# The State of Virtual Reality in Education



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# The State of Virtual Reality in Education

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**Abstract**

Virtual Reality (VR) or supplanting reality with a digitally created world, has moved from popularity in the tech and gaming industry to the mainstream. High quality hardware is now widely available to consumers, along with cheaper solutions that leverage smartphone displays. Major tech companies are now pushing VR and releasing their own versions of VR hardware and software. VR has also been trumpeted in the media as the next frontier of entertainment and has even been described with lofty labels such as "the empathy machine", suggesting that it can transport users into other's shoes to help promote cultural understanding and world peace. The technology is also finding its place in education as a powerful medium for teaching and learning. VR is being adopted and experimented with in many educational institutions, and has even been integrated into the curricula in some cases. This paper will explore the ways VR is being used in education, and offer suggestions for their effective use in classroom curricula.

**Introduction**

In recent years, one technology has received widespread attention from a variety of sectors, including conventionally disparate fields such as economic development and entertainment. The media have been lauding this technology as "an empathy machine" (Pierce, 2016) and think-tanks have pondered on the impact it may have on the future. This technology, virtual reality, has now become a real, accessible product widely available to common consumers. Virtual reality (VR), or replacing one's surroundings with new digitally created environments through the use of a head mounted display, provides a way to immerse users in wholly novel situations and environments. VR originally gained traction in the entertainment sector, primarily in video gaming, but is already used widely in a number of different disciplines and fields. The applications are seemingly endless; doctors have used VR to control surgery, and NPOs have used it to help users feel empathy for refugees and gather donations (Swant, 2016). Many science fiction writers have imagined a future where VR is the primary mode of escape or entertainment. Palmer Luckey, referred to as the father of modern VR, commented, "If you have perfect virtual reality eventually, where you're be able to simulate everything that a human can experience or imagine experiencing, it's hard to imagine where you go from there" (Luckey, 2016). Needless to say, the technology is extremely important and will be more so in the future.

One of the great promises of VR is immersion and presence, tricking the senses of the user to suggest that they are actually in a disparate environment. Presence, according to one definition is “a mental state in which a user feels physically present within the computer-mediated environment” (Sanchez & Slater, 2005, p. 4). By invoking experiential presence, VR creates a holistic, rich experience that is user-centric and interactive in nature. VR demonstrates its real power by allowing users to become part of a narrative; every VR experience is, to some degree, personal. The personal, interactive and transportative nature of VR makes it especially promising in the field of education. Though it is now in the hands of consumers, with a relatively low cost of entry, VR is still in its infancy, especially in education. Many educators are devising lessons and applications to teach content in new ways, as well as content which has heretofore been difficult to teach in the absence of this technology.

Rapid innovation with VR is happening in part due to the current nature of VR hardware. Currently, there are three tiers of VR hardware that are built with the same general premise in mind, but offer different levels of immersion. The three tiers are high-end, mobile, and mass distributed VR (see Hirsch, 2016 and Gilbert, 2015). Each have different benefits and limitations, but can be powerful tools in education. This paper will first give more information about the nature of each tier, provide a brief overview of the use in education up until the date of publication, discuss potential applications of the technology, and explain the limitations of each.

## High-end virtual reality

High-end VR is what most people think of when they hear about VR. They imagine a large headset connected to a powerful computer that attempts to simulate an environment that the user can be immersed within. The first VR headset was created in 1968 and while this kind of VR did make a brief appearance both in arcades and homes during the mid 1990s, high-end VR was most commonly found only in research institutes and universities.

This changed however in 2013 with the release of the Oculus Rift Development Kit (DK1). The Oculus Rift DK1 was the first affordable VR headset to be released to the mass market in almost 20 years. It featured the ability to track a user's head rotation and update the onscreen visuals without any perceived delay. The Oculus Rift DK2 was released in 2014 and added a small infrared camera that was capable of tracking the headset's position in addition to its rotation. This allowed for users to move freely in a real environment and have that movement replicated in a virtual environment. Finally in 2016, Oculus and its new competitor HTC both released new VR headsets, adding the ability to have movement tracked in larger spaces and hand tracking via two controllers.

While the capabilities of the DK1 have been matched by mobile VR headsets, position tracking such as those found in the DK2, HTC Vive and Oculus Rift are currently beyond the capabilities afforded by smartphone hardware. This means that the only way to become fully immersed within a virtual environment and interact with it as you would in reality, is to own high-end VR hardware. Only high-end PCs are capable of displaying realistic details such as accurate lighting, reflections, and details in 3D environments that are too intensive for a smartphone to display. While 360-degree videos have afforded users the opportunity to travel virtually to many locations around the globe, high-end VR alone has the ability to recreate those environments in a way that lets a user walk around them almost as if they were truly there.

**High-end virtual reality in classroom practice**

Educators looking to engage their students in active and kinesthetic learning can benefit greatly by having one or more high-end VR systems in their classroom.

Another of the great advantages of high-end VR over mobile solutions is that whatever the VR user is seeing can be displayed onto a screen or projected onto a wall for the other students to see. One student in VR can therefore work with a group of observers to construct anything they can imagine. *Google Blocks,* a 3D environment modelling application, and *Google Tilt Brush*, a program that allows users to paint in the air, are two pieces of VR software Google has released that work well with this kind of activity.

Photogrammetry—taking measurements from a large number of photos of objects at different angle to create 3D models—is a powerful new tool for recreating real world locations in VR. High-end VR has the capacity to render these realistic 3D scenes, which can create opportunities for students to not just passively experience new locations by watching a video, but actually immerse themselves into the spaces and interact with them as if they were really there. *Google Earth VR* is one of a growing number of programs that make use of photogrammetry and can take students to almost anywhere around the world, where they can do anything from practicing navigation through the streets of Rome, to gaining a greater empathy towards people living in locations directly affected by climate-change.

There are also a large number of other applications that are uniquely suited to high-end VR and the level of interaction that it enables. Movie creation tools such as *Mindshow* give students opportunities to build and act out scenarios inside any world they can imagine. There are also numerous job, task, and presentation practice simulators available such as *Engage: Communicate, Teach, Learn*.

The educational uses of high-end VR are almost unlimited, and if it were not for the high price tag and the prospect of more capable VR systems in the future, it would be unequivocally the best option for any school. While high-end VR is an order of magnitude cheaper than older pre-Oculus Rift systems, they are still far too expensive to provide one to each student in a class. Not only are the hardware costs for each student prohibitive enough to limit most schools to one or two systems, but the software itself is also expensive, as software developers look to recuperate their investments in creating detailed and realistic scenarios and environments.

Over time, the number of high-end VR users is expected to continue to rise, allowing for hardware and software developers to reach larger markets and lower their prices. As a result, until cheaper mobile VR hardware is powerful enough to match the level of detail and immersion afforded by high-end VR, high-end VR is expected to remain the only solution for educators looking to provide their students with the most motivating means of interaction and collaboration in virtual environments, if they can afford it.

**Mass-distributed virtual reality**

As previously explained, VR has existed for quite some time, but it was either too expensive or underdeveloped for widespread use by the average consumer. Mobile technologies have changed this by providing the needed display and computing power necessary to run VR experiences. Mass-distributed VR gained widespread traction in 2014, when Google introduced its Cardboard platform. At this time in history, many people had heard of VR, but had never been able to experience it, as only extremely high-end hardware was available to well-funded organizations. Google, as one of the largest and most powerful tech companies, created Cardboard as a way to get everyone to experience VR (Pierce, 2016). Google Cardboard is essentially a cheap headset design created using cardboard and convex optical lenses. Google released the plans to build the headset, and manufactured kits for creating it. In 2016, Google shipped its 5 millionth Cardboard kit, indicating that they are well on track for their goal to get VR into as many hands as possible (Pierce, 2016). Google, in a simple brilliant move, showed that VR could be experienced by and impact everyone, not just the rich or well connected. However, as a cheap, entry-level VR experience, there are some key differences that distinguish mass-distributed VR from its more expensive high-end counterparts.

The greatest difference is that Cardboard and other mass-distributed VR solutions are primarily designed with less interaction in mind, meaning they are inherently more passive experiences. Wasn't the whole point of VR immersion and presence? Does a passive experience break these vital components? The answer is not completely, as mass- distributed VR still includes key features that serve to create presence and immersion. Most importantly mass-distributed VR solutions still give the user the ability to move their head and have the motion translate into the virtual environment. Additionally, the fidelity of a smartphone display can rival high-end VR hardware. Samsung's Galaxy S line of smartphones, for instance, feature the exact same resolution as the HTC Vive and Oculus Rift and can produce a similar quality image, albeit with a narrower field of view. However there are some key differences as well, chief among which is that high-end VR is capable of tracking full-body movement and translating it into the virtual world. Mass-distributed VR essentially only allows user-input through gaze. Mass-distributed VR is designed for mostly passive experiences. Users can enjoy 360-degree videos and other virtual experiences that do not require extensive user interaction.

**Mass-distributed virtual reality in classroom practice**

Of all the tiers of VR hardware, mass distributed VR has found the most traction in education. The low cost-of-entry and simple set-up process makes it extremely easy to integrate VR, particularly in the form of 360-degree video, as supplemental experiences within existing curricula. 360-degree videos have been pushed by not only Google, but other technology companies such as Facebook. Facebook founder Mark Zuckerberg stated a goal to have 1 billion people in VR (Gartenberg, 2017). Facebook, Google, and others have integrated the ability to view 360-degree videos into their platforms. YouTube, at the time of writing, has over 750,000 360-degree videos containing a wide variety of content from all around the world. 360-degree videos and photos can be used to take learners to new locations on virtual field trips. *Google Maps with Street View* allows students to visit almost any location on the globe. Teachers can assign tasks to learn about an area and send the students to the location.

Google has also released a robust educational field trip application, *Google Expeditions*. *Google Expeditions* is a teacher guided virtual tour. Students join the teacher, who leads them through a series of locations that are enhanced with spoken dialogue and text to explain history and points of interest. In addition, *Google Expeditions* allows users to visit occupational environments to learn about careers (Pilgrim, 2016, p. 92). Google has also created the *Arts and Culture* application, which acts as a virtual museum tour, taking students through interactive virtual art galleries. Other content is available to help make science more visual and easy to understand in simple VR experiences. *Titans of Space* is a great application that can be used to provide more information about the solar system and beyond.

Mass-distributed VR acts as a very simple way to explore and introduce content, concepts, and information, however it is limited to very short term experiences. The quality of the image and experiences are only suitable for relatively short periods of time, and therefore can only fill a very small part of a lesson. Mass distributed VR has major limitations, but as of the writing of this article, has been the most widely employed and effective method of bringing VR to the masses. Its use has also prepared consumers for eventual mass distribution of future high-end VR.

**Mobile virtual reality**

A final category of VR that merits consideration resides in the space between mass-distributed and high-end. Mobile VR, which may very well become mass-distributed in the near future, is distinct from either of the other tiers of VR. Current mobile VR technology is similar to mass-distributed VR in that it requires a smartphone to function. However, mobile VR is more exclusive and less equalitarian, in that it requires an expensive, flagship-tier smartphone and a specialized headset that comes with a controller. The experience of mobile VR is more passive than the high-end, due to its lack of whole body tracking, but there is the added affordance of a hand controller that allows for interaction on a greater level than mass-distributed headsets.

As of 2017, there are two major players in the mobile VR arena, Google Daydream and Samsung Gear VR. Both are similar and have begun to blur the lines with high-end VR. The Gear VR platform in particular, works in partnership with Facebook-owned Oculus, and has access to much of Oculus' large catalogue of applications and content.

Hardware capable of tether-free full-body tracking has been announced, meaning that high-end tethered situations will become obsolete in the future. As the requirement for a high-end smartphone or gaming PC becomes less necessary, adoption of VR will only continue to increase.

**Future of virtual reality**

As the VR industry expands with further adoption, and the technology available continues to improve, the opportunities to use VR in education will of course continue to expand along with them. Minor improvements to high-end VR, such as increasing the field of view and the resolution of the headsets, will lead to gradually increasing levels of immersion as the years go on, but there are some more dramatic advancements coming to VR in the near future as well.

Larger international companies are looking to get in on the growing VR customer base. Microsoft for example, in conjunction with a range of manufacturers, has started releasing its own line of VR headsets that are cheaper the pre-existing solutions and do not require the placement of lasers or cameras around the user to track their position in VR. Microsoft's Mixed Reality series of VR headsets have the cameras built into the headsets themselves. This advancement means that setting up VR for class use will potentially be a lot more hassle free, allowing teachers to focus on the VR content and not the VR setup.

The level of interaction possible in VR is also expected to continually increase over the coming years as more advanced controllers and body tracking equipment reaches the consumer space. Current hand controllers, while advanced, often cause the user to feel like they are controlling a set of virtual claws rather than using their own hands. Controllers that measure individual finger movements will allow better motor control in VR. As VR user input reaches a more natural level of interactivity, students will be able to utilize VR to experience new learning scenarios and skill-based educational opportunities.

Ultimately, a lot of the above content will filter down into mobile VR and mass-distributed VR as smartphones increase in computing power and hand controllers and body tracking become smaller and cheaper to produce. It is finally becoming possible to envision a time soon when VR will enable large groups of students, regardless of their real world physical distance from each other, to interact with one another in any possible historical situation or skill-training exercise.

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