DESIGN FOR MIXED REALITY EXPERIENCES

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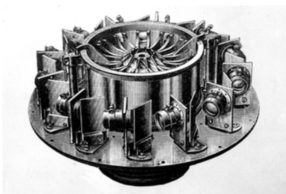
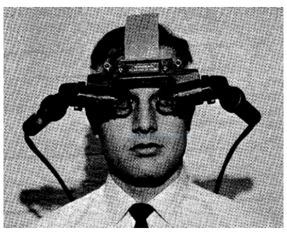
1. INTRO



The Lumière brothers pioneered cinema technology. Among their inventions was a patented 360-degree projector, the Photorama Lumière (Figure 1), which projected panoramic images (Institut Lumière). At the beginning of the 20th century, this innovation enabled visual immersion through the panoramic projections of photographs.

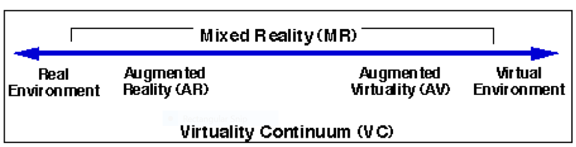
Figure 1. Photorama Lumière, 1902



50 years ago, Ivan E. Sutherland invented the augmented reality machine called "The Sword of Damocles" (Figure 2). The head mounted display (HMD) device allowed the user to see augmented content utilizing a miniature cathode ray tube (CRT) for each eye. The freedom of use, especially user movement, was limited by a mechanical head-tracking unit. However, Sutherland's work was visionary.

Figure 2. Sutherland's HMD, 1968

In today's information age, we are witnessing the collision of social media, internet of things (IoT), cloud computing, big data, artificial intelligence, virtual-, augmented- and mixed- reality (VR, AR, MR). Wearable computing technology is capable of processing relevant, large amounts of information quickly. The importance of engaging in the virtual-, augmented- and mixed- reality subject is highlighted as a significant issue in John Maeda's 2018 Design In Tech Report (Maeda, 2018).



The term mixed reality was first coined in 1994 (Milgram, Kishino). The diagram (Figure 3) shows the Virtuality Continuum from the real environment on the left to the virtual environment on the right.

Figure 3. Virtuality Continuum

Milgram and Kishino also provide a classification of various MR devices. Further, Billinghurst remarks that a MR "display is any head worn, handheld or fixed display that can show a combination of real and virtual world imagery (Billinghurst, 2018).

The first wearable holographic computer that is completely untethered is the Microsoft HoloLens. Deservingly, the "Mercedes" of MR devices won an IDEA Gold Award in 2017. Not only is the physical design of this MR device excellent, but also its interaction experience and technical details, such as spatial mapping. Furthermore, Microsoft created HoloLens apps, such as HoloTour, that highlight the product system capabilities in a compelling way.

The recent development of MR devices and apps hint at an exciting future. To be true to the inherent innovative spirit of the industrial design profession, it is important to investigate the impact of mixed reality on the future of industrial design. This paper examines how MR will influence the design process and why it is crucial to prepare industrial designers for MR design opportunities. Takeaways from MR projects conducted at Syracuse University will also be shared. This is a design education story that exemplifies the unique value of engaging in MR design development.

2. IMPACT OF MR ON DESIGN PROCESS

Inspired by Sutherland's breakthrough, military application of heads-up displays in fighter jets pushed the development of MR technology. As pilots became fatigued by sophisticated combat scenarios, heads-up displays presented an opportunity to relieve them (Azuma,1997).

The automotive industry utilizes CAVE projection for design development and VR simulation for training. Recently, BMW and Ford announced that they have incorporated the HoloLens in diverse applications. BMW experiments with a marketing approach to connect customers with their products: "The BMW X2 Holo Experience and Microsoft HoloLens immerse users in the world of the BMW X2, where they can get to know the new model in an interactive way". At Ford, the emphasis is on training for manufacturing and the design process. Craig Wetzel, design technical operations manager at Ford mentions that the "HoloLens allows us to review full-size 3D designs with designers and engineers around the world in real time" (Ford Media, 2017). The majority of the use cases currently take place in development environments with large budgets, although it is foreseeable that the price of entry will be reduced over time, thus allowing smaller design consultancies to participate.

Often times, stakeholders in business scenarios are distributed globally. Reviewing new designs collaboratively, regardless of the participants location, is especially useful for product development. PTC is a software company that invests heavily in providing solutions for IoT devices and the augmented software development market (Vuforia). Vuforia Studio is a software solution for authoring augmented experiences to a smartphone, tablet or a HMD such as the HoloLens. The software is able to import Computer Aided Design (CAD) files into an augmented scene and can add interactive elements. The scene is then published to a server. Using a marker as a positioning and scaling tool, PTC's ThingWorx software enables multiple users, wearing HMD's, to be viewing the same augmented, holographic content.

In summary, if MR is part of the design process, it happens at the end: Finished 3D models are reviewed and discussed. The diagram, a combination of the visualized design process from Stanford's d.school and a graph of the level of MR usage illustrates current applications (Figure 4).

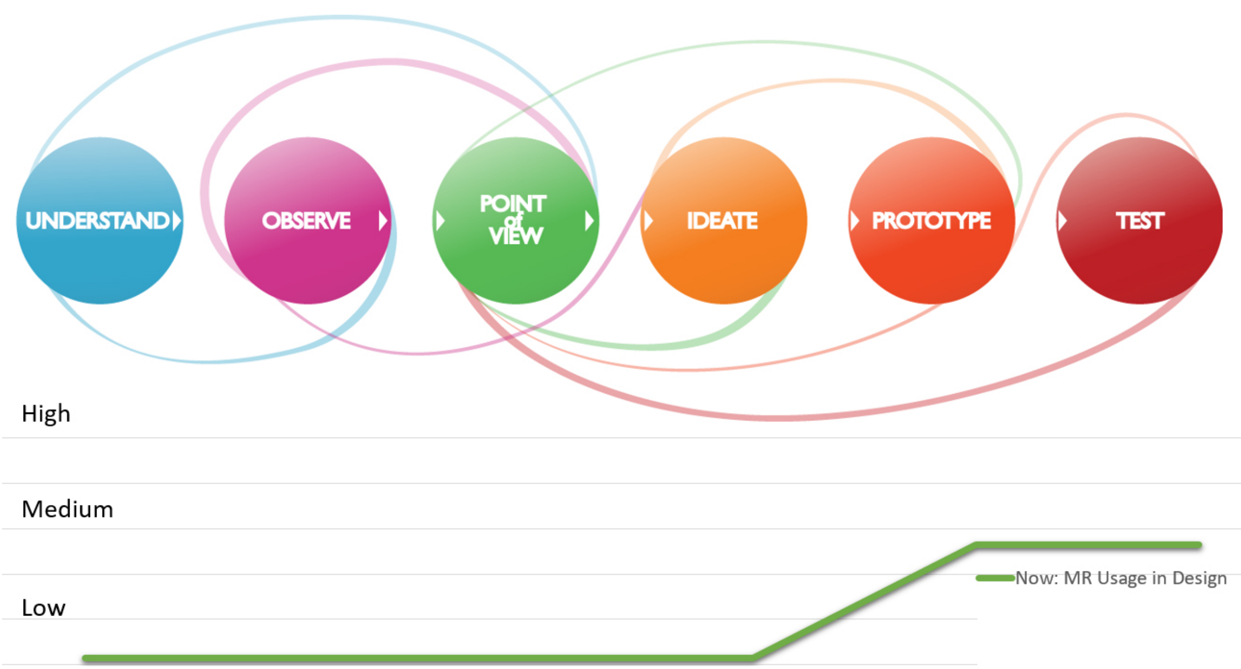


Figure 4. Impact on design process now (design process image: dschool 2009)

The current situation presents an opportunity gap for new applications that support an iterative design process from the fuzzy front end of understanding the problem that needs to be solved (Cagan, Vogel, 2012) all the way to transitioning the design to engineering. Although the research phase of the design process is not the target of current MR tools, the following questions provide food for thought: What if mindmaps could be created collaboratively in MR? What if observing users could be documented in MR while insights are flagged in real time? Could the red thread of design decision making, from user insights to the final product experience, be documented in MR? If so, the integration of MR into the design process should be more profound (Figure 5).

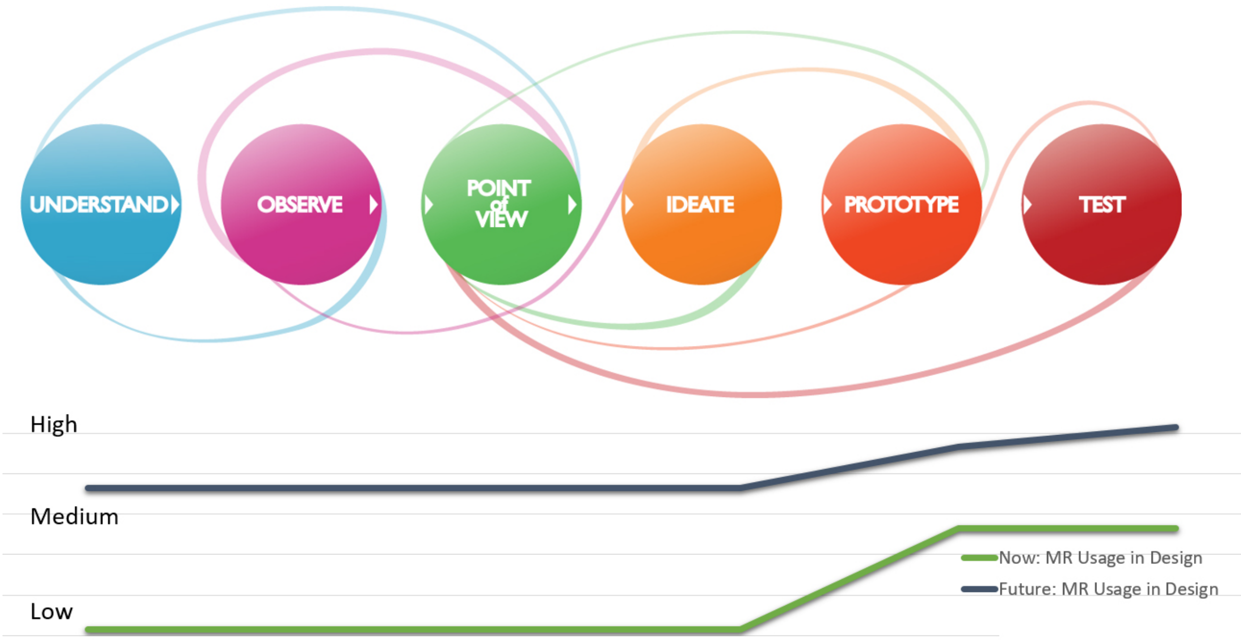


Figure 5. Impact on design process in the future (design process image: dschool 2009)

From a business point of view, the market is moving quickly. “Worldwide spending on augmented reality and virtual reality (AR/VR) is forecast to reach $17.8 billion in 2018” (Shirer, Torchia, 2017). A recent Harvard Business Review article outlines the value of augmented reality (AR) to businesses and “provides a road map for how companies should deploy AR” while explaining “the critical choices they will face in integrating it into strategy and operations” (Porter, Heppelmann, 2017). When management pushes MR projects forward, opportunities for design will be created. Consumer and professional users have varying expectations, which are crucial for success (Schmalstieg, Höllerer, 2016). The design discipline needs to evolve quickly to capitalize on this trend.

3. IMPLEMENTING MR IN DESIGN EDUCATION

CAD became an essential design tool in the 1990s, but its success was not instantaneous. Design schools could only afford a few of the expensive SGI workstations, therefore students had to compete for limited access. YouTube tutorials were nonexistent, the trial and error approach combined with a lot of patience was necessary to improve one’s skills. Furthermore, CAD design development was limited to upper level classes.

These days incoming freshman frequently are equipped with CAD modeling skills gained in high school. When conducting a tech survey in our program, out of 19 participants, 57.9 % attended a CAD course in high school (Figure 6).

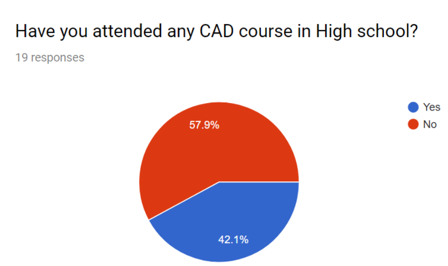


Figure 6: CAD Survey

New students also expect collaborative software that is available in the cloud, which supports working on files with multiple users.

Similarly, in the near future, MR devices are likely to become a fundamental feature in design education. The current state of MR development is showing parallels to the CAD example. Schools can only afford a few devices (if any) and the learning curve is steep.

C# programming skills, gaming experience and Unity game development skills are an immediate advantage. This is not the typical skillset of industrial designers. On the other hand, the designers' grasp of three dimensions, time based media and command of the user centered design process allow them to contribute to the interdisciplinary MR development.

In the design program at Syracuse University, MR has been introduced to students in upper level courses to provide a studio project experience where students navigate the problem-based, user-centered design process with cutting-edge MR technology fully integrated. The course allows them to explore and understand MR design issues. In addition, students develop a specific skill set for MR user experience development.

3.1. OBJECTIVE

The semester-long project was organized around the user-centered design process, navigating from the understanding phase to the ideation phase and concluding in the refining phase. Over the course of the semester, students were expected to respond to these important issues:

- Explore and identify a design opportunity around a specific theme in which mixed reality is a game changer
- Design a system that includes a design concept for a mixed reality experience
- Ideate scenarios that demonstrate an improved task flow enabled by mixed reality
- Tell the story of why mixed reality makes this specific experience better
- Visualize details of the mixed reality design
- Apply the user-centered, stakeholder-focused design process

3.2. PROJECT PATH

The studio project focused on three distinct areas of exploration, each area framed by a central question:
1. How could mixed reality impact machinery solutions for industrial process automation and integration?
2. How could mixed reality improve the fuzzy front end of the design process?
3. How could mixed reality benefit the stakeholders of a fire department?
Students were asked to form research teams for each theme.

At the beginning of the project, students researched the topic mixed reality and explored MR capabilities with the Microsoft HoloLens. The students had access to one HoloLens. The advantage with the HoloLens is its portability and untethered functionality.

To exercise the students' creativity, in addition to secondary research, they were tasked with developing a MR concept for a prospective student visiting campus. An analog ideation design sprint was followed by a more refined sprint, which included creating photo-shopped images for storyboards. Finally, the students crafted 45 second videos which required them to develop a coherent story of the MR experience. Without any programming skills and without the use of MR technology, but with an understanding of MR possibilities, students communicated their ideas while playfully immersing themselves in the topic.

Then the students formed groups of five and talked to the user base to understand stakeholder needs in order to gain a thorough understanding of their chosen area of exploration. They visited the local fire station, went on a fieldtrip to Bartell, a local engineering and machining firm, and interviewed fashion design students. To learn about issues of use associated with the HoloLens, the students immersed themselves in the field of mixed reality and benchmarked current HoloLens apps (HoloMaps, Holotour, Roboraid, etc.). A research report after the first third of the semester summarized their learnings.

3.3. CONCEPT DEVELOPMENT

Proceeding into the ideation phase, the students regrouped in teams of two. At this point in the semester, many insightful questions were asked and answers sought. Ethical concerns regarding the technology were discovered, e.g. “If a MR device is used in the communication of multiple individuals, how could misuse be detected and controlled?”

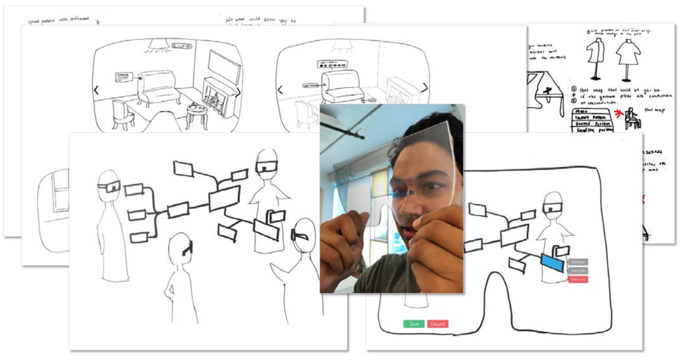


Figure 7: Sketching MR ideas

After the opportunity areas were defined, the teams envisioned future scenarios that illustrate an improved task flow with the integration of mixed reality technology (Figure 7). The students deducted functionality questions through testing existing HoloLens apps such as the Thingworx Viewer (Figure 8). Moreover, they followed up with stakeholders to address in-depth questions and to get feedback about their ideas.

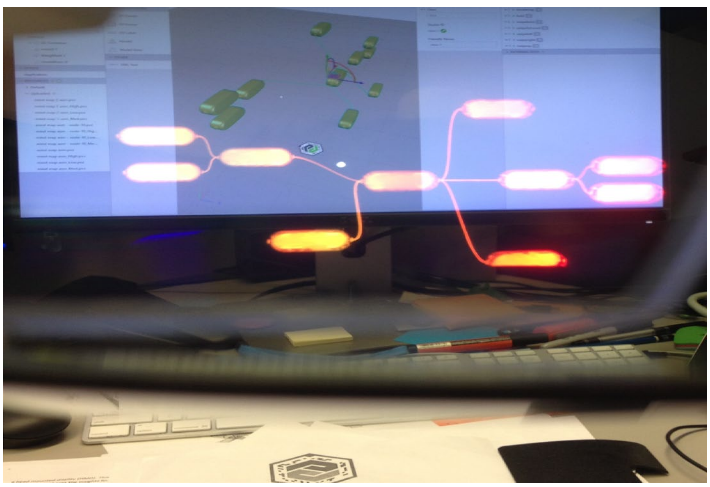


Figure 8: Thingworx test

The midterm presentations accelerated decision-making, formalizing ideas and creating a sequence of comprehensive visualizations that describe the concepts. The reality sequence template supported the design process of multi-step user interactions (Figure 9). An external expert Rich Hanks from the industrial and user experience design consultancy Tactile Inc., visited the studio, critiqued the work and provided valuable feedback for future design decisions. This guidance came at a critical time to align each projects’ direction. After the midterm, the students developed the story of their concept through advanced visualizations.

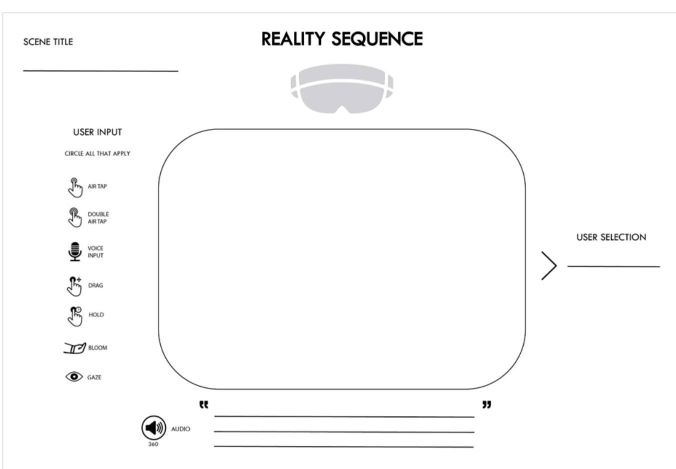


Figure 9: Reality sequence template (Warner, L. 2017)

3.4. FINAL MIXED REALITY DESIGN PROPOSALS

3D interaction is a critical component of the user experience in any MR project. Utilizing 3D user interface guidelines (Kruijff, 2017), the students gained valuable experience in designing a user interface (UI) for a MR experience. They learned that the level of interactivity in a MR experience needs to be adjusted to the task at hand. The proper management of information is a key element. Here is a selection of the four best student projects.

The teams developed their own framework and unique solutions to the problems they discovered. The team that tackled machinery solutions for industrial process automation and integration focused on installation and maintenance. They implemented a translation function in the MR user interface, which improves the interaction with operators during assembly while overcoming language barriers. Improper lubrication can cause premature failure of moving components such as bearings. Therefore, it is critical that the operator inspects moving components for damage and excessive wear. Since many of the lubrication points can be difficult to identify, the MR supported maintenance schedule helps the operator to correctly perform lubrication (Figure 10).

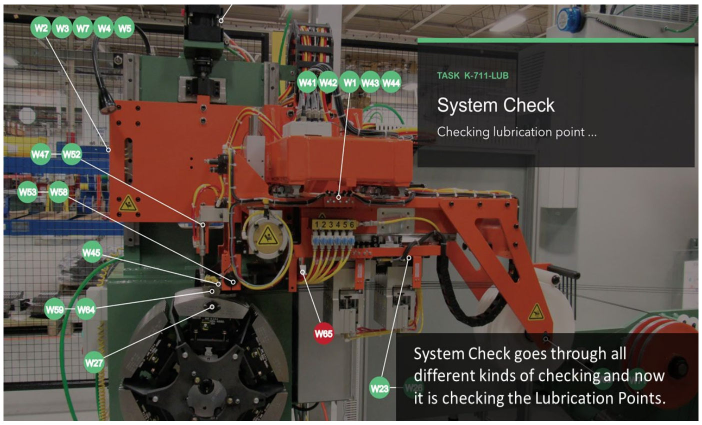


Figure 10: MR Illustration of lubrication points

The team that developed ideas for MR design process applications took two different routes. One team looked into supporting design teams throughout the design process. They envisioned collaboration that seamlessly transitions from reality to mixed reality. Team members could use tablets or MR devices to contribute (Figure 11). The entire design process would be captured in a mixed reality project space that shows the red thread of design decision making. Furthermore, remote client team members could be invited to the MR project space.

Figure 11. MR Mindmap

Another team created a HoloLens App that streamlines the workflow of fashion designers. Multiple insights from observing and interviewing fashion design students led to a coherent MR tool that allows fashion designers to access their resources, make modifications, test their work and have their design come to life in a MR space.

Figure 12. Illustration of an MR app for fashion designers

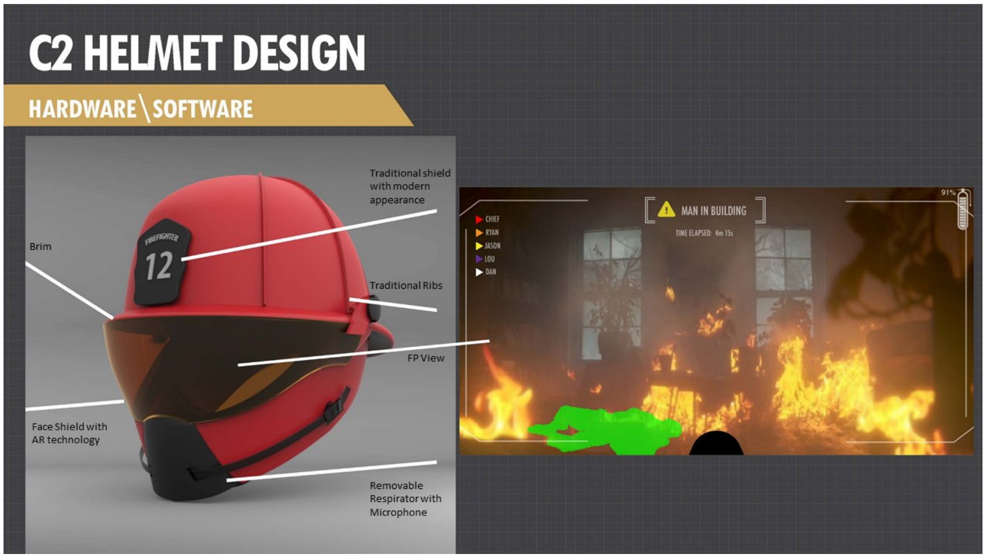


Figure 13. Illustration of an MR system for firefighters

The team that designed a MR solution for the stakeholders of a fire department chose a different approach. They combined the redesign of a firefighter helmet that carries traditional elements such as the brim, shield and ribs with a MR visor that optimizes communication and navigation while responding to emergencies.

In a compelling presentation, the students demonstrated their idea by developing the helmet in CAD, 3D printing a physical model and mocking up the MR user experience in a video using After Effects.

At this time, integrating MR in design education makes sense in higher-level design studio courses. As the digitally native generation enters college age, their fluid handling of digital tools will support the use of MR technology in freshman and sophomore courses. For design educators it is important to be prepared for this transition and to support students in playfully working with digital content and tools.

4. TAKEAWAYS

Critical inquiry in all phases of the design process

When working on a project without many case studies for comparison, it is critical to be an advocate for the user and to understand the stakeholder's needs. It is important to ask critical questions throughout the design process to justify why an augmented solution is better than the non-augmented solution.

Combine old and new design tools

To accelerate the iterative MR design process, sketching (analog/digital) remains valuable. Interaction sequence templates that call out user actions are useful. The use of existing VR apps such as "Tiltbrush" or "Gravity Sketch" support the ideation process in three-dimensional space. The designer should be in command of design tools that bridge the traditional physical product design with MR interaction design.

Exploring 3D interaction possibilities is hard work

The pervasiveness of traditional 2D interaction of computers, smart phones and tablets presents a challenge to the students. Although industrial design students hone their ability to design in 3D, extra steps should be taken to encourage the exploration of 3D interaction possibilities. The untethered HMD device enables collaboration in new ways. Spatial mapping and 3D information graphics open up new opportunities and challenges. Information can be displayed in 3D and interconnected with big data in real time.

Visual narrative

Tell the story in a sequence with compelling images that highlight the advantages of the new idea. Practice storytelling, introduce film making skills and benchmark gaming experiences. The best student outcome included a short video, in which a narrator explained the MR concept with moving imagery and digitally overlaid visuals.

Academic space that supports tech in design
The best academic setting invites students to experiment in emerging technology spaces. At Syracuse University, faculty can reserve the Digital Scholarship Space in the library. This space is equipped with multiple MR ready computer stations. Supporting curiosity about emerging technology enables the students to hone skills that could lead to promising career opportunities and contribute in a meaningful way to design work in the future. Design educators should take an active role in introducing the potential of mixed reality interactions.

An ample amount of time should be reserved for course preparation. The speed of hard and software innovation and updates is fast. Routinely testing and preparing equipment for the classroom prevents wasting class time for trouble shooting. Utilizing flipped classroom strategies for learning new software is also advisable. Lynda.com offers many high quality tutorials (e.g. for Unity) that can be deployed via blackboard.

Considering the complexity level of MR projects, the exploration of the mixed reality space allows for excellent collaboration opportunities across campus and with industry.

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