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# Scenario Innovation of Virtual Reality in Medical Education: Possibility, Advantages and Barriers

**Yuqi Liu[1] and Yunlu Liu[2]**

[1]Academy of Arts & Design, Tsinghua University, Beijing, China
[2]Faculty of Science, Engineering and Computing, Kingston University, London, United Kingdom

## ABSTRACT

The development of digital technology is profoundly transforming the practice of medical education. Virtual simulation based on virtual reality technology is increasingly becoming the cornerstone of clinical education and training. This study analyzes the scenario innovation of virtual reality in the application of medical education, and summarizes the possibilities, advantages, and barriers of technology use. In terms of the possibility of scenario innovation, the following five points can be considered: firstly, the functions and operation method of medical equipment and pharmacological effects of medicine can be demonstrated via virtual reality; Secondly, patients can be informed of diseases situation and surgical plan risks in a more intuitive and understandable way and simulate the process of surgical implementation, to improve the doctor-patient empathy and communication; Thirdly, virtual reality can help patients and users receive dual psychological and physiological treatment and rehabilitation guidance; Fourthly, institutional teaching and clinical training can be conducted without the limitation of time and space as well as physical samples; Fifth, virtual reality can make contributions to health knowledge popularization, healthy lifestyles promotion and emergency rescue training, also,disaster response education can be carried out in a virtual way. The advantages of virtual reality technology in medical education innovation mainly include three points: firstly, the virtual simulation system makes the learning of clinical experience intuitive, diverse, and repeatable; Secondly, it greatly frees up the burden of medical experts and senior teachers; Thirdly, it allows universities and medical institutions to provide simulated teaching with fewer resources and lower costs. The disadvantages of virtual reality technology in medical education mainly include three points: firstly, virtual simulation systems are not suitable for all medical education scenarios; Secondly, due to the technological limitations of virtual reality, the implementation of related teaching activities still requires the support of human teachers; Thirdly, virtual reality systems provide medical knowledge in a form of simulation learning that cannot completely replace expert educators.

**Keywords:** Virtual reality, Medical education, Scenario innovation, Virtual simulation system

## INTRODUCTION

With the increasing budget and standardized teaching pressure of universities and related medical institutions, Virtual simulation system based on virtual

reality technology as a highly potential medical education tool (Abdul et al., 2022; Turso Finnich et al., 2023) has attracted high attention from international medical colleges and institutions (Yang, 2016; Zhang, Gao and Zhang, 2016; Al Hiyari, Jusoh and IEEE, 2020). Virtual reality can replicate real medical scenarios, learners can simulate their learning methods and activities in the virtual environment through gamified elements and immersive interactivity. The system will provide real-time feedback and reports on their learning performance (Papagiannakis et al., 2018). The medical industry is a field that places great emphasis on practice, but due to the scarce medical resources, current medical teaching practices are not very common, especially for complex anatomy and special disease cases (de Faria et al., 2016; Alharbi et al., 2020; Turso Finnich et al., 2023). Physical based medical education has significant limitations due to the rare sample size and the lack of opportunities for surgeries practice. As a solution,medical simulation education based on virtual reality technology is not limited by time and space (Dhar et al., 2023), does not consume physical drugs and samples, does not require real medical devices and physical materials, and has strong repeatability (Pierce et al., 2008). Learners can access the system anytime and anywhere through the Internet and related wearable helmet devices for learning. Virtual medical simulation is effective in many fields and has been proven to be "superior to traditional clinical education, as it can generate powerful educational interventions and immediate results." (Zhao et al., 2021). So, what kind of innovative scenarios could virtual reality technology bring to medical education? What are the advantages and disadvantages compared to traditional medical education? This study will explore these issues in detail.

## THE INNOVATIVE SCENARIO POSSIBILITY OF VIRTUAL REALITY TECHNOLOGY IN MEDICAL EDUCATION

Virtual Reality (VR) is mainly used to create a virtual computer system. It can provide users with immersive simulation effects through visual, auditory, and tactile effects (Iserson, 2018). Users can act directly, intuitively, and in a timely manner in this virtual simulation space, and can manipulate virtual objects within it for real-time interaction. Virtual reality technology utilizes 3D graphics generation technology, sensor interaction technology, and high-resolution display technology to generate a three-dimensional realistic virtual environment (Yu et al., 2019). It integrates multiple sciences such as computer graphics, image processing and pattern recognition, intelligent technology, sensing technology, language processing and audio technology, and network technology, and is an advanced development and breakthrough in modern simulation technology (Yang, 2016). Due to its multi-sensory, immersive, interactive, and imaginative characteristics, virtual reality technology has a wide range of applications in scenario innovation in medical education. The following will explore the possibilities of innovation in relevant scenes from five aspects.

### Medical Procurement and Marketing

- **Functional operation of medical devices:** Medical device sellers can use virtual simulation to allow users to immerse themselves in the usage scenarios

and working principles of medical devices, intuitively demonstrate the functions and operation methods of the devices, increase users' understanding, and serve the marketing and procurement of related products. The relevant roles mainly include the following three aspects: First of all, VR can model medical devices in virtual space through virtual simulation and provide a realistic three-dimensional environment, allowing users to personally experience the use scenarios of medical devices. Secondly, by simulating the actual operation and real-time interaction of medical devices, users can more intuitively understand the working principles and operation methods of medical devices, providing a decision-making reference for the final purchase. Finally, VR can also be used for remote display and sales of medical devices, allowing sellers and buyers to break through the limitations of time and space and remotely understand the relevant features and functional principles of the product, making procurement easier.

- **Medical equipment maintenance guidance:** Virtual reality can be used for repair and maintenance training of medical devices. Operators can simulate equipment failures and repair them in the virtual environment, which greatly reduces the risk of operating on actual equipment. First, VR can help maintenance personnel operate virtual medical equipment under the guidance of remote experts. In this way, experts can provide real-time guidance at any time and anywhere to help maintenance personnel solve complex problems. Second, the interactive nature of VR allows maintenance personnel to interact with virtual equipment to understand problems more intuitively. By operating virtual equipment, operators can better understand the working principle and maintenance process of the equipment and improve maintenance efficiency. In addition, VR can also provide an immersive operating experience, allowing maintenance personnel to practice repeatedly in the virtual environment until they master maintenance skills. This ensures that related personnel can perform maintenance operations with more confidence when facing actual equipment. Finally, VR's remote guidance function can also reduce maintenance costs, saving time and resources.
- **Introduction to pharmacology of medical drugs:** The virtual reality environment can simulate various pathological conditions and characteristics, and display the pharmacology of how related drugs work. First of all, VR can simulate the metabolic process of drugs in the human body, so that drug purchasers or users can better understand the molecular structure, therapeutic principles and pharmacological effects to make better choices and decisions. Secondly, VR can simulate the process and symptoms of adverse drug reactions, so that purchasers or users can better understand the safety and risks of drugs,and can guide patients to rationally use drugs after purchase. Finally, VR can also educate patients on the use methods and precautions of drugs. Through virtual reality technology, patients can understand the possible consequences of different use methods in a safe environment, which helps to improve patients' medication adherence and therapeutic effects.

## Empathy and Communication Between Doctors and Patients

- **Patient inquiry and condition explanation:** Virtual reality can play an important role in doctor-patient communication, especially in disease consultation and explanation.. Medical concepts and terminology usually have a high threshold for understanding. Virtual reality technology can present unfamiliar and difficult medical concepts in a more immersive way, which is helpful for patients to understand their own conditions. At the same time, it can provide an interactive environment to make doctors and patients communicate more intuitively and vividly. For example, doctors can show patients the pathological changes and treatment methods of the disease through virtual simulation, while receiving feedback from patients and generating more empathy (Dyer, Swartzlander and Gugliucci, 2018; Li et al., 2021). Then, according to the virtual experience and feedback of patients, doctors can formulate more targeted treatment plans, put forward personalized treatment suggestions, and improve treatment effects.

- **Communication of patient's surgical plan:** Virtual reality technology has a significant effect in introducing surgical options to patients. First, VR can be used to communicate with patients before surgery. Doctors can use VR technology to explain surgical plans and precautions to patients in a comprehensive and detailed manner, answer patients' questions, reduce patients' anxiety and uneasiness, and allow patients to understand surgical plans and possible risks to make more rational treatment decisions. Secondly, VR can be used for surgical simulation before formal surgery, allowing patients to experience the surgical process firsthand in advance, enhancing trust and cooperation between doctors and patients (Iserson, 2018), helping doctors and patients establish closer cooperative relationships, and improving the efficiency and quality of medical services.

## Medical Rehabilitation Training

- **Psychological rehabilitation therapy:** Virtual reality (VR) technology has broad application prospects in psychotherapy, providing more humane, precise, and efficient solutions. This is mainly reflected in the following aspects: first, exposure therapy. VR can create a real and safe environment to help patients face and overcome their fears, anxiety, and other problems. For example, for patients with acrophobia, VR can simulate a high-altitude environment, allowing them to gradually overcome acrophobia in a virtual environment. Secondly, scenario simulation. VR can simulate various scenarios, including social scenes, to assist patients in the treatment of social phobia. Help patients overcome social anxiety by gradually guiding them to adapt to different social situations. Thirdly, attention training. VR can provide rich visual and auditory stimuli to help patients with attention deficit hyperactivity disorder (ADHD) improve their ability to concentrate and self-control. Fourthly, psychological education. VR can provide rich psychological education resources to help patients better understand psychological problems and improve their ability to regulate their own psychology. Fifth, remote psychotherapy. VR

and AR devices can provide psychotherapists and patients with a more immersive remote treatment experience. Therapists can use these devices to immerse patients completely in the virtual world, or enhance treatment effectiveness through digital tools and experiences.

- **Physiological rehabilitation training:** Virtual reality technology also has various functions in physiological therapy, helping patients better perceive and understand their physical state, and enhancing their body health training. This mainly includes the following aspects: Firstly, rehabilitation treatment. Through the immersive experience of VR, patients can undergo rehabilitation training in a safe environment, which not only improves their enthusiasm for rehabilitation, but also increases the efficiency and quality of rehabilitation treatment. For example, for patients with neurological damage, VR can simulate real-life scenarios and activities to help them recover motor function during the rehabilitation process. For patients with muscle atrophy, VR can also provide a specific training environment to help them restore muscle strength and balance ability. What's more, virtual reality technology can also be used for a large number of postoperative rehabilitation treatments. Secondly, pain management. VR technology can be used for pain management, especially for patients with chronic pain and postoperative pain. By providing an immersive relaxation experience, VR can help patients divert their attention and reduce pain. This can not only reduce patients' drug use, but also improve their quality of life. Thirdly, sleep improvement. VR technology can also help patients alleviate anxiety and stress, and improve sleep quality. This is very helpful for people with long-term insomnia and poor sleep state.

## Medical Education Teaching

- **Institutional teaching:** The scenario innovation of virtual reality in medical teaching is mainly reflected in the following four aspects: first, experimental simulation and operation. VR technology can enable students to simulate real human experiments and medical operations in a safe environment (Sales, Machado and Moraes, 2011). This not only reduces the use of experimental samples and live animals, but also reduces costs, while improving the repeatability and safety of the experiment. Secondly, complex case learning. VR technology can simulate complex cases, allowing students to understand the diagnosis and treatment process of diseases in simulated cases. This can help students better understand complex cases, improve their clinical thinking and problem-solving abilities. Finally, remote education. Remote medical education based on virtual simulation allows students to learn and practice at any time and place. This can improve the efficiency of utilizing educational resources while providing students with more flexible and convenient learning methods.
- **Clinical training:** The scenario innovation of virtual reality in clinical training is mainly reflected in the following aspects: first, surgical simulation. VR technology can provide surgical simulation training, allowing medical students to perform surgical operations in a simulated environment. This not only reduces the use of real surgical instruments, but also

reduces surgical risks, while improving the proficiency and accuracy of surgical procedures. Secondly, clinical decision-making simulation. VR technology can simulate various clinical scenarios (Hsin et al., 2022), allowing medical students to experience the clinical decision-making process in the simulated context. This can help students better understand clinical problems and improve their clinical thinking and decision-making abilities. Thirdly, patient interaction simulation. VR technology can simulate interaction scenarios with patients, enabling medical students to learn communication skills and treatment plans through interaction with simulated patients. This can help students better understand the needs of patients and improve their communication and collaboration skills with patients. Fourthly, emergency response simulation. VR technology can simulate various emergency situations, enabling medical students to learn emergency handling skills in simulated situations. This can help students better respond to emergency situations, improve their emergency response ability and rescue success rate.

## Medical Science Popularization

- **Medical knowledge popularization:** The effectiveness of virtual reality technology in medical knowledge popularization is mainly reflected in the following aspects. Firstly, it can create online virtual medical knowledge exhibition halls to popularize obscure medical concepts and knowledge to the public. Secondly, VR technology can simulate the internal structures and functions of different organisms or human bodies, enabling people to have a deeper understanding of the relevant body structures and functions. Thirdly, VR can also be used for simulating the process of medical experiments, allowing the public to learn medical knowledge and experimental skills in a highly interactive and secure environment. Through VR technology, the popularization of medical knowledge can be more immersive, vivid, and funny, thereby enhancing the public's health literacy and learning interests.
- **Healthy lifestyle promotion:** The effectiveness of virtual reality technology in promoting healthy lifestyles is mainly reflected in the following aspects. Firstly, using virtual reality technology, various health education applications can be developed to provide vivid health knowledge to the public, such as nutrition knowledge, sports skills, disease prevention, etc. Secondly, VR can provide users with personalized fitness training plans, users can engage in safe and effective exercise at home through the virtual simulation environment. In addition, virtual reality can also provide real-time feedback to users, helping them correct their motion posture and improve their motion performance. Thirdly, the realistic simulation effects of VR can educate people about the harmful effects of habits such as smoking, alcohol and drug abuse, unhealthy diets, and sedentary lifestyles. Illustrative 3D models can show how the human body gradually undergoes changes under the influence of these habits, and how long it takes to recover from damage fully or partially. This visualization provides an

understandable and relevant approach to promoting healthy living and urging people to change their lives before it is too late.

- **Disaster prevention and response education:** For natural disasters such as fires, floods, earthquakes, mudslides, avalanches, or crises related to large-scale epidemics and infectious diseases, virtual reality technology can simulate real disaster scenarios, allowing people to experience the disaster scene firsthand, and provide a series of guiding and interactive disaster prevention, response, and post disaster recovery education, such as how to evacuate, how to use emergency equipment,how to avoid danger, etc. This practical operation can enhance learners' emergency response ability and practical operation ability. Educate the public to ensure their personal and property safety in the first instance of a disaster. Secondly, utilizing virtual reality technology for disaster prevention and response education can save personnel and material expenses required for on-site teaching, and reduce educational costs. At the same time, virtual reality technology can also avoid potential security risks in real disaster scenarios. Finally, virtual reality can provide personalized learning experiences based on learners' learning needs and levels. Learners can practice and explore repeatedly based on their learning progress and understanding ability to improve their disaster response ability.

- **Emergency rescue training:** For situations where individuals or others experience sudden illness or personal accidents that require emergency rescue, if the personnel implementing the rescue lack the correct knowledge and methods of emergency rescue, it is often easy for the victim to miss the optimal rescue time, causing irreparable loss or tragedy. Therefore, it is necessary to maximize public participation and learn necessary first-aid skills and rescue training, especially in areas with frequent disasters. And virtual reality can provide learners with numerous trial and error opportunities for simulating real scenarios and human bodies, avoiding the risk of operational errors for real patients, and continuously repeating trial and error. Secondly, virtual reality can simulate numerous emergency scenarios, such as fires, car accidents, drowning, etc. Through training, learners can comprehensively master various emergency skills. Finally, virtual reality systems can provide real-time feedback, guide learners in their operation process, and help them improve their skills and decision-making. These advantages will greatly benefit learners and improve their training effectiveness.

## ADVANTAGES OF VIRTUAL REALITY IN MEDICAL EDUCATIONS APPLICATIONS

The advantages of virtual reality technology in medical education applications are mainly reflected in three aspects: learners, educators, and medical education institutions. The following is a detailed explanation:

### For Learners

For learners, virtual simulation systems based on virtual reality technology make learning clinical experience simple. VR systems typically include

a combination of Earphones, helmets, and laptops. They are commercially available, so they are easy to set up, convenient to use, and safe. Many VR systems work without the need for instructors. Learners can access virtual systems easily and participate in simulations, allowing for larger and more flexible access without being limited by time and space. The flexibility of this access allows for the integration of simulation based education into daily practice. It is very important that VR scenes are repeatable (Barteit et al., 2021). This allows learners to safely make mistakes and then improve performance through deliberate practice. This is one of the core features of successful virtual simulation. The psychological safety, pleasure, and gamification potential of VR can greatly enhance learners' active participation to promote autonomous learning.

## For Educators

For educators, virtual simulation systems equipped with virtual reality technology can greatly release teachers' time and space. Some VR settings require the presence of instructors, while others do not, and instructor input is usually determined by the specific use case of a given VR system. VR can provide clinical scenarios in a small space (2 x 2 m) in less than 5 minutes of setup. The simplicity of this use allows teachers to conduct other simulation activities in the center during VR simulation. This can allow teachers to focus more on advanced communication skills or primitive simulations. In some teaching scenarios where educators are not required to be present, teachers can free up time and energy from teaching tasks to engage in more crucial medical research and development projects.

## For Universities and Medical Institutions

For universities and medical institutions, virtual reality technology allows for simulated teaching with fewer resources and lower costs. In medical education and simulation, costs are often difficult to assess and often underestimated. The cost of physical simulation is usually high and complex. The cost of virtual simulation typically includes hardware and software. The installation cost of high-end VR hardware includes laptops and headsets or headphones. The software cost depends on the supplier and product quality but is usually less than one tenth of the physical simulation cost independent of the supplier. Therefore, virtual reality can save a lot of setup and operational costs. These systems can also generate a large amount of performance data. These data have great reference significance for relevant universities and medical institutions to optimize their own education and training policies. In addition, many immersive systems allow institutions to create customized simulation courses to meet specific needs. From a global health perspective, this reduction in access costs and fairness allows simulations to be distributed globally.

## DISADVANTAGES OF VIRTUAL REALITY IN MEDICAL EDUCATIONS APPLICATIONS

Although virtual reality has great advantages in the application of medical education, VR simulation is not omnipotent, it is a tool used to complete

specific learning tasks. Therefore, it should be integrated into the curriculum and teaching methods of the institution to ensure effective use.

**Virtual simulation systems equipped with virtual reality technology are not suitable for all medical education scenarios.** For example, it is not the best method for teaching inquiry, such as abdominal palpation, which does not require complex immersion in this situation, only real and accurate physical manifestations. This also applies to some task training, such as intubation or many other procedural skills. Virtual characters are usually controlled by artificial intelligence (AI) systems, and although virtual reality technology is rapidly developing, it is not yet suitable for certain learning objectives, such as sudden emergencies. At present, the complexity of language processing and facial expressions in virtual simulations still cannot be accurately represented, and it is best to solve it by real patients rather than virtual patients.

**Virtual simulation systems equipped with virtual reality technology have their own technical limitations.** The development of any new technology faces difficulties, and its implementation requires the support of teachers. Teaching staff may find it difficult to attract more senior members to participate, as they may view VR as a game rather than an educational tool. However, many companies offer trial periods to satisfy educators with this technology, and as the use of VR becomes more widespread, concerns and fears about VR related issues will also be addressed.

**Virtual simulation systems equipped with virtual reality technology cannot replace expert educators.** Just as physical simulation should not replace clinical training, VR is just a technology that provides simulated learning. Some learning objectives are best taught through physical simulations, while others are best taught through VR. Educators need to determine the goals they wish to improve and determine the most suitable teaching delivery method. Virtual reality technology can help clinical doctors, universities, and medical institutions increase simulation delivery at lower costs, while reducing the burden on teachers and ensuring training quality.However, the knowledge that virtual reality typically delivers is general medical knowledge without perfect replication in simulation accuracy. They are powerless for the dissemination and research of complex, rare, or unknown medical samples, and therefore cannot replace senior medical experts and researchers.

## CONCLUSION

Virtual reality technology can provide cost-effective, repeatable, and standardized clinical training for learners and educators, and has profoundly transformed the way medical education is conducted,which mainly including medical procurement and marketing, doctor-patient empathy and communication, psychological and physiological rehabilitation training, medical education teaching, and medical science popularization. It can achieve large-scale, real-time, cross-regional, and interdisciplinary medical education, freeing medical education from the classroom and allowing multiple learners to participate in truly cross-professional, vivid simulation education without geographical restrictions. It allows learners to constantly try and make mistakes in repeatable virtual systems, learn from mistakes, and apply their

knowledge to practice. Especially in the context of public health crises, virtual medical training systems can greatly alleviate the shortage of personnel in medical institutions, protect working personnel, and obtain a large number of well-trained medical staff in the short term. The psychological safety, pleasure, and gamification potential of virtual medical simulation system can greatly enhance learners' interests and promote autonomous learning. For educators, it can greatly reduce the workload, freeing up their time and energy for more clinical diagnosis and medical research. For universities and medical institutions, it can tremendously reduce the physical costs of education and training, and expand the scale of training. The future of VR lies in its continuous integration with courses and technological development that allows for shared simulated clinical experiences. In addition to these advantages, virtual simulation systems equipped with virtual reality technology cannot be applied in all medical scenarios, cannot replace medical experts and educators, and have limitations in their own technological development. Therefore, relevant universities and medical education institutions should seize the development trend of future medical education, combine their own educational demands and effective resources when developing and applying virtual reality technology, effectively integrate virtual simulation systems, and apply VR technology to benefit their learners to improve the quality of medical teaching and training.

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