Outline

- RESEARCH WITHIN ARTIFICIAL INTELLIGENCE
- ROLE OF EDUCATIONAL ASSOCIATIONS AND INDUSTRY
- LEGAL AND ETHICAL CONSIDERATIONS

Report prepared by Dr Elif Bilgic (Postdoctoral fellow) and Dr Jason M Harley (PI) (2021)

Key Takeaways

- There is a need to build a collaborative culture to promote AI in health sciences education (HSE, includes education within fields such as medicine, nursing, and physical and occupational therapy), both in research/development and implementation phases. This includes interdisciplinary partnerships between industry, hospitals, societies, and individuals from law, ethics, education, computer science and engineering, and health sciences (including students).
- The development of AI enhanced educational technologies should be driven by educational theories, so that the most effective technologies can be developed.
- It is important to gather multiple data using different data collection techniques, in order to capture different aspects of performance and train more accurate AI enhanced educational technology models.
- Even though the pandemic created many challenges, it also provided opportunities to improve HSE through online and remote learning. Accordingly, educators and researchers should explore the role of AI-enhanced educational technologies within remote learning contexts.
- It is important to understand the limitations and uncertainties of AI models when making decisions about a students' performance.
- Current focus of AI-enhanced educational technologies is on performance assessment, especially in differentiating novices from experts, moving forward, there is a need to explore the role of AI in providing real-time feedback.
- Associations such as the Royal College of Physicians and Surgeons of Canada (RC) have a role in creating new initiatives and support systems to address the emerging needs of students and health scientists regarding AI (e.g. for medicine, addition of another CanMEDS role: the competency of digital literacy)
- Everyone involved in developing or using AI-enhanced educational technologies, including future health scientists need to be well informed about issues of privacy, confidentiality, discrimination, bias, fairness, accountability, transparency, and legal concerns as they relate to AI.

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INTRODUCTION

An increase in AI-enhanced educational technologies has been seen in health sciences education, particularly in response to COVID-19 where AI-enhanced simulations are providing opportunities for students to continue their training outside of in-person simulation centres.[1-3] In these settings, AI-enhanced education has the advantages of being more flexible (e.g., can repeat learning scenarios, do at home when convenient) while still providing standardized educational experiences and offering feedback for skill/knowledge improvement.[4] While interest in AI-enhanced educational technologies have increased, health sciences education lags behind when it comes to best practices to guide teaching and learning with these advanced tools. To address this gap, Dr Jason M Harley (principal applicant) and Dr Elif Bilgic (postdoctoral fellow) aimed to bring together an interdisciplinary team of experts in the field of AI in health sciences education from industry and academic centers for a panel discussion, to explore their perspectives and experiences related to current research advances, roles of educational organizations/industry, and legal/ethical considerations.

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METHODOLOGY

A virtual panel titled 'Exploring the Roles of Artificial Intelligence in Health Sciences Education' was hosted on June 22, 2021, led by Prof. Jason M Harley, PhD and Elif Bilgic. PhD. The panel was open to the public, and was supported and organized by The Simulation, Affect, Innovation, Learning, and Surgery (SAILS) Lab, Research Institute of the McGill University Health Centre (RI-MUHC), McGill University, and The Social Sciences and Humanities Research Council (SSHRC), which brought together an interdisciplinary team of scholars across Canadian institutions and educational technology companies who are actively involved in the fields of AI and health sciences education. Specifically, the panelists/moderator were from Queen's University, University of Alberta, University of Toronto, McGill University, Royal College and Physicians and Surgeons of Canada, CAE, and MEDTEQ.

The virtual panel was organized around three themes: (1) current advancements (4 panelists), (2) roles of educational organizations and industry (2 panelists), and (3) technical/ethical considerations (3 panelists) for the advancement and implementation of AI in health sciences education. Each panelist had 5 minutes to present, followed by a discussion and question/answer period for each theme (between 14-22 minutes each).

KEY FINDINGS

1. Research regarding AI-enhanced educational technologies in health sciences education (HSE)

A. Application of educational theories

There are 21st century skills that are important to consider within health sciences education (HSE, includes education within fields of medicine, nursing, physical and occupational therapy etc.). These skills include critical thinking, problem solving, collaboration, social skills that are essential for teamwork, skills for monitoring and controlling our own learning, skills to deal with internal and external pressures that are emotion related, and skills to keep ourselves and learners motivated to pursue goals and be persistent.

To build AI-enhanced educational technologies to help with teaching and learning of these skills within HSE, there are certain educational theories that influence the development and implementation of these technologies. Expertise can be defined as identifying levels of proficiency and cognitive components that differentiate experts from novices. As a part of this, we need to understand that expertise is specific to a domain, with experts being consistently faster, accurate, and superior in their performance, and that a key component is deliberate practice (e.g. repetitive, goal-oriented), with well-informed mentors. Mentors can be human or computer, so in the case of AI, those mentors are computer coaches.

Modelling, scaffolding, and tutoring (Bandura social learning theory) involves students learning by observing, modelling, and imitating the behaviours, attitudes, and emotional reactions of others. Hence, students are provided with models of expert thinking to establish a learning trajectory. AI-enhanced coaches can provide adaptive scaffolding based on both student and expert models that present deliberate practice opportunities.

Self-regulation of thoughts and emotions emphasizes that students need to become their own coaches, need to monitor their own skills and realize that there are social elements to learning, become aware of others experiences as well as their own, and to regulate their emotions as well as others'. Emotions are a key aspect of thinking, and using different data collection techniques, all of the things that are important to looking related to emotions can be done through AI technologies.

Cognitive apprenticeship focuses on the importance of creating real-world apprenticeships, as we learn from others, and we learn by modeling experts. AI-enhanced educational technologies can provide an opportunity for students to practice real-world skills outside of the clinical setting. However, for this, we need to study experts and develop the content by looking at the expert thoughts and performance, to model and coach the right knowledge/skills.

In summary, AI enhanced theory driven designs, linked to cognitive apprenticeship, and thinking of the emotions and motivations experienced are what can help to design AI enhanced educational technologies.

B. Performance assessment with AI-enhanced educational technologies

AI-enhanced educational technologies assess knowledge/skill by inferring about a student's performance, then using the performance data to make adjustments to the activities to specifically target and develop student knowledge/skills. In some domains where there is a single correct answer, it is easier to assess performance, and more difficult in domains where there could be answers of varying degrees of appropriateness or more than 1 correct possible answer. Also, even though AI-enhanced educational technologies have a lot of potential for assessment, it is important to understand the underlying assumptions and simplifications of the models, so that the results can be interpreted accordingly.

Historically, the focus has mostly been on knowledge and skills assessment, but since the 2000s, there have been attempts to model 'group skills and interactions', and then attempts to model students 'affect and interests'. Currently, AI is mostly applied in augmented reality, virtual reality, and mixed reality, and most often used for distinguishing experts from novices, which is important as the goal is to infer about what the students know and do not know. Performance measures that are used most often include completion time, errors made, or deviance from the performance of experts. Additionally, there has been a shift to develop models to make inferences about performance in real-time. Outside of this, AI can be used to cluster students based on their attitudes (e.g. towards technology, towards learning etc) and their mindsets to compare performances of students across clusters. Nonetheless, future research should focus on using AI to provide feedback, which is currently not something done widely.

C. Examples of what has been developed/published so far

One example is of a cognitive apprenticeship environment that was designed to support clinical reasoning, called BioWorld. This virtual simulation was developed by studying how expert physicians solve various clinical problems, to create a robust model of how they think. By comparing the student and expert models, adaptable feedback is provided to students, situating student learning in a meaningful activity, providing deliberate practice, and encouraging reflection. When different data collection methods and metrics are used, researchers can look at how students think and perform (e.g. facial expressions, physiological data (e.g. sweating)).

Second, we will report results from a scoping review of AI in surgical education (unpublished results). Over the past 5 years, there has been a major growth in the number of papers published within the field of AI in surgical education (80% of studies published between 2015-2021). Currently, published studies focus on (a) performance assessment / skill classification alone (60% of studies), (b) technical skills, which can be defined as skills (e.g. respect for tissue, instrument handling, knowledge of instruments and specific procedure) needed to perform a surgical procedure (96%), and (c) simulation setting (90%). However, among the studies, only 1% assessed perceived quality of the AI-enhanced simulation training compared to other simulation training methods, and only 1% briefly mentioned theory being used to guide their research. The reason why usage of educational theory was not mentioned by authors could be due to the fact that majority of the articles were published in computer science/engineering or medical journals. Even though researchers might have considered theories, journals do not always provide much space for authors to talk about educational theories they may have used in their studies. Additionally, having a multidisciplinary research team could help make the connection regarding theory and AI more feasible.

Within this review, as future directions, we identified that (a) 38% of studies mentioned the need for experimental studies, and diverse participants, (b) 100% mentioned a need for balanced datasets, larger sample sizes, and improving and/or testing other metrics and AI techniques. (c) 59% mentioned using AI for feedback generation and delivery, including improving the feedback content and quality, and how to provide the feedback (e.g. verbal, visual, haptic). (d) 27% mentioned applying AI in more complex skills or whole procedures, and increasing the number of skills targeted. Finally, (e) some mentioned the application of AI for education in the operating room, as currently, surgeons or observers fill out forms to assess trainees, which is time consuming and there could be rater-related factors affecting the trainee score.

2. Role of educational associations and industry in enhancing HSE through AI

A. Role of the Royal College of Physicians and Surgeons of Canada (RC) for medical education

As an organisation that oversees the training of medical specialists in Canada, The Royal College of Physicians and Surgeons of Canada created a task-force to understand the implications of emerging digital technologies and AI for medical training. The task-force concluded that:

- AI will not replace doctors; however, doctors who refuse to use AI will ultimately be replaced. This is important to understand, as currently, students are hesitant to choose image-intense specialties thinking that AI will replace them. However, AI is meant to be an adjunct to clinical and educational practice, rather than a replacement.
- Doctors of the future will require new skills and within the 7 CanMEDS roles, including the integrating role of 'Medical Expert', we should add another role: the competency of digital literacy**.** To add this competency, it will be important to determine the core information that everyone needs to learn (e.g. basic understanding of the math that generates decision-making through AI), and then support students if they want to develop their skills further in this field (e.g. through summer internships that fund students interested in AI research).
- Consider introducing a new specialty for medical graduates in clinical informatics, as there's a growing movement that not all doctors who graduate with medical degrees will necessarily enter clinical medicine.
- As a part of continuing medical education, RC needs to provide support in developing new competencies and in facilitating career transitions, as how something is done now will not be done (or done the same way) in the future. Currently, there are no mechanisms for career changes or career transitions, or even for learning fundamental new competencies after training finishes. The RC can play a role in supporting physicians.
- The best AI tools will not be developed by computer scientists, but by computer scientists and medical specialists, creating a multidisciplinary

team. The RC will support medical specialists to co-develop, refine, validate and spread AI-enabled technologies.

- The patient (in the case of education, student and educator) voice will be important in developing effective AI tools, as the students and educators are the ones who will use these technologies, so their input is valuable.
- Future doctors need to be well informed about issues of privacy, discrimination, and ethical and legal concerns as they relate to AI.
- AI is powered by data; inherent biases have the potential to perpetuate or exacerbate health inequities. Hence, increasing physicians' knowledge of the social justice implications of AI-based technologies is crucial, as the AI developed/used is as good as the data that goes into it.

B. Partnership of industry and health sciences educators: Upcoming technologies to fill the gap

Collaboration between universities, hospitals, societies, and industry is crucial. There has been hesitancy with healthcare organisations to work with industry. However, these partnerships can create opportunities to develop impactful AI-enhanced educational technologies, when ethically-driven. Companies, such as CAE, aim to develop AI-enhanced educational technologies that can help reduce the need for instructors:

- Example 1: Using computer vision to develop a mobile application for training of the vaccine injection. This application can measure speed of insertion, the angle, and the depth of insertion, providing feedback to the users.
- Example 2: Using computer vision to enhance a central line placement simulator, to make sure that students are following the right sequence of steps. If the steps are followed in the right order, then you have the green dots at the top, and if you miss one it's a red dot.

As future directions, CAE is investigating the development of AI instructors for real-time trainee guidance, through a chat system, or a 3D avatar, which is especially interesting within the pandemic setting. Here, it is important to note that the goal is not to remove real instructors, but rather provide an opportunity to remove bottlenecks. Additionally, work is being done to increase realism and immersion of simulations by improving patient conversation using natural language processing for example.

3. Legal and ethical considerations when implementing AI-enhanced educational technology

There are 3 core areas of AI ethics that should be considered. However, it is important to note that it is challenging to define these areas due to different interpretations of what they are across disciplines (e.g., law, social sciences, quantitative fields etc.).

First area is fairness. In law, it is defined as protecting against discrimination based on membership in social groups such as race, sex, age, etc. In quantitative fields, it is defined as when algorithms make mistakes across the different groups. Sometimes, it is not possible to achieve multiple definitions of fairness as it is difficult to align the definitions from different fields. As a hypothetical example, trainees are assessed on how well they can perform suturing. Technology used involves machine learning, and the AI system in place has a higher error rate in individuals with darker skin than lighter skin, which is commonly found in many computer vision systems. As a result, students with darker skin color could have lower grades, which would be very problematic, and caution is needed to ensure that the AI system works fairly, independent of a person's social group.

Second area is accountability, which can be defined as an ethical and legal obligation to accept responsibility for the actions of an algorithm, especially in concordance with accepted standards. It is important to educate trainees about using AI enhanced technologies, especially as decision support systems, as at the end, health scientists are liable in case anything goes wrong.

Third area is transparency, which can be defined as the ability to glean insight into how an algorithm makes a 'decision'; viewed as an enabler of accountability. This helps explain how the AI system came to its final decision (e.g. why gave a student a lower versus a higher score). Also, as AI models have uncertainties, it is important to understand how transparency relates to decision-making under uncertainty, and how to teach health scientists to better handle uncertainty.

Regarding future directions for legal/ethical considerations when developing AI-enhanced educational technologies, one area to consider further is the diversity of data that is collected, since in Canada, there are individuals from diverse backgrounds, so there is a need to make sure that the data is representative of the diverse population. Another area is related to improving privacy and confidentiality of data captured and analyzed with AI. For example, using machine learning on operative videos, people's faces can be blurred/de-identified. However, if the video shows a colourful surgical cap that is unique to a person, the trainee/surgeon in that video becomes identifiable, so when deploying, further steps are needed to be taken to improve privacy and confidentiality. Nonetheless, it is important to note that there needs to be a balance between achieving privacy, while not steeling away the ability to gain insights from the data (e.g., to not lose information with clinical and educational value). Third is about needing a realistic model of risk in AI deployment and in education, as it is unrealistic to expect the risks to be 0 or success to be 100% assured, so there is a need for a better understanding of risk. Finally, there is a need to continue the interaction between technologists, clinicians, and individuals in social sciences (including law and ethic).

CONCLUSION

In conclusion, AI in health sciences education is still in its infancy, and there is a need to build a collaborative culture to promote research/development and implementation of AI with interdisciplinary partnerships between industry, hospitals, societies, and individuals from law, ethics, education, computer science and engineering, and health sciences (including students). Additionally, associations such as the Royal College of Physicians and Surgeons of Canada have a role in creating new initiatives and support systems to address the emerging needs of students and health scientists regarding AI (e.g. for medicine, addition of another CanMEDS role: the competency of digital literacy).

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