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# Artificial intelligence, applications and challenges in simulation-based education

## *Inteligencia artificial, aplicaciones y desafíos en la educación basada en simulación*

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### Abstract

The rapid advancement of Artificial Intelligence (AI) has taken the world by “surprise” due to the lack of regulation over this technological innovation which, while promising application opportunities in different fields of knowledge, including education, simultaneously generates concern, rejection and even fear.

In the field of Health Sciences Education, clinical simulation has transformed educational practice; however, its formal insertion is still heterogeneous, and we are now facing a new technological revolution where AI has the potential to transform the way we conceive its application.

### Key words

Simulation-based education; ChatGPT; Artificial intelligence; Machine learning; Educational innovation.

### Resumen

El rápido avance de la inteligencia artificial (IA) ha tomado al mundo por “sorpresa” debido a la falta de regulación sobre esta innovación tecnológica, que si bien promete oportunidades de aplicación en diferentes campos del conocimiento, incluido el educativo, también genera preocupación e incluso miedo y rechazo.

En el campo de la Educación en Ciencias de la Salud la Simulación Clínica ha transformado la práctica educativa; sin embargo, aún es heterogénea su inserción formal, y ahora nos enfrentamos a una nueva revolución tecnológica, en la que las IA tienen el potencial de transformar la manera en que concebimos su aplicación.

### Palabras clave

Educación basada en simulación; ChatGPT; Inteligencia artificial; Machine learning; Innovación educativa.

## INTRODUCTION

Clinical simulation has proven to be useful in multiple areas of health sciences education — undergraduate (1,2) and graduate training (3-5), and ongoing education (6,7)—, making efficient practice possible in safe learning environments, with the help of technological techniques and components and supported by different perspectives of educational theory (8-10).

Technological breakthroughs undoubtedly drive the evolution of different fields of knowledge, with health sciences education and the specific field of Simulation-Based Education (SBE) being no exception, considering the important developments which are already a reality (11,12). Among the group of technologies applicable in education, artificial intelligence (AI) has gained momentum and been adopted at dizzying speed in recent years (13), ushering new possibilities for practical application; however, knowledge of its real application in clinical simulation training is still in its infancy.

This article explores some key concepts that will enable readers to understand the broad field of AI, its potential applications in the practice of simulation-based education, and the challenges which await those who teach health sciences, from the perspective of education science, computer engineering and mechatronic engineering.

### What is artificial intelligence?

AI is a computer science study area focused on developing systems capable of performing tasks germane to human intelligence (learning, decision-making, natural language comprehension, problem solving, pattern recognition). AI study and research is not new. The term “artificial intelligence” was coined by John McCarthy in 1956 and, since that time, the field has been evolving continuously, fed by different approaches and interests, to become an academic discipline in its own right (14).

In the 1960s, work revolved around automatic learning programs and neuronal network construction. Then, after research came to a standstill during the 70s and 80s, it gained strong momentum in the 90s with advances in computing and microprocessor development and research in various areas such as natural language programming, automatic learning, deep learning, and applications in robotics, autonomous driving, diagnostic medicine, and education, among many other fields (14,15).

AI is not actually “intelligence,” at least not in the sense of human intelligence (HI); in practical terms, AI is rather a simulation of HI. It operates based on algorithms and complex mathematical models, providing machines with the ability to process huge amounts of data in short periods of time and make decisions with a low probability of error, using pattern recognition almost in real time (14).

A conceptual background is required in order to enhance our understanding of this relatively new field of AI application, considering that the new buzzwords like Chatbot, NLP, LLM, Machine Learning or Deep learning can be confusing.

### Natural language processing (NLP)

NLP is one of the most important elements of all AI used as part of daily life. It focuses on enabling seamless and consistent text or voice communication between computers and human beings. NLP extracts information from an input, performs semantic, syntactic and context analysis and provides the user with a response that is similar to what a human being would provide, obviously with a margin of error. Currently, systems like Apple’s SIRI, Amazon’s Alexa, and customer service bots are used daily, while the more recent advanced NLP systems such as chatbots are also gaining popularity.

Worthy of mention among NLP models are Large Language Models (LLM), which contain billions of parameters. The parameters in these models are adjusted

and optimized by means of large text datasets. This has given rise to skills such as contextual learning, following instructions and step-by-step reasoning, which were not present in older pre-trained language models (PLM) (16).

A chatbot, an interactive agent, digital assistant or artificial chat entity, is a computer program which understands one or more human languages, uses NLP and automated machine learning to interact with the user in response to inputs and context. It can be classified depending on the discrimination criterion, for example, by sophistication (basic-advanced, simple-complex), function (information, banking, etc.), interface (text, voice, mixed), target audience (children, older adults, students, etc.) (17,18).

One of the most important and best known chatbots today is ChatGPT from OpenAI. This AI-driven virtual assistant model is based on GPT (generative pre-trained transformer) which, in turn, is built on a neuronal network that trains using big data without the need for supervision, and is capable of generating highly accurate quality data in a matter of seconds in response to relatively simple inputs. Moreover, it can consider the context of previous input, making it very efficient and useful (19-21); however, it has given rise to much questioning in the academic and scientific world (16,22).

### Machine learning

In the AI field, machine learning is a feature of the greatest importance with practical applications in health sciences, mainly in diagnostic imaging in medicine (23). Machine learning refers to the way in which computers learn through data and how they can use statistics and probabilities to enhance their performance (14,24).

Automated machine learning is usually classified into three types depending on the learning mode (supervised, unsupervised and reinforcement). In supervised learning, the machine uses previously labeled data

to learn how to predict; in unsupervised learning, the model learns directly from the dataset where it finds patterns; and in reinforcement learning, the machine requires feedback regarding its actions (24,25).

## Deep learning

The human brain has a huge network of interconnected neurons, and deep learning (a subfield of automated learning) seeks to replicate the human brain structure. In this form of automated learning, multiple layers of artificial neuronal networks that process and analyze a large amount of data are used. It has wide applications in practice, including natural language processing and image-based disease detection (23,26).

## Role of AI in health sciences education (HSE)

### AI in training

AI is revolutionizing the field of education in health sciences as it provides information within seconds, enhancing learning speed. In the past, health sciences students used books and encyclopedias; eventually, they moved to online sources using search engines and subscription databases. With generative AI connected to the net, students may obtain summarized, organized and coherent information using relatively simple inputs, without the need to review, compare or summarize the information they receive (22,27,28).

### AI in evaluation

AI can be of help to teachers in the teaching-learning-evaluation process. It could identify learning patterns, the speed at which students analyze and how much information they retain and then create individual learning models that could be

used to provide immediate, high-quality feedback to each student (21,29).

AI has many potential applications. However, concerns have emerged in the realm of education regarding open access to AI and its potential impact on the student's original creation in essays and other work (20,22). Although the most advanced AI can generate high quality text in natural language, the focus should be on how to reinvent the way to educate and how to update the existing educational structures considering that higher education institutions are closely tied to the concept of the 19th century university, with professors —most of them from the 20th century — and thinking models aligned with the logic of traditional education, while most of the students were born already in the 21st century, and are digital natives and consumers of disruptive technologies, as is the case of AI (30).

## The role of AI in simulation-based education (SBE)

### Development of simulators

There is growing interest in the application of technology to the development of simulators that can evoke a physiological response to the interventions from the participants, thus improving their experience through realism (31). A simulator with embedded AI capability could eventually provide real time response to the intervention (e.g., rhythm change in supraventricular tachycardia with after adenosine administration, without the need for an external operator in the control room).

### Assistance with instructional design

Creating and drafting mock cases suited to the needs of the audience is usually time consuming (32); now, with specific

instruction, the time required to write the cases is significantly shortened, personalizing the experience for the participants even more and allowing instructors additional time for other tasks.

### Skill development analysis

Skill development requires the acquisition of groundwork concepts (declarative knowledge) and performance of the skill in practice (procedural knowledge), where deliberate practice leads to the achievement of good results (33-35). In skill development, dedicated AI could assess the performance of the participants, gather information and provide more accurate feedback (36), even allowing participants to use a chatbot to gain a better understanding of their own performance and obtain feedback (Figure 1).

### Assistance with debriefing

A central aspect of simulation-based education is guided conversation in the form of two-way feedback or deeper level debriefing (37). Although educational debriefing is desirable in zone 2 and zone 3 simulations (38), it is not always easy to do, in particular for novice instructors (39). AI has the power to analyze the discourse of the participants, find their mental models (40) and propose ways to improve, becoming an assistant to the debriefer.

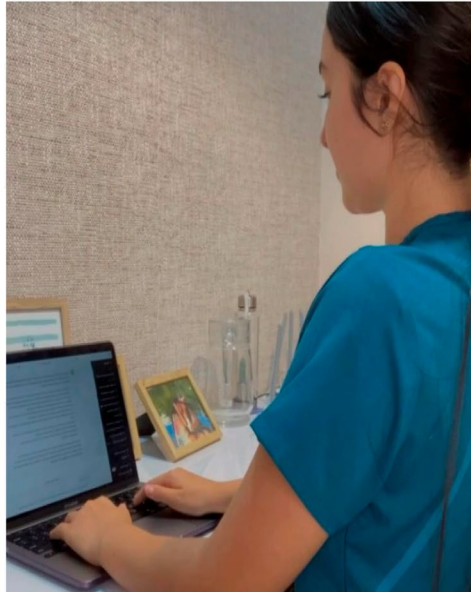
## Challenges to AI insertion in teaching practice

Although AI is already a reality within reach in health sciences education (HSE) — albeit less so in SBE — and it could bring about very interesting breakthroughs in the not-too-distant future, it is true that there are some financial, interaction and ethical limitations to its implementation in daily practice (20,27,29,41-43), as illustrated in Table 1.

**Figure 1.** Medical student using ChatGPT to get feedback of her performance in simulation.

Today I did a clinical simulation, in the case, a 65-year-old patient who was driven to the emergency room by his wife after he experienced sudden right-side weakness and difficulty speaking. On arrival, the patient showed signs of neurologic compromise, weakness of the right arm and leg and asymmetrical facial expression. Ischemic stroke was suspected based on the clinical presentation and the findings of the clinical assessment. I was the leader, but I panicked, I did not make good decisions and led the team to make medication errors. Could you give me feedback on how to improve based on the information above?

Thank you for sharing your experience. The following are some comments and suggestions to improve your performance in similar situations: 1. Keep calm: It is understandable that you should feel frightened or overwhelmed in emergency situations, but it is important to remain calm in order to make adequate decisions and provide effective leadership to your team. Try to control your emotions and focus on the task at hand. 2. Make sure you know the protocols and proceed accordingly."



Source: Authors.

**Table 1.** Limitations for incorporating AI in HSE and SBE.

Challenges	Description
Financial	Implementation of new technologies entails costs. Regional economic inequalities are a limitation for the adoption of tools to embed AI into simulators and AI-driven applications in low and middle income countries, considering that the development of this technology requires substantial financial investments.
Data training	AI will be powerful to the extent it is trained using large amounts of good quality data. HSE is heterogeneous and not standardized and, besides, there are data confidentiality policies, all of which can delay AI training.
Context comprehension	Clinical contexts are ever-changing, medical professions are diverse with varying training needs, and requiring very different settings. This could pose some challenges, at least in the short and medium term.
Human interaction	Incorporation of technologies that learn as they are used can mean that people will become less necessary; however, the aim of SBE is to ensure patient safety, many times through teamwork, which requires human-human interaction.
Social biases	Literature on AI in health has shown the potential for social biases given the programming received. These same biases can show up in SBE and have a negative impact on learning and/or evaluation.
Ethical	AI incorporation in simulators or in specific chatbots can give rise to ethical issues related to student privacy violations.

Source: Authors.

## CONCLUSIONS

SBE brought about a revolution in the way health sciences are taught and learned; now, with AI, a new revolution has arrived, bringing with it the potential to change the way in which we teach and learn.

AI is a reality, and it has many practical applications in education. Teachers must learn to use it as part of their daily practice within the teaching-learning process. From the authors' perspective, AI is more an assistant or copilot than an actual threat.

Over the next few months, AI will probably be incorporated into clinical simulation technologies, allowing for more personalized experiences tailored to the progress of individual students. However, there are countless challenges and limitations that must be addressed and studied in depth if the right policies and regulations are to be implemented.

## Conflicts of interest

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