

ARTIFICIAL INTELLIGENCE IN HEALTH PROFESSION EDUCATION

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Abstract

Artificial intelligence has revolutionised education with three key advantages through individualized learning practices, performance of administrative work, and evaluating performance with smart technologies. AI solutions nowadays transform processes related to health education as they optimize learning methods and increase educational value for students and instructors. This paper elucidated the application of AI in public health education, with a focus on AI in public health, AI in education, role of AI in supporting student learning, AI and health profession education, AI and continuing professional education and status of AI in health profession education.

Introduction

Public health education is the cornerstone for maintaining and improving community health standards, preventing diseases, and promoting healthy lifestyles. Public health education typically relies on five fundamental and core disciplinary areas, including biostatistics, epidemiology, environmental health sciences, social and behavioral sciences, and health policy and management (Ghaffar, Rashid, Wanyenze & Hyder, 2021; Winskell, Evans, Stephenson, del Rio & Curran, 2014). Historically, traditional teaching methods have dominated the field of education, heavily dependent on didactic teaching methods, face-to-face interaction, and standardized curricula (Griffiths, Li, Tang, Ma, Hu, Meng et al. 2010; Wartman & Combs, 2018). Although these methods are foundational, they have limitations in scalability, accommodating diverse learning needs, and rapid dissemination of information, particularly in the context of global health crises such as the COVID-19 pandemic in recent years (Liu, Liu, Liu, Luo & Xia, 2020).

Contemporary public health education faces several challenges that impact its effectiveness. A one-size-fits-all approach often fails to consider the diverse demographic and socio-economic backgrounds of learners, leading to gaps in health literacy (Woodruff, Angelos & Valaitis, 2008). Moreover, the static nature of traditional educational resources can result in outdated information, restricting the responsiveness of public health education to emerging public health threats (Ghaffar, Rashid, Wanyenze & Hyder, 2021). At the same time, there is a growing demand to enhance the practical skills of public health professionals, and traditional lecture-based methods fall short of efficiently addressing this issue (Wang & Li, 2024).

While facing these challenges, the emergence of Artificial Intelligence (AI) in educational reform heralds a new era of potential solutions. As an emerging technology of the 21st century, AI has penetrated various fields such as economy, science, and healthcare, becoming a significant driving force for future development (Hamet & Tremblay, 2017; Yu & Beam, 2018). Indeed, the World Health Organization emphasized

in its 2018 report that digital technologies and AI are poised to become key tools in achieving its global strategic goals: to increase the number of people benefiting from universal health coverage by one billion, to increase the number of people protected from health emergencies by one billion, and to improve the health and well-being of one billion people (Kolachalama, 2022). AI technologies can personalize learning experiences, process vast amounts of data to obtain the latest learning resources, and provide interactive training through simulations (Masters, 2019; Erduran, 2023). AI can effectively tailor educational content according to individual needs, thereby improving learners' comprehension and retention rates (Masters, 2019). Furthermore, the application of AI in public health education is extensive, ranging from automating administrative tasks to facilitating the resolution of complex problems and decision-making processes in public health scenarios (Wang & Li, 2024).

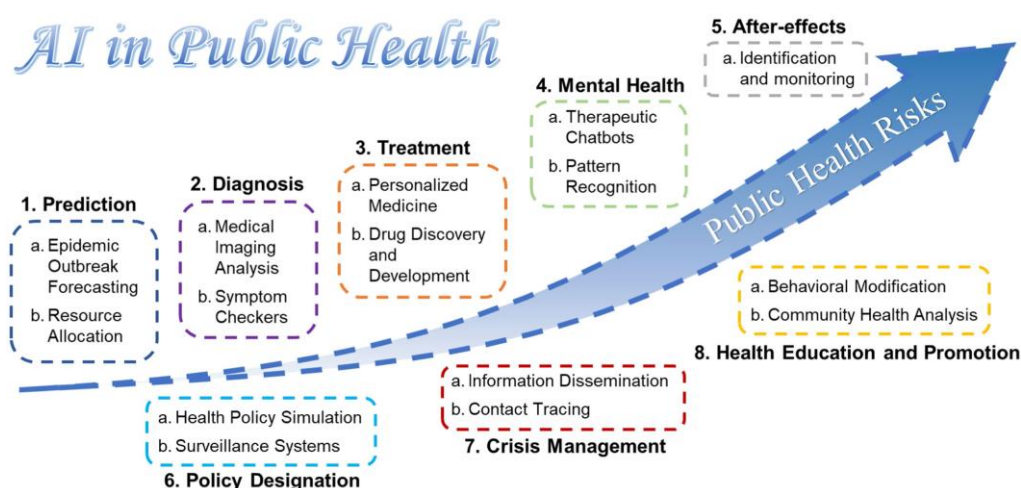
The prospects of AI promise to overcome the rigidity of traditional educational systems, offering opportunities for continuous lifelong learning and rapid adaptation to dynamic public health environments (Wang, He, Wei, Li & Liu, 2022). By integrating AI into public health education, there is not only the potential to enhance the quality and effectiveness of education but also to innovate the tools and methods of imparting public health knowledge, ultimately equipping current and future public health professionals with the capabilities needed to meet the multifaceted health challenges of the 21st century. This study aims to elucidate the application of AI in public health education, with a focus on AI in public health, AI in education, role of AI in supporting student learning, AI and health profession education, AI and continuing professional education and status of AI in health profession education.

Artificial Intelligence in Public Health

One of the primary tasks in optimizing public health systems is the integration of information technology and data science to strengthen disease prevention and health monitoring capabilities. This monitoring involves systematic and continuous collection, management, analysis, and interpretation of data, aimed at stimulating and guiding specific preventive measures. The application of big data analytics and AI can facilitate the early detection of epidemics and other public health risks, providing support for the implementation of targeted and precise public health strategies (Khoury & Ioannidis, 2014; Khoury, Iademarco & Riley, 2016; Fisher & Rosella 2022). AI's capability to sift through and make sense of extensive health data can revolutionize public health and disease tracking, setting the stage for more targeted health strategies. The examination of vast amounts of health information from diverse sources about individuals, locations, and times could offer deeper and broader perspectives on what causes illnesses, tailoring insights to both individual care and community health. This could speed up disease monitoring and inform the development of health policies and their execution (Rasooly & Khoury, 2022). Incorporating cultural considerations into the AI frameworks used in public health is imperative for ensuring that these technologies respect individual preferences and promote equity. As highlighted by the OECD, responsible AI in health must be adaptable

to change, respect individuals, champion equity, and achieve better health outcomes for all (Anderson & Sutherland, 2024).

Based on the literature, Rosella (2022); Corpuz (2023) and Jacobson and Jokela, (2022) summarized the following eight application scenarios of AI in the field of public health. For example, during peacetime preceding public health crises, it is imperative to harness AI models to integrate public health data from various regions to enhance forecasting capabilities, thereby achieving rapid response. Additionally, AI should be leveraged for timely resource allocation based on predictive outcomes. Furthermore, AI can facilitate the swift diagnosis and personalized treatment of patients during crises, as well as support post-crisis mental health education and the monitoring of related sequelae (Jacobson & Jokela, 2022). For management and decision-making bodies, AI can rapidly provide the most sensible policy recommendations based on model data (Corpuz, 2023).



Artificial Intelligence in Education

Artificial intelligence (AI) has the potential to transform the educational landscape by automating administrative tasks, providing prompt feedback, and customizing teaching strategies to meet individual student needs. Furthermore, it can aid with assessment and grading, allowing educators to concentrate on designing curricula and delivering exceptional instruction. It is expected of institutions of learning to innovate in teaching and learning to keep up with new technological advancements (Aldosari, 2020). Artificial intelligence techniques, including machine learning, deep learning, artificial neural networks, natural language processing, and genetic algorithms, have enabled the development of intelligent learning environments that support behavior detection, model construction, and personalized recommendations for learning materials (Ouyang & Jiao, 2021). The principal objective of artificial intelligence is to facilitate machine information processing that approaches problem-solving as closely as possible to that of human beings.

Artificial intelligence is impacting education in two primary ways, according to Aldosari (2020; Klutka, Ackerly & Magda, 2021), curriculum designed with AI in mind,

which can be customized to fit the unique requirements of every learner. AI systems can create individualized learning pathways by analyzing student data, including learning preferences, skills, and shortcomings; and automation of administrative duties: By automating administrative duties, AI can free up educators' valuable time so they can concentrate on instructional activities and student engagement. Regular administrative duties like assigning grades, setting up classes, and maintaining student records can be performed by AI-powered systems: AI-generated emails can notify students of upcoming deadlines, encourage them to sign up for classes, turn in assignments on time, and pay fees on schedule. Furthermore, AI-based software is getting better at identifying plagiarized assignments. Artificial intelligence is currently being used in a variety of educational activities.

Role of Artificial Intelligence in Supporting Student Learning

AI can reduce the burden on both students and teachers and can offer students effective learning experiences (Loeckx, 2016). AI will play an important role in creating individualized learning experiences and in the gamification of learning (Zhai, Chu, Chai, Jong, Istenic, Spector, *et al.* 2021). Intelligent tutoring systems (ITSs) are an important application of AI in education and HPE (Boulay, 2016). ITS can provide personalized/individualized learning experiences in four ways. These are monitoring input provided by the student, providing appropriate tasks, providing feedback, and applying interfaces for human–computer interactions. In education, there is a growing realization that with the advent of AI the roles of teachers may need to be adjusted (Fenwick, 2018). Teachers will have to collaborate and work together with AI systems to advance student learning. Collaborating with AI will also be an important skill for HCPs.

Providing Feedback to Learners

Knowledge may need to be reorganized and represented according to the learner's reactions and understanding. Feedback is important to develop learners' proximal learning patterns (Melo, Flores, Carvalho, Teixeira, Loja & de Sousa Gomide, 2014). An artificial neural network is used to provide feedback to the learners so that they can gradually get used to abstract concepts and be able to perform practical exercises. Students can learn from the feedback provided when they are in error (Petit, Roura, Carmona, Cortadella, Duch, Gimnez&Jutge, 2018). Intelligent algorithms provide automatic feedback to students. Feedback is provided in a timely manner and specific to the student and the student's response. An intelligent virtual laboratory has been developed to provide appropriate feedback to students who face difficulties with completing their practical activities. A learning website, jutge.org was developed to provide feedback to learners and help students learn from their mistakes and progressively solve problems.

Intelligent Tutoring Systems

Visualization can help make complex topics interesting and entertaining and improve learners' motivation like in game-based learning (Horakova, Houska & Domeova, 2017). Extended/augmented/virtual reality can provide a highly simulated learning context that

may be challenging to achieve in real life. The analysis of human emotions and feelings captured by sensors and affective algorithms known as affection computing can enhance human-computer interaction and ITS was modified to incorporate the detection of students' emotional status to also provide them with timely emotional feedback (Lin, Wang, Chao & Chien, 2012).

Students assume various roles during role-plays and ponder on various problems with the activation of the affective domain also. Role-plays with an intelligent artificial agent were used to enhance learners' investment in their interaction with computers. Students' sense of responsibility was also activated, and they may work harder for their intelligent agent than they may do for themselves (Chase, Chin, Opezzo & Schwartz, 2009).

Cognitive Learning

The AI chatbots can be used as a powerful tool to enhance the effectiveness of study topics for the HPE contexts for learning, such as healthy lifestyles; growing and changing; alcohol and other drugs; food and nutrition; mental health and well-being; and healthy relationships. One of the strengths of AI chatbots is their ability to respond to prompts given by users in natural language and generate human-like text in response. Because both the prompt (input from student) and response (output from AI) are in natural language, they can be potentially used as conversation agents that enable students to act as tutors and learn by teaching. When learning a new health concept, students can explain it to the AI chatbot, similar to explaining it to another student. For example, when learning about the effects of sugar consumption on health, a student can prompt the AI chatbot by asking, "Can you explain how too much sugar affects the body?" After receiving a response, the student can refine their understanding by re-explaining the concept back to the chatbot in their own words, reinforcing their comprehension. The use of AI chatbots by students as a conversational partner strengthens their understanding of health-related topics. This process mimics the concept of teaching material to someone else, which is deemed an effective approach for reinforcing learning of concepts. Furthermore, the AI chatbot is likely to be a friendly peer because it often is fine-tuned to behave kindly and gently. Students can use AI to create meaningful formative questions (e.g., multiple choice, mix and match, short-answer questions) with which they can practice and revise their health classwork at home, with accompanying feedback that helps them learn from their mistakes (Seo et al., 2021). This approach helps students reach a deeper understanding by generating their own questions and feedback while creating a question bank for practice.

Personalized Learning

Educational games are a powerful learning method and are successful if the educational design, domain knowledge, gameplay, and affection elements are integrated. AI can help in the integration of the game and the knowledge elements, and help the game adapt in a dynamic manner to the players'/learners' emotional responses and actions (Thomas & Young, 2010). Educational games can take place in the setting of augmented, virtual or

extended reality and complex scenarios difficult to recreate in the real world can be presented. In personalized learning, learning objectives, instructional approaches, and content can vary depending on the individual learner's needs. In personalized adaptive learning, the learners' data are continuously fed to the system followed by continuous assessments and real-time feedback (U.S. Department of Education, 2017). Most systems also incorporate a dashboard to help learners better evaluate their progress and identify potential obstacles (Palanisamy, Thilarajah & Chen, 2021). AI can support personalized learning through intelligent agents, autonomous scoring and assessment, and chatbots. AI compiles various information including students' prior learning and academic achievement and can help map out an individualized learning pathway in an economical manner.

Learning Analytics

Personalizing learning material improves the motivation of the learner and learning outcomes. Adaptive learning systems provide learners with the resources and tools to attain mastery at their own speed (Peng, Ma & Spector, 2019). Instructors are provided with information about learners' progress in a continuous manner. Learning analytics (LAs) uses data gathered from learners and analyzed to better understand and optimize the learning process. Data are automatically collected from learners' interactions with learning technologies, and this can be used to predict specific learning needs (Khan & Al-Badi, 2020).

Chatbots

AI chatbots are being increasingly used in HPE. A chatbot is a machine conversation system that interacts with human users through natural, conversational language. Multiple applications for chatbots in education have been highlighted including quizzing learners about their existing knowledge, creating higher student engagement with a learning task, and mentoring students toward success (Corra, 2021). Metacognition chatbots help learners better understand their own learning styles and help them reflect on their coursework. Chatbots can provide a direct response to learners at any time of the day and can support health professions students 24 × 7 across geographically distributed locations. Repetitive learner questions can be dealt with effectively by chatbots and faculty may focus on questions requiring greater thought and input. Chatbots have been used to practice night call, interprofessional education consult, lab interpretations, and to learn advanced anatomical concepts.

A study skills chatbot provides learners with evidence-based studying strategies to improve their understanding of the content. A faculty development chatbot provides faculty members with just-in-time evidence-based answers to faculty development issues. Most teaching practices can be effectively offered in short bursts demonstrating the skills involved (Corral, Post & Bradford, 2018). Chatbots can advance interactions with virtual patients to a true conversation rather than computer-based text interactions and may better develop learner competencies.

Learning Analytics in Workplace-Based Learning

LAs has been used more in traditional formal education formats. Its use in workplace-based learning has been less. Workplace-based learning is experiential, social, situated, and practice-bound (Shum, Littlejohn, Kitto & Crick, 2022). Data-informed automated feedback can provoke reflection leading to a reframing of oneself as a part of professional growth. Professional learners must chart their learning needs and align these with the needs of the workplace. As the workplace needs change, they must reframe their learning needs. LA must address challenges regarding how these needs can be scaffolded, supported, and enhanced in the workplace. As AI technologies constantly advance LA can be offered in more complex, nontraditional workplace settings. Skills analytics, reflective writing analytics, and dispositional analytics can be helpful. Analytics tools can help the professional reflect on where she/he is on the career journey, and what skills should she/he aspire to acquire. Reflective writing analytics helps with making sense of challenging experiences, changing as a professional, and how to handle professional dilemmas better next time. Dispositional analytics focuses on professional purpose, how to learn better, and how to transfer formal education and training to the job.

Serious Games and Simulations

Many simulation approaches have been developed to educate students to deliver health-care safely (Lin, Chen & Cheng, 2016). Serious games and simulations help students learn new skills and experience in real-time the consequences of their decisions and address system anomalies while not putting patients at risk. In addition to inexperienced health-care workers simulations can also help experienced workers learn new skills. Difficult procedures can be rehearsed multiple times and training on patient complications and equipment failure (which may be rare in practice) requiring decisive action and skilled performance can be provided. AI can support serious games and simulations. Gamification is the use of game elements in a nongame context (van Gaalen, Brouwer, Schönrock-Adema, Bouwkamp-Timmer, Jaarsma & Georgiadis, 2021). In HPE, gamification can improve learning behaviors and attitudes toward learning. Game elements such as points, leaderboards, and prizes are used in a nongame context. AI is being increasingly used to support gamification.

Educational Data

Education data mining (EDM) explores the unique types of data resulting from educational settings to better understand students and their learning environments (Corral, Konstantinidis & Bamidis, 2021). EDM focuses on modeling and predicting student progress and creating computer systems that can adapt without needing human intervention in the learning cycle. HPE programs have complex learning situations and span both academic institutions and clinical practice settings. There are several challenges in obtaining data for LA and EDM. Among these is the fragmentation of data across different systems, the data not being continuously updated, being out of sync, and data volume may be low within individual HPE programmes. Data fragmentation can be addressed with systems being able to talk to each other, and use of AI systems in

assessment may result in assessment results being made available faster. HPE data can be messy. The personalized prediction uses various methods with existing data to predict future outcomes (Christopher & Thompson, 2017). Health professions schools would like to predict the characteristics of students who are most likely to be successful practitioners; they may want to predict students who are most likely to succeed in licensing examinations and match into postgraduate and fellowship programs. These may use longitudinal datasets over multiple years to improve predictive accuracy.

Data-based methods in HPE are reductionist in nature and this may be a significant limitation, especially considering the importance now provided to noncognitive attributes like empathy, collaboration, and communication skills in HPE (Frank, Snell, Cate, Holmboe, Carraccio, Swing, *et al.*, 2010). There are also concerns related to data privacy and how the data are obtained as most of this is obtained when students use required learning systems as they may not be in a position to refuse to provide the data.

Use of Artificial Intelligence in Assessing Learners

AI can be used to automate performance assessment, provide feedback, and predict patient outcomes (Tolsgaard, Boscardin, Park, Cuddy & Sebok-Syer, 2020). ML algorithms can be used to improve the efficiency of assessing surgical skills. Surgeons' experience levels were used to train an algorithm to distinguish between different levels of operative skills (Uemura, Tomikawa, Miao, Souzaki, Ieiri, Akahoshi *et al.*, 2018). A novel motion tracking system and algorithm were developed to automatically evaluate trainee performance at a pediatric laparoscopic suturing task (Oquendo, Riddle, Hiller, Blinman & Kuchenbecker, 2018). ML was used to assess the level of neurosurgical skills among postgraduate learners on a simulator (Winkler-Schwartz, Yilmaz, Mirchi, Bissonnette, Ledwos, Siyar *et al.*, 2019).

Artificial Intelligence and Health Professions Educators

AI has the potential to carry out routine administrative tasks and repetitive jobs and can free HPE educators to focus on tasks requiring creativity and specialized knowledge (Lomis, Jeffries, Palatta, Sage, Sheikh, Sheperis *et al.*, 2021). The authors mentioned that the basic premise of AI is to supplement and not supplant the work of educators and misunderstanding this concept may be responsible for the hesitancy to adopt AI along with resistance to change. With rapid development and incorporation of new technologies health profession education curricula suffer from information overload. However, the addition of AI can reduce curricular overload by migrating some biomedical and clinical knowledge to AI algorithms (Wartman & Combs, 2019). There should be a careful examination of the amount and type of information that HCPs should memorize in a world where information can be continually accessed without difficulty. Educators using AI should be aware of both the advantages and the risk of bias in big data and algorithms. Data collected by humans can impact the efficacy of AI algorithms and can introduce unconscious bias. The Georgia Institute of Technology in the United States is using an AI application, called Jill Watson to function as a teaching assistant optimizing the use of scarce human resources (Eicher, Polepeddi, Goel & Watson, 2018).

Artificial Intelligence and Continuing Professional Education

Competency-based approaches are becoming common in HPE. These approaches rely on rich programmatic data about each learner. Obtaining and managing this vast amount of data and using it to guide future learning has been a challenge. AI enables precision education by identifying individual performance trends and supporting individualized learning pathways. AI can support continuing professional education by incorporating longitudinal and innovative formative assessment methods that can help identify knowledge and skill gaps and support learning (American Medical Association House of Delegates., 2019). AI can monitor a health-care provider's patient panel and outcomes and recommend appropriate educational resources that can be provided just in time. The Amplifire's platform mines health system metrics and electronic health record data to identify opportunities for improvement and learning that can be used to design system-wide training across the professions (Amplifire, 2020).

Status of Artificial Intelligence in Health Professions Education

The workload of health professions educators can be optimized by automating some processes, thus reducing stress and burnout. Health professions students at risk of suicide can be identified through natural language processing algorithmic models and a smartphone application (Coentre & Góis, 2018). A review concludes that AI till now, has primarily provided individualized feedback to students (Chan & Zary, 2019). AI has not yet been used in curriculum review and this could be due to the limited digitization of learning management systems which is essential to create a digital curriculum map. The use of AI in assessments has also been limited and this could be due to the lack of availability of the necessary data pool necessary to train AI systems and the sensitive nature of assessments.

Conclusion

Although AI applications can provide deep and permanent learning in individuals by moving away from traditional methods, the development of teachers' skills related to AI is a necessity (Lee & Lee, 2021). To achieve successful AI implementation in education, teachers and other stakeholders should participate in AI creation, development, and integration (Celik et al., 2022). The integration of AIEd opens new possibilities for tailoring instruction to individual needs, promoting self-paced learning, and fostering student engagement (Seo et al., 2021). By leveraging AI tools and platforms, educators can optimize content delivery and implement effective pedagogical practices to maximize student learning outcomes.

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