Virtual Reality Toolkit for Medical Educators

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This toolkit will help you implement immersive technologies such as virtual reality and augmented reality into your curriculum. We also hope this could help launch a research project related to immersive technologies.

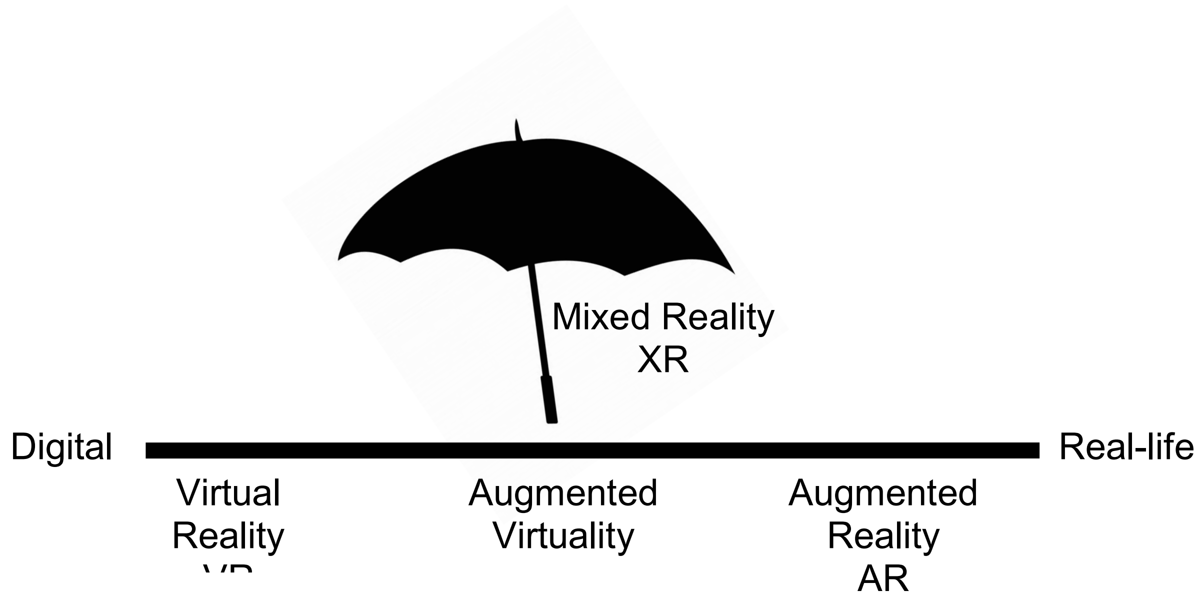
First off, let's start with some basic definitions

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. These 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 space. 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 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 realistic digital patient is placed in the same location of the real-life CPR dummy. From the users 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 involved can be called mixed reality. Technologies that project a digital object into the real life space, like the pokemon go game, are better called mixed reality instead of true augmented reality. The authors of this presentation recommend using the term mixed reality whenever there is an interaction of the real world and the digital environment.



Degrees of Freedom - Another concept is to understand how much the user is able to move through the virtual space. The industry describes this as '*degrees of freedom.*' ***Three degrees of freedom*** refers to only being able to look around in the three dimensions, but not move around in space. ***Six degrees of freedom*** means that now the user can walk around in space. With six degrees of freedom, the experience can then play out at 'room scale,' in that the user can explore the actual room. In the more limited three degrees of freedom, the user experiencing the game 'seated.' Setups that are seated with three degrees of freedom can be more simple and require less sophisticated hardware. Room-scale setup with six degrees of freedom allow for more sophisticated simulation and may be better applicable to medical education. These room scale setups also tend to give users less motion sickness for those that are sensitive to motion while seated.

When deciding what type of setup to use, the first consideration unfortunately has to do with money. What is your budget? We've divided recommendations up into budget constrained and budget unconstrained. Be aware that the technology investment is a relatively minor expense for any implementation of technology. The real cost comes into paying people to support the technology.

Budget Constrained Setup

This section will discuss how to develop and experience VR content without breaking the bank.

Recording 360° video is the cheapest way to develop immersive scenes. These cameras can record in 360° (or 180°), which can then be edited and uploaded to free platforms like youtube, vimeo, or facebook. Users can then watch these immersive videos on their own device. Alternatively you could provide a higher end device to watch the video.

360° cameras - can find additional information here

Insta360 One - $299
Vuze XR - $439, can be used as 360° or 180° with 3D
Rylo 260 - $499
GoPro Fusion - $599
Many of these cameras come with their own editing software. Once you've created the video, you can host online for easy access. Common places to host are youtube.com, facebook.com or vimeo.com. Specific instructions on how to upload 360° videos can be found at each of these websites, or use this summary.

Once you have the 360° video's hosted, then users can access these videos with any type of VR headset. Here we'll introduce the low budget headsets. 360° videos can also be viewed on higher end setups. Also, 360° can be viewed on non-VR devices to view the content, but then it is not immersive.

Beyond 360° video, a significant budget is really required to create your own VR content. However, there is VR content that can be purchased. Here are some examples of VR software:

Anatomy[1]

- 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.

Didactic and presentation platforms:

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

Once you've created your 360° video or purchase software, you'll need to decide on the hardware that your students will use. For budget constrained setups, consider smartphone VR headsets and standalone VR headsets. See the budget unconstrained section for VR headsets tethered to a computer.

Smartphone VR headsets

Not including the price of the smartphone itself, smartphone VR headsets are the least expensive option to view VR content. These devices use the smartphone as the screen, head motion tracking, and audio. The phone rests inside the VR headset that will include lenses to focus each eye on the different stereoscopic images displayed on the phone's screen. These types of headsets can be effective ways to view VR content, but have limited opportunities for advanced controllers (hand tracking) or to track movement in real space. Thus these headsets will generally be used seated with only three degrees of freedom. Also, they tend to be less comfortable and have somewhat lower quality visual display compared to dedicated VR headsets. There are MANY headsets available for apple and android phones. These three are example of an inexpensive, moderately priced, and higher priced smartphone headset.

- Google Cardboard - $15. Works with any smartphone.
- Google Daydream - $99. Pixel or other supported android phones.
- Samsung Gear VR - $129. Includes controller. Samsung Galaxy phones only.

Stand Alone VR headsets

These setups do not require a smartphone or computer to run. All of the computing power is in the headset itself. Many of these headsets are priced affordably compared to more comprehensive VR setups. These are technically cheaper than having a smartphone VR headset if users do not already have a smartphone. These tend to have better visual display and more comfort than smartphone headsets, but less quality display than VR headsets tethered to a computer.

- Oculus Go - $199. Has a controller. Only three degrees of freedom with seated scale.
- Lenovo Mirage Solo with Daydream - $399. Six degrees of freedom with room scale.
- Oculus Quest - $399. Coming in Spring 2019. Six degrees of freedom with room scale.
- Vive Focus - $599. Higher quality display. Six degrees of freedom with room scale.

Budget Unconstrained Setup

This section will highlight ways to develop and experience VR content, but may require some funding to be successful. The funding required to purchase actual equipment is relatively modest when compared to other types of simulation. However, more significant funding is required if hiring people to develop and maintain the VR content.

Creating virtual reality scenarios requires computer engineering knowledge to build in gaming platforms such as Unity or Unreal Engine. It is unlikely that medical educators will have the time and skill to be proficient at building VR scenes. If you plan to build your own VR scenarios, then we recommend collaborating with experts. Grant funding can help provide the resources to support these collaborations.

More and more companies are starting to develop VR related content. These either charge by scenario or have a subscription fee. Here are some examples of VR related software. Also see in the previous section for software related to anatomy teaching and presentations.

Simulation Platforms:

- SimX - subscription-based software for virtual reality simulation scenarios using HTC Vive. Can have multiple players in the scenario, requires synchronous instructor to control the simulation.
- Acadicus - create custom VR scenarios, videos, educational experiences, remote, multi-user meetings using Oculus Rift without coding.
- Oxford Medical Simulation - simulate various types of patient encounters, with medical, nursing and pediatric curriculums.
- OssoVR - VR for surgery.
- Touch Surgery - free app to work through virtual procedures, but not really VR/MR as not immersive.
- Embodied Labs - This company takes VR simulation and flips the script. Instead of having students play the doctor and treat patients, now the student plays the patient. Because of the unique abilities of VR, then learners can have a sensory experience that mimics the patient experience. This currently is a subscription-based platform that has three cases -- macular degeneration, alzheimer's, end-of-life discussions -- that insert the user into an immersive VR environment where they are the patient and are interacting with a scenario. These type of cases can be used in conjunction with OSCE or clinical skills exams and may have a larger role in undergraduate medical education beyond just teaching history and exam skills.

Once you've settled on your software, you'll need to decide on the type of hardware to experience the VR content. Here we've outlined some of the most popular VR headsets that require a PC. Also review above for smartphone VR headsets and stand-alone headsets, especially if attempting to scale up with multiple devices.

VR headsets that require a PC

Oculus Rift - $349. Includes controllers and two sensors for minimal room scale, additional sensor $59 recommended but max room size smaller than Vive.

HTC Vive Pro - $799 for headset only, professional grade version $1399 includes sensors to allow 15'x15' play space. Ability to use wireless module ($299), and mixed reality applications to place tracker on real life objects ($99).

HTC Vive Cosmos - soon to be released VR headset in the Vive series. Promises superior graphics and six degree of freedom tracking with sensors in the headset, so has unlimited room size.

Computers can range in cost based on specifications from $800-$2100.

Do not underestimate the time it takes to maintain this technology. The major cost of any technology implementation is YOUR time and to pay others to help support the technology. Any grant should include funding to pay for building the content and maintaining the technology.

Evidence to support a grant application for VR in medical education

To be successful in writing a grant, it is important to first find one project to focus initial resource investment. The benefit of this type of investment is then the equipment can be used for other teaching activities. Successful projects in the past have been related to disaster medicine, trauma resuscitation, and anatomy teaching for a few examples. Below we've listed refereces we've collected that could be used to support a grant application.

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<u>Virtual Environments - like second life. This is related to VR but different</u>

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