# A Review on Reimagining Medical Education with Virtual Reality in Emerging Medical Disciplines

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*Abstract: Involvement of emerging technological improvements is essential in medical disciplines to provide adequate medical treatment. Virtual reality is one of the latest and most applicable technologies that can facilitate medical professionals and patients in several ways while treating diseases. Furthermore, virtual reality enhances a medical student's knowledge and abilities in various ways. Therefore, it is fascinating to explore the potential of virtual reality for improving the medical education experience in an academic study. This research provides a review of virtual reality in medical education and finds how medical students and professionals are aware of the applications of virtual reality in medical education and practices*

***Keywords:*** *virtual reality, medical education, simulation, 3D environment, medical training*

## 1. Introduction

Medical education in teaching, learning, and practical aspects of the human body and health aims to produce medical professionals who can diagnose and reduce diseases. Mainly, medical education is not limited to in-class academic studies and exams. Still, it is expanded by understanding and handling the complexity of the human body practically and regulating its functions with proper medical applications. However, limitations in the availability of human bodies and learning from mistakes in live human bodies are the main blockers to medical education practices.

Virtual reality (VR) is one of the most emerging technologies which makes digital evolution in several fields (Elmqaddem & N., 2019). It is noticeable that medical education has specialized in digital technologies within the classroom and other educational sectors. The virtual medical environment can simulate teaching and learning of human healthcare with virtual patients, human bodies, and medical technologies (Kelly, et al., 2022). Simply, the medical professionals might be involved in the virtualized 3D environment of medical labs or operation theatres as well as participate in handling the virtual human body, visualizing practical functions of human organs, and a variety of human body structures by using the features of computers, internet, head-mounted visuals, cameras, censored gloves, and trackpads (Dhar, et al., 2021). This research was conducted to review reimagining medical education and its potential using virtual reality in advanced medical disciplines.

## 2. Virtual Reality

Virtual reality (VR) is a cutting-edge human-computer interface that allows users to walk around a virtual world, see it from multiple perspectives, reach it, grab it, and alter it (Bouloukakis, et al., 2019). Therefore, there is a potential for virtual reality to lead to innovations in various fields, which will influence people's daily lives. There are fundamental aspects of virtual reality applications.

- Immersion
- Interaction
- Imagination

- 360-Video

### 3. Importance of Medical Education

Health care is the maintenance or improvement of health through diagnosis, treatment, and prevention of disease, illness, injury, and other physical or mental impairments in a human being. In that area, Medical training is critical, and doctors should be provided several years of practical training before they step into self-medical practice. These continuous training practices during academic and internship periods will help to gain adequate experience.

Expertise in particular medical fields can be improved through regular training and proper education. For that, advanced medical research highly focuses on various diseases and illnesses. Furthermore, improving the emotional intelligence of medical practitioners help medical professionals handle patients without fear or unstable mental conditions during treatments.

### 4. Virtual Reality in Medical Education and Medical Training

Virtual reality is a technological tool that facilitates understanding the cranium's morphology through immersion in a virtual reality environment created by the generation of anatomical models in neuroradiology and neurosurgery (Izard, et al., 2016 Nov 2). As the virtual reality trend increases, these realities may give medical training in procedures, methods, and equipment usage and mimic patient interactions in a more immersive and realistic way.

*A. USES OF VIRTUAL REALITY IN MEDICAL EDUCATION*
In the field of medicine, virtual reality is becoming increasingly popular. In addition, some medical universities use virtual reality for their medical training and education.

- University of Oxford: Mobile Virtual Reality System, Effective learning method, Speedup the practices, Encouraging staff performance and experiential learning (Nordahl, et al., 2014).
- Indiana University-Purdue University Columbus: Train students through virtual scenarios and an Integrated Virtual Reality system (Barker & R.T. and Stowers, 2009).
- University of São Paulo: High fidelity simulation labs, Virtual and stereoscopic anatomy and Rehabilitation after Spinal Cord Injury (Mariani & A.W. and Pêgo-Fernandes, 2011).
- University of Northampton: Learning in a simulated environment (Pottle & J., 2019).



Figure 1 Virtual reality in medical training

The following utilization categories are determined using VR in medical education.

*1) Educational purposes:* In medical education, academic and practical are the most widespread virtual reality applications. Simply, medical students can take virtual excursions through all systems of the human body to understand the functions from inside, similar to virtual walks of tourists through modeled landmarks. Medical studies institutions can provide high-definition 3D models of human organs, which are more convenient and illustrative than traditional exhibitions of jars of organs in laboratories. Virtual reality enables the reduction or obviation of the conventional usage of dead bodies as visual aids or training dummies in medical training.

In European countries, the number of cadavers is limited for studying anatomy by dissection. Since there are fewer chances for traditional dissections, virtual reality is used in medical studies to fulfil the anatomy discipline theoretical knowledge. Furthermore, this technology helps to better understand anatomical relations of structures within the body compared to traditional dissections by resembling the actual tissues and organs in a real living human.

*2) Surgical training:* Medical surgical training can be done in a significant, cost-saving, effective manner and without facing real-life consequences, with the application of virtual reality technology in practical skills, which are high-risk activities such as real-time surgeries. Specialized virtual reality medical training platforms such as OssoVR help to get regular and frequent practices with various surgical procedures that can adjust settings and scenarios (Clarke & E., 2021). Mistakes in traditional surgery may harm patients' lives or organs, but virtual reality surgical training will improve skills by learning from mistakes, realistic visuals, and repeated feedback.

*3) Dentistry training:* Virtual patients with various symptoms and 3D models of teeth designs and specially configured drills are used in dental practices to improve practical skills, imitate real-life tactile models, and on-time feedback. HapTEL was one of the virtual dental training systems presented as a breakthrough learning method instead of the conventional way involving mannequins with plastic teeth (Wang, et al., 2016).

*4) Healthy lifestyle promotion:* Healthy lifestyles such as physical exercise and harmful effects of bad habits such as smoking, alcohol and drug addiction, sedentary lifestyle, and unhealthy diet can be explained through the visual impact of virtual reality technologies among the public and youth. Realistic visualizations and intelligible and reliable promotions through the latest technologies will urge people to make awareness.

*5) Paramedic training:* Virtual reality can be used to train paramedics by allowing them to interact with simulated emergency or accident virtual environments with people at minimal risk. These scenarios are realistic and allow professionals to experience a high-stress situation, respond accordingly and improve their emergency lifesaving skills.

*6) Nursing education:* The use of virtual reality as an educational tool corresponds to constructivist learning theory and speaks to the experiential learning paradigm for nursing and midwife students. Therefore, virtual reality should be included in nursing education while keeping the risk of motion sickness, the costs of this technology, and the requirement for a priori training among students and educators (Hardie, et al., 2020). For nursing education, the equipment called SimX does virtual reality programming for health professions (Ralston, et al., 2021). Therefore, it is a more flexible and accurate methodology for nursing education.

## B. *ADVANTAGES OF VIRTUAL REALITY IN MEDICAL EDUCATION*

Virtual reality is no longer just a tool for gamers or the entertainment business; it is a cutting-edge technology with the potential to reduce safety hazards and save lives, particularly in the medical sector. Virtual reality is also being used to educate the future generation of physicians, paramedics, and other medical professionals, and it has been demonstrated to have various advantages. VR is primarily used to help cure phobias, anxiety disorders, post-traumatic stress disorder, disability, and rehabilitation, as well as to demonstrate 3D anatomy, simulate surgery and surgical planning, and help treat

phobias, anxiety disorders, and post-traumatic stress disorder, and disability (Baniasadi, et al., 2020). The advantages of VR in medical education are categorised as follows.

*1) Physical Rehabilitation and Cognitive Functioning are aided:* Virtual reality training can enable medical practitioners to help their patients exercise and move their bodies in ways that are difficult to achieve in physical therapy. Virtual reality training will provide medical professionals with the hands-on experience they require while assisting their patients in several ways directly.

*2) Provide effective methodologies for medical training:* A high-quality virtual reality training program can teach students the fundamentals and specifics of many processes, and the technology may transfer a learner inside a human body, allowing them to better see and practice in places that are not easily accessible. Virtual reality training programs for dentistry students and practitioners are being developed using virtual reality technology. A 3D representation of the teeth is created to imitate a genuine patient in virtual reality. The original intraoral scan is then used to construct a haptic model. Finally, the model is put through its paces in a virtual reality haptic dental simulator.

*3) Patient-centred virtual reality training:* Patient-centred virtual reality training is a new invention in the area, and the results have been promising; therefore, this new training module in dentistry education is likely to be used on a big scale.

*4) Learn from the mistakes:* Fresh students of precision who are not well prepared and lack skill clearly make mistakes in surgery. There are many cases of patients who died because of surgeons who used the incorrect procedures and the incorrect treatment during the surgery. However, when they are trained using virtual

reality technologies, they might get experiences any time, and they don't get fear their actual surgeries.

*5) Feel the different types of pains of the patients:* In several settings, medical students who learn to use virtual reality for a variety of objectives might assist reduce their patients' discomfort. For example, when a patient is engrossed in a virtual reality experience, the somatosensory cortex and the insula become less active. It may also assist patients in enduring medical procedures that are typically excruciatingly unpleasant.

*C. CHALLENGES OF THE APPLICATION AND DEVELOPMENT OF VIRTUAL REALITY IN MEDICAL EDUCATION*

Despite the advantages of virtual reality in medical education and treatment, various problems and limits lead to the technology's ineffectiveness or misuse.

*1) Immaturity and Theoretical Uncertainties:* Establishing a solid theoretical foundation and standards, as with the creation of any new discipline, is critical to the field's progress. The fact that the exact nature of virtual reality's influence on the therapeutic condition of interest is often unclear adds to the intricacy.

*2) High Costs: The cost* of implementing virtual reality is comparatively high.

*3) Lead to motion sickness:* The medical students will face motion sickness related to using a headset. The persons who are dealing with virtual reality, are never want to move.

*4) Reduced face-to-face communications:* Since there is no face-to-face communication between users (such as learners) and' actual patients' in virtual reality-based educational settings, assessments should be conducted in real-world situations to guarantee the program's success.

*5) Safety concerns: The application* of VR in medical education might cause safety issues. Usage of these advanced technologies must be regulated by proper practices and expertized professionals to reduce the following issues related to safety aspects. VR is still not adequately familiarized by most health professionals. Virtual reality devices may cause users nausea, vertigo, and disorientation symptoms while using them for an extended period (Caserman, et al., 2021). And also, fully virtualized practices might cause insufficient realistic training for doctors while practising in actual circumstances. Therefore, VR can create safety challenges for patients.

## 5. Integration of Virtual Reality and Medical Education

Over the years, the use of technology in medical education has progressed. Medical education is a dynamic area that is always changing and evolving. In medical education, a variety of technologies are now in use. Imagining the advancement of usage of virtual reality technologies in medical education in the context of an emerging medical discipline is pretty interesting.

Virtual reality is an excellent tool for developing an interactive training system since it enhances the realism of the simulation. Virtual reality has been used to enhance, and in some cases replace, traditional medical education and training methods for years. Virtual reality experiences are also repeated. This allows students to make errors safely and improve their skills via focused practice. This has been identified as one of the most important aspects of good simulation.

Virtual reality can give the clinical situation in a small space with minimal setup time. Because of its ease of use, additional simulation activities at a centre can take place simultaneously with virtual reality simulation, such as more faculty focus on advanced communication skills or in situ simulation, neither of which are well-suited to virtual reality (Schröter, et al., 2021). Virtual reality technologies give the hands-on experience needed to gain knowledge and comfort with procedures but in a safe and controlled environment. As a result, when students make mistakes, they may be fully rectified in real-time and without danger. Because virtual reality modules still demand interaction, abilities might become second nature before being used in real-life situations.

Learners can benefit from virtual reality in medicine by learning how to be empathic. Empathy is required across the healthcare industry when physicians must convey bad news or when dealing with a particularly sensitive or impaired patient. Learners will be better prepared for these real exchanges across their intended practice if they practice these discussions and internalize various replies and emotions. Learners are then sent to the school's neurosurgical anatomy lab, where they may examine and touch the same anatomical parts in a 360-degree cadaver after the virtual reality session (Atli, et al., 2021). The virtual reality warm-up is intended to help students prepare for dissection while improving their learning. When viewing a 2-D image on a screen, trainees can spot traits and anomalies that they would not see otherwise. All of this is done in order to better prepare students for actual procedures. The ultimate aim of the Virtual Reality Research Centre is to enhance surgical procedures and results through a better knowledge of surgical neuroanatomy, endoscopic skull base anatomy, microsurgical neuroanatomy, white matter dissection, and imaging (Torous, et al., 2021).

Overall, virtual reality in medicine has fundamentally changed how healthcare is taught in colleges, universities, technical institutions, and hospitals. Compared to the usual classroom experience, which mainly

consists of textbook instruction, this way of learning is far more sophisticated and successful.

## 6. Methods to Develop Virtual Reality in Medical Education

VR and simulation in medical education are being evolved in a range from basic reproduction of single parts of human organs to complex human organic interconnections, which are demonstrated by simulated patients or high-fidelity human patient simulators replicating complete body appearance and various physiological characteristics. A customized simulation system in VR technology is one of the emerging requirements from medical students' and patients' sides. Leveraging immersive visualizations, embodied simulations, and capturing personalized analytics can be used to personalize the systems to educate the struggling students from their level of understanding and treat the patients from their level of seriousness of the disease (Lercari, et al., 2018).

Medical surgeries can be guided, and medical experts can facilitate surgeries using Machine Learning to Assess Surgical Expertise (MLASE) in virtual reality simulation (Lungu, et al., 2021). Medical knowledge, surgical expertise, technological evolution, and future research will empower this MLASE system to make surgeries efficiently with the involvement of VR and machine learning. For example, based on the research of the centre of Advanced Technology in Surgery at Stanford, medical physicians in future industries shall practice surgery with a projectable tangible hologram developed from the patient's personal medical history and conditions (Hernandez-de-Menendez, et al., 2020). In addition, robotic assistance can execute these practices on the whole day of surgery in labs. Therefore, educating, training, and filtering appropriate surgeons who can handle VR, web-based electronic learning, and

customized robotic aid will be suitable for these practices in the future.

Orthopaedic physicians prefer fully computerized orthopaedic VR applications to educate the patients and treat them with their specific diseases and diagnostic methods. These applications can demonstrate the actual condition of the patient and the upcoming surgical procedures using VR technology as they are in the operation theatre in surgery. Automated bot assistance also will be introduced in these orthopaedic physical joint evaluation tests and surgeries. The involvement of immersive VR technology in understanding and handling the empathetic issues or older age-related diseases such as macular degeneration, high-frequency hearing loss, vision and hearing loss, and Alzheimer's disease is getting developed through previous research (García-Betances, et al., 2015). Physicians, doctors, and surgeons can use VR software to customize the simulation of every person to understand the empathy of the patient's perspective conditions and medicate, assist and treat them efficiently.

Continuous medical treatments and therapies for psychological disorders such as post-traumatic stress disorder (PTSD) and Alzheimer's are being shifted to VR treatment methods because of the efficient method of immersive therapies (Difede, et al., 2019). These virtual environments will be able to re-create traumatic situations that trigger intense emotional responses and enable therapy in a more skilful way by handling delicate patient interactions. Furthermore, future upgrades of VR diagnostic tools and systems will be able to analyse and visualize medical data of patients accurately, project statistical plots and reports, and create medical procedures with significant steps for the patient and doctors with more accuracy and with more processing power, high resolution, better advanced haptic devices and creative scenarios.

The current VR medical assistance systems trend is limited to hand controls and basic movement sensors. In the future, improvements in hand control and body movements, as well as voice control abilities, will be available in the VR technologies used for medical purposes. Integration of AI with the application of VR will make another step in the technological evolution in medical immersive virtual environmental and robotic assistant technologies. These evolutions might make another milestone in 3D virtualized hologram video conferencing medical guidance. Mobile Virtual Reality Centres can be created as virtual reality offices or clinic centres which can move from place to place with the facilities of in-person doctor applications with hologram meetings or 3D virtual conversations. These mobile centres will be able to make facilities for patients to consult a doctor in a virtual environment as well as treat them with limited surgeries available.

In the future, these primary devices can be designed with more complex and advanced instruments that can perform efficiently. Advanced simulated surgical equipment and technologies will be used in future endoscopy, laparoscopy, cholecystectomy, or appendectomy in more accurate ways. Medical education and practices can be developed through these advanced technologies of virtual reality, augmented reality and distance-conferencing in accordance with fully automated virtual reality-equipped operating theatres with 360° cameras and simulators with well-trained staff and programmed robotic assistance.

## 7. Discussion

Under this research, a survey was conducted online to collect data about the awareness and application of VR in medical education and practices among medical students and professionals. A set of questionnaires was circulated among students from state universities, foreign universities, and some medical professionals practising in the local healthcare sector. The main aim of this survey was "find the level of awareness about VR in medical education among medical students as well as their opinion about the application of VR in medical practices, and the understanding of VR technology among our Sri Lankan medical students". This survey's responses were not limited to a few universities or our country. The responses were gathered from 14 different university medical students and professionals. This survey was a unique part of this research to review the use of virtual reality in medical education, and other researchers haven't conducted a comprehensive survey accommodating a more expansive audience like this study.

According to the responses, most of the medical students in Sri Lankan universities do not have an awareness of VR technology in the medical sector. Mainly, 94.1% of the medical students heard about this technology in the medical field, but only 17.6% have experienced the usage of VR in medical studies. Significantly, only foreign university students have experienced these technological applications in their medical studies, such as in anatomy, pathology, and topography anatomy. Nevertheless, on the other hand, 88.2% of students believe that the application of VR will improve the standards of medical education and training, and they have stated some of their opinions as reasoning for this thought. In addition, most of the participants have suggested their opinions on the possibilities for the application of VR in the medical sector and stated that they had appreciated this technology in their studies and training practices.
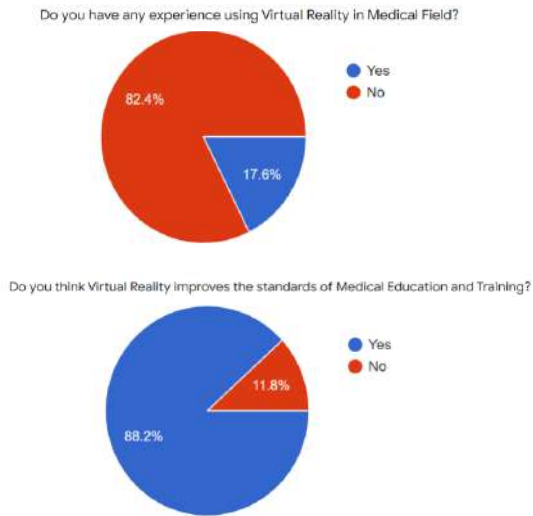
Figure 2 Summary of the survey

In a nutshell, based on the overall analysis of this survey responses, 88.2% of medical students believe that virtual reality in medical education and practices can enhance medical education and training practices.

However, it is noticeable that Sri Lankan medical students have low awareness of the usage of VR, but they showed that they are interested in using this technology for their work. Therefore, it is clear that there is potential in applying VR in this domain, and it will significantly improve medical education practices.

As the virtual reality trend increases, these realities may give medical training in procedures, methods, and equipment usage and mimic patient interactions in a more immersive and realistic way. The intended outcome of this review is to research reimagining medical education with virtual reality in the context of an emerging medical discipline and identify the practical concerns and difficulties associated and the ways to enhance virtual reality with medical education in future.

## 8. Conclusion

Throughout this study, the main objective was to review the possibilities of virtual reality applications in the medical field and medical studies. As medical education is integrated with human organs and lives, it is essential to educate medical students with broad knowledge and adequate experience.

Mainly, the covid pandemic has limited students' chances of actual medical practices and affected the treatment method for patients. A virtual environment, 3D modelled organs and equipment, and simulated scenarios will help overcome the limitations in medical education. Most Europe and American countries were already implemented some of these virtual reality concepts in actual medical practices. In addition, some medical institutions are providing virtual reality-based industrial training for medical students abroad. Currently, most of the theoretical principles of virtual reality are being revealed to practical applications in the medical industry.

Even though there are some limitations and disadvantages to using virtual reality in medical education and practices, most of the previous studies and research emphasized the importance of virtual reality. Therefore, from this research, we can understand the transformation of medical studies, disciplines and practices with virtual reality, as well as the advantages, disadvantages and upcoming possibilities of implementing virtual reality in medical studies. Making continuous awareness regarding virtual reality's applications in medical education to medical students and professionals will definitely improve the medical education system for emerging medical disciplines.

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