

# Augmented Reality, Virtual Reality, and Mixed Reality

## Scenario

Capitalizing on its locale in the Silicon Valley, Atherton University has been a pioneer in the world of augmented reality, virtual reality, and mixed reality. That work has created a rich palette of new teaching and learning opportunities across diverse disciplines.

As Atherton's undergraduate school of arts and sciences has acquired more headsets such as the Oculus Rift, opportunities for learning by virtual reality have taken root in the curriculum. Historical anthropologist Brent Manuel takes students on virtual field trips of important archeological sites. Using apps developed by the University of Cape Town, for example, students can explore the ancient Jordanian city of Petra as if they were there when it was first thriving, with learning enhanced by the app's cultural, historical, and architectural data. Students can use the technology to find and analyze artifacts including coins and pottery shards.

VR is also found in other disciplines. Students in environmental science can dive virtually to the bottom of the ocean to study damage that pollution has caused to coral reefs and other marine life. Astronomy students routinely use [Google Cardboard](#) to journey through the solar system. Similarly, students in sociology use the same technology to travel with a refugee uprooted by war in a VR experience developed by the *New York Times*. Atherton's history students can experience combat as Roman gladiators. In a public speaking class, students use VR to practice addressing large and small audiences in several virtual contexts.

AR, VR, and MR have particularly caught hold in the health sciences. Learning how to conduct office visits, for example, medical students are using ODG smartglasses to gain quick access to patient data without the need to consult a paper folder or laptop, leaving more time for interactions with patients. Using Microsoft HoloLens, nursing students access holographic videos for simulations in which virtual patients present a variety of health concerns. Administrators believe that MR simulations may one day replace those using live actors as patients, a practice that is expensive and hard to standardize. Nursing students and other biomedical trainees at Atherton are also using HoloLens to better understand human anatomy. Building on the capacity of HoloLens to enable users to interact with holograms using hand gestures and word commands, for example, researchers at Atherton are helping students learn from their own physical movements while studying a virtual model.

## 1 What is it?

The rapidly evolving world of AR (augmented reality), VR (virtual reality), and MR (mixed or merged reality) **offers new opportunities to create a psychological sense of immersive presence** in an environment that feels real enough to be viewed, experienced, explored, and manipulated. Although definitions of AR, VR, and MR are in flux, in part because the technology is evolving rapidly, augmented reality can be described as experiencing the real world with an overlay of additional computer generated content. In contrast, virtual reality immerses a user in an entirely simulated environment, while mixed or merged reality blends real and virtual worlds in ways through which the physical and the digital can interact.

## 2 How does it work?

With tools like the Vuzix Blade 3000 and ODG glasses, users can **view digital information without stopping to consult other sources of information**—for example, a surgeon could see a patient's vital signs without pausing in an operation. Head-mounted devices like the Oculus Rift and the HTC Vive provide access to virtual reality, such as taking an immersive, interactive tour of an ancient city. Headsets such as Microsoft HoloLens use sophisticated lens and sound technology to create wireless access to immersive, holographic mixed-reality environments. Using that technology, for example, engineers can explore virtually every technical aspect of a building that exists only as a concept, doing so in the context of the site where that structure will one day be constructed. Apart from the sophisticated hardware, AR, VR, and MR also rely on specialized apps and software, as well as controllers, cameras, sensors, 360° video, and object- and gesture-recognition technologies.

## 3 Who's doing it?

In Grinnell College's [Immersive Experiences Lab](#), teams of faculty, staff, and students collaborate on research projects, then **use 3D, VR, and MR technologies as a platform to synthesize and present their findings**. In addition to installing VR technology in an active learning classroom, the University of Notre Dame has developed VR applications in diverse disciplines, including a chemistry molecule builder and apps for environmental engineering, Chinese language acquisition, and psychological memory research. At Stanford University, the project [Examining Racism with Virtual Reality](#) creates a "virtual shoes" experience of encounters with

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various forms of racism. Virginia Tech developed a [meteorological immersion project](#) that synthesizes data from a 2013 tornado to create a fully immersive research and learning experience. Researchers and students at [Washington and Lee University](#) have used VR technology to create interactive structural biology models and a model of the college's town in 1867.

## 4 Why is it significant?

AR, VR, and MR constitute technologies that many experts see as the evolution of computing, with potential impact as broad and deep as that of the Internet browser and smartphone. Such technologies create social platforms that are beginning to transform how we communicate, create, learn, and collaborate. [Researchers](#), for example, have demonstrated the ability of immersive VR to promote empathy and facilitate alternative perspectives. In terms of equity, AR, VR, and MR **have the potential to democratize learning by giving all learners access to immersive experiences** that were once restricted to those with financial means or the right connections.

## 5 What are the downsides?

AR, VR, and MR are still in relatively early stages of development, and the technologies are seeing rapid changes. To date there has been **relatively little research about the most effective ways to use these technologies as instructional tools**. Combined, these factors can be disincentives for institutions to invest in the equipment, facilities, and staffing that can be required to support these systems. AR, VR, and MR technologies raise concerns about personal privacy and data security. Further, at least some of these tools and applications currently fail to meet accessibility standards. The user experience in some AR, VR, and MR applications can be intensely emotional and even disturbing, which raises further questions about the ethical and psychological responsibilities of offering such technologies. Finally, lack of standards in the field is another challenge.

## 6 Where is it going?

The tools that provide access to AR, VR, and MR will see continued development. The hardware will become less cumbersome, and the cost of the technology will drop, making it more ubiquitous and more broadly accessible. Already, the technical requirements to build and use AR, VR, and MR are becoming less

demanding. The technology will become more sophisticated, particularly in such applications as headsets, wireless access, and tools like eye-tracking and motion capture. Applications will also expand—already AR, VR, and MR have progressed beyond being thought of largely in the context of gaming and entertainment, and **a wider range of applications in the worlds of business, education, and healthcare** is emerging. Development may hinge in part on the vocabulary around these technologies becoming more standardized. In higher education, institutions engaged with AR, VR, and MR will continue developing new applications and conducting research into the impact of the technology, and more institutions are likely to integrate these tools into makerspaces, innovation labs, and visualization studios. Especially as the technology becomes more affordable, more institutions will gradually adopt the learning experiences that AR, VR, and MR offer across disciplines.

## 7 What are the implications for teaching and learning?

AR, VR, and MR can enhance teaching and learning by immersing users in **recreated, remote, or even hypothetical environments as small as a molecule or as large as a universe**, allowing learners to experience “reality” from multiple perspectives. The sense of presence provided by immersive experiences can be effective for contextualizing knowledge within a simulated real-world space and for promoting situated and embodied cognition. AR, VR, and MR technologies lend themselves to task-based and problem-based learning, simulations, data retrieval, experiential learning, and game-based learning. Inherently predicated on immersion and interactivity, AR, VR, and MR technologies may lead more students to engage more actively in their learning. In short, the immersive experiences that AR, VR, and MR technologies create can provide a deeper understanding of emotions, the human condition, and the cultural and social systems that situate human activity and imbue it with meaning.

## In Memoriam

Jeffrey Bain-Conkin (1981–2017) of the University of Notre Dame served as a guest contributor for this publication. ELI and EDUCAUSE express our deep condolences to Jeff's family, friends, and colleagues at Notre Dame and in the higher education community. We dedicate this publication to Jeff.