More Than Meets the Eye: Virtual Reality in Medical Education

Dr. Michael Barrie, Dr. Warren Wiechmann, Dr. Timothy Koboldt

Objectives

After this session, learners will be able to:

1. Discuss what virtual reality and augmented reality technology are.
2. Describe the best practice for implementing virtual reality technology in simulation curriculum.
3. Discuss innovative ways to implement virtual reality in medical education.

Immersive technologies, such as virtual reality and augmented reality, are becoming affordable and more widespread applications for the emergency medicine medical educator. Learning theory supports the use of interactive teaching methods. Specifically, constructivist learning theory sees knowledge as subjective and actively constructed as learners engage with, and make meaning of, their ***lived experience*** (Kay 2016). Immersive learning technologies provide this engaging and interactive platform to generate a stimulating learning environment. One application of this technology is to create patient simulators. Simulation allow for an immersive, interactive patient encounter in the a 'safer' environment. Medical educators have been using simulation for decades. But now with the development of cost-effective immersive technologies, educators have the potential to take simulation to a new level. We will also present other applications of VR technology including creating interactive didactics, VR collaboration, and using VR to implement gamification into a curriculum.

For specific details and setting up a immersive technology lab, see our toolkit.

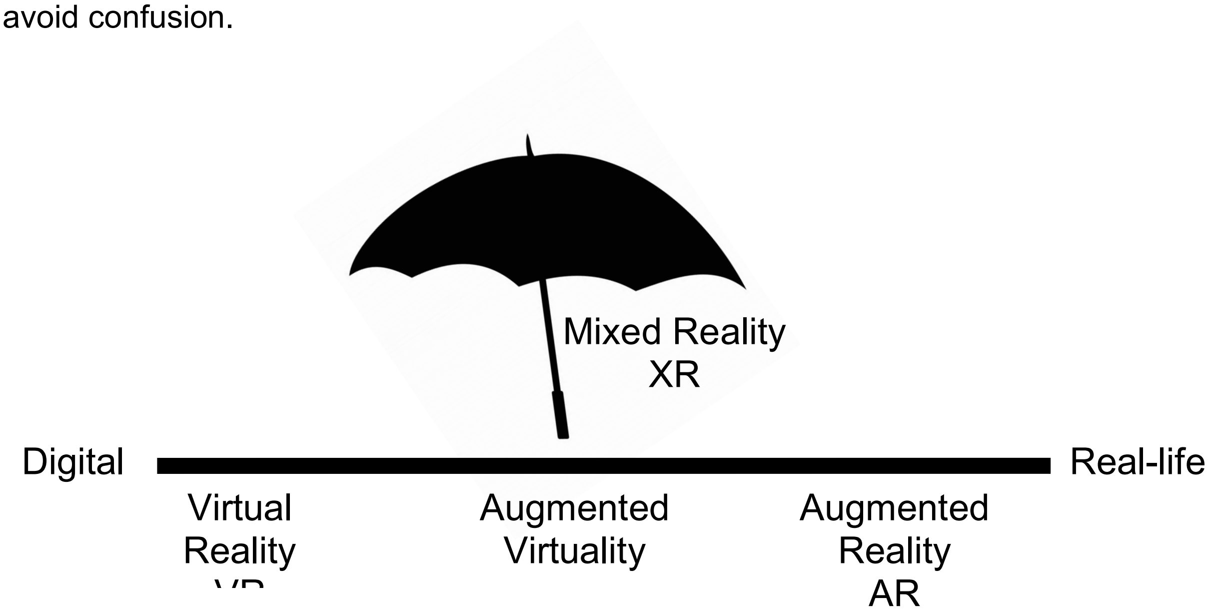
Before we get started, going over some basic definitions of immersive technologies can be helpful to understand their application to medical education.

Virtual reality - technology that allows the user to be fully immersed in a digital world. The user wears a headset with stereoscopic lenses that provide a 3D visual experience, and a sensor to track head movements. These also provide immersive audio. Headsets can be tethered to a computer (wired or wireless), or be a stand-alone device with all of the computing power in the headset itself. Some devices can allow walking around in the virtual room. This is accomplished with either external sensors to watch the headset move, or sensors on the headset itself to track movement through the room.

Augmented Virtuality - The learner wears a headset and is immersed in a completely digital environment, but then real-life objects are either projected into this digital environment, or are users are able to interact with this digital environment. An example is for teaching ACLS, the CPR dummy is visually tagged so that the virtual reality headset can localize the real-life CPR dummy. Then a digital patient is placed in the same location of real mannequin. From the user's perspective, they are fully immersed in a digital scene, but now they can interact and put hands on the CPR dummy. Are you confused yet? This is the least common used term related to this technology.

Augmented reality - technology that digitally augments something that is in the physical world. A good example of this are snapchat lenses that change a user's face. Another example is the application Google translate that changes signs into a translated language. This term is also loosely applied to technologies that superimpose a completely virtual object into the real world. However, these are better described as mixed reality because they do not augment a physical object.

Mixed reality - an umbrella term that helps explain the divide between augmented and virtual reality. Anything that includes both digital and real-world objects can be called mixed reality. Technologies that project a digital object into the real-life space, like the Pokémon Go game, are more accurately called mixed reality instead of augmented reality. The authors of this presentation recommend using the umbrella term mixed reality whenever there is an interaction of the real world and the digital environment to avoid confusion.



BUT, being overly picky about labeling something as augmented reality or mixed reality does not help improve the educational experience. Instead, medical educators should develop a vocabulary that better defines the capabilities and limitations of the technology. In the following discussion we'll use these terms somewhat interchangeably, as again the specific technology is less important to educational outcomes than how the technology is specifically applied. So, if we are discussing virtual reality, presume it also applies to the other immersive technologies for developing patient simulators.

Simulation is one of the emerging uses of immersive technologies in medical education. Technology has been incorporated into simulation education for decades, with some of the first high-tech simulators developed in attempts to make these scenarios more realistic. "High-fidelity" was a term coined to describe these more technical simulators that could mimic a patient encounter. However, Hamstra et al pointed out that the term high-fidelity does not adequately align the capabilities of these simulators with educational objectives (Hamstra 2014). Instead, they recommended describing the simulator's structural fidelity and functional fidelity. Structural fidelity describes the visual realism of the simulator. Functional fidelity describes what the simulator can actually do. This distinction is important because many educational objectives rely heavily on the functional fidelity, and less so on the visual realism. The application of these two concepts to virtual reality is useful but also problematic. For instance, in virtual reality it is possible to have a very realistic appearing simulator that also talks, cries, sweats, bleeds but at the same time the learner cannot actually interact with the simulator. In this way the distinction between structural and functional fidelity is blurred. To better describe aspects important to the design of simulators using immersive technology, we recommend the important categories of sensory realism, learner interaction, facilitator control, and scenario immersion.

Sensory Realism - This is similar to structural fidelity as described by Hamstra, as to what degree the simulator appears like the real thing. But immersive technologies can go further than just visual realism to simulate all of the learner's senses. Most commonly this will be to include auditory stimulus such as having the patient talk or make other sounds, or to include background scene sounds. Other sensory including olfaction are certainly possible but not routinely incorporated into medical education simulation. Tactile sense falls into the next category of learner intractability. Learning objectives that require the learner to make diagnoses and medical decision making based on sensory information would require a high degree of sensory realism.

Learner interaction - This design characteristic describes how the learner can interact with the simulator. This would describe if learners are able to touch the patient in the digital environment and if they get haptic (tactile) feedback from this interaction. What sort of procedures are capable to perform on the simulator? Is it possible to talk to the simulator and get a response? Making virtual simulators interactive can be challenging, but technology innovations are making tactile interaction more feasible. Mixed reality or augmented reality applications are particularly suited to allow for learner interaction, as realistic digital images are projected onto real-life, highly functional task trainers. It would be important to design highly interactive simulators to address learning objectives related to procedural competency or more complex clinical diagnosis and decision making.

Facilitator control - current simulation paradigm nearly universally requires the presence of a knowledgeable facilitator to guide the teaching activity. A simulation technician is also required to run complicated simulators. Virtual reality has a unique ability to design the simulator with varying degrees of facilitator input. It would be possible to mirror the current simulation paradigm to allow full facilitator control of a VR simulation. However, it is also possible to program a VR simulator to act autonomously. This could be very advantageous if the goal is to assign the activity as homework so students can work with the simulator on their own time. But facilitator control may be required if educational objectives aim to provide high level medical decision making in cases that could have multiple potential outcomes.

Scenario Immersion - One of the key reasons for using simulation-based teaching is to immerse the learner in a simulated clinical encounter. However, the degree of this scene immersion is up to the scenario creators. Designers have a choice to include background visual and auditory scene. Also, the game play itself can have varying degrees of immersion, with the potential to “pause” the scene for teaching. Varying levels of scenario immersion may be required based on the educational objectives. In more formative, instructional-type teaching activities, it may be advantageous to pause the scene and explain pathophysiology or other teaching points of the case. For more advanced, summative scenarios it might meet objectives best to play through the scenario fully immersed before breaking away for an educational debrief.

Future of simulation and virtual reality - There has been some conjecture that one day, virtual reality could replace in-person simulation in medical education. Because of the points discussed above, we would advocate for a continuum of immersive learning where virtual reality and in-person simulation co-exist. The software and hardware needed to support virtual reality continue to improve, shrink in size and cost. One could imagine that learners could engage in immersive learning in a conference room, in a clinical area, or from the comfort of their home. While virtual reality alone may lack the haptic feedback and some sensory realism, it creates a new opportunity for learning. In person activities at the simulation center could then focus less on primary exposure of content and instead pivot towards individual learner assessment and interprofessional collaboration.

While simulation is one of the most promising applications for mixed reality technology, there are many other applications to medical education. The most common application is teaching anatomy. Here is a list of software applications that allow students to explore human anatomy in virtual reality. These technologies are particularly useful in anatomy because the technology can allow an exposure to interactive, 3D anatomy without having to participate in a cadaver lab.

Anatomy[3]

- 3d Organon VR Anatomy - Fully-featured virtual reality anatomy atlas. You can manipulate bones, muscles, vessels, organs and other anatomical structures in 3D space.
- Body VR: Anatomy Viewer - View 3D volumes generated from CT/MRI scans in virtual reality.
- Medical Holodeck - View and modify dicom images to create new perspectives of CT and MRI scans in virtual reality. New features being added regularly.
- Physiology of the Eye: VR - Teaches you about the anatomical structures and physiology of the eye.
- You by Sharecare - YOU is a real-time simulation of the human body. It allows you to explore organs and systems in a fully immersive 3D environment in virtual reality, display diseases in varying states of severity, and add treatments to visualize and understand medical options.

Another interesting application of this technology is to bring people together in more interactive ways than simple video conferencing. Educators can build presentation in virtual reality for students to experience later, or can host virtual didactic presentations in real-time. Also, applications in engineering allow for remote collaboration to design 3D models within a virtual reality platform.

Didactic and presentation platforms:

- Engage - virtual classroom, training, meeting. Supports multiple devices.
- VRavo - VR and mixed reality presentations. Can be synchronous or asynchronous. Integrates with learning management systems.
- Adobe Captivate 2019 - create e-learning modules in VR without programming. 360 and immersive content.
- Enduvo - create VR presentations that users can directly interact with content to simulate a hands-on session.

Handout References

1. Hamstra SJ, Brydges R, Hatala R, Zendejas B, Cook DA. Reconsidering fidelity in simulation-based training. Acad Med. 2014 Mar;89(3):387-92. doi: 10.1097/ACM.0000000000000130
2. Kay D, Kibble J. Learning theories 101: application to everyday teaching and scholarship. Adv Physiol Educ. 2016 Mar;40(1):17-25. doi: 10.1152/advan.00132.2015
3. VR anatomy software list curated from Penn State Health Science library.

VR and MR in Simulation References

1. Andreatta, P. B., et al. (2010). "Virtual reality triage training provides a viable solution for disaster-preparedness." Acad Emerg Med **17**(8): 870-876.
2. Cheng, A., et al. (2014). "Technology-enhanced simulation and pediatric education: a meta-analysis." Pediatrics **133**(5): e1313-1323.
3. Courteille, O., et al. (2018). "Learning through a virtual patient vs. recorded lecture: a comparison of knowledge retention in a trauma case." Int J Med Educ **9**: 86-92.
4. Luigi Ingrassia, P., et al. (2015). "Virtual reality and live simulation: a comparison between two simulation tools for assessing mass casualty triage skills." Eur J Emerg Med **22**(2): 121-127.
5. Michael, M., et al. (2014). "Performance of technology-driven simulators for medical students--a systematic review." J Surg Res **192**(2): 531-543.
6. Pierce, J., et al. (2008). "Comparative usability studies of full vs. partial immersive virtual reality simulation for medical education and training." Stud Health Technol Inform **132**: 372-377.
7. Sakakushev, B. E., et al. (2017). "Striving for Better Medical Education: the Simulation Approach." Folia Med (Plovdiv) **59**(2): 123-131.
8. Semeraro, F., et al. (2013). "Motion detection technology as a tool for cardiopulmonary resuscitation (CPR) quality training: a randomised crossover mannequin pilot study." Resuscitation **84**(4): 501-507.
9. Wilson, K. L., et al. (2013). "Using augmented reality as a clinical support tool to assist combat medics in the treatment of tension pneumothoraces." Mil Med **178**(9): 981-985.