

# Generative Artificial Intelligence and Immersive Technology for Medical Education: Opportunities and Challenges

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## ABSTRACT

Medical education is embracing digital transformation with immersive technology and artificial intelligence. These technologies have gained acceptance in education and practice to create realistic and engaging learning experiences for students and professionals. In the recent fast-growing interventions in Artificial Intelligence (AI) research, generative AI proved as a great resource for novel and realistic content, such as images, text, music, or code, based on some input or data. Integrating generative AI in immersive technologies can offer many opportunities and challenges for medical education, as well as ethical and social implications. This article focuses on the prospects of generative AI in immersive technologies for medical education and future opportunities. It also highlights some of the potential benefits and risks of generative AI in immersive technologies for medical education. It covers the enhancement of diversity and richness of the learning experiences, fostering the creativity and innovation of the learners, ensuring the quality of content and outcomes, as well as addressing ethical and legal issues. This article also stimulates further research and debate on this emerging and promising field.

**Keywords:** Immersive Technology, Virtual Reality, Generative AI, Artificial Intelligence, Medical, Education

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## Introduction

Immersive technology as a learning tool integrated with generative Artificial Intelligence (AI) has vast opportunities and potential for revolutionizing medical education. One key opportunity these technologies can provide is the creation of realistic and customizable simulations to allow students to practice a wide range of medical procedures in real-time in a risk-free environment. These simulations can be developed in a variety of clinical scenarios, enabling learners to develop critical decision-making skills and learn techniques in a variety of situations (1). Additionally,

integrating generative AI can help to develop personalised learning experiences, catering to the uniqueness of individual learners. Immersive technology also offers the potential to develop collaboration among students and healthcare professionals, enabling remote learning and interdisciplinary training (2). As these technologies continue to advance, they can transform medical education into a more engaging, effective, and accessible for healthcare professionals globally (3).

## *Immersive Technologies*

Immersive technology refers to the use of digital devices and software that create

interaction with simulated environments (4). It includes Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), and haptic feedback. In medical education and clinical practice, immersive technologies have many applications and benefits (5, 6).

The field of medical education encounters various challenges worldwide, each context-specific across different settings. These challenges are often described as “wicked issues” (7) — complex problems that defy straightforward solutions and are perceived differently by various stakeholders.

### *Benefits of Immersive Technologies in Medical Education*

Immersive technology in its different forms can provide realistic and engaging learning experiences for medical students and clinical professionals (8, 9). For instance, immersive technology can create virtual patients, scenarios, or environments that mimic real-life medical situations, such as surgeries, emergencies, or epidemics (10, 11). The use of VR/AR also proved helpful for learners to practice their skills, knowledge, and decision-making in a safe and controlled manner without dealing with real patients or risking errors. In recent research, immersive technology has proven to enhance the accessibility and flexibility of learning in different contexts (12-14). For example, by using VR, learners can access medical resources, experts, or peers from anywhere and anytime, using their own devices or platforms (15). The option of creating personalised learning content is also possible in immersive learning content, which can enhance the learning pace, level, or style to meet the preferences of learners (16).

### *Generative AI*

Generative AI is a branch of AI that aims to create novel and realistic content, such as images, text, music, or code, based on data (17). By using generative AI, we can produce content learned from previous data. Generative AI can create images that do not exist in reality but look realistic and diverse.

Generative AI can also create text, such as stories, poems, or essays, that are coherent and meaningful based on provided keywords. It can also create music, such as melodies, harmonies, or rhythms, that are original and pleasing, based on some genres, moods, or instruments. At a more advanced level, it can write code, such as programs, algorithms, or functions, based on some specifications, inputs, or outputs (18).

On the technical side, generative AI uses different models and techniques to create content, such as Variational AutoEncoders (VAEs) (19), Generative Adversarial Networks (GANs) (20), transformers, or diffusion models. These models learn from data and generate content, such as encoding and decoding, competing and cooperating, attending and predicting. It also utilizes different modalities to create content, such as text-to-image, image-to-image, text-to-speech, or speech-to-text. These advanced-level contents use Natural Language Processing (NLP), Computer Vision (CV), or Speech Synthesis (SS) (21).

### *Benefits of Generative AI in Immersive Learning for Medical Education*

Integrating generative AI in immersive learning environments can offer many benefits for medical education.

Using generative AI in immersive learning environments can enhance the diversity and richness of the content by developing scenarios that learners can experience (22). The advanced level generative AI, like GPT-4 and Google Bard, can create realistic and varied images of clinical scenes and cultural artefacts or develop natural phenomena that learners can explore in virtual or augmented reality. When it is required to make the immersive experience more personalised, generative AI can generate adaptive and personalised text or speech that can guide, instruct, or interact with learners in different languages and learning styles.

In terms of creativity and innovation in immersive learning, generative AI can foster the creativity and innovation

of learners by allowing them to explore countless opportunities and access the world of content generation (23). Generative AI has the capability of providing feedback, suggestions, or case studies for learners who want to create their content, such as music, art, or code, in immersive learning environments. Applying generative AI in immersive learning can inspire learners to generate new ideas or solutions and present them with novel scenarios that challenge their assumptions and expectations (24).

### *Challenges in Immersive Technology and Generative AI*

Immersive technology in medical education also poses some challenges and limitations. The top challenge is the cost and availability of the technology and equipment (16). Advanced-level immersive technology requires expensive hardware, software, or infrastructure, which may not be affordable or accessible for all learners or institutions. The application of immersive technology in medical education also requires technical support, maintenance, or updates, which may not be readily available or reliable in different settings.

Using generative AI in immersive learning environments also comes with challenges and risks for medical education. One of the major challenges is the quality and reliability of AI-generated content. Based on the available data and learning from it, generative AI may produce content that is inaccurate, incomplete, biased, or inappropriate for the learning objectives ethically or in the context of the classroom. There are also possibilities that generative AI content may be indistinguishable from human-made content, which will raise ethical and legal issues in terms of ownership, authorship, and credibility.

On the other hand, content generated by AI can influence motivation, engagement, and performance in positive or negative ways (25). It can also affect cognitive, social, and emotional skills and attitudes (1), such as critical thinking and collaboration. Therefore, content developers require careful

design, evaluation, and regulation to ensure its effectiveness and appropriateness for immersive learning in medicine.

Generative AI, such as GPT-4 and Google Bard, has the potential to revolutionise the future of medical education by offering opportunities to create immersive and interactive learning simulations. The combination of these technologies will generate realistic and diverse scenarios, questions, feedback, and assessments that can enhance the learners' engagement, motivation, and retention. The ability of generative AI to adapt to the learners' needs, preferences, and personalised learning paths will be a game changer in the future (18). By enabling learners to interact with each other and virtual characters in simulated environments, generative AI will also foster collaborative learning among students.

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### **Authors' Contribution**

MZ. I and M. H conceptualized the study, wrote the manuscript and oversaw all processes until submission. MZ. I handled revisions and responded to comments. Both authors approved the final manuscript.

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The authors have no conflict of interest.

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### **Availability of Data and Materials**

All data supporting the manuscript is available from articles where DOIs are provided and in books and book chapters available online.

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