

# Virtual Reality and Augmented Reality in the Architectural Design Education

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## 1. Virtual Reality, Augmented Reality, and Mixed Reality

The virtual reality (VR) and augmented reality (AR) industries are some of the quickest growing technology-intense industries boosted by the latest innovations of hardware and software. During the past decades, the way of communication and representing has been constantly changed in the design industry with the aid of technology and computer. New human-computer interaction is pushing the user experience to a new level. VR & AR based media, also called mixed reality (MR), has blurred the line between reality and virtual. MR refers to a hybrid reality in which the real and virtual worlds merge to produce new environments where physical and digital objects co-exist and interact in real time. Especially with the recent availability of smart glasses, AR-ready mobile phones, and Microsoft HoloLens, VR headset such as Oculus Rift, HTC Vive, as well as open source software, the MR technology is reintroduced as the new visualization instrument into the architectural practice. MR is already becoming allowing a client to look around and walk through space to give them a better idea of scale and materiality of that space. As educators, we must start to think how MR will affect architecture as a discipline? Will architects have to design for the physical world or the virtual environment?

## 2. Application of MR in architectural design education

We started to introduce MR technology for design communication at the School of Architecture and Interior Design, the University of Cincinnati in 2015. Technically, the current AR and VR devices already allow designers to visualize and virtually inhabit 3D spaces at full scale that are interactive and rendered in real time where we can do design work with natural hand and body movement. Through various MR applications in the architectural design studios, we would like to investigate how does this new method of communication impact the traditional design education? While being immersed has applications for film and gaming experiences, would the MR technology make physical architecture obsolete and what would result is a general placeless throughout architecture? With these questions, we examined the theories and technologies related to MR through books, films, and social media. For instance, William Mitchell discussed how the “electronic forms of human relationships challenges old ways of viewing workspace, home space, and city space and demands a redefinition of architecture and urbanism” in his book *City of Bits* ( Mitchell. 1996). Bicocca and Levy discussed the ‘essential copy’ and ‘physical transcendence’ as the two main drives behind the formation of all MR worlds. They go on to describe the searching for the “essential copy” as seeking “...a mean to fool the senses, a display that provides a perfect illusory deception”. While they illustrate the “physical transcendence” as “...an ancient desire for escape from the confines of the physical world, free the mind from the ‘prison’ of a body” (Bicocca, Levy, 1995). In our studio, the terminologies and relationships among “perception, fiction, simulation, and layers of simulatcurm”<sup>1</sup> were also discussed in the context of new MR technology. “Whereas,

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<sup>1</sup> Baudrillard. *Simulacra and Simulation*. Simulacra are copies that depict things that either had no original to begin with, or that no longer have an original. Simulation is the imitation of the operation of a real-world process or system over time. The simulacrum is never that which conceals the truth—it is the truth which conceals that there is none. The simulacrum is true. wiki page. [https://en.wikipedia.org/wiki/Simulacra\\_and\\_Simulation](https://en.wikipedia.org/wiki/Simulacra_and_Simulation)

simulation attempts to obliterate the difference between real and imaginary; simulacrum leaves an untouched difference between reality and illusion” (Tang, Anderson. 2009).

These theoretical dissuasions were very fruitful and led to many reflections. Student Adam Sambuco questioned the physical nature of architecture in his essay. “The step from physical to VR is therefore altogether different, as VR will likely surpass the physical in importance due to their adaptability, utility, accessibility, and lack of constraints. Why would an architect focus on the physical world when the virtual one holds so many more possibilities?” Student Christian Austin argued that “Architecture can incorporate simulacrum, strange in its verisimilitude, which goes beyond from merely copying reality to copying the copy of reality. Furthermore, when the technology is used in this way, it can be so pervasive that it will exist not only on the intimate scale but also on the urban scale.” Student Robert Kish also expressed his concerns and hopes of architecture as a discipline in his essay. “VR will open doors into new worlds. Architects will not lose jobs; they will gain them. Architects will not only need to design the physical but also the virtual spaces. In the beginning, the virtual will have to mimic the real world lest people reject it for feeling too foreign and outlandish to them. As time goes on, however, these virtual realms will break the bounds of the rules and regulations of the physical and become a new archetype which is unbound and wild, only listening to the rules implemented by the designer. We will become expert programmers to realize our newly fabricated world.

Besides these intense discussions, students were introduced several MR hardware and software and experienced the holographic environment in person. They discussed its effectiveness of communication, user interface, and sensory-motor experiences. In the studio, the students also learned how to build MR system including a desktop computer, VR head-mounted display, and Microsoft HoloLens. They used Unreal and Unity game engines to study their conceptual models in real time. Students also learned how to add voice and gesture control and output the stereoscopic display and 360-degree animations. They implemented their newly acquired skills into their presentations successfully. This new feedback loop enabled students to incorporate MR technologies as new means of communication.

### **3. The outcome of integrating MR in studio**

Through three studio courses taught at the school of Architecture and Interior Design, including “future city” studio in 2015, “urban mobility” studio in 2016, and “mixed reality in architecture” studio in 2017. Students learned how to integrate VR & AR into the design timeline and accelerate the studio workflow. In particular, the third studio, “mixed reality in architecture” studio, has been focused on the future hybrid environment integrated with MR technology, where sensory-intensive, immersive experience would facilitate new ways of living. In the studio projects, students proposed the following eight future buildings through concept evaluation, program planning, to final prototyping. The MR allowed proposed future scenarios to be generated, visualized and shared quickly.

#### **3.1 Future library with MR**

MR is changing how we interpret and receive knowledge. The internet is allowing people to access knowledge across many different places, but why do we need a physical place or library to learn when everyone can access information anywhere anytime. However, a library is still needed in the future to provide a space for the community, a space for collaboration, and to perform. However, more importantly, MR will affect how we visualize data and how we learn. Data is traditionally represented in books and papers where users analyze and extract the information they are looking for by reading the text. With MR, we can visualize text and 2D data by creating physical volumes that represent what we want to learn. The users operate an interface that allows them to explore a digital library of content and then extract that data into the real world. For example, one student wants to analyze traffic patterns in the United States. He or she could pull up that data from a virtual library and then generate virtual

volumes of that data to understand it more efficiently. Other people observing the student can also come along and communicate ideas using MR, resulting in more communication and efficient learning. Also, users can leave a trace of what they have discovered. When someone dies, his or her knowledge is lost. However, people can see what others have learned by leaving a virtual path of breadcrumbs showing how he or she obtained their data. Instead of spending countless hours researching a topic with little direction, people can collaborate and visualize different directions to obtain what they are looking for.



Figure 1. Future library. By Joseph Gruzinsky. UC.

### 3.2 Future school with MR

The first use of MR technology in the site is within the existing Elizabeth Courville Elementary School. On the first level, there are multi-purpose spaces that are large enough for VR simulations or AR demonstrations. Teachers would be able to schedule times to use the spaces in addition to their lessons. On the second level, there are more traditional classrooms for when students are not working in VR. The other use of the MR technology in the site is in the holographic viewing space. Next to the existing school, there is an open-air roof structure that can host holographic images of the material that the students are learning in the school. The hologram is hosted to water vapor that emits from the ground, and it also serves as a cooling mechanism in the summertime. In the space, any member of the community can sit and view different lessons and possibly interact with the holographic material. During the nighttime, it can illuminate the street and make this area of the neighborhood feel safer. It is meant to form a center point for the community that is based on the positive growth of Detroit youth.

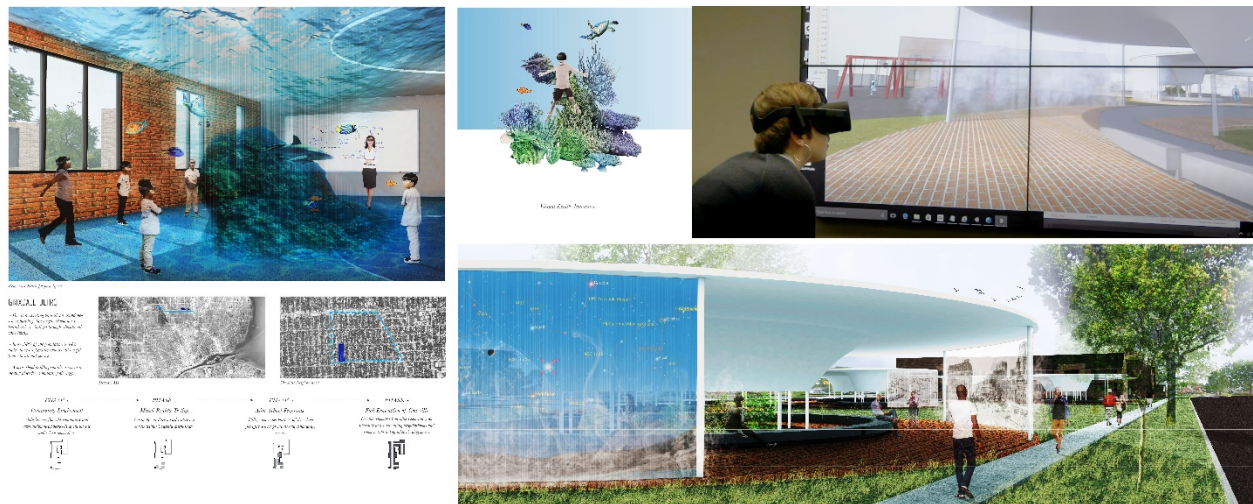


Figure 2. Future school . By Elizabeth Feltz. UC.

### 3.3 Future farm with MR

The project “future farm” used VR to satisfy social needs of individuals in areas disconnected from civilization. Without easy access to activities to satisfy the primal instinct of socialization, we as humans begin to go insane, losing a part of who we are to the machinations of silence that is instilled in the lack of sociality. With VR, however, we can be physically detached from the world while still being virtually connected. Virtuality is even more powerful than the physical, allowing for endless possibilities for work, leisure, spiritual and educational desires. While the Earth is set in stone, the virtual world is a blank medium which can take any form and be any genre. In these locations far detached from the urban fabric and other human life, the spiritual needs of the user may also be in jeopardy. With VR a congregation is just a few wavelengths away, farmers can be a part of grand cathedrals of old, listening to sermons and taking part in the church’s activities.

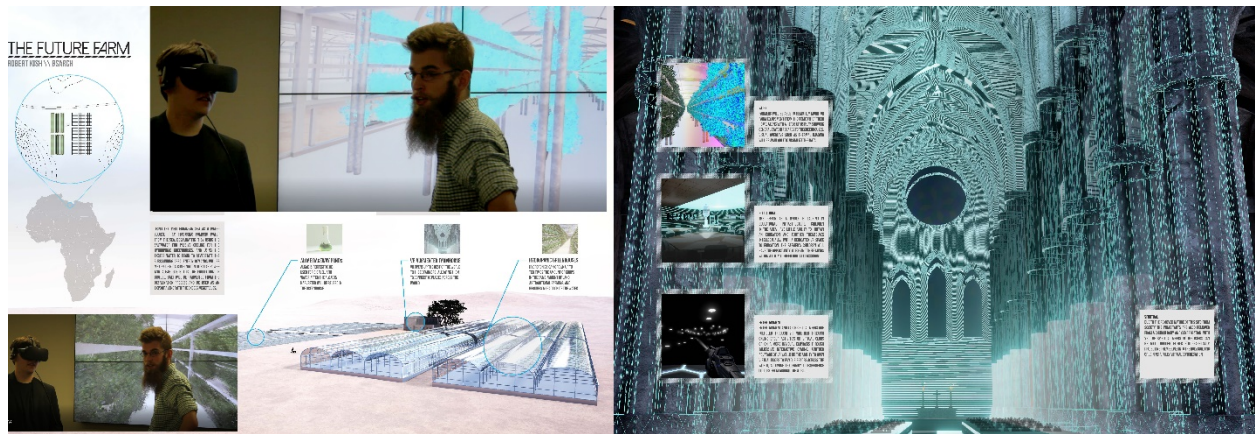


Figure 3. Future farm. By Robert Kish. UC.

### 3.4 Future apartment with MR

The purpose is to establish the utility of MR for those who do not have particularly high income. If a piece of dynamic millwork were installed on a wall, able to adjust to different heights or collapse out of the way, would this supply sufficient grounding to allow smart software to increase the functionality of the apartment, both visually and functionally? “The Layered Apartment,” as it is named, creates a single space that can function as a bedroom, office, dining room, rec room, fitness room, and theater, all with a fold-up bed and dynamic millwork. The millwork supplies the tactility, and it can be adjusted to various heights depending on the occupant’s location within the virtual world. In the office, it is a desk or standing desk. It is gone in the bedroom. The dining room needs a dinner table, and the fitness center could use a step for plyometric, an empty space for aerobics, or any number of locations for body weight exercises. The big change, however, is the surrounding environment. Nearly as important as the design of each space is the transition between them. Moving from layer to layer must feel like traversing a much larger house. The interaction, something as simple as picking up an object or pulling a lever, serves to sever the mind’s connection to the current space just enough that the new layer feels new; it does not feel like being stuck in a small room.



Figure 4. Layered apartment. Adam Sambuco. UC.

### 3.5 Future art gallery with MR

A traditional gallery's main drawback is the space required to house and display a large volume of selected works. When you condense the artwork into the virtual field, the space required is instantly erased. There is no need to store and display artwork when the viewer can choose from a limitless volume of artwork. Furthermore, the curator does not need to go through great lengths to acquire rare pieces of artwork or works from famous artists. If the artwork is documented in the digital realm, the gallery can acquire the image or sculpture and display it digitally without the concern of the physical product. While the display is not the actual piece, it can provide affordances that the original piece could not. You could virtually touch it, get as close as you wish, and even view the artwork with extreme clarity that would otherwise not be obtainable. The curator no longer needs to concern themselves with the quality of lighting or the ambient space when the user experience is almost entirely digital. Additionally, the level of entry to see these artworks is dramatically reduced. The viewer no longer has to forgo seeing famous works of art when they can visit the nearest virtual gallery and almost experience the actual display. This level of accessibility is increased when we consider artwork that is strictly digital. In this instance, the artwork just needs to be sent in a digital copy to the curator, and it is instantly available for display in a gallery across the world. To see a world famous three-dimensional sculpture, you just need a virtual VR and the quality equal regardless of the environment. The barrier of entry becomes so low that VR has a similar effect on artwork that MP3's had to the music industry.



Figure 5. Future art gallery. By Mark Specker, UC

### 3.6 Future meditation space with MR

MR can re-engage humans with their surrounding environment, thus creating an intense attunement with space, materiality, and body. Furthermore, the layering of realities provides the potential for physical engagement with both the physical and digital worlds. To study this approach to the layering of realities, the project attempts to address the synthetic qualities of an architecture of MR through the program of a series of meditative spaces manifested in the traditional spiritual form of a dome. The domes are both physically and virtually kinetic to engage the visitors' bodies and minds. The variability that mixed reality provides is something that is explored through the virtual and physical kinetics of this project. Historically, spiritual and meditative environments vary in form and scale, dependent on religion, individuals, groups, etc. These forms mostly have a few things in common: light from above, verticality, and pure geometric form. What if our spiritual spaces were ultimately variable so that each visitors experience fit their parameters? The inherent infinite scales and formal relationships that can be displayed with MR technology allows for this. Ultimately, it changes the concept of authorship in architecture and the role of the architect. It does not remove the architect from the equation but rather, initiates a more in-depth dialogue between architect and spatial experience. When the architecture is variable and in motion, the architect becomes closer to the experience of the architecture.

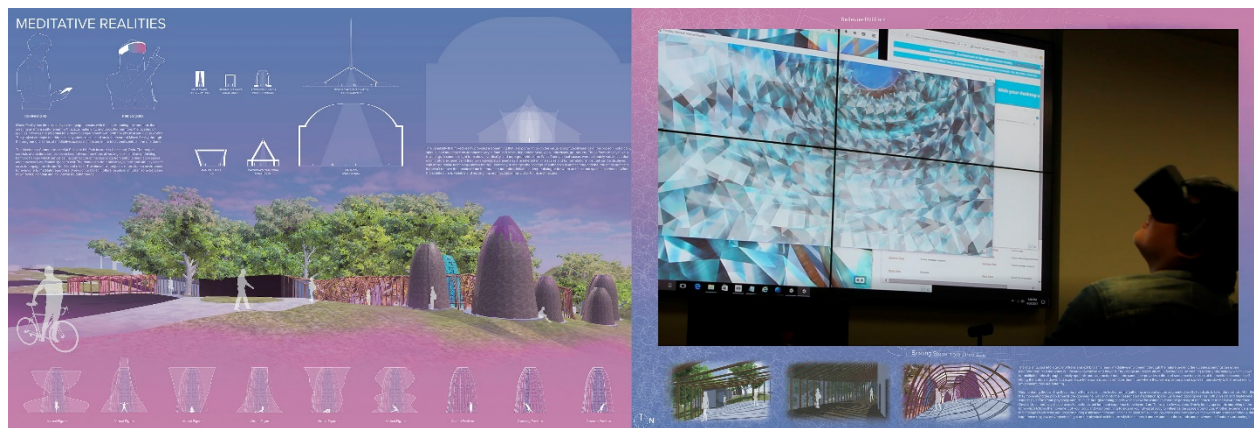


Figure 6. Future meditation space. By Jamie Ferello. UC

### 3.7 Future archeology museum with MR

With the integration of vision, touch, and sound, this center provides an immersive multi-sensory experience. It encourages participation and communication through digital interactive installation and activities space for both kids and adults. As a research center, people can get far more information and better experience from MR technology and online database. While only a few of caves are open for public access, MR enables people to browse any one of the caves they are interested. Without the limitation of time and space, any archeology detail within this virtual cave can be extracted and displayed as holographic models to the visitors.

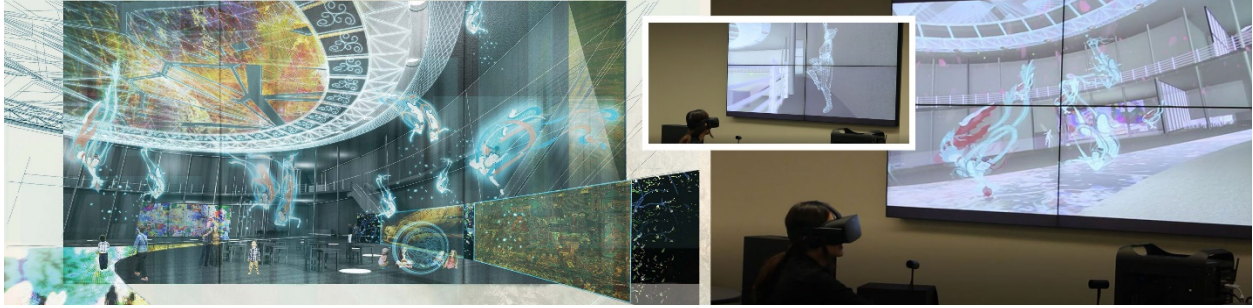


Figure 7. Future archeology museum. By Xianing, Chen. UC.

### 3.8 Future restaurant/office/hotel with MR

The major architectural component of the concept is a kinetic floor system. Made up of an array of three foot deep blocks tied to the building's structure, the tops of the blocks become the floor surface. Driven by a hydraulic system, the blocks are lifted to various heights, creating tables, seats, and partitions. In this way, blocks can be adjusted in various groups to allow the building to function as an office from 9 am to 5 pm, a restaurant from 5 pm to 1 am, and a hotel from 1 am to 9 am. The blocks are made of a material that is taut when stretched but soft when pressure is released. The system can make a group of blocks function as a hard surface like a table to work at or eat at, or a soft surface like a chair to sit on or a bed to sleep on. The blocks are pushed above the floor using a hydraulic system. This system is controlled through the building's central computer system. The building sends signals to the reservoir on a schedule to direct the fluid to specific modules. In this way, modular and kinetic architecture lends itself to multiple uses in the same location. The most impactful change between the three programs besides the furniture is the atmosphere—the lighting, decor, and finishes are changed virtually since they are primarily visual stimuli.



Figure 8. Future restaurant/office/hotel. By Tanvi Shah. UC

## 4. Conclusion

Through the studio teaching and observation, we believe the VR & AR should be promoted and used in architecture education to provide sensory experience and create a sense of reality. It should become a playground which will allow students to explore, discover, evaluate, and improve their designs. At the end-of-studio survey, student Christian Austin described the benefit of using MR as a communication tool in the studio. "Viewing something in 3D allows us to find problems that we could not see before, and exploring them virtually goes one level deeper: evaluating the scale, and user experience as

opposed to objectifying the mass of the building as a tiny object on our computer screens. Bring our designs into an occupiable space earlier in the design process can improve our understanding, and thus the design itself." Student Joseph Gruzinsky described how he learned architecture is not just a physical object, but the spatial experience and perceptions which can be augmented through MR. "Architects can exaggerate scales in interiors or exteriors through physical objects. However, architects can dramatically alter how we perceive space through AR. Instead of deceiving the mind through physical objects and spaces, we can make spaces feel larger through layers of digital information. By reducing the size of spaces, we can increase the density of physical environments by making spaces feel less claustrophobic. This will allow cities to become denser than ever before, only constrained to the physical space of the human body."

Student Mark Specker expressed his excitement for the tremendous opportunities the MR can help the new generation of architects. "I think the MR in architecture is the perfect solution to experiment with the avant-garde without the real world consequences that come with construction. We are no longer bound to the outlandish diagrams and conceptual models. We can inhabit and become a part of the space while the world around us is none the wiser. Experiencing and criticizing, we come to a better understanding of what the future might hold for architecture. Without the need to withhold the traditions and norms of architecture, our minds are free to explore every concept with unprecedented clarity and redefine the tenets that define architecture."

With its significant benefits and challenges for the future architects and educators, using MR in the studio teaching can be concluded, as student Robert Kish reflected in his studio essay. "The technology is advancing at a rapid pace, and it will not be long before we all have access to a world where these two realities are intertwined. There will be those that resist this change, as there always will be, however, we must forge forward into this new world and use these intermingled realities to continue innovating, or else the field of architecture will quickly be left behind with its now archaic tools as future technology leaves the profession behind in the dust."

## **Acknowledgment**

Thanks for the contribution from my students, Adam Sambuco, Christian Austin, Elizabeth Feltz, Jamie Ferrell, Joe Gruzinsky, Mark Specker, Robert Kish, Tanvi Shan, Xianing Chen. My students in the studio also include Fei Man, Grant Wagner, Wensheng Hou, Sho Sugimoto, Shuyang Chen at the University of Cincinnati. More information on the teaching is available at <http://ming3d.com/VR>

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