics and machine learning algorithms to understand how physicians manage patients in real-life circumstances. When a prescription from a doctor detracts from a standard treatment plan, it is reported as a possible error, prompting the physician to double-check for any possible errors (12). MIT researchers created a prototype for MedEye, which they claim would eliminate drug errors. It uses cameras to scan and identify other drugs. MedEye confirms the accuracy of medication by comparing it to the hospital information system and utilizing image recognition and machine learning to verify it (13). PerceptiMed, a safety medication developing company, collaborated with the University of Missouri to develop and test a safe and individual medication system for long-term care facilities called MedPassTM. It is a personalized medicine dispensing technology that verifies every pill and prevents medication errors (14).

The Homer Stryker M.D. School of Medicine at Western Michigan University has built a cutting-edge simulation centre. The medical school is testing a tool that simulates patient meetings using chat robots with artificial intelligence developed by the UK-based start-up "Resource Medical" to help second-year students practice clinical skills. In addition, users can communicate with the robot to replicate a patient visit, such as inquiring why the robot needs medical attention and learning about the symptoms and medical history of the robot (15). Although various surgery simulation applications like Buckingham Virtual Tympanum, Touch Surgery exist, in which students can learn about anatomical details of surgical procedures, it is nowhere comparable to the training done with real subjects (16, 17).

Distance education is a type of teaching that is not constrained by time or space, allowing for

real-time online and offline instruction. China has implemented a "dual approval system" for institutions and initiatives in continuing medical education. Since 1996, the Ministry of Health has approved Shuang Wei net, Haoyisheng net, China Stomatology net, Shanghai Zhongshan Hospital, West China Medical Centre, and Medical Network College of Peking University to conduct distance medical education. From 2000 to 2010, roughly 3 million certificates were awarded through the aforementioned online learning institutes. This is four times the traditional schooling approach in the same time frame. In 2005, online reporting, online assessment, and online publication of national continuing medical education projects were started (18).

Data centres, teaching resources libraries, and cloud platforms are being built with the latest technology for student recruitment, training process management, and evaluation, increasing the overall quality of management of these programs.

DxR Clinician (a Virtual Inquiry System) is a virtual patient system for teaching hospitals, medical institutions, and residents that leverages artificial intelligence technology. The approach is commonly utilized in teaching medical students and clinical thought evaluation. The software compiles hundreds of genuine patient data into individual cases, which are then studied with the help of AI. These data deal with a variety of clinical problems. Thus, medical students construct diagnosis and treatment plans for virtual patients using inquiry, simulated physical examinations, and supplemental examinations (1).

AI in Medical Education: Future Perspective and Challenges

A systematic review by Han et al. discusses the future trends of medical education (3). The review article encourages medical students to develop a more humane perspective by working together with other healthcare professionals. It also emphasizes providing the students with a patient-centred healthcare environment early on, studying in a setting other than the limits of a hospital, and supporting the student with cutting-edge technology for learning. Using cutting-edge technology, medical students can be given learning tools with advanced technology to encourage personalized learning, contact with peers and instructors, and access a wealth of information. Virtual patient and augmented reality simulations can provide realistic clinical scenarios without endangering patients and help medical students learn and participate more effectively. Using commonly available technology, mobile, and online learning can supplement the students' knowledge and promote peer-to-peer or student-to-faculty interface (3).

Healthcare is just one of the many industries that artificial intelligence (AI) has the potential to completely influence. AI has enormous potential to improve medical education, increase diagnostic precision, and influence the future of healthcare professions. There are a variety of views and difficulties to be taken into account when looking forward (19).

The capability of AI to modify and personalize the learning process is one of the most critical future possibilities in medical education. AI can assist in meeting the specific needs of today's digital learners, who have different preferences and learning styles. Artificial intelligence (AI) can deliver adaptive instructional content that is suitable for each student's knowledge gaps and learning speed by analysing enormous amounts of data and utilizing machine learning algorithms. This tailored approach encourages a deeper comprehension of complex medical ideas and increases participation (20).

Despite the enormous potential, there are obstacles that must be overcome if AI is to be successfully incorporated into medical education. The ethical application of AI is one of these issues, as AI spreads, worries about algorithmic bias, security, and data privacy surface. It is crucial to build strong ethical frameworks to guarantee that AI algorithms are transparent, just, and unbiased in their decision-making processes. Another challenge is the need for education and healthcare professionals to upgrade their skills and acquire the necessary training. To apply AI in medical education effectively, teachers must be trained with the knowledge and abilities to employ AI in teaching and evaluation. Healthcare professionals must also be aware of AI systems' promise and limitations in order to use them effectively in clinical practice (21).

For AI to be used in medical education, many infrastructures and technological support are required. Educational institutions and healthcare organizations must make investments in cutting-edge computing hardware, data storage, and secure networks if they want to fully benefit from AI. The establishment of uniform standards, frameworks, and guidelines requires collaboration between academics, businesses, and regulatory institutions if AI is to be used correctly and successfully in medical education. AI provides a promising future for medical education with personalized learning experiences, enhanced diagnostic capabilities,

and easier curriculum creation/implementation. It is critical to solve the problems of ethics, training, and infrastructure in order to fully realize the potential of AI in medical education. By effectively integrating AI technology, medical education can keep up with the rapidly evolving healthcare landscape and provide prospective healthcare professionals with the knowledge and skills they need to deliver high-quality patient care (22).

Application of AI in Educational Technologies and its limitation

Teachers can use a virtual inquiry system like "DxR Clinician" as a beneficial analysis tool to assist them in understanding their students' behaviour and altering their courses based on the assessment results. Students can gain skills to solve clinical problems quickly. They can learn a lot about critical disease diagnosis by interacting with the examples. Simultaneously, the system can detect errors made by students during the case study, do deep learning and analysis, and assist students in resolving these issues. "Intelligent Tutor Systems", similar to DxR Clinician, can also follow the learner's "psychological processes" in solving problems to diagnose incorrect notions. It also evaluates the learners' level of understanding. It can also provide learners with timely support, advice, and clarifications and inspire them to be involved in self-regulation, self-monitoring, and self-explanation (1).

Although there are numerous technical advantages to digital learning using improved technologies, computer-based learning, and artificial intelligence algorithms can be taught to be biased against specific groups or toward any objectives. Therefore, we must carefully address ethical and moral issues. Above all, future clinicians should stress a humanistic approach to cope with the bio-psychosocial complexity of patients, which is not easily reachable to machines. Therefore, it is crucial to schedule mutually convenient times for engagement, especially in remote learning. Even though learners are in different locations than educators and other students, online peer tutoring is effective when they feel linked to and belong to others, i.e., emotional attachment and encouragement. It does not, however, simply entail converting traditional lectures to online collaborative learning because students' motivation and involvement are influenced by the course structure, which should be structured to encourage them to participate in discussions and work on projects (3).

Application of robots in medical sciences and their limitations

Surgical robots have already shown promising results even though the technology is still in its early stages and is primarily controlled by humans. Surgical robots have a high precision in controlling their actions' trajectory, depth, and speed, so that their direct positive influence on healthcare will be tremendous. When dealing with delicate areas like the eyes, surgeons must have remarkably steady hands. AI technology for removing the membranes from the patients' eyes or blood beneath the retina caused by age-related macular degeneration is effective in tests. In some circumstances, using a robotic device to do surgery was more effective than performing the procedures manually (23). They are particularly well-suited to operations that demand the same, repetitive movements because they don't get tired. Robots can also hold their position for an extended period and go where conventional tools cannot. For example, AI can identify trends in surgical procedures to improve best practices and improve the accuracy of surgical robots to fine precision. Intelligent robots are those that have been programmed with artificial intelligence software, and this software will someday do surgery without the use of humans. These surgical techniques will become standard in a near future, and medical schools that do not teach robotic surgery will be at a loss (24-26). Artificial intelligence reduces the criticality in the professional lives of patients, doctors, and hospital administrators. Healthcare-Data driven AI technologies like Human Dx, MedAware, MedEye, MedPassTM, etc. perform tasks more accurately and economically. Artificial intelligence will continue to serve the healthcare system more efficiently by machine learning technology, as it automatically learns and improves from experience without being explicitly programmed.

There are always two sides to every coin. While there are numerous advantages in using robots to conduct tasks in healthcare, there is also the possibility of errors and malfunctions. There is always room or chance of human error/mechanical failure with these powerful robots. A single mechanical failure can result in fatality and even human death. Another significant disadvantage is the cost. Surgical robots are only used in industrialized countries, research institutes, and advanced hospitals. Patients and some educational institutes, too, may find that robotic surgery is out of their financial grasp in some circumstances. Furthermore, the healthcare provider must invest a significant amount of

money and effort in training the personnel to handle robots; the workforce's lifetime is at stake. Thus, the possibility of error and high cost for educational institutes might hinder the wide use of robotic surgery until the cost of technology declines with time.

Optimum Training for the Application of AI in Medical Education:

AI must first be taught sufficiently and appropriately to harness its benefits in a healthcare system. The role of doctors and other healthcare professionals is crucial here. The most common threat is that AI systems will occasionally be incorrect, resulting in patient damage or other healthcare issues. For example, a patient could be harmed if an AI system prescribes the wrong treatment, fails to detect a tumour on a radiological exam, or allocates a hospital bed to one patient over another because of the AI system error. Although many injuries occur in medical setups even without the use of AI, it can be argued that AI errors are theoretically different because if AI systems become more widely used, one flaw in the AI system might result in thousands of patients being harmed, rather than the small number of patients harmed by a single provider's error. The clinicians need comprehensive training to extract accurate patient data and feed it into AI systems. We have already had lessons on medical AI systems that did not succeed due to various unforeseen reasons, and one of them was insufficient training, such as the case of IBM's Watson (27).

The best training must achieve application of AI in medical education to its fullest potential. It calls for the use of a multidisciplinary approach that combines expertise in the fields of computer technology, medicine, education, and ethics (27). Training programs should emphasize developing abilities in data analytics, AI algorithms, and moral considerations surrounding the use of AI. Educators and healthcare professionals need to be equipped with the necessary skills, so that they can properly integrate AI technology into curriculum development, instructional delivery, and assessment procedures. Medical schools can augment the faculty preparedness by conducting focussed "faculty development programs". Additionally, constant learning and collaboration between academia, industry, and regulatory agencies are essential for keeping up with the rapidly changing landscape of AI in medical education (8).

Ethical Issues in Artificial Intelligence

Artificial Intelligence applications encompass the physical world with robotic prostheses, manual work assistance, and mobile apps facilitating online medicine. This powerful technology can jeopardize patient preference, safety, and privacy. It poses a new set of ethical challenges to be identified and addressed (28). Gerke *et al*. point out four key ethical challenges of AI in healthcare, as explained below (21).

- **Informed consent to use**: The patient clinician interaction will be transformed by health AI applications such as imaging, diagnostics, and surgery. Nevertheless, there are many challenges regarding the responsibilities of the professionals in educating the patients about the complexities of AI. As, the AI uses "black-box" methods, physicians may sometimes find it difficult to comprehend and interpret a variety of machine-learning techniques, that will lead to the lack of transparency in certain situations. This area needs more focus so that the outcomes becomes more and more predictable.
- **Safety and transparency**: One of the main challenges for AI in healthcare is safety. IBM Watson for cancer treatment is a well-publicized case of one of the main problems for healthcare analytics. It has recently drawn criticism, for allegedly making "unsafe and incorrect" suggestions regarding cancer treatments. The field has received negative attention as a result of this real-life incident. It also demonstrates how crucial it is that AIs should be reliable and efficient. But how can we make sure that AI maintains its word? Stakeholders, in particular AI developers, must ensure two critical factors in order to fully utilize AI's potential: the validity and trustworthiness of the datasets, and transparency.
- **Algorithmic fairness and biases**: The data used to train any Machine Learning (ML) system, or a human-trained algorithm is only as reliable, effective, and fair as the data used to train it. When choosing the ML technologies/ procedures they want to employ to train the algorithms and what datasets (including evaluating their quality and diversity) they would like to use for the programming, they should pay particular attention to the risk of biases. AI is also vulnerable to prejudices and, as a result, discrimination. Several real-world cases have shown that algorithms can be biased, resulting in discrimination based on ethnic origins, skin colour, or gender.
- **Data privacy:** Patients were not fully informed about the processing of the test data, which they shared with «Streams,» an app that aims to diagnose and identify acute renal damage to conduct clinical safety tests. Even though the

«Streams» app does not use artificial intelligence, this real-life example has emphasized the risk of violation of privacy when building technology solutions (21).

Conclusion

The involvement of AI in educational institutions has increased since 2018. Although the academic bodies work hand in hand with IT firms to develop cutting-edge technologies like prescription error detection, personalized medicine dispensing, and individualized learning, there is a long way to go for full scale and error-free artificial intelligence and machine learning technologies.

The future of medical education will essentially run with the AI-driven technologies, assisting teachers in understanding their students better and helping each student learn as per his/her learning pattern and enabling the educational institutes to focus more on teaching communication, ethics, and morals. Although the risk of bias persists in these AI-driven education frameworks, more research will help in clarify this issue to a greater extent.

The use of AI robots in surgery is still in its infancy. As it involves minimizing the risk to the patient's life and conserving finances, advancement in this subject is anticipated to be gradual. These surgical treatments will become commonplace as technology and cost advance, and medical schools that do not provide robotic surgery will quickly lag behind. On the one hand, medical education must eventually incorporate AI to stay relevant. However, correctly educating the "AI Systems" is equally essential. Finally, educating future medical practitioners about AI technology and its ethical issues is essential for creating a healthcare system that will differ from the way medicine is practiced today.

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Authors' Contribution

All authors contributed to the discussion, read and approved the manuscript and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated resolved.

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