



The Holographic Studio

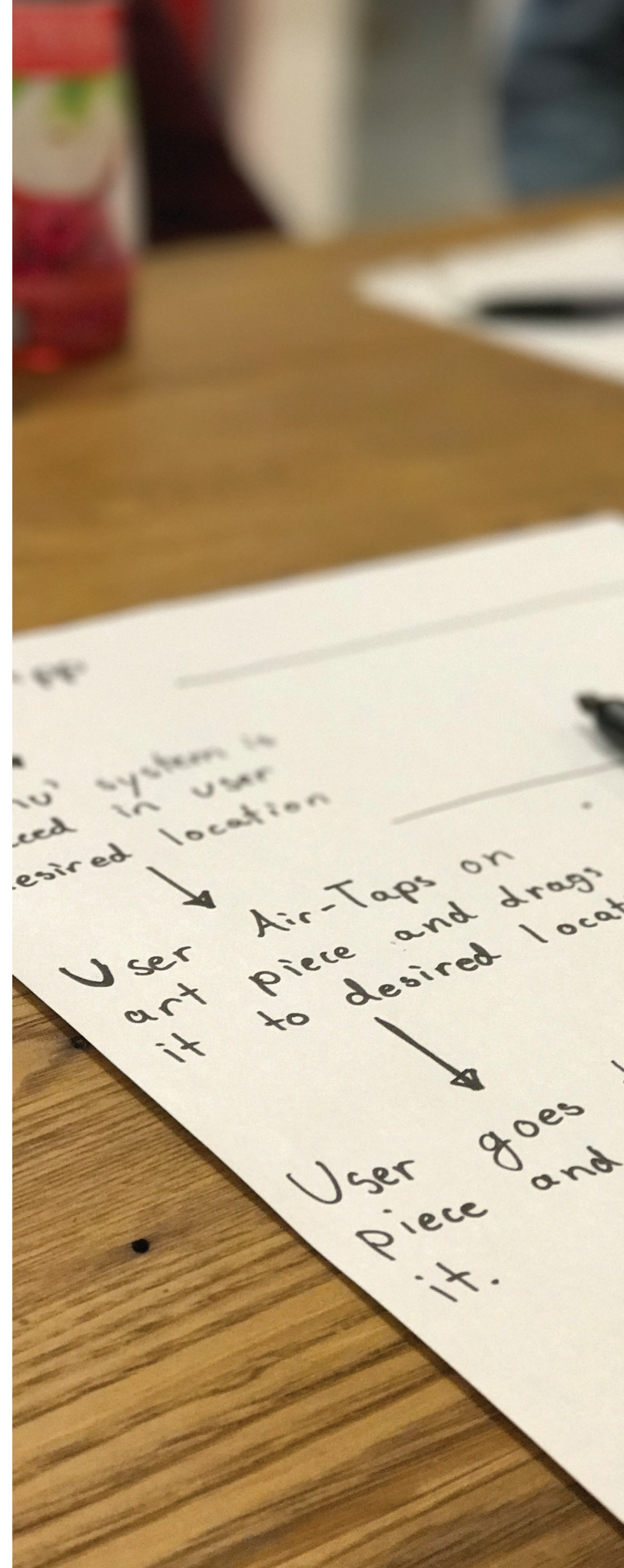
Designing the Artist Studio Experience of the Future

Will Hsu • Jing Huang • Brian Hui • Alexandros Lotsos • Tyler Mechura • Ankit Ruhela



NYU

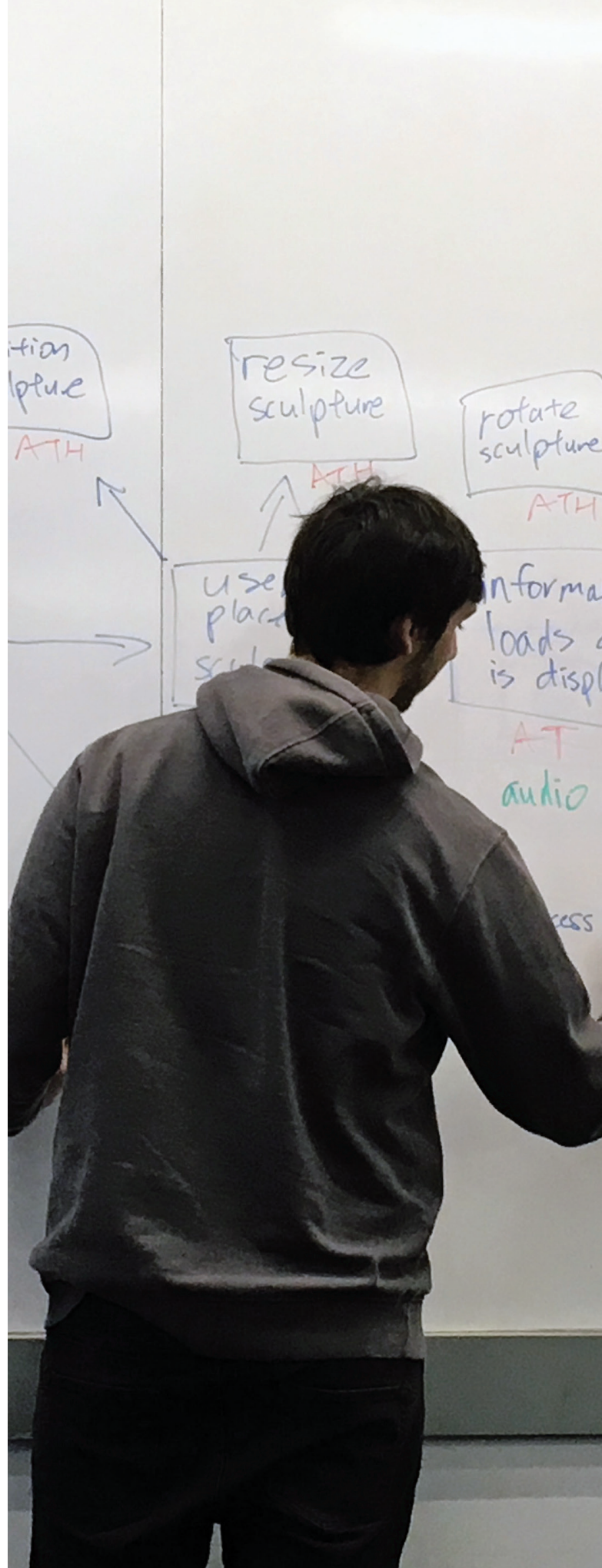
TANDON SCHOOL
OF ENGINEERING





Contents

1.	Our Team	1
2.	Project Summary	5
3.	Research & Brainstorming	9
4.	Comparative Analysis	15
5.	User Research	17
6.	Prototyping & Iterative Process	21
7.	User Testing Outcomes	31
8.	Table of Elements	35
9.	Final Thoughts & Insights	37



A background image showing a portion of a classical building facade with columns and a white flag hanging from a pole. The flag features a black torch logo and the letters 'NYU' in black. A large white number '1' is overlaid on the left side of the image.

1

Our Team

Introduction

Team HelloLens was formed to carry out the design challenge that was issued for the graduate level User Experience Design class taught by Dana Karwas. The design challenge was created with consultation from Joshua Walton, Principal Interaction Designer on the Microsoft HoloLens team. Our design challenge team is comprised of undergraduate and graduate students in the Integrated Digital Media program at New York University's Tandon School of Engineering.

Our team members are from India, Greece, Taiwan, China, Canada, and the United States with backgrounds ranging from graphic communications management to mathematics to management of information systems. Bringing together a team with diverse cultural and academic backgrounds has allowed us to synthesize our backgrounds with what we are learning at New York University to develop unique insights and ideas to carry out the requirements and deliverables for the HoloLens Design Challenge.

Meet the members of HelloLens. We hope that this project will inspire you to push what mixed reality will do for the masses. We had an amazing time blazing this trail for mixed reality and we hope that you are as excited as we are for what the future has in store for holographic computing.



Will Hsu

Will is from Taiwan and is passionate about technology and design. He believes technology is about the people - only when people are involved can we build something that is useful and meaningful. Will has a Bachelor's degree in Management of Information Systems. This is where he got insights into the IT industry. He is currently working on his Master's degree in Integrated Digital Media at New York University, focusing on user experience design and product design.

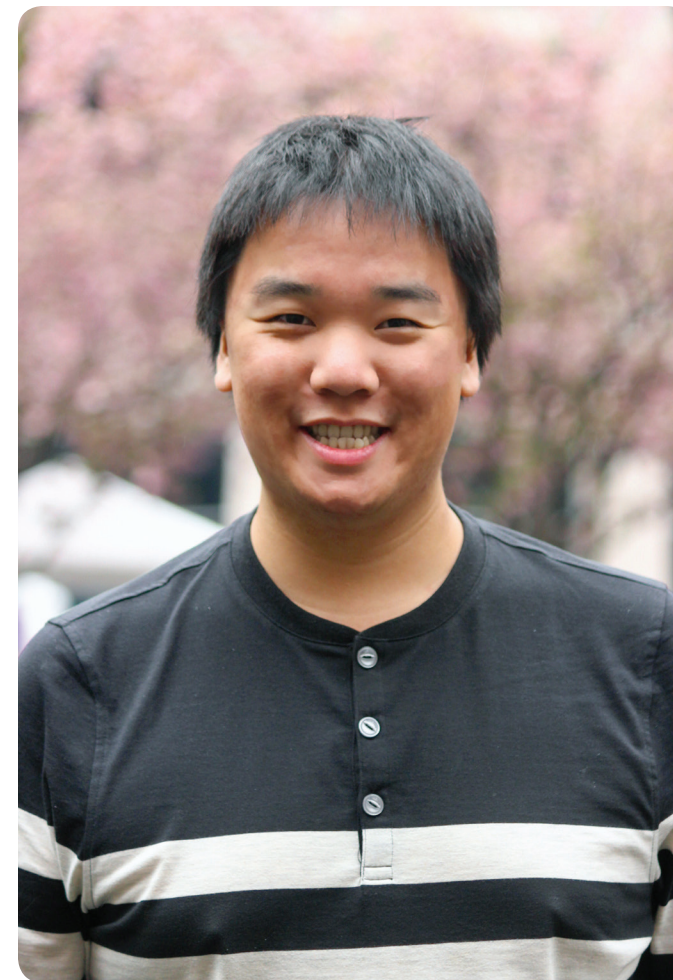
Will has a lot of interest in the fields of augmented and virtual reality. Working with the HoloLens and mixed reality design has been an exciting and worthwhile learning experience for him.



Jing Huang

Jing is from China and has a background in Media Production and Communication in her undergraduate study. After she got her Bachelor's degree from Donghua University in Shanghai, she came to New York University and became a graduate student in the Integrated Digital Media program.

Jing is interested in video production and digital media. Her work in HelloLens includes producing videos to showcase prototypes as well as user flow. She is excited to see the future combination of video production and how digital media technologies like the HoloLens can influence it.



Brian Hui

Brian is from Vancouver, Canada and has a Bachelor of Technology (Honours) in Graphic Communications Management from Ryerson University in Toronto, Canada. Now, he is an Integrated Digital Media graduate student working towards a Master of Science degree at New York University focusing on user experience design as well as design for augmented, virtual, and mixed reality.

Brian has always believed that collaborative work through human-centered design can be helpful to design products and services that people will care about. He is happy to have been a part of the HelloLens team as the project manager as it has helped him better understand the complexities of what designing for mixed reality entails.



Alexandros Lotsos

Alexandros is from Athens, Greece and previously attended Boston University as an undergraduate where he double majored in mathematics and philosophy. Alexandros is currently a graduate student in New York University, pursuing his degree in Integrated Digital Media with a focus on creative coding and game design.

Alexandros views his work with team HelloLens as an opportunity to explore the cutting-edge frontier of mixed reality and its design similarities with games and other interactive mediums. Moving forward, he would be very interested to experiment with designing games and other interactive experiences for the HoloLens.



Tyler Mechura

Tyler is from Monmouth County, New Jersey, and has been in NYC for the past four years. He has been attending NYU Tandon School of Engineering for his Bachelor's degree in Integrated Digital Media with a focus on User Experience Design.

Before Integrated Digital Media, he was working towards his Bachelor's in Computer Engineering. As an undergraduate, the mixed reality HoloLens project is an amazing experience for him and allows him to expand his knowledge of different products and technology in the media field.



Ankit Ruhela

Ankit is from New Delhi, India with a background in Information Technology and self-taught graphic design skills. His broad outreach towards merging technology and design together to serve as a unique medium to elevate human experience is what brought him to NYU's Integrated Digital Media program in New York City.

By designing and developing for mixed reality experiences offered by Microsoft's HoloLens, Ankit hopes to explore and surpass the traditional boundaries of user experience often seen on rectangular screens with varying sizes.



2

Project Summary

Project Description

Imagine a holographic portfolio that enables you to experience and sense art works in a new and exciting way. Our team was tasked with designing a proof of concept for a holographic portfolio that covers the end-to-end experience of an artist's portfolio that would be deployed and viewed through the HoloLens. The design brief challenged us to create an experience for interacting with different types of artwork in a mixed reality environment. The approach is based on the experience of a studio visit and is meant to be used by curators as a supplementary curatorial tool. This challenge was developed by our professor, Dana Karwas, and Joshua Walton, Principal Interaction Designer at Microsoft HoloLens.

This project was started on March 6, 2017 with an introduction of the project from Dana and Joshua. The project concluded on May 8, 2017 with a presentation of our findings and our concept prototype to the class as well as Nicholas Kamuda, Creative Director for Microsoft HoloLens and Windows Holographic at Microsoft, and other special guests.

What is Mixed Reality?

To understand what mixed reality is, we should first understand what virtual reality and augmented reality entails¹.

Right now, virtual reality is defined more by a head-mounted display unit. The Oculus Rift, HTC Vive, Samsung Gear VR, Google's Daydream View, and PlayStation VR are just a few examples of current iterations of the head-mounted display unit. However, these units do not run independently and are powered by tethering to computers (Oculus Rift, HTC Vive), smartphones (Samsung Gear VR, Google's Daydream View), or game consoles (PlayStation VR). These headsets create a new digital reality that is displayed on screens. This transports the user to completely new environments and allows for limited interactions in these environments.

¹ Johnson, Eric. "What are the differences among virtual, augmented and mixed reality?" What are the differences among virtual, augmented and mixed reality? - Recode. July 13, 2015. Accessed April 1, 2017. <https://www.recode.net/2015/7/27/11615046/whats-the-difference-between-virtual-augmented-and-mixed-reality>.

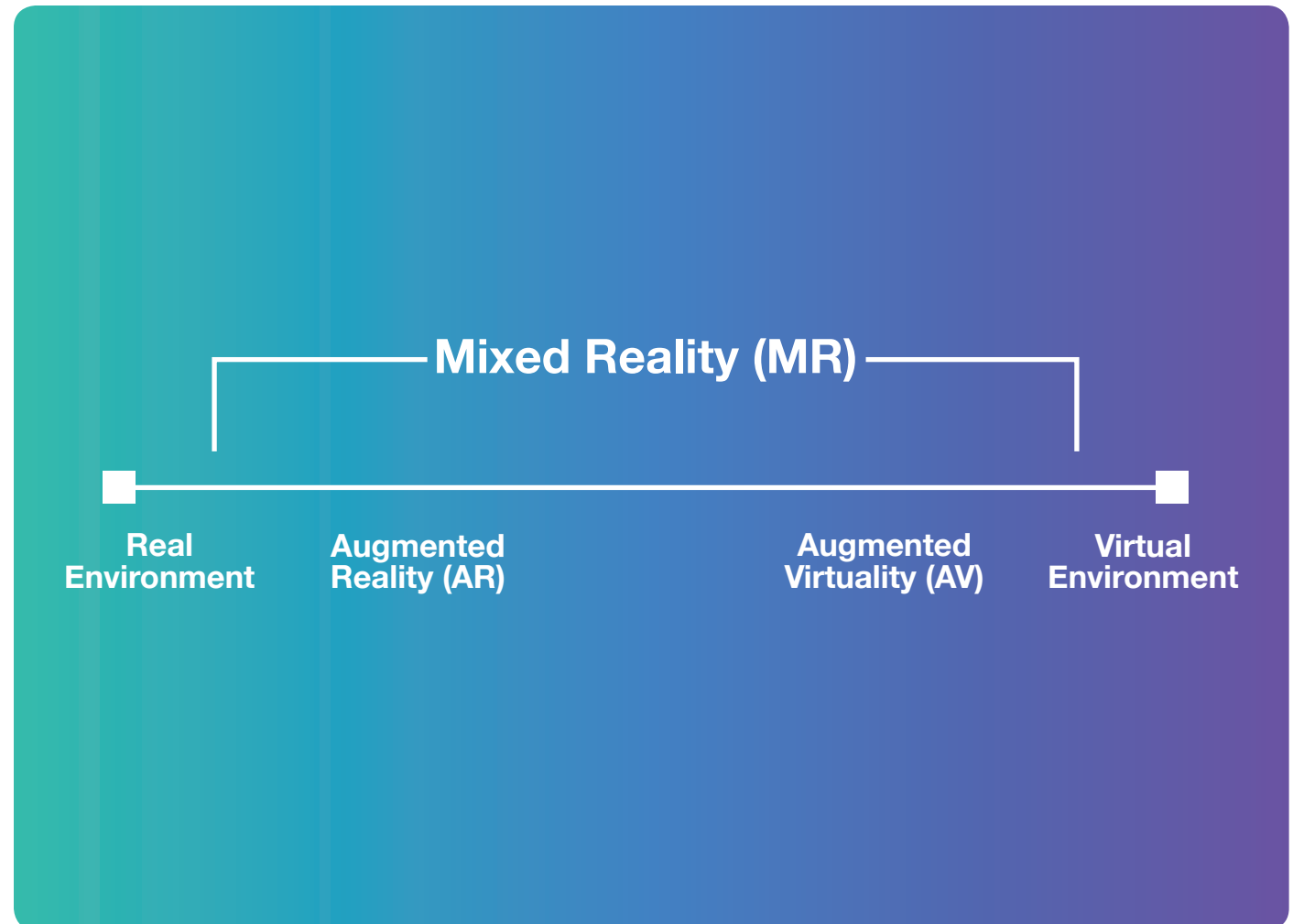
Augmented reality currently has a more utilitarian use. Augmented reality functions by overlaying information on top of the real world via a head mounted unit (Google Glass) or, more commonly, by using your smartphone and smartphone camera. Examples of augmented reality use in smartphones include Pokémon GO, Yelp's Monocle feature, LayAR, and Aurasma. These apps utilize your smartphone to display content on top of the world without taking into consideration what is actually in the world, thereby augmenting reality by placing a layer of information over reality.

Mixed reality (MR) is almost like AR+. Mixed reality utilizes depth sensing to detect and map the environment you are in. This allows any content that is displayed in reality to be aware of objects in the environment. For example, content that is placed on the ground behind a counter-top would not be visible once the user walks behind the counter. Furthermore, the further you walk away from the object, the smaller it will appear. This makes it appear that the placed object is anchored in reality. Compare that with AR, where information is laid on top of the real world and, no matter what you do, the information will always be the same relative distance from you.

Milgram's Reality-Virtuality Continuum², seen on the right, played a part in helping us understand mixed reality. Today, with the rise of virtual reality and augmented reality, it is easier to understand how the different points on the continuum could exist. Whereas a real environment is defined by the existence of real-world objects in the real-world environment and a virtual environment is defined as a wholly constructed and fabricated environment and objects.

Project Goals

Since holographic computing and mixed reality is a new design medium, our team thought of overarching themes we wanted to focus on that had the potential of laying out the groundwork for future mixed reality user experiences.



With this project, our team strove to:

1. Create a simple and clear way for the potential user to view an artist's work.
2. Provide a consistent experience when the user is interacting with holograms.
3. Design an unobtrusive and intuitive way to navigate through the entire experience.

Project Outcomes

The project culminated in a proof of concept, developed in Unity, and then deployed on the HoloLens.

Some of the major insights we learned from this project include:

- Developing a concept interactions map to figure out the possible types of interactions was helpful in brainstorming.

- Sketching a few of these interactions to see how one could complete simple tasks was useful in helping develop for the HoloLens.
- Creating a draft Table of Elements to help determine what you want to include in your experience, including what design techniques for Mixed Reality you intend to use. You can follow-up by creating a final Table of Elements once your project is near completion.
- Constructing holograms from available materials to create low fidelity prototypes.

Overall, the HoloLens Design Challenge and our final proof of concept can be summed up in the case study image on the right. This image visualizes our ideas and takes elements from our Table of Elements to summarize our concept in a visual diagram.

² Milgram, Paul, Haruo Takemura, Akira Utsumi, and Fumio Kishino. "Augmented reality: a class of displays on the reality-virtuality continuum." *Telemanipulator and Telepresence Technologies*, 1994, 282-92. Accessed March 22, 2017. http://etclab.mie.utoronto.ca/publication/1994/Milgram_Takemura_SPIE1994.pdf.

Case Study: Holographic Artist Studio



Physical Space

Floor
Walls
Variable Layouts
Ambient Environment

User Input

Gaze
Air Tap
Air Tap & Hold
Voice Commands

Holographic Form

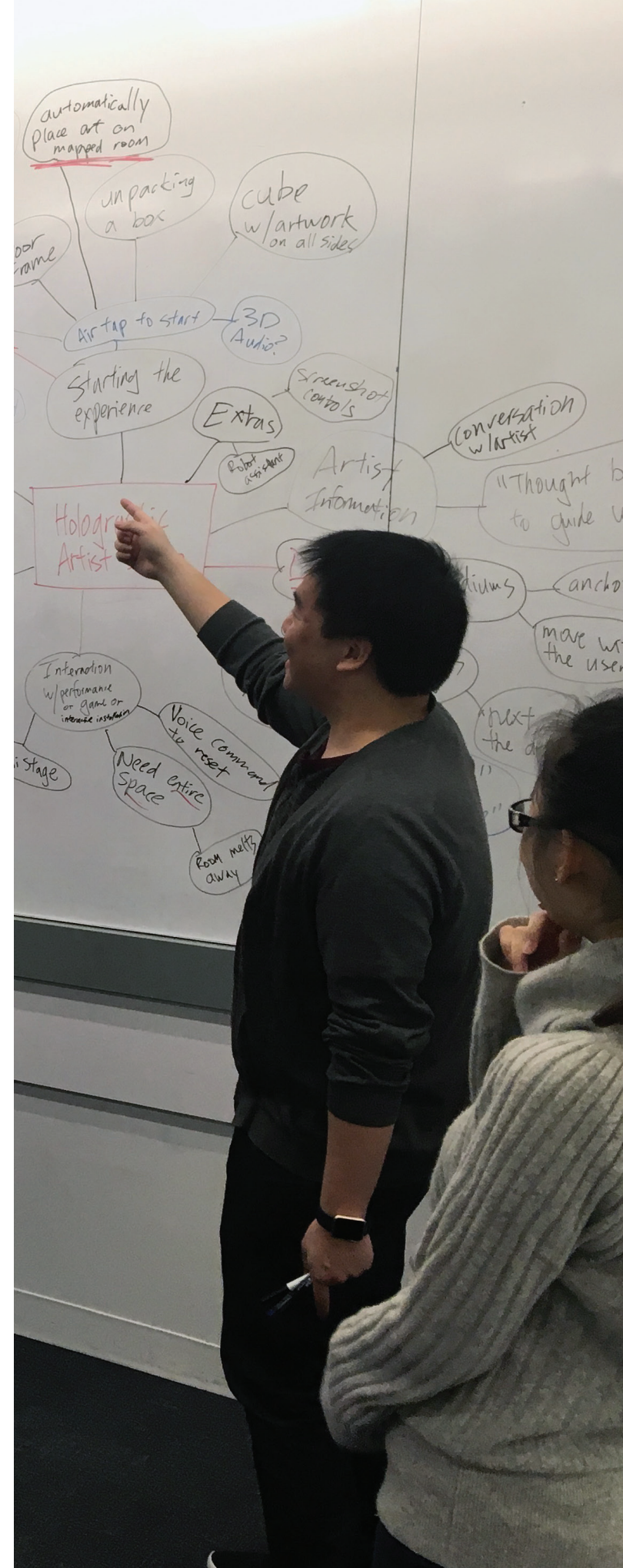
3D Sculpture
2D Painting
Holographic Installation
Holographic Video
UI Elements
Animated Avatar
Holographic Artist Bio

3D Sound

User Interaction
Feedback Audio
Object-Specific
Audio Cues
Avatar Dialogue
Spatial Sound
For Navigation

Mixed Reality Design Methods

Transforming Surfaces
Mixed Reality Immersion
Avatar Interface
Shared Holographic Space
Information Overlay



3

Research & Brainstorming

When we started to think about how to develop for mixed reality, we had to change the way we thought about human interactions with technology. The most familiar interactions that we were used to involves a two dimensional surface. Everyone on the team knew how to design for smartphones and tablets and computers, but how could we further design an experience by integrating the real world as part of the design?

Before we could even brainstorm about how to design an experience for the HoloLens, we had to do some basic research and understand how the HoloLens works, what it was capabilities were, and what its limitations were.

Initial Readings and Research

Our team familiarized ourselves with a few key readings on virtual reality, augmented reality, and mixed reality. Through multiple articles and reading forums, we gained a better understanding of how other people have deployed their own methods for the user experience design process for mixed reality. Notable resources that we used for our research include (but were not limited to) “The UX Workflow for HoloLens & Mixed Reality” by Juan on HackerNoon.com, “Best Practices For Mixed Reality Design in 2017” by Lucas Rizzotto on Medium.com, the Microsoft HoloLens YouTube channel, and the works and blog of the Seattle-based company, 8ninths.

We also sought to familiarize ourselves with McLuhan’s idea of sensory ratios. McLuhan’s idea of “sensory ratios” claims that our perception of media by our individual sensorium has the potential to change our mental interaction processes. With mixed reality, we have the potential to create experiences that will allow users to use natural affordances that will have no change to the sensory ratio. Our team believes that how content is displayed is going to play a big part in allowing for a minimal or negligent change to our natural sensory ratios so that we won’t feel bombarded or overwhelmed by the content that is displayed.

Left:
Will at the HoloLens demo

Right:
Group brainstorming session



Understanding the HoloLens

To understand the HoloLens better, our team went to the Microsoft Store on Fifth Avenue in New York City to take part in demos that showed off the capabilities of the HoloLens. These sessions were one hour in length and demonstrated to us three use cases for the HoloLens - as a mixed reality showroom, pinning holograms into a room for playful and fun interactions, and a mixed reality game.

The one hour demo session that we went to was key to helping our team understand the vision for Microsoft has for the HoloLens. It also introduced us to concepts that are important when developing a mixed reality experience. 3D sound, gestures, voice commands, and the limited field of view all had to be accounted for when we started to think about just how this experience would take shape.

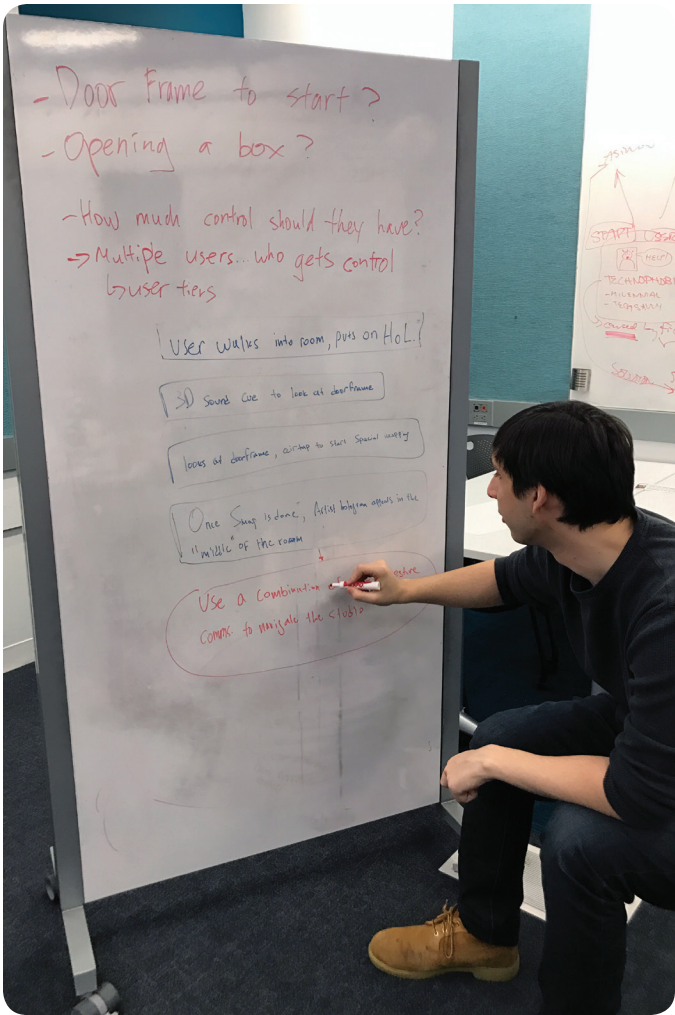
Thinking About Interactions

After understanding what the HoloLens could do, our team opted to dive right into thinking about what this could mean in terms of this design challenge. We sat down and brainstormed potential interactions that our team could integrate into the app that would meet the goals we set at the beginning of the project.

We wanted the experience to have as few obtrusive interface elements as possible as the user would be processing information about the holograms in relation to the room or space that they would be in. Therefore, this brainstorming session was heavily focused on using air tap gestures as well as voice commands to interact with the artwork while having only a few buttons to tap on and interact with. We had to take a lot of things into account when we were brainstorming

including. One of the hardest things our team had to do in this session was to stop thinking of design in a two dimensional space and instead try to think of interactions that would make sense in a 3D space where the user can walk around their space.

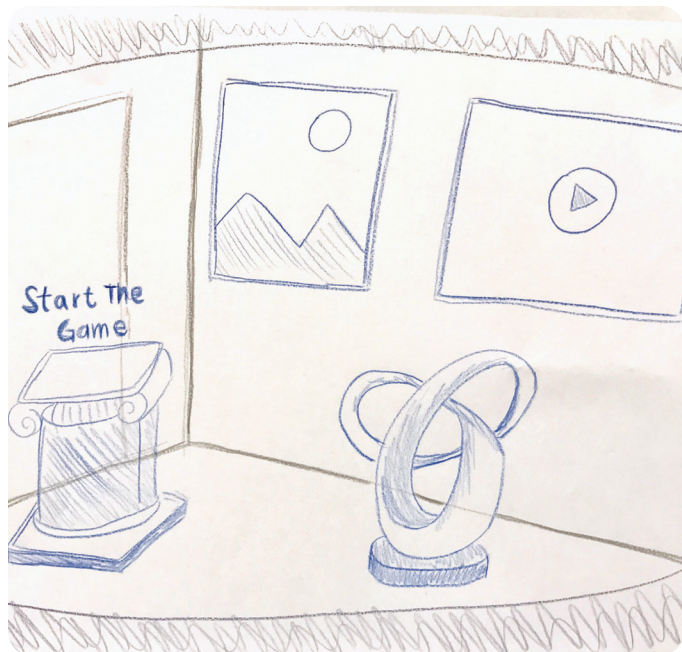
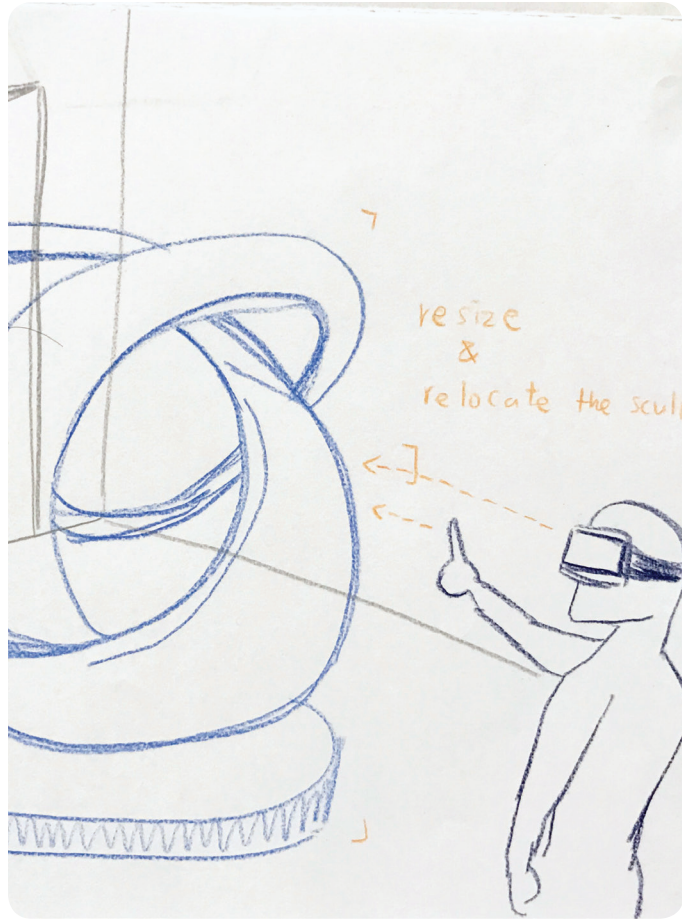
The interactions map on the next page is a visualization of this brainstorming session. Our team agreed that traditional 2D elements such as a paintings, photographs, videos, or films would have limited interaction given their 2D nature. Users would be able to resize and reposition these elements while the videos would have the added interactions of play and pause. For 3D elements such as sculptures or interactive installations, we agreed that these pieces should start at scale unless they were too big to be displayed in the room. We also thought that there should be additional interactions to these art pieces such as rotate, resize.



Additionally, we also tried to think of how to display the artist's contact information, information about future, current, and past exhibitions, as well as an artist statement in a way that wasn't too text heavy. Here, our team thought of multiple ideas that would allow the information to be displayed without the interface becoming too crowded with text. Ideas we had included a simple plaque to display all the information. We weren't too keen on this idea but it was a simple, albeit text heavy, solution. We also thought about a avatar of the artist appearing in the room as well. This was an idea we all agreed would be best as it would display a minimal amount of text. The avatar of the artist would appear and utilize the environment to walk around. There are many potential interactions that we thought that we should include. These features include walking around the studio with the user as well as providing information about themselves and their work.

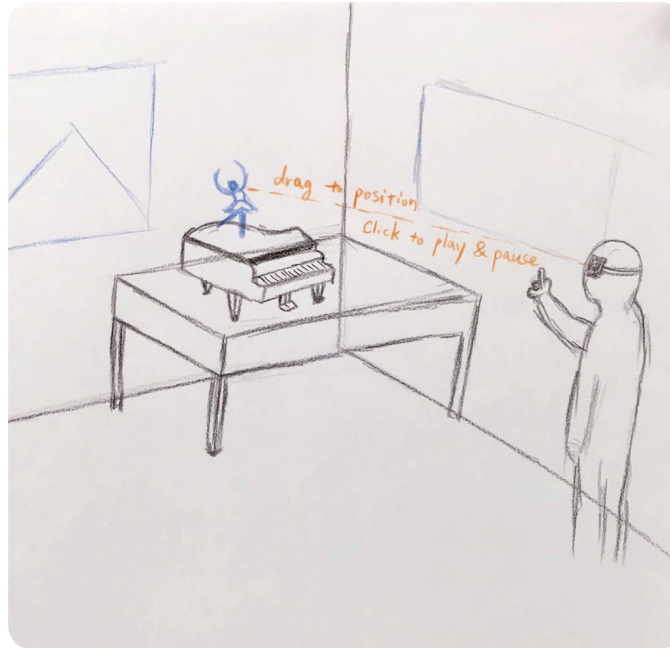
Top Left:
Sculpture resizing and reposition visualization

Bottom Left:
Visualization of artwork auto-populating room



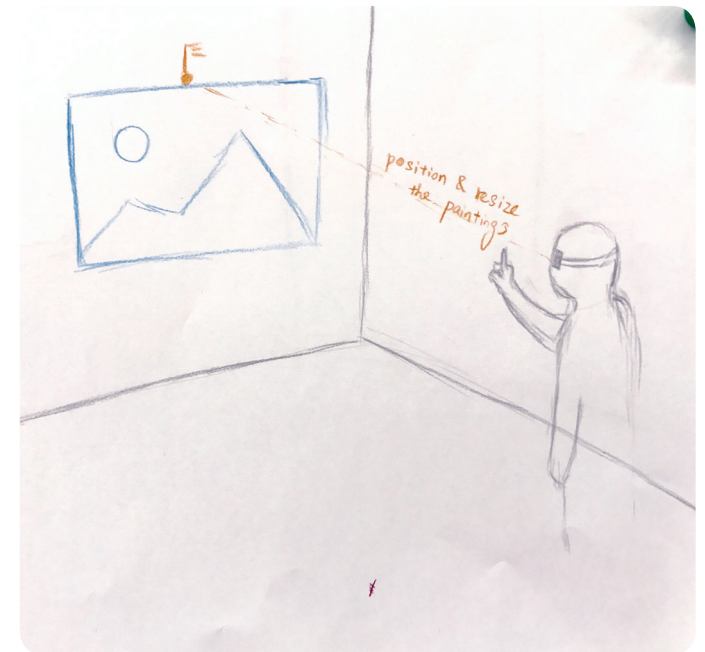
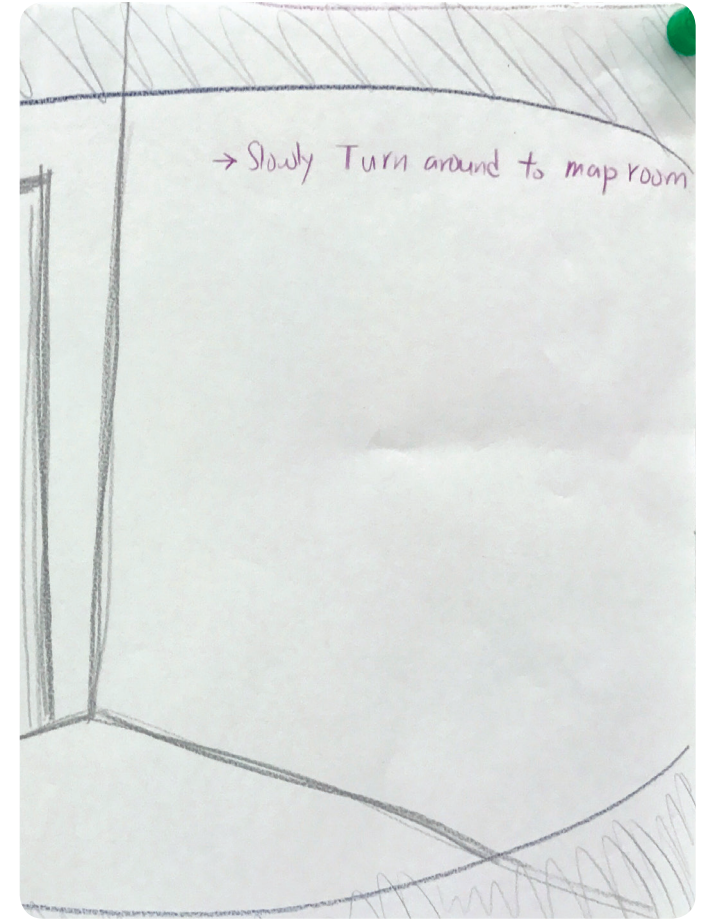
Top Middle:
Performance display and interaction visualization

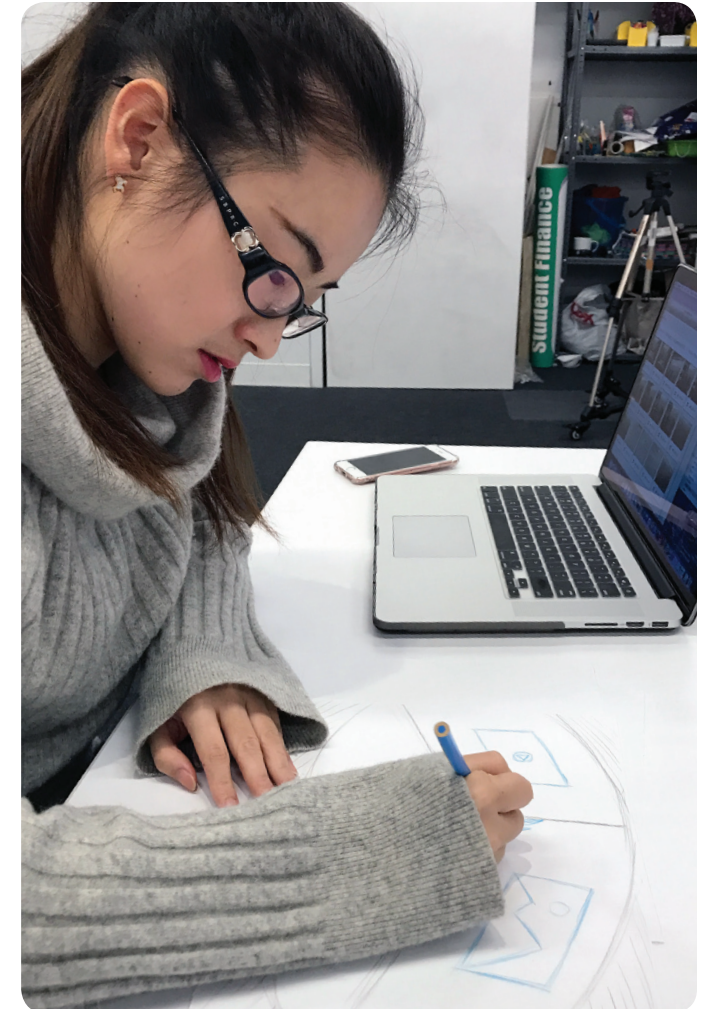
Bottom Middle:
Game display and interaction visualization



Top Right:
Audio cue visualization to map the room

Bottom Right:
Painting resizing and reposition visualization





Visualizing Our Concepts

To help us gather feedback on our initial concepts, our team decided it would be better to sketch out some of our ideas. We sketched out a few of our ideas onto paper. We used different colors to represent different elements of the mixed reality experience. Physical room elements would be in black or grey, mixed reality holograms would be in blue, interactions and gestures would be in orange, and audio cues and dialogue would be represented in purple. This color coding scheme was borrowed from the article “The UX Workflow for HoloLens & Mixed Reality” by Juan³. Color coding

³ Juan. “The UX Workflow for HoloLens & Mixed Reality – Hacker Noon.” Hacker Noon. December 02, 2016. Accessed March 10, 2017. <https://hackernoon.com/the-ux-workflow-for-hololens-mixed-reality-3bf59192e577>.

these elements allowed us to quickly identify and differentiate the elements and allowed us to convey our ideas in a quick and efficient manner.

We chose to sketch only a few of our ideas so our team could collectively decide on what direction we wanted to take with this project. Some of the sketches we created can be found on the previous page.

Brainstorming User Flows

To help us further narrow our broad range of ideas that we generated at the first brainstorming session, we also wanted to brainstorm user flows. These user flows would later be substantially changed as we switched concepts. However, our team felt these user flows helped us focus our thinking on elements that would be necessary for the user to complete the tasks.

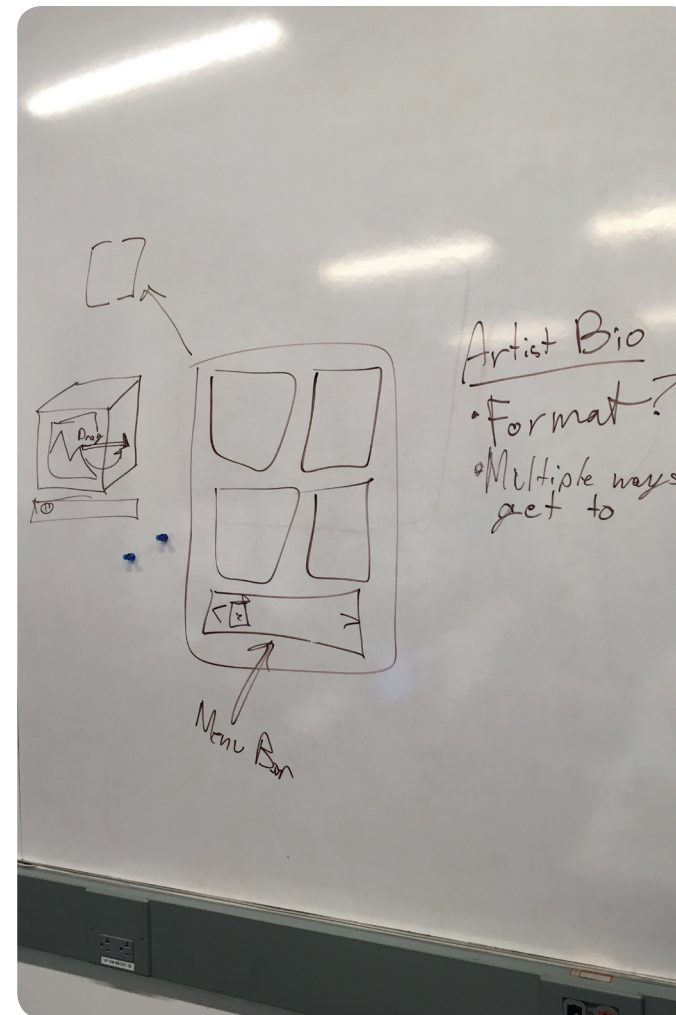
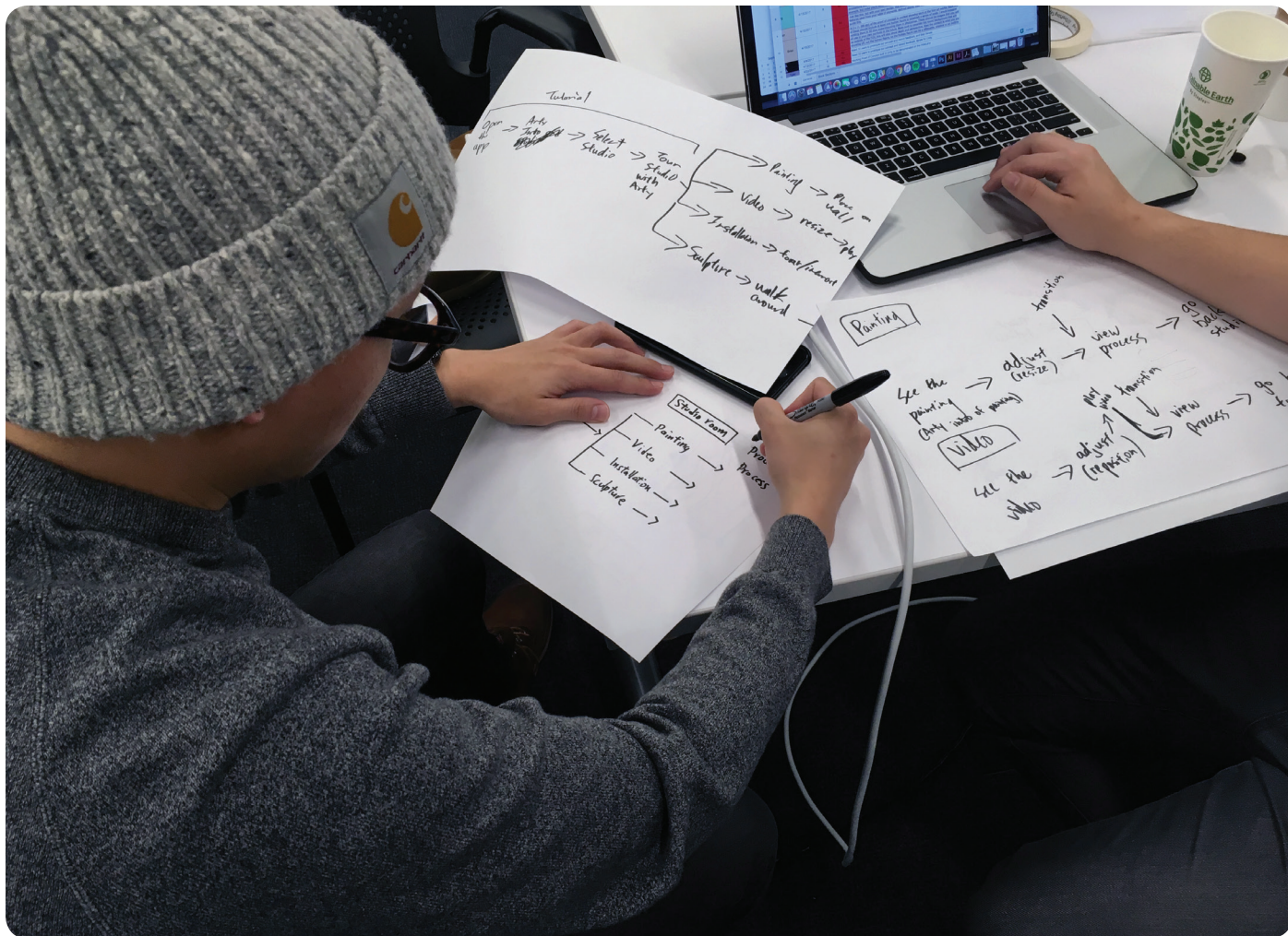
Mixed Reality Design Techniques

During the research and brainstorming phase, we also decided to focus on these mixed reality design techniques to help us realize our ideas from the concept map of potential interactions:

- **Transforming Surfaces.** Potentially using existing surfaces and altering them to display content.
- **Mixed Reality Immersion.** This would allow us to transform the room into another room, potentially to show individual art pieces in its own space.
- **Mixed Reality Play.** This would be used if we decided to include a game into our project.
- **Information Overlay.** This technique would allow us to display information on top of the real world.

Left:
Drawing potential user flows

Right:
Potential layout of information for Artist Bio



- **Shared Holographic Space.** This would allow two or more users to see the same content.
- **Avatar Interface.** This would allow an avatar to act as a guide or navigator throughout the experience.

Brainstorming Feedback

When we presented our ideas, we gathered some valuable feedback for the brainstorming and research we produced so far. Everyone had positive feedback to the design of the concept map we developed for the potential interactions. We also received feedback from our class and Dana to continue our research on artists and curators and their needs in mixed reality.

More Questions Than Answers

After this phase, there were still many questions we did not know and our ideas were based off of our group member's individual experience with art. We did not yet take into account artist and curator experiences with studio visits. Our team decided that we would be developing our ideas and prototyping at the same time we conducted more user research. Gaining their insights would be valuable to further the development of our ideas.

Key Insights

Here are some key takeaways and insights from the research and brainstorming phase:

- Building an Interactions Concept Map helped us think about how users could interact with holograms.
- Sketching helped us visualize how interactions would be possible.
- It's easy to think for design for 2D surfaces, we needed to constantly remind ourselves to consider the environment around us.

4

Comparative Analysis

In order to better understand the concept of exploring and seeing art pieces with virtual reality or augmented reality, we looked up some existing applications in the market to see how people design this kind of experience. We chose three gallery visit experience applications currently in the market for different platforms. We then compared those experiences to each other and our concept to see how they designed for a digital experience. The applications we chose are “VR Museum of Fine Art” on HTC VIVE, “Immersivly’s Digital De Re Gallery” on Oculus Rift, and “Renwick Gallery Wonder 360” on iOS and Android. After reviewing those applications, we figured out some common problems within these kind of gallery applications. Most of them are really basic and simple, the users barely have options for more information and little to no interaction with the art pieces. Furthermore, some of them are designed for specific galleries or showcases. This means that these applications are limited and users do not have the option to visit more than one artist or multiple showcases.

Besides evaluating and comparing the features of these existing applications, we also looked to Jakob Nielsen’s 10 Usability Heuristics for User Interface Design⁴ as the reference for our design and made sure our application has met the requirements of these principles.

1. Visibility of System Status

Most of the applications give users the freedom to walk around by themselves, but might be lacking when it comes to informing users about what is going on and where exactly they should move on during the experience. In a virtual environment, people might get lost easily and be confused about what they can do in the virtual space. In order to make sure the system status is visible, we’re planning to let our digital assistant walk users through the whole gallery, so they will be able to clearly distinguish where the art pieces are. Additionally, users can call out for Arty, our in-app digital assistant, whenever they have questions during the experience.

⁴ Nielsen, Jakob. “10 Usability Heuristics for User Interface Design.” 10 Heuristics for User Interface Design: Article by Jakob Nielsen. 2005. Accessed March 10, 2017. <https://www.nngroup.com/articles/ten-usability-heuristics/>.

2. Match Between System and the Real World

In order to make information appear in a natural and logical order, we make any user-triggered pop-up information stick to the closest wall to the users. Otherwise, the floating information may be uncomfortable for people to look at.

3. User Control and Freedom

We want the users to feel comfortable in this mixed reality gallery experience as well as have full freedom of control. We will let our users have two ways of input, voice control and gesture control, to complete tasks. Users would be free to use whichever method they felt more comfortable with.

4. Consistency and Standards

We will be attempting to use less text and less user interface elements in the application to simplify the interface when designing it. The consistency and standard of the application will hopefully be both intuitive and easy to use.

5. Error Prevention



It is hard to prevent users from making mistakes, especially in a mixed reality environment since it will be more unfamiliar for most people. Besides considering every condition and scenario users would encounter, we believe that the design of a digital assistant will help greatly in the area of error prevention.

6. Recognition Rather than Recall

In order to minimize what the user needs to remember, we will make sure the instructions for interactions in the experience will be clear and well explained. This is the purpose for touring the whole experience in the beginning. Furthermore, we conducted several user tests to make sure the objects, signs, and buttons appearing in the application are not confusing or unintuitive.

7. Flexibility and Efficiency of Use

For novice users, they will need to learn how to interact with the HoloLens headset before using the application. They will theoretically learn the command gestures, air tap and voice control, at the beginning

Product	Platform	Art Piece Interactions	Detailed Information	More than One Studio	Digital Assistant	View Artist Process
						
VR Museum of Fine Art	VIVE	✗	✓	✗	✗	✗
Immersivly Ltd. Digital De Re Gallery	oculus	✓	✗	✗	✗	✗
Renwick Gallery WONDER 360	 	✗	✗	✗	✗	✗
HelloLens HoloStudio	Microsoft HoloLens	✓	✓	✓	✓	✓

of the experience or through explanation or through the provided Tutorials that come with the HoloLens. After learning about these basic controls, the user will be able to interact with the application with better proficiency. The time it takes to learn these controls should not be long or complicated.

8. Aesthetic and Minimalist Design

As we mentioned earlier, we wanted to keep our design simple and with the least amount of text possible. With this in mind, our team sought to minimize the user interface elements and rely on voice control. Upon initialization of the experience we will provide a voice tutorial with the digital assistant Arty.

We also strove to keep irrelevant information out of the interface. One reason was that the HoloLens provides a very limited field of view to display holograms. Another reason was, in mixed reality, too much information provided at a same time can be overwhelming to users.

9. Help Users Recognize, Diagnose, and Recover from Errors

Users may be easily lost when in mixed reality and virtual reality environments. They can be confused in terms of what they should do next, or what direction should they look at. These issues are currently

happening more often in virtual reality environments. When designing these experiences, we need to be aware we are designing for a 3D environment and not a 2D surface. This means it will be important for us, the designers, to know and think about how to help users understand and make them feel comfortable in these environments.

In order to help users recognize, diagnose, and recover from errors, we try to make every sign and buttons clear and simple. Furthermore, as we mentioned in error prevention, showing users what they can do from the beginning will be incredibly helpful.

10. Help and Documentation

The help section in the application would be our digital assistant as it will cover almost every problem users could encounter. We might design a help section or tutorial section in the beginning, but overall it will rely on the digital assistant.

For documentation, the HoloLens has its own screenshot and video recording features. Users can also share the screenshots and recorded videos to their social media profiles. The problem might be that this feature is not very intuitive, and it is a little difficult for people to figure it out. Therefore, we might need to design a better way for users to utilize this feature.



5

User Research

To better understand how we should develop this app, our team needed to get a new perspective. Since no one on our team were artists or curators, we needed insight on how artists interact with curators and vice versa. The opinions and experience of artists and curators would be important to inform, change, and validate our design decisions. However, our team faced the challenge of how to contact artists. We would ultimately rely a lot on our peers and professors to get in contact with artists and curators.

Since curators were supposed to be the main users of the product that would result from this design challenge, we sought to put an emphasis on interviewing curators. For curators, our team talked to Mark Scala, Chief Curator at the Frist Center for the Visual Arts in Nashville, Tennessee, as well as Lee Glazer, Associate Curator of American Art at the Freer and Sackler Galleries in Washington, DC. For artists, we turned to one of our professors, Katherine Bennett, at the Integrated Digital Media program as a starting point. We also visited Toni Dove's studio and talked to her about her experiences with curator, creating her installations, and her opinions on mixed reality. Lastly, we also talked with Allison Berkoy about her art projects as well as mixed reality design.

Every artist and curator that we interviewed had insights into how mixed reality could be implemented and how it could enhance their work, personal, or professional lives. Some of these insights are recorded into the table on the next page, detailing their opinions on the HoloLens, concerns, and insights.

Below:
Table of insights from interviews with artists and curators

Artist	Type of Art	Setup	Opinions on HoloLens	Concerns	Insights	Documentation
Katherine Bennett	Digital Installations	<ul style="list-style-type: none"> Tech impacting social interactions Post-human 	<ul style="list-style-type: none"> Sees potential in using it to create art In terms of viewing, finds it limited 	<ul style="list-style-type: none"> Limits of mixed reality in its current state How curators view work through Mixed Reality 	<ul style="list-style-type: none"> Pinpoint what the app will do 	<ul style="list-style-type: none"> Video Format What viewer would see Light & Sound
Toni Dove	Interactive Installations	<ul style="list-style-type: none"> Full room setup One Wall 	<ul style="list-style-type: none"> Mixed Reality is what she attempts to design for already Wants to implement her piece to Mixed Reality 	<ul style="list-style-type: none"> Would her piece be able to be fully realized in Mixed Reality's current state? 	<ul style="list-style-type: none"> Studio is for experiencing art, not viewing it 	<ul style="list-style-type: none"> Video Format What viewer would see Light & Sound
Allison Berkoy	Interactive Installations	<ul style="list-style-type: none"> Screen user movement 	<ul style="list-style-type: none"> Using HoloLens for previewing work Use for different curators, or a single curator? 	<ul style="list-style-type: none"> Audience for the App Virtual Assistant type 	<ul style="list-style-type: none"> App will be for Viewing Art Will not replace Studio Visit 	<ul style="list-style-type: none"> Video Format What viewer would see Light & Sound
Curator	Type of Art	Setup	Opinions on HoloLens	Concerns	Insights	Documentation
Mark Scala	Contemporary Installations for the Frist Museum	<ul style="list-style-type: none"> Designed around theme, artist, and piece. Limitations make the setup 	<ul style="list-style-type: none"> Unless the art is using mixed reality than you are still 'separate' from the piece It will still require a studio visit 	<ul style="list-style-type: none"> Studio Visit is important due to discussion with the artist and experience with the piece 	<ul style="list-style-type: none"> Artists who use more than one medium of delivery Interactive Installations 	<ul style="list-style-type: none"> Exhibition needs info Who is the owner? Time? Time Available? Conservation?
Lee Glazer	Historical and Contemporary art	<ul style="list-style-type: none"> Theme Find art piece Find out how piece fits in space 	<ul style="list-style-type: none"> Did not know about HoloLens Experience boils down to using VR to view a 3D panorama 	<ul style="list-style-type: none"> Scale, texture, interaction with light, spacial volume Space of Installation 	--	--

Katherine Bennett

Katherine is a professor at NYU and a programmer for large scale installations using physical computing. She was contacted for an interview regarding the HelloLens project and was happy to oblige.

When discussing the HoloLens, she was somewhat familiar with the term Mixed Reality, and was interested in what it could provide to the medium she works in. Generally, her art involves discussing how technology impacts social interactions and post-human art pieces. Her opinion of the HoloLens from the presented material and explanation provided to her is that she sees potential in using it to create art in a space, but in terms of actually viewing art that is from a different

medium she thinks that it will be rather limited in terms of audience and functionality compared to traditional methods.

Her concerns about the HoloLens and mixed reality in general match up with her opinion; she is concerned about the limits of mixed reality in its current state. She is also concerned with how curators would work with Mixed Reality.

At the time of her interview, which was conducted early in the research phase, she suggested that we pinpoint exactly what the app will do before discussing how it would do it. Documentation that she generally presented to curators for review would be in video format of what the viewer would see.

Toni Dove

Toni is an interactive installations artist based in New York City. Her current installation is called “The Dress that Eats Souls” that makes use of Microsoft’s Kinect Sensor to read body motion. Toni expressed interest in figuring out a way for the HoloLens to work with her current or future installations. Technically speaking, Toni has been designing this piece with Mixed Reality as it’s base, but without the HoloLens to support it.

After a studio visit and viewing the current iteration of The Dress that Eats Souls we combined it with our knowledge of the HoloLens and it’s capabilities and realized that this piece can use components of the HoloLens to enhance the installation, but would not be fully realized inside the HoloLens. When we talked to her about getting involved in a curated exhibition, Toni



told us that the Studio Visit is meant for experiencing art, not viewing it. The documentation she provides curators before they visit her studio is, like Katherine, in video format.

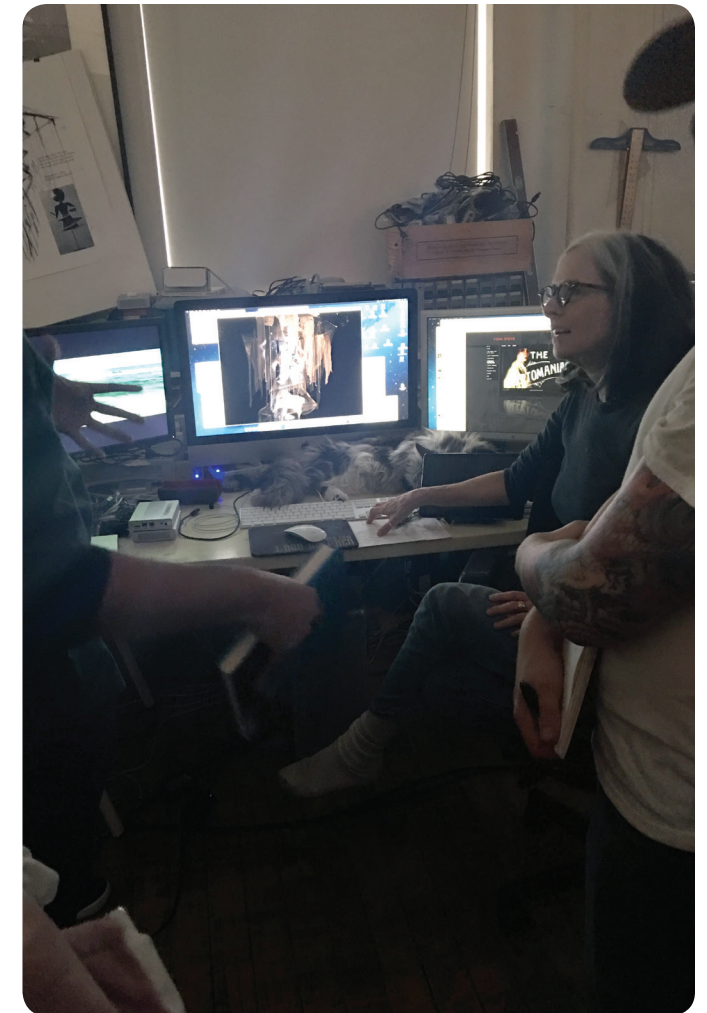
Allison Berkoy

Allison Berkoy was the final artist that we interviewed. At this point, we were in the process of designing our second prototype and were looking for some final bits of feedback, and discuss some aspects of art viewing that we might have missed. Her information was valuable in a sense that it gave us ideas for other ways this app could be used. One of the ways that this app could be used would be to just preview artworks. This could be used for viewing an artist's warehouse, auctioning artwork, and working with the Artist Pension Trust.

In terms of our prototype, Allison warned us to be careful with how Arty is represented, and that it should be ambiguous. Her insights were that the app could never replace a studio visit, but that it could see a lot of use for Viewing Art.

Mark Scala

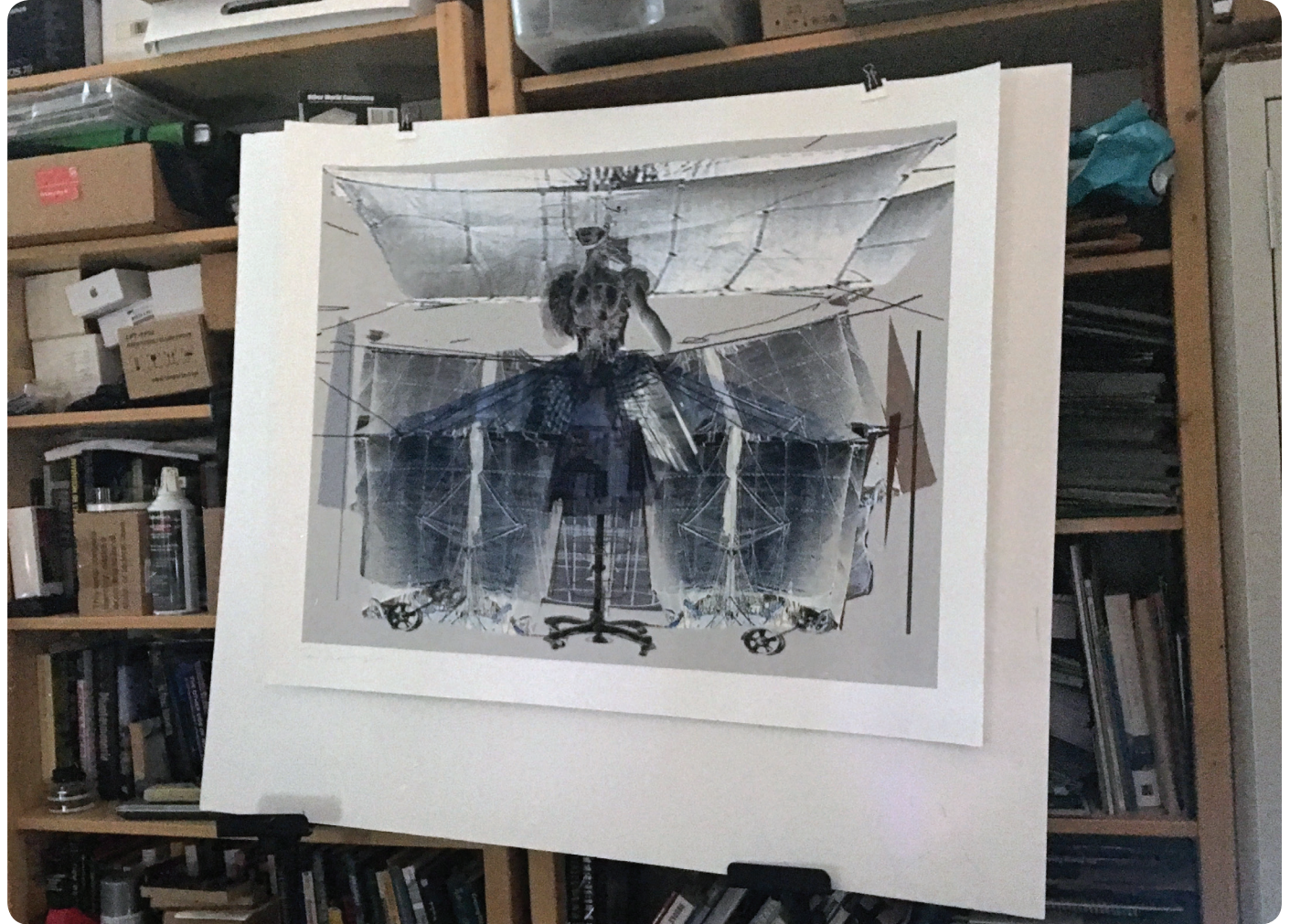
Mark Scala was the first curator that we interviewed. Mr. Scala is the lead curator for the Frist Center for the Visual Arts in Nashville, Tennessee. He is a curator of contemporary art who designs exhibitions for the Frist Museum and commonly works with paintings. Mr. Scala has a great interest in interactive installations or art that give an out of body experience. He has been working as a curator for 27 years.



To him, Mixed Reality is a brand new term and opens up some opportunities view art. A critical question that he asked was, "How is this [using the HoloLens] different from viewing the art in a picture or video?" At the time, we could not provide a solid answer. Since curators are the main user demographic for the app, Mr. Scala provided us with major specifications of his work, including his installation setup and critical process steps. From these, we were able to conclude that the HoloLens could not replace a studio visit and that unless the art piece was using mixed reality as part of its presentation, the user would still be viewing the art as a form of documentation.

Left:
Toni Dove's assistant providing a demo of her latest work

Right:
Toni Dove's drawing of her latest work-in-progress



Lee Glazer

Lee Glazer is a historical and contemporary art curator for Freer | Sackler Galleries at the Smithsonian Institution in Washington, D.C., and has been working there since 2007. This interview was brief, and rather technical. Ms. Glazer provided us with her process of finding an art piece for an exhibition; find the theme first, then find the art piece, and finally find out how the art fits in the space for the installation.

In regards to the HoloLens, she had never heard of Mixed Reality before. Her main experience boils

down to using Virtual Reality to view a 3D panorama. When the HoloLens was introduced to her, Ms. Glazer expressed concerns with how an art piece would fit within the application, including scale (is it too big?), Texture (would limitations in graphics effect viewing the piece?), Interaction with Light, Spatial Volume, and the space of the installation itself.

Unfortunately, Ms. Glazer was unable to provide us with insights for our ideas, but the information she provided was especially useful for understanding our user demographic.

Key Insights

These interviews played a critical role in some of the decisions we made. It was noted that our digital assistant would need to be ambiguous and non-distracting. After reviewing all of the insights and concerns from our user research, we concluded that both artists and curators would only benefit from this app for viewing art before visiting a studio, and that not all art could be viewed through this app due to technical limitations. A potential main use of this app would be to view interactive installations in a 3D space, but in regards to sculptures, paintings, and viewing video documentation, provides no benefit over other conventional means of viewing.

A person with long dark hair is working on a prototype structure made of white PVC pipes and brown paper. The structure is a cylindrical frame with a top ring. The person is using a marker to draw on a piece of brown paper that is part of the structure. In the background, there is a whiteboard with a drawing of a person's head and some other sketches. The overall scene is a workshop or lab setting.

6

Prototyping & Iterative Process

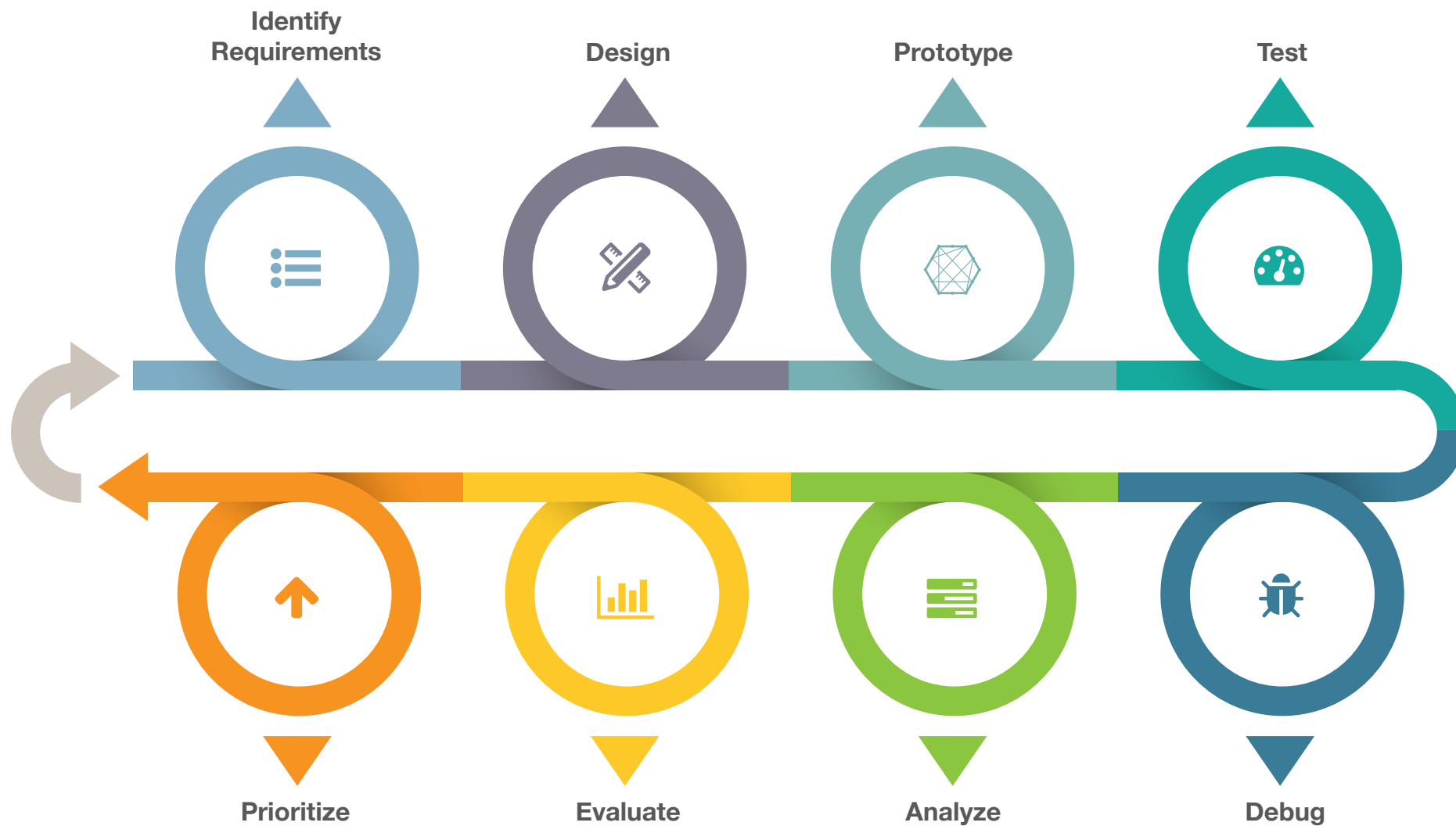
After extensive brainstorming and research, our team had to begin to prototype our ideas. The iterative process for prototyping was divided into eight phases. Prioritize, enlist requirements, design, prototype, test, debug, analyze, evaluate. If we were satisfied with the prototype, we would deploy it for user testing.

Before we actually created a paper prototype, we had to decide how we would be prototyping holographic elements in the real world. We had to rethink how to prototype as we were no longer prototyping for a screen, and thus, we didn't think it would be useful for us or the users to test on InVision or Marvel's POP. We had to think outside of these 2D prototyping software to better convey our ideas.

Prototyping Tools

Since prototyping in a 3D environment was new to us, our team brainstormed ideas on how to prototype. Ideas were brought up including drawing on paper and having people hold it up or just build it out with purchased materials. However, as we were students, we wanted to spend the least amount of money possible while also creating a prototype that users could potentially interact with.

Our team collectively decided that we should build elements to represent the holograms. This would allow users to see the "holograms" as they appear in real life and interact with them. At the IDM Graduate Research Lab, we had an abundance of materials that we picked through to create prototypes. We wrapped brown paper over



polyvinyl chloride (PVC) pipes to create our holograms. Incidentally, this created a lot more work for us when we had to do user testing since we had to carry around our existing holograms and physically create new ones whenever we needed to.

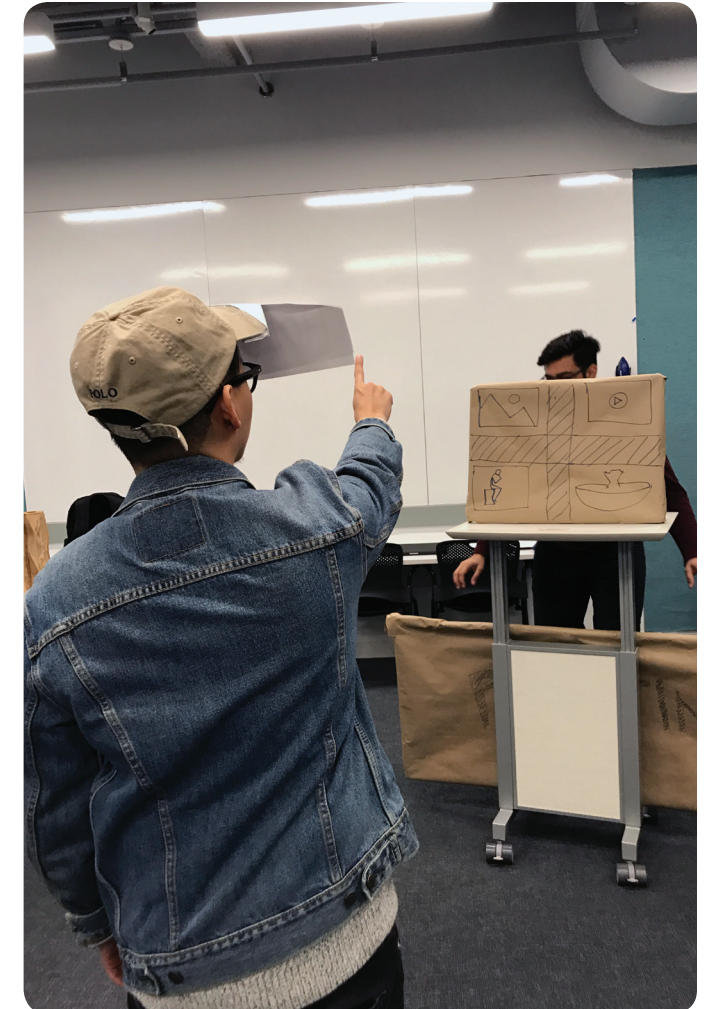
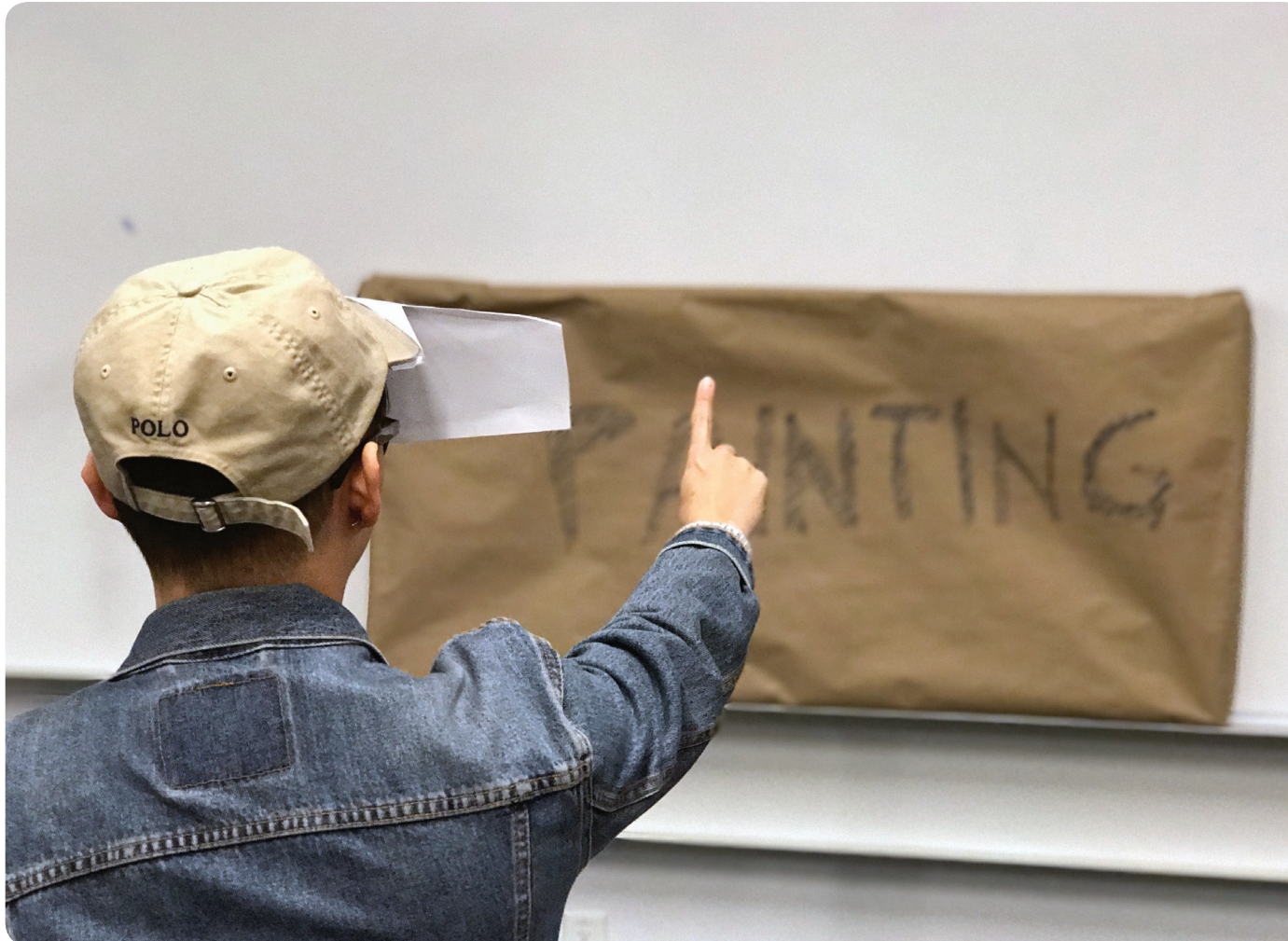
Ultimately, our prototyping method excelled at preserving the scale of the holograms in relation to the user and let us better visualize the composition of the mixed reality space we were creating. However, it should be noted that our prototyping method did not do a good job of accounting for the limited field of view that the user experiences when wearing the HoloLens. It wasn't until later user testing sessions that we built a small frame to hold over the user's eyes in order to simulate the "window" that the user sees through the HoloLens.

The Prototyping & Iteration Process

Dividing the process of prototyping and iterating upon the existing ones using the above laid out steps, our entire process became a lot more systematic and optimized. On a large scale project such as this, losing sight of the right deliverables could prove to be costly. We used these steps in accordance to every prototype we created. When taking the agile approach, using elicitation techniques put forward by object-oriented programming concepts can help create a robust framework from the most basic brainstorming and ideation to creating a stable end product.

1. **Identify Requirements.** For every prototype, we referred to the project brief provided. Taking each point that described the project and creating a postulated list of items that need highest attention to the the lower ones.

2. **Design.** On the basis of all the requirements that are established, we can start working on creating preliminary designs that reflect those postulates into a visual language making it easier for our imagination to grasp the concept, and when dealing with a 3D space, the best tools to create a cost-effective and quick design workflow are paper, pen/markers, cardboard boxes, PVC pipes and wooden structures.
3. **Prototype.** Using all the above elements, we created, functional yet raw, objects that could exist as holograms in the 3D space. Giving us much needed insight about how things will appear and should appear in the world around us. If this step, were to be done on traditional 2D softwares, it wouldn't be able to provide us with crucial information such as space and time



measurements, how close can an object be placed in front of us without it feeling unnatural.

4. **Test.** Creating all the elements for a 3D space and then noting down all key information points, is only as useful as the insight it can give, and insights can change according to perspectives. Allowing the stage set up using the prototyped elements to be open to prospective end-users for basic user testing opens up an entirely new dimension that provides us with great deal of information that can be further used to refine the end product. The feedback coming from external users helped us understand things that, we as a team, oversaw, assumed or just simply didn't think about. Multiple user-testing sessions with each prototype we created, helped us out a lot.

5. **Debug.** The problems and shortcoming that are brought out by the extensive user-testing sessions inform us great deal about how we can fix things, and improve upon them. The debug phase, allows us, in lo-fi paper prototyping stages as well as hi-fi unity development stages, to fix things that aren't either running properly or poses a problem for the end-user to effectively get a task done. We point out these problems, prioritize them, fix them, and put it out into the prototype again.
6. **Analyze.** By this time, there is a great amount of information and data collected. As a team, our responsibility is to parse that information into actionable points which can be further evaluated. Analyzing every situation and scenario an end-user runs into, it is here we decide what feature

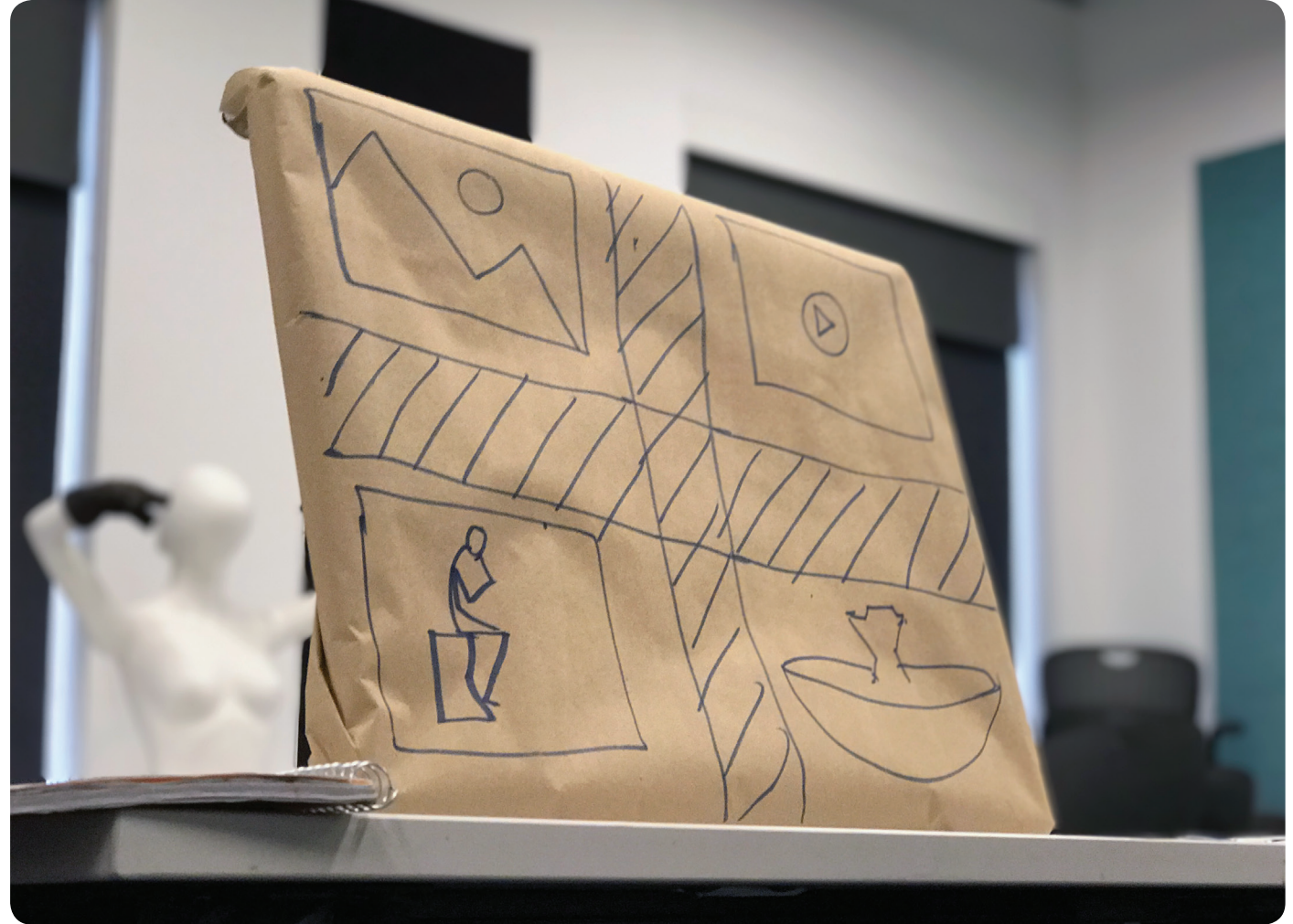
will be incorporated into the end product, or which feature will not see the light of the day.

7. **Evaluate.** The analyzed data is put through evaluation and decided upon it's viability and feasibility.
8. **Prioritize.** In this step, we prioritize all the requirements for the end product that needs to worked on by the developer team that needs to be incorporated into the end product.

Deploy. After analyzing and evaluating every prototyping phase, with all the debug sessions successful. We can deploy each phase of the prototype for further user testing sessions and gain feedback from them. This step, is also the final step while going through the iteration process for the final time, which gives us the final end product that is ready for shipping.

Left:
Second prototype construction

Right:
First prototype: Art menu



First Prototype

Our team's first prototype took on a more traditional approach. Upon starting the app, the user would be tasked with placing a menu into the world and using it to drag and drop art pieces into the space around them. The menu was displayed as a metaphorical drawer that art pieces could be pulled out of. We thought this would be a good idea as it allowed the user to place a menu that acted as a waypoint and allow the user to conveniently return to a common point for future interactions.

This idea also allowed us to incorporate the physical space around the user to add a creative spin to our prototype. By having our users place holographic art pieces into the world, we were aiming to have them feel like they are designing their own studio

experience. Once they had populated the room with holograms, users would have access to some simple interactions like resizing and rotating art pieces, as well as tangentially having access to artist and process information. In this concept, information about the art pieces would be arranged in layers, just a glance away from the art piece itself.

We decided to film a short video in order to showcase this first rough idea. Consistent with our "Prototyping tools" section, we used a variety of low tech, simple materials to create the physical holograms and the entirety of the video was a clear walkthrough of a typical user flow in this concept. We spent less than three hours prototyping and shooting in this phase and we tried to keep it simple so our user testers would be able to ease into the concept of mixed reality.

To read more about our user testing outcomes for our first prototype, please go to section 8 - User Testing Outcomes.

Second Prototype

Our second prototype focused more on recreating the experience of a studio visit and is very much intertwined with the inclusion of a digital assistant that we named ArtDroid-82, or Arty for short. In this version of the prototype, the user would be able to "visit" an artist studio that is pre-designed, presumably by the artist himself, rather than placing holograms into space.

The user is transported into the studio which is already populated by holograms of the artists work and is also introduced to Arty and his abilities over mixed reality space. Arty conducts an optional tour of the studio



where the user is taken from art piece to art piece and given basic information about the work as well as information on how to control and adjust the holograms in the studio.

Once the tour is concluded or if the tour had been skipped, the user is left free to roam the studio, and now has the ability to enter any of the specialized exhibits through the “view process” button. When the user hits one of these buttons, existing holograms in the room will be unloaded and replaced with holograms regarding the creative process and background information of the specific piece.

It’s easy to visualize the layout of our second prototype in terms of spatial information architecture where the user first has access to a hub room that contains observation models of all the part pieces, just like a home page on a website. Through this hub, the user then has the option to move back and forth within specialized exhibits for each work.

To read more about our user testing outcomes for our second prototype, please go to section 8 - User Testing Outcomes.
















User Flows

When we were constructing and finalizing the concept for our digital assistant prototype, we thought more about how the users would interact with Arty and what the limitations could be. We had to develop a simple user flow to illustrate how Arty would affect the studio experience and when it would make sense for him to be on-screen rather than on standby and out of the frame. Through user testing, we were able to further refine interactions with the art pieces and when it would make sense for Arty to appear and guide the user.

The user flows on the next pages represent how the typical user would go through the holographic studio experience.

User Flow of HoloStudio

Icon Definition Chart		
Experience	User Input	Display & Feedback
 Sculpture	 Voice Command	 3D Objects
 Interactive Installation	 Gaze	 Holographic UI Elements
 Video	 Air Tap	 Audio Feedback
 Painting	 Other Gesture	 Interaction Feedback
 Artist Information		

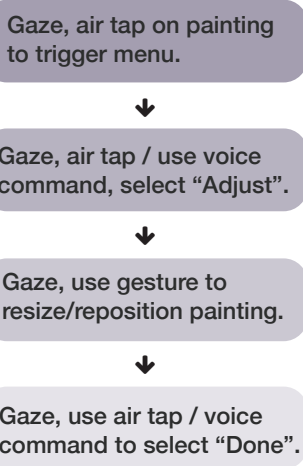


Painting Interaction

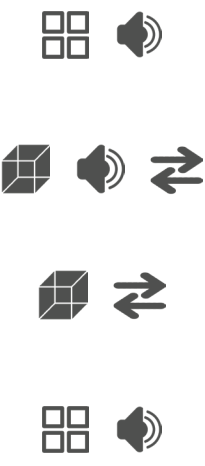
Input



User Flow



Display & Output

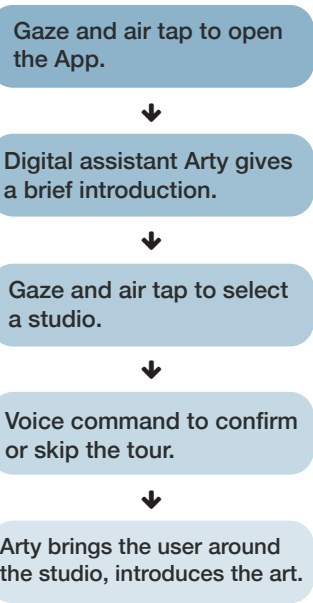


Before the Studio

Input



User Flow

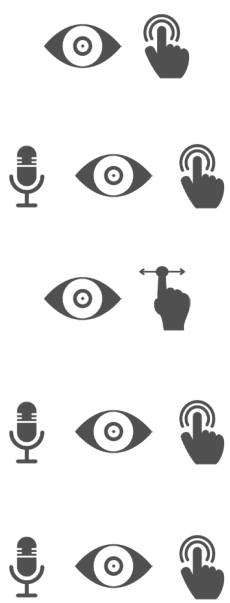


Display & Output

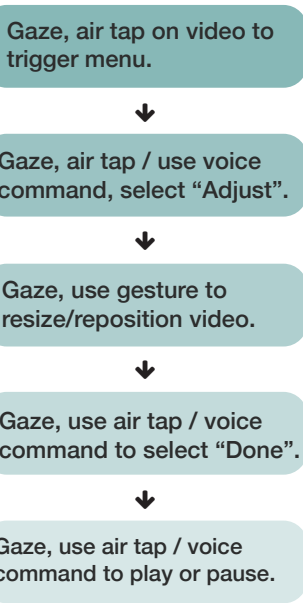


Video Interaction

Input



User Flow

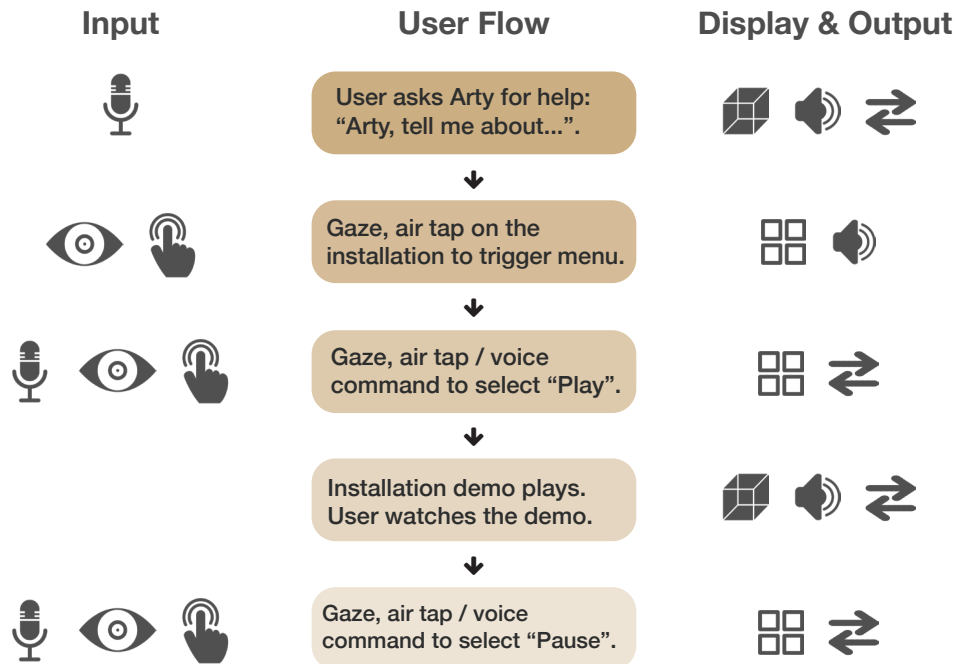


Display & Output

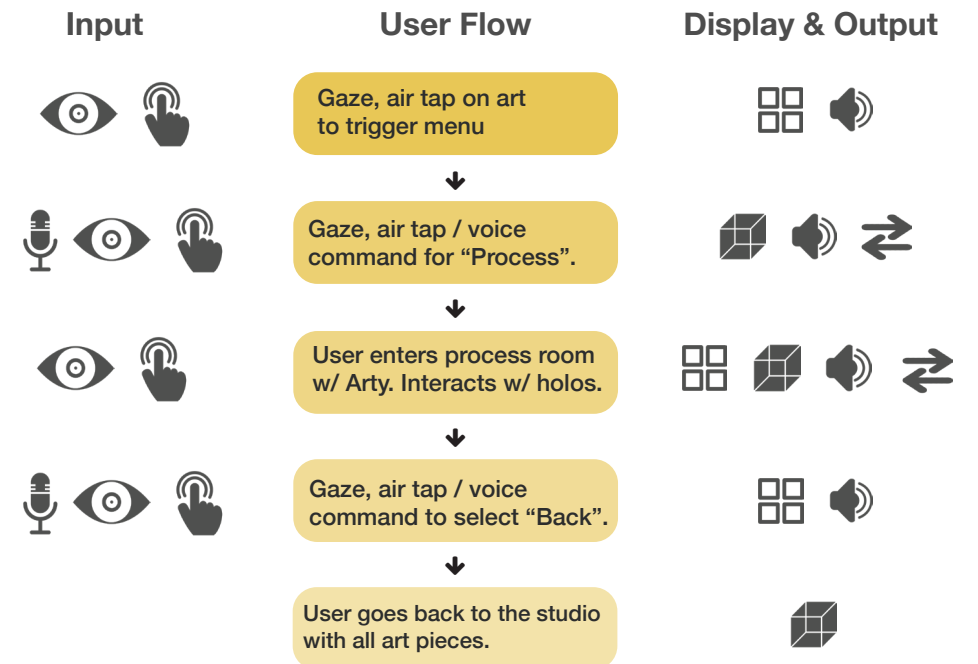




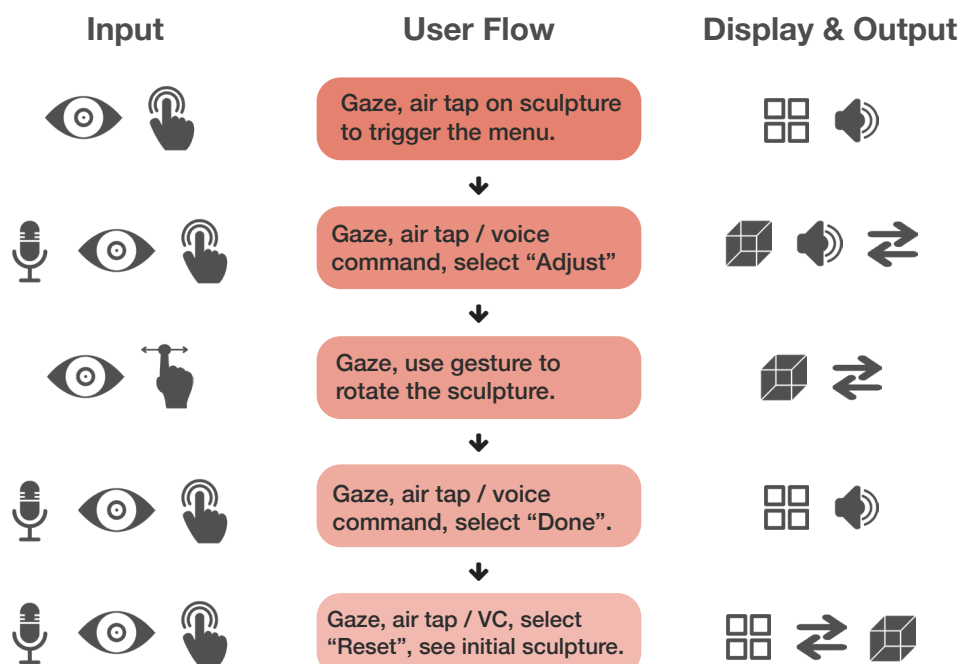
Installation Interaction



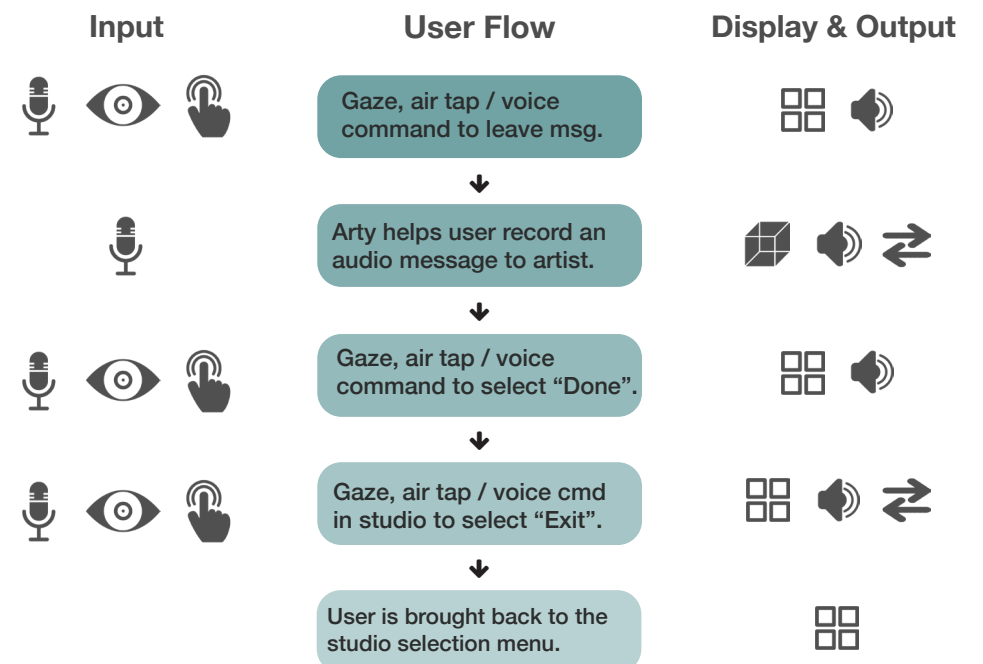
View Process



Sculpture Interaction

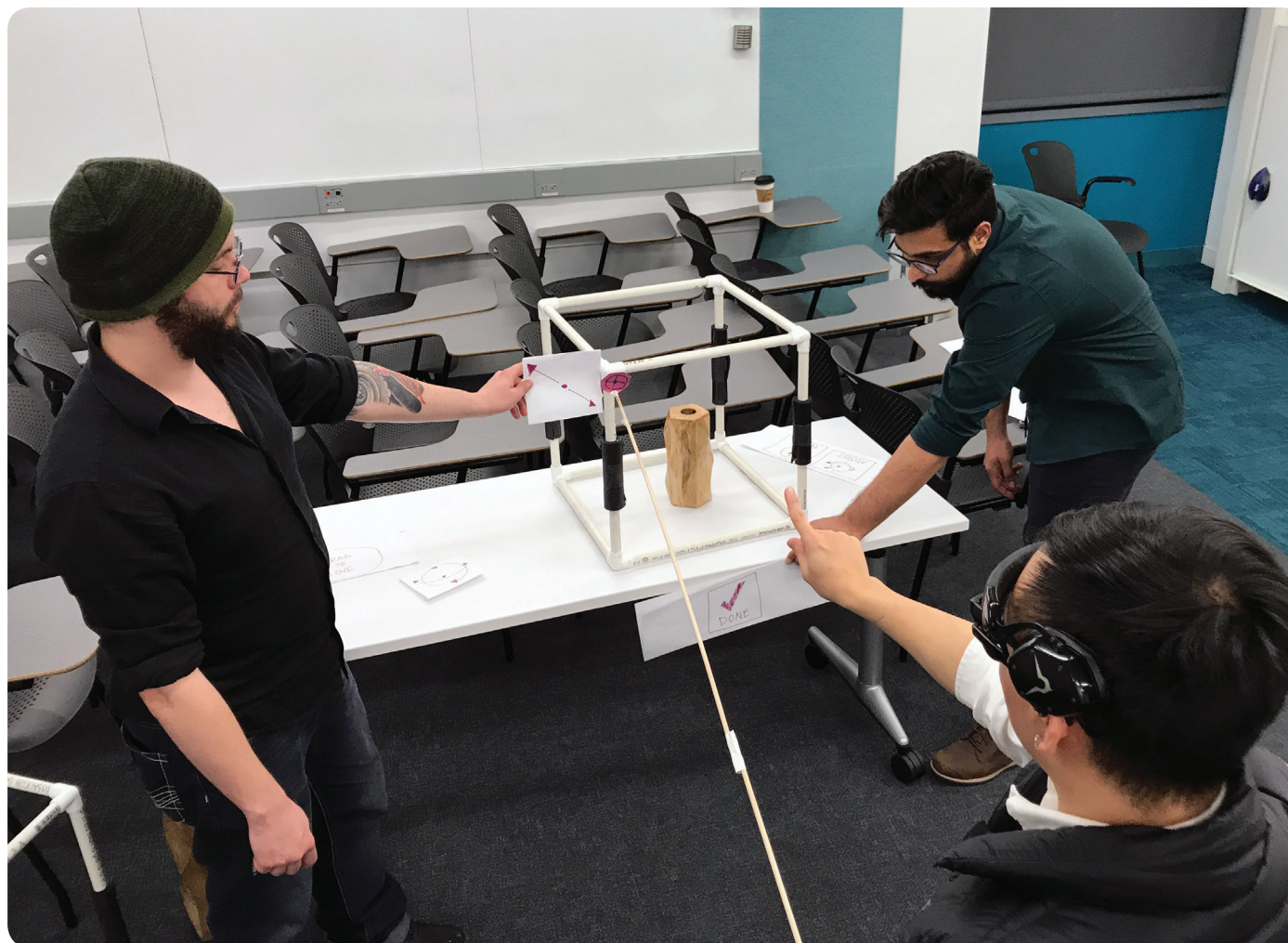
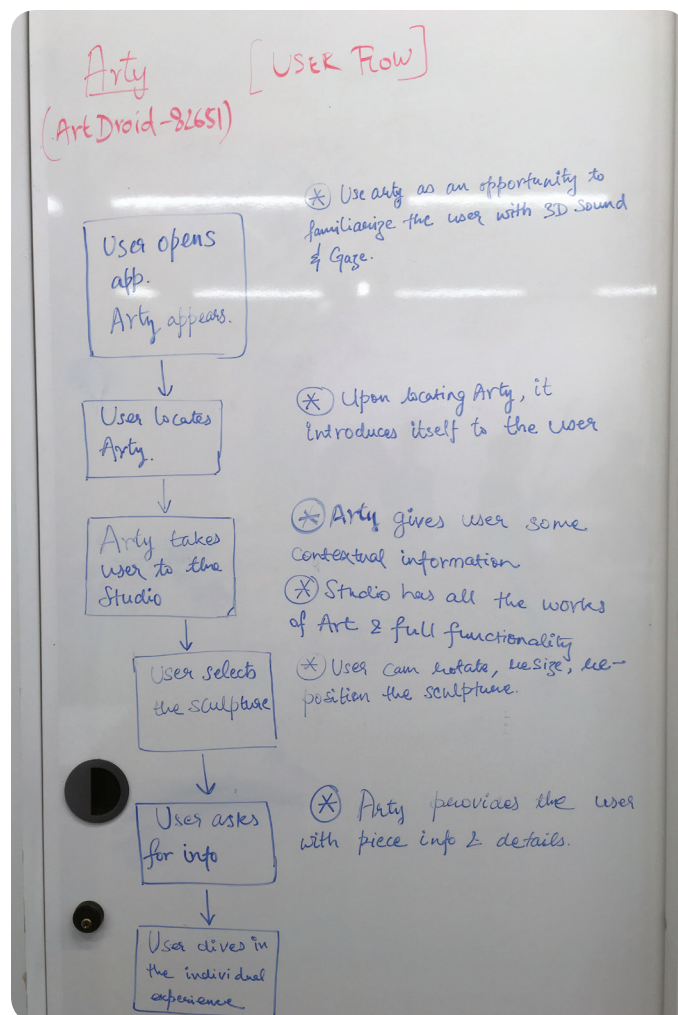


Artist Information Interaction



Left:
Prototype user flow with Arty

Right:
Bodystorming the second prototype



Prototyping in Unity

After two iterations of physical prototypes and user testing, we decided that we finally had a concept that was worth transferring to Unity. The goal was to develop a prototype that would showcase user interactions with holographic art pieces in mixed reality space, and how Arty could enhance that experience. The final version of the prototype is rough but polished enough to feature a full set of gaze, gesture and voice controls, an alpha build of Arty and at least one completed process room.

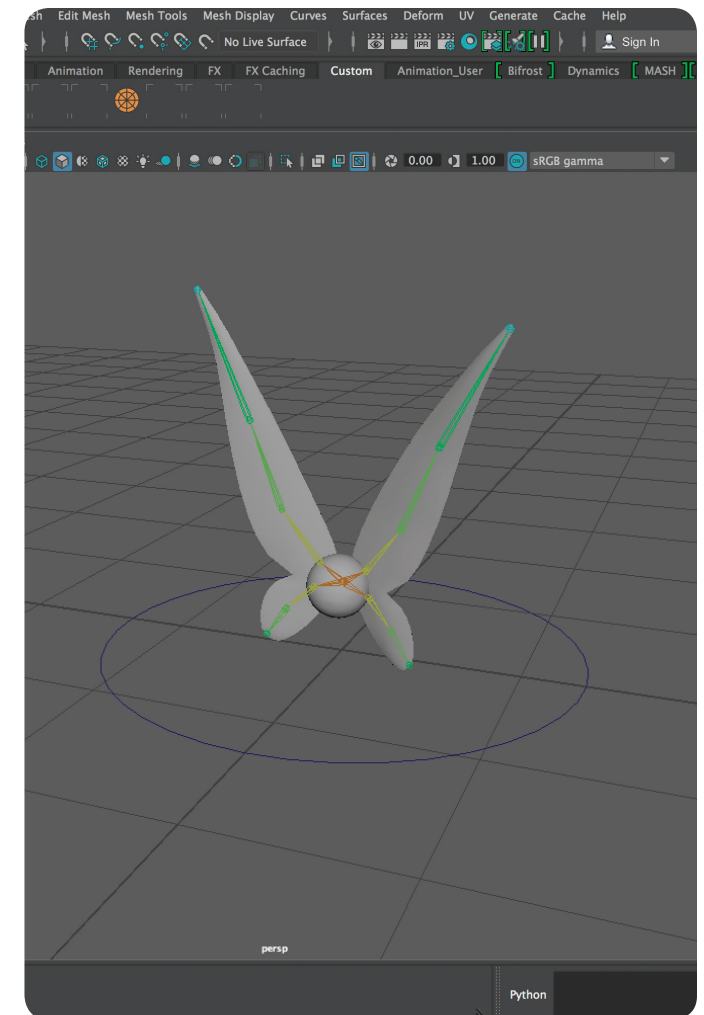
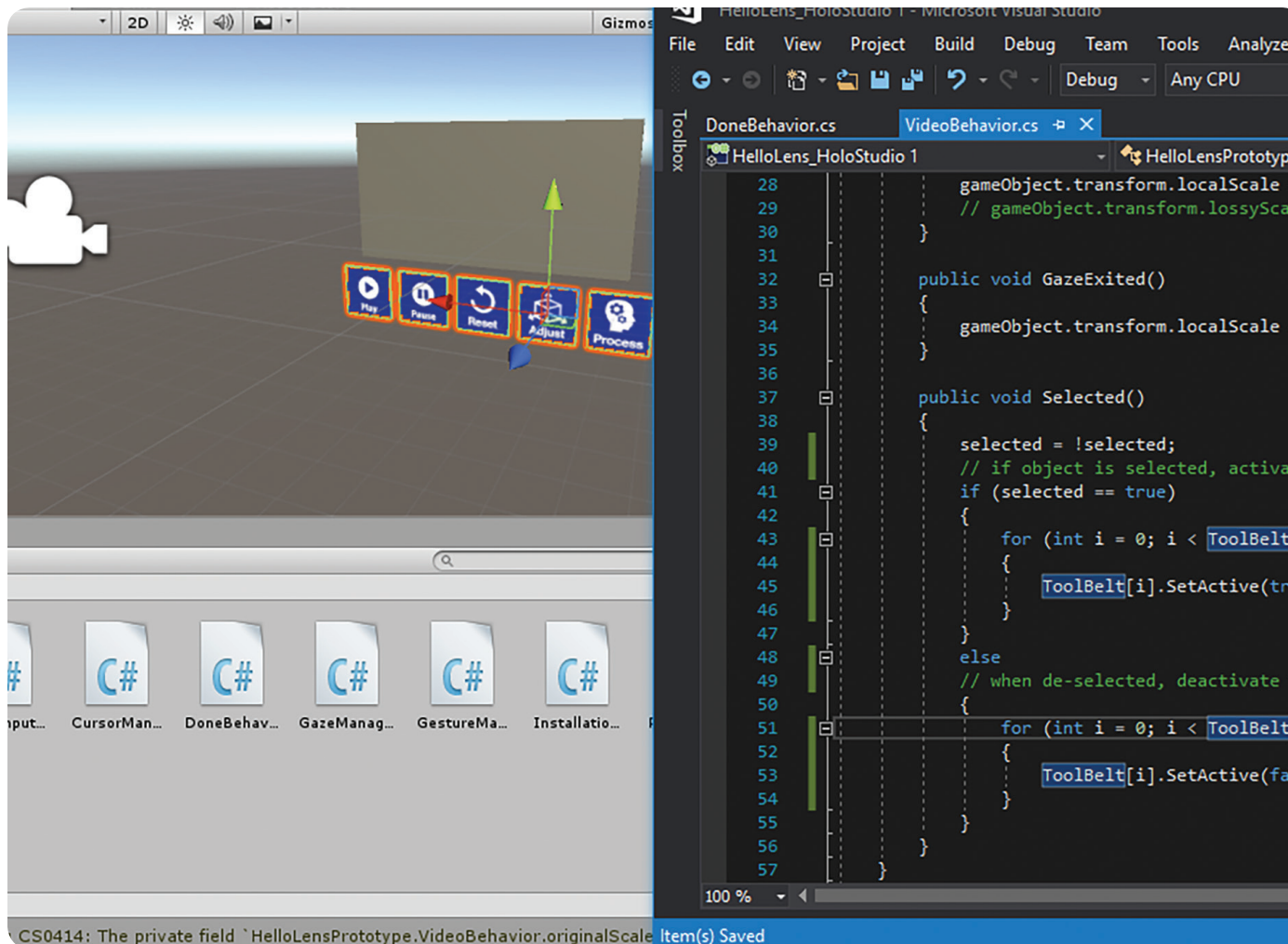
In the beginning of our development process we mainly focused on creating a set of controls that were responsive and pleasant to use. We made use of a stable and accurate gaze input system that would let our users focus on their desired art piece, and a robust

gesture input system that made appropriate use of air tap, navigation and manipulation gestures to give our users a sufficient sense of agency in mixed reality space. Finally, we supplemented our gaze and gesture input systems with a working voice command input system that mainly focused on making menu navigation less frustrating and tedious. Being able to rotate, scale and translate holograms in an intuitive way, as well as being able to navigate menus without much difficulty, created a set of controls that provided our users with a fundamentally sound set of ways with which to express themselves. Once our control systems were in place, we set up a basic scene for testing purposes. We populated it with fully interactable placeholder art pieces, and most importantly, we introduced Arty to the HolosStudio! In this iteration, Arty was sadly unable to do much since the actual implementation of an AI assistant was beyond our reach.

The Rise of Digital Assistants

In order to cut down user interface elements in the design, we came up the solution of building a digital assistant in the application. We originally had this “robot assistant” idea when we were brainstorming the project, and after our first paper prototyping, we decided to carry out this idea and go further for the next iteration.

There are already a lot of examples for this kind of concept out there. Today, it seems that many people are getting used to the idea of a digital assistant that can help them carry out tasks. The big four assistants, Cortana, Siri, Google Assistant, and Alexa, are all quickly becoming ubiquitous in products that Microsoft, Apple, Google, and Amazon, respectively, are creating. We think a big part of why technology companies are



doubling down on this technology is that people want to connect to another human, or in this case, an entity that takes on human characteristics in terms of natural language processing and understanding.

Also, we read the article Best Practices For Mixed Reality Design in 2017⁵ and it mentioned that when designing in mixed reality, turning voice commands into conversations will be a good way to make the users more engaged, as opposed to shouting out voice command lines at the emptiness of space. It also said to “give users a clear visual point of reference for them to talk to. This can be a character or a simple animation

⁵ Rizzotto, Lucas. “Best Practices For Mixed Reality Design in 2017 – FuturePi – Medium.” Medium. January 16, 2017. Accessed March 20, 2017. <https://medium.com/futurepi/best-practices-for-mixed-reality-design-in-2017-7dab602574eb>.

that triggers on speech.” This is the core design concept for our digital assistant.

Unity Prototyping Challenges

While our team made a lot of progress in terms of prototyping in Unity, we hit a number of hurdles along the way. We initially struggled to understand how user input would work from a technical perspective. How would the defining HoloLens input of gaze, gesture and voice be implemented in Unity? How would we implement a cursor in our prototype and what would menus look like?

Since the HoloLens runs a version of the Windows OS our team expected the development process to be very similar to that of a .NET application or any other native Windows application. We expected to have access

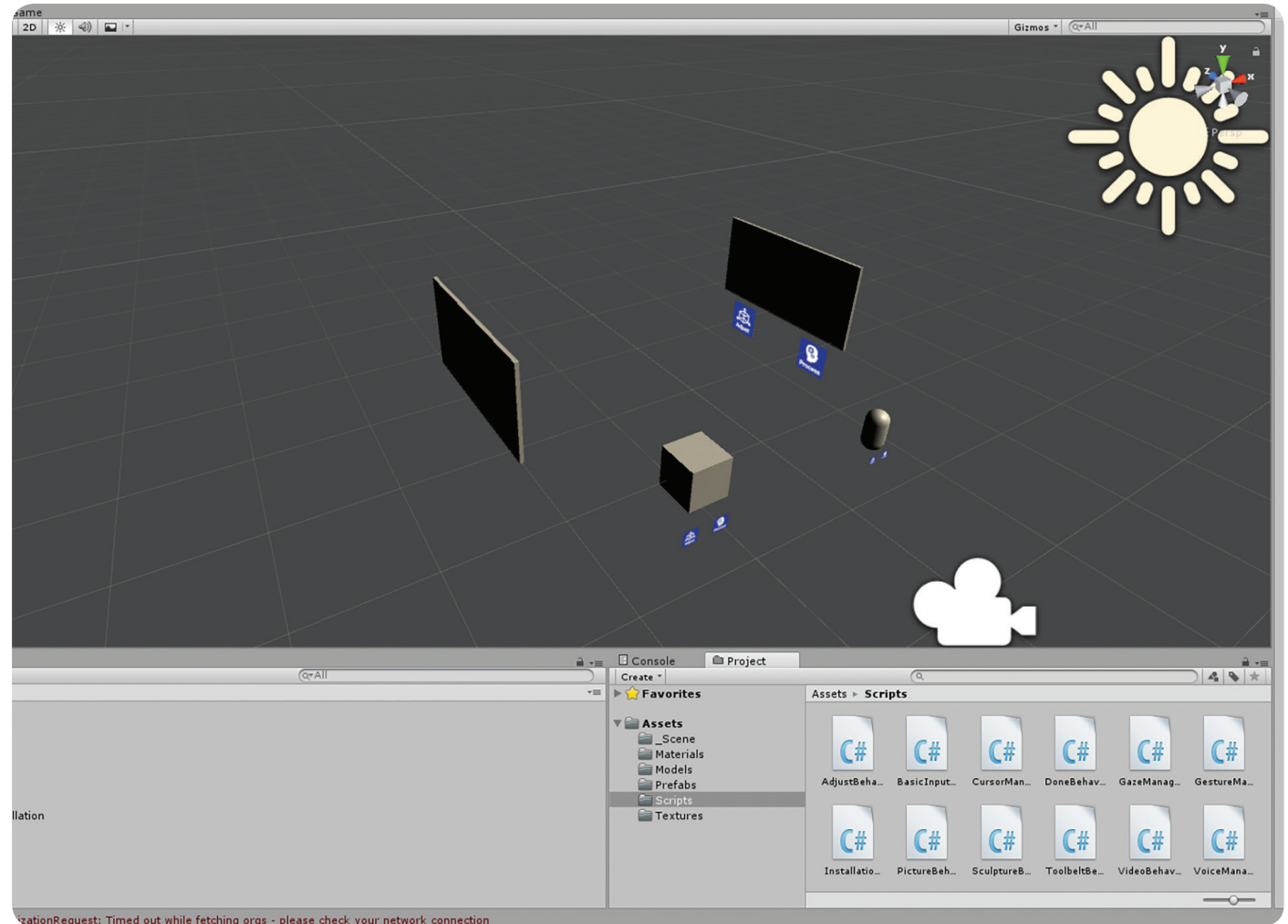
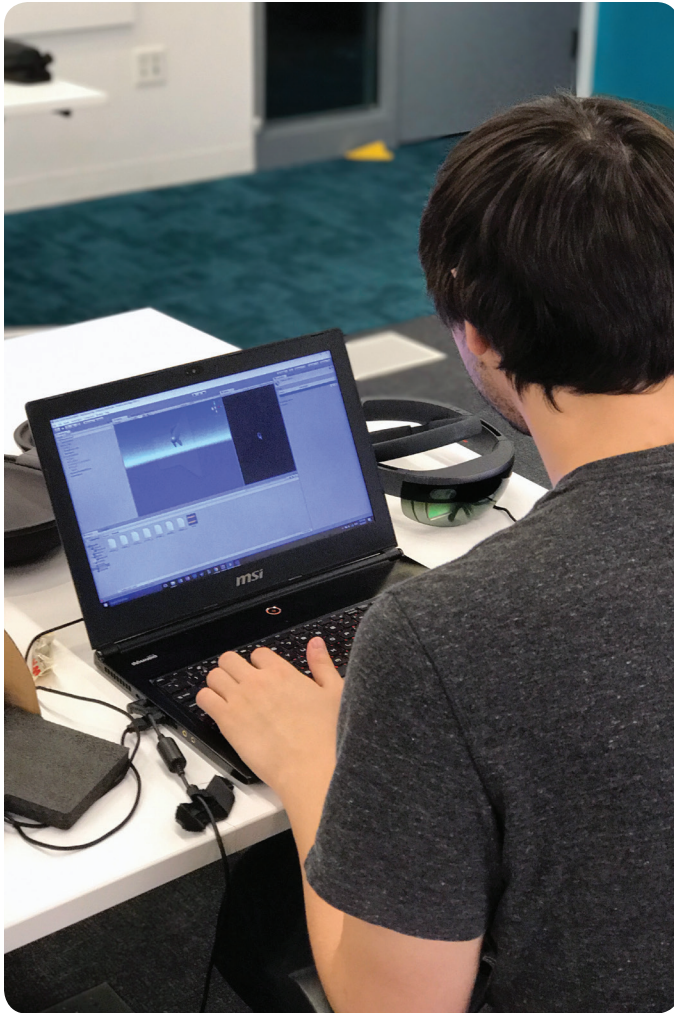
to default HoloLens cursors and menus, as well as implementations of the basic input systems right from the get-go.

Unfortunately, we learned the hard way that during “Prototyping in Unity” there was a lot of emphasis on the “Unity” part. In a lot of ways, developing an application for the HoloLens is similar to developing a game in Unity. Besides the fact that every hologram had to be a GameObject, every UI and input element also had to be a GameObject. This meant that we had to reframe our assumptions about how HoloLens development would go, and think about how to make Unity’s “Entity-Component” system, speak the language of the HoloLens.

Another problem we had to face was the fact that a lot

Left:
Alex working in Unity prior to HoloLens deployment

Right:
Unity development screenshot



of the UX design concepts we wanted to apply to the HoloStudio would manifest in purely aesthetic ways in our Unity prototype. Things like menu animations and different cursor models are all created outside of Unity in software like Maya and Cinema4D. For example, capturing the nuanced psychological effects that Arty would have on our users, or experimenting with our information architecture requires the creation or editing of 3D models. Unfortunately, the absence of asset artists kept us from implementing a lot of our ideas and it got in the way of us being able to showcase a lot of features in our Unity prototype.

Key Insights

After completing a number of tutorials from the Microsoft Holographic Academy, we were finally able to get started and conceptualize an event pipeline for our

prototype. User input is handled in a 3-step process where each step focuses on a different entity. The first step focuses on the user and the latter two focus on Unity scripts that we called “Manager” and “Behavior” scripts. In the first step, we focus on a macroscopic view of the user wearing the HoloLens. During device usage, the HoloLens receives raw input information from the user such as the position of the HoloLens relative to where it started, whether the gesture recognition system is picking up anything and whether the microphone is receiving voice commands.

In the second step, this raw input is transferred to Unity and interpreted by the “Manager” scripts. These scripts leverage the Unity physics engine, Windows and VR API to translate the raw input into messages that can be sent to GameObjects to make them behave in a certain way. For example, the user’s gaze is tracked by a

physics Raycast, fired directly straight from the current position of the camera every frame. Taking advantage of the Raycast class in Unity, the application is able to know whether the user is gazing at a GameObject or not and send an appropriate message to that GameObject.

Finally, each GameObject has it’s own “Behavior” script. These scripts define the behavior of a GameObject and how it will react to the messages sent by the “Manager” scripts in the previous step. They are no different than the scripts you’d see during traditional game development in Unity and contain event-handler methods that are triggered when a message is received. For example, an art piece like the sculpture might have an “OnGazeEntered” method that makes it ‘glow’ softly when it’s gazed at, in order to help the user focus on the art piece.

7

User Testing Outcomes

The user testing sessions that we conducted served to inform us of what made sense and what didn't. We would ultimately take much of the feedback we received from testing to further our prototype before bringing the design into Unity for development.

Testing the First Prototype

On April 1, 2017, we tested three users with our first prototype with two user. A female (age 26), female (age 27), and male (age 24). During these tests, we wanted to see how someone would navigate through the app and note any confusions, inconsistencies, and general user behavior when they were going through the app. During this time, all users noted that the menu was familiar and it felt very easy to go through the experience. There didn't seem to be any confusion at this point.

When we were going through the prototype with our professor, Dana, she also thought the experience was very familiar and easy to go through as the concept of a menu had become very intuitive in user experience design. She challenged us to rethink the menu, or bring something different to the table. Our team thought about it and would iterate our idea to bring in a digital assistant, combined with a toned down menu system when it made sense to have one.

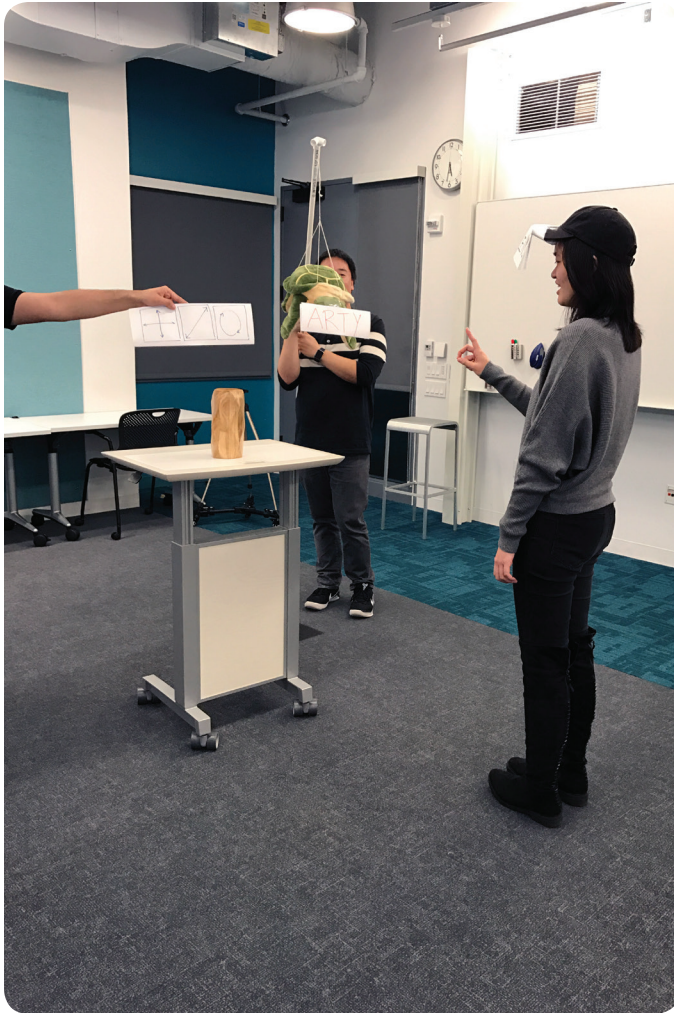


Left:

User testing the first iteration of the second prototype

Right:

User testing the second iteration of the second prototype



Testing the Second Prototype

After we created our second prototype, we conducted more user testing to see how people reacted to our digital assistant: ArtDroid-82, aka “Arty.” We brought back the users that helped us test the first prototype. During this time, Arty was used quite frequently to answer questions about controls. After the tests, we received some feedback to help us develop our idea. A notable point was that they all liked Arty, the digital assistant. An important point was brought up with one of our users and that was that Arty should not be distracting or have an annoying personality. Furthermore, this user helped us think more about what Arty should be. She noted that symbolism is very important in art and that we should seriously consider what could be a neutral symbol.

After this testing session with the three users, the most significant change we made was switching out Arty from being a stuffed turtle to a white orb with wings.

Iteration of the Second Prototype

On April 8, 2017, we conducted four more user tests. Some small iterations to the controls were made that did not justify designating a new prototype number, but it cleared up a lot of confusion that was present in our previous tests.

The three testers, male (22), female (25), and male (25) could easily navigate the app with less help from Arty. One of the users mentioned a few things during the feedback session. Notably that “Thanks Arty” is a good phrase to use to dismiss it. From that comment, our team decided that there should be multiple phrases

to do the same thing for many of Arty’s functions. The female (25) user noted that Arty was distracting during the tour and suggested moving Arty closer to the painting. Another user also suggested a slider for resizing instead of a corner drag. The male (22) user also forgot most of Arty’s narration. He noted that this could have been a result of the amount of words or his personality. Even so, the male (22) user preferred listening to Arty over reading.

Our last user’s feedback mentioned several things about Arty as well. The first was that the narration was too fast and full of fluff like his long name during his introduction. He also did not know what to do with Arty after the tour and was distracted by Arty during the tour. Despite all that, the male (25) user still liked Arty’s presence, but found less use for him than other testers.

On April 10, 2017, we tested two more users for our second prototype. Changes were made to the controls and Arty’s presence. His speech was reduced. Our graduate assistant was our first tester. He suggested clearer directions for menu commands. This included repositioning the tools and making all of them visible during the “Adjust” interface. He also wanted to go back to the Studio Selection and was confused about the “Done” button, not recognizing that it was also a confirmation of adjustments made to the piece. Once notified of this, he mentioned that there should be a reset button for the piece. He also suggested a restart button for the video. Our graduate assistant also suggested a “photo” mode that removes interactivity to take photos. Finally, he also felt that there was too much of a disconnect between art pieces.

Our second tester was our professor, Dana. Dana decided to explore every piece of the application that she could. Her feedback on the video piece was that the “Play” button clashed with the “Adjust” and “Progress” toolbar, and suggested that the video controls should be included on the “Adjust” and “Progress” toolbar, creating a single line of controls for the user to focus on. For Arty, Dana suggested that Arty should be an ambient part of the room, and possibly include a fun game or distraction if the user needs to step back from observing the art pieces. For the tools, Dana mentioned that they are intrusive when viewing the art, and would like to have a way to hide them, or if they are hidden by default, revealed through user action such as air-tapping on the holograms to reveal the UI. Dana also said that she would like to use Arty to adjust the holograms without the interfaces. The last piece of feedback was that Arty could take voice messages or feedback from the user to send to the artist.

On April 12, 2017, our team conducted the last round of user testing. There were two testers today, a male (24) and female (24).The male (24) user had some new feedback for us regarding Arty and the Process. He felt like he had a tour guide who left him high and dry when Arty’s tour was finished and Arty “flew off” to let him explore the room. There was nothing for him to go on and, therefore, was confused about how to proceed. This might change if a curator is using the device and knows what they are looking for, which generally tends to be the case as concluded from our interviews with curators. The male user also wanted audio information while in studio mode. This would allow him to get an audio description of the art pieces.

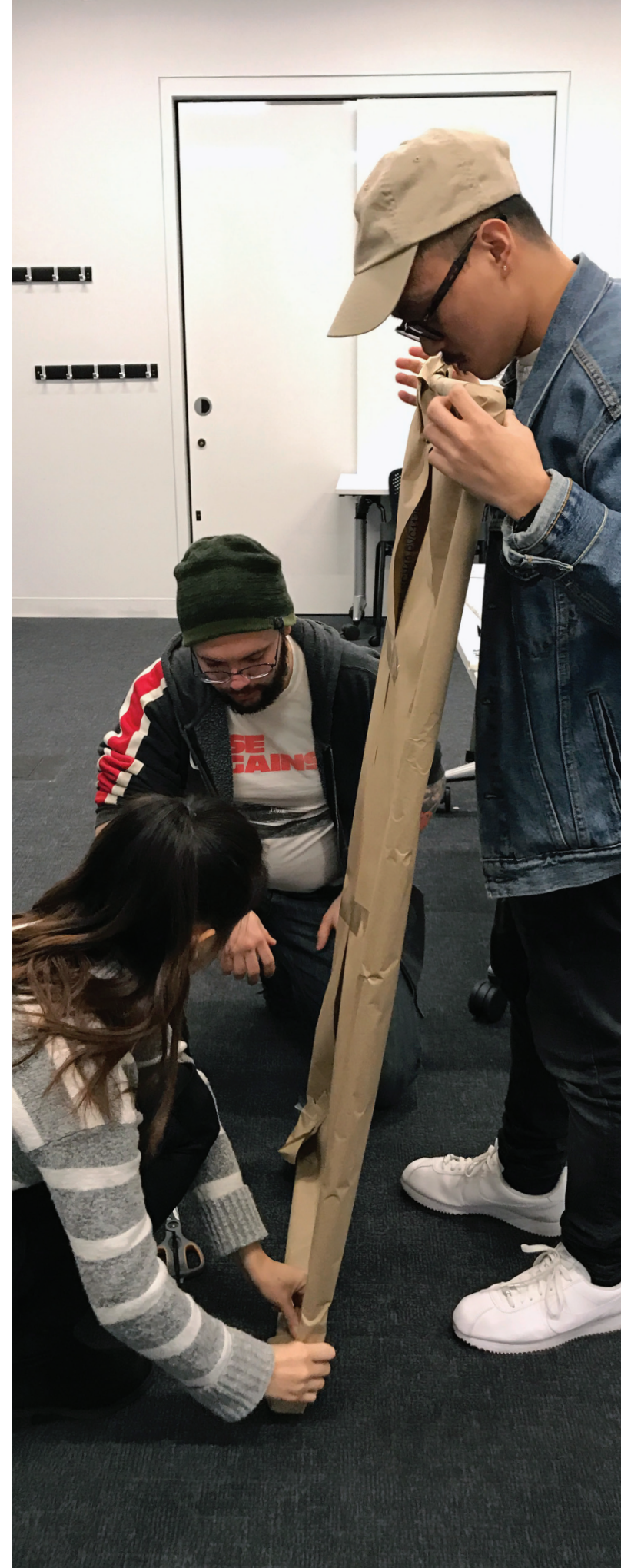
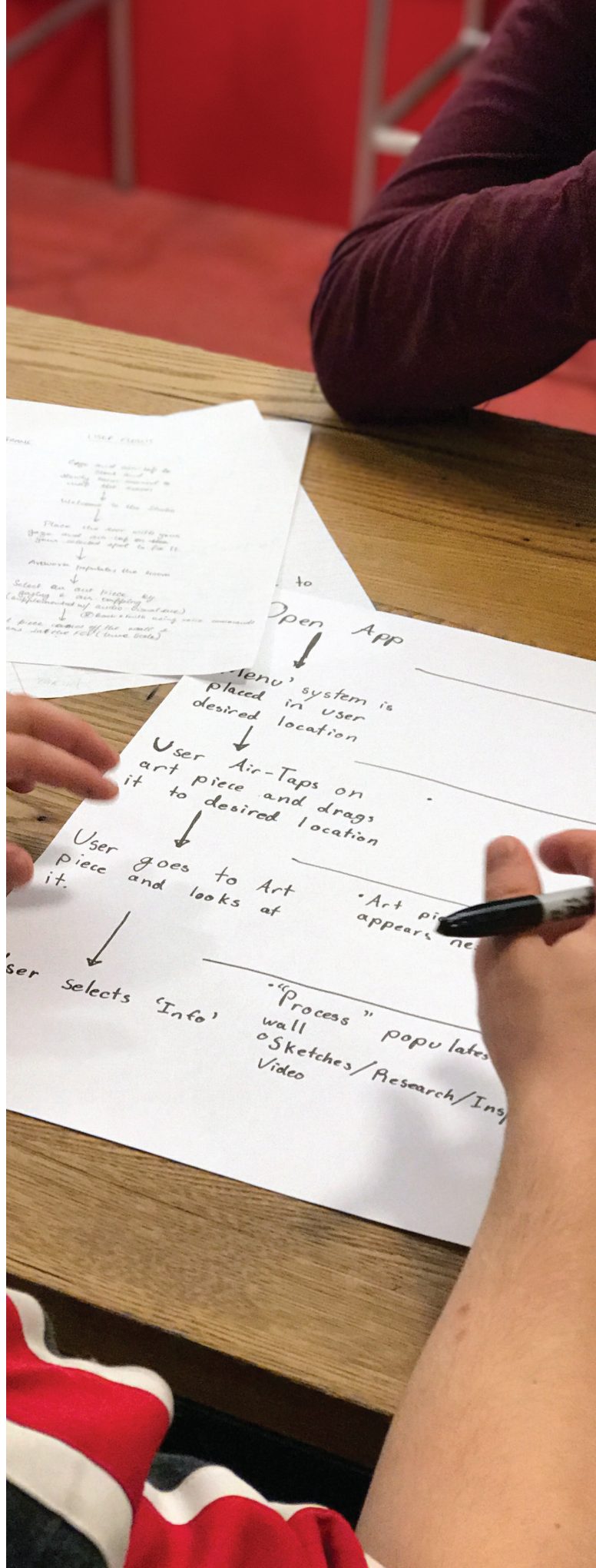
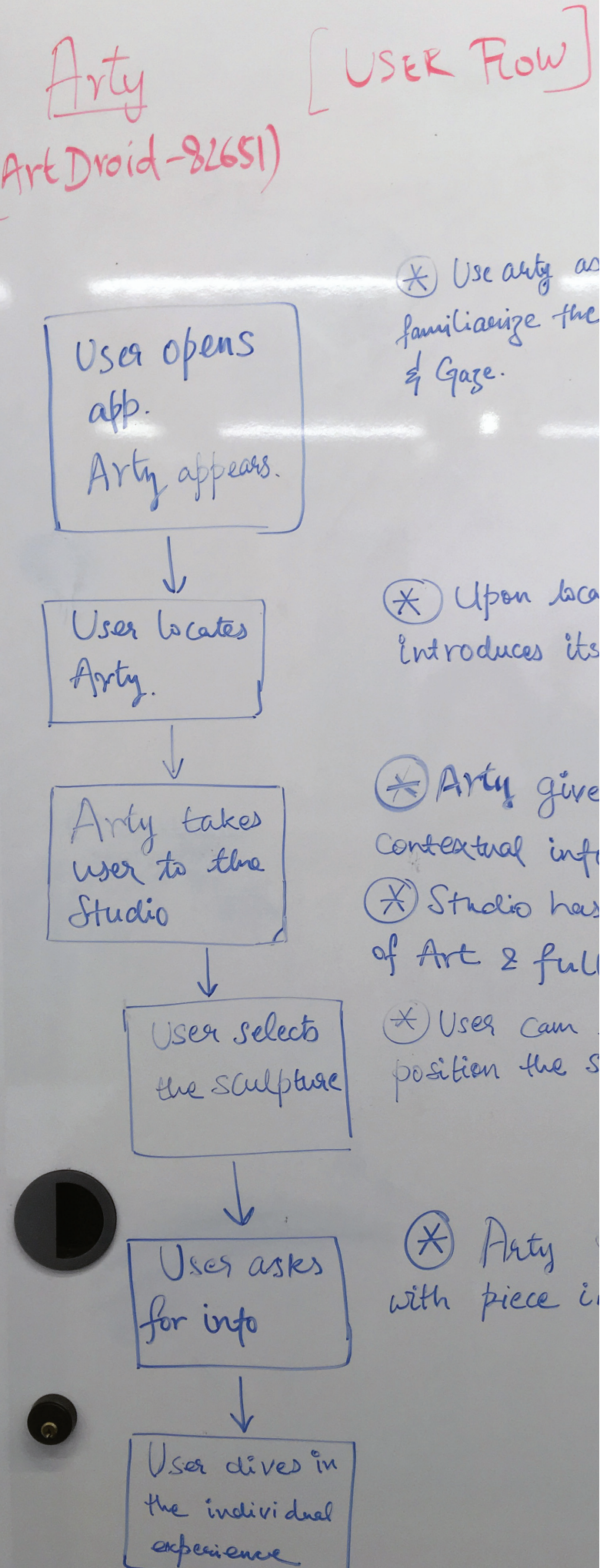
Limitations	Behaviors and Motivations	Goals and Needs	Frustrations
Digital assistant can be limited in responses	Confirmed, “Yes” right when Arty asked a Yes/No Question	Control and view art pieces in the room	This confirmation actually skipped the tour
3D sound is not present in paper prototype	Was able to Identify art pieces in the room without a tour	"Help" needs either a list of commands or Arty needs lines	Not all supplies were available to test all aspects of User Test
Interactive Installation is not fully interactive, it is only a preview	Followed Arty, though was not required	Adjust video while it's playing	Controls were not visible when adjusting, needed to hover over to see them
Arty will continue on tour whether or not user is following him.	Did not react to the noise of Arty flying around them. This is Hit or Miss	Wants Arty to be a "presence" in the room instead of just disappearing	Multi-depth for toolbelts is confusing
--	Attempted to interact with the “interactive installation”	Game with catching Arty would be fun	Explanation was not clear for "interactive installation"
--	Pressed “Play” on video before Arty was finished with tour	Connect with the Artist directly from the App	Get rid of menu and view sculpture not possible in current prototype
--	Not sure what to do after Arty leaves the user to explore the studio	Way to remove toolbelt from art piece	Did not know what "View Process" meant

He further suggested that this could potentially be categorized under assistive technology in future builds of our prototype.

The female (24) user also had some interesting feedback regarding the “Artist Information” panel. She suggested that the app could call the artist or message them directly through the app or by opening an external app such as Skype or Outlook email. She thinks this would be a good way to communicate with the artist on the spot and within the app. Further functionality could be added to schedule a studio tour with the artist.

Feedback and Implementation

Overall, through the feedback we received when testing the prototypes, we were revise our prototype for when we started to develop in Unity. Some of the changes we made included: adding a “Replay” button for the video, “Reset” button to bring the art back to its original size and scale, implemented a button for users to record a voice message, and brought the video playback controls onto the toolbar.





8

Table of Elements

The Table of Elements was an integral part of our project. The Table of Elements we used was based off of an augmentation of the one from 8ninths⁶ that Juan used in his HackerNoon article⁷. This Table of Elements allowed us to see what interactions and elements we would be utilizing in the HoloStudio.

As soon as we finished our first round of brainstorming, we came up with the first version of our table of elements. The table of elements includes physical space, user input, holographic form, 3D sound and Mixed Reality Design Methods. To add more possibilities in the HoloStudio, we thought of some holographic elements that could possibly be present in the studio experience. During one of our initial brainstorming sessions, we tried to use the door as a target to scan the whole room and use the ambient environment so the user can manually place the different art pieces into the room. Additionally, another idea we had was an animated avatar to represent the artist, which could guide the user during the tour, and give more information when prompted. We listed all the user input possibilities and 3D sound effects that we thought we would want to include in the experience in the first version of our table of elements. This would give us more choice when we started getting deeper into the design process. In the first version, the art pieces we included in our studio were a painting, a sculpture, a video, and a game. Therefore, we built this version around these art forms.

⁶ 8ninths. "HoloLens Design Patterns." HoloLens Design Patterns - 8ninths. May 12, 2016. Accessed March 10, 2017. <http://8ninths.com/hololens-design-patterns/>.

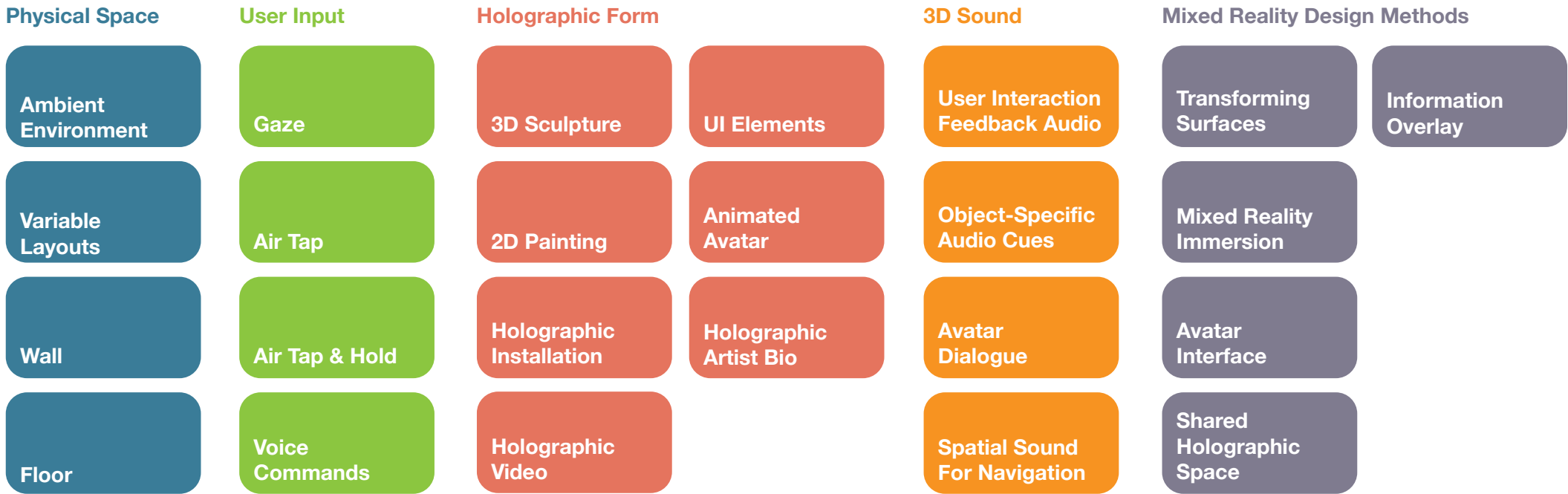
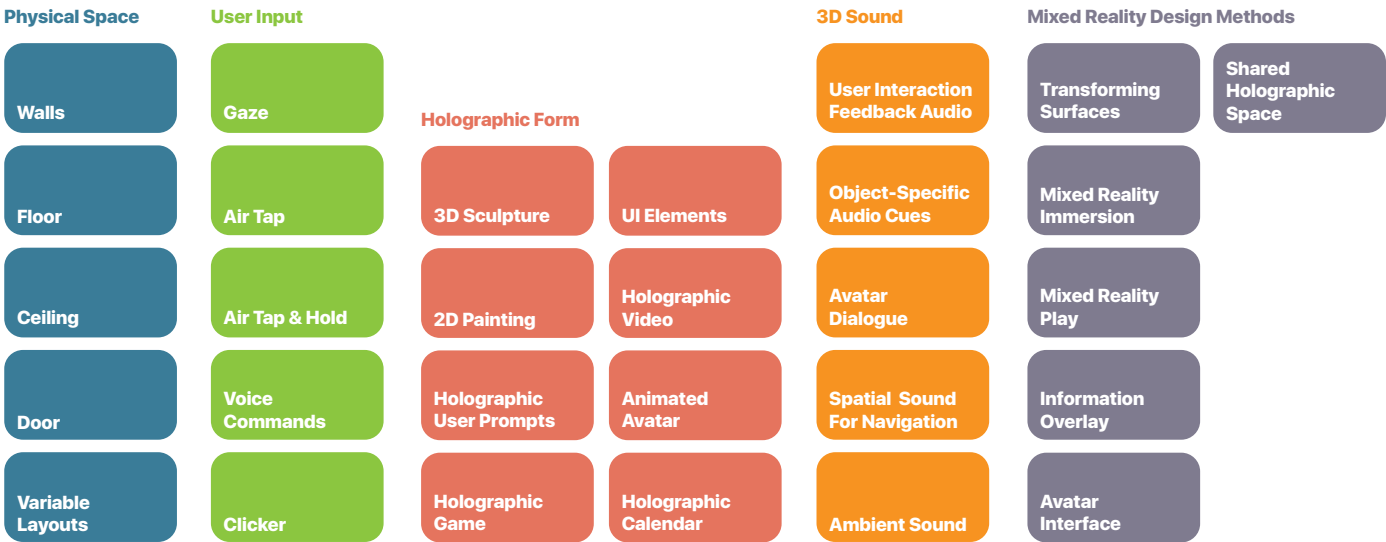
⁷ Juan. "The UX Workflow for HoloLens & Mixed Reality – Hacker Noon." Hacker Noon. December 02, 2016. Accessed March 10, 2017. <https://hackernoon.com/the-ux-workflow-for-hololens-mixed-reality-3bf59192e577>.

Right:
Old Table of Elements (Brainstorming Phase)

Bottom:
New Table of Elements (Unity Development)

After several rounds of iteration during the design and development process, we changed some parts of the table. We went to Toni Dove’s studio and decided to add an interactive installation instead of a holographic game. According to the new list of art pieces, we deleted some elements such as clicker input or the design method about mixed reality play, which were all related to holographic gameplay. We also got rid of the door scanning part since different users may be experiencing the HoloStudio in different and varied environments. We thought that some users may not be in a room with have a door as they started the experience in a hallway or other large space. Additionally, we expanded on the idea of creating an animated avatar and, instead of a hologram of the artist, created a digital assistant for users to interact with. The assistant, nicknamed Arty, can guide the user and always give a hand to user during the whole studio experience. In our several rounds of user testing, this idea was really popular and the majority of the feedback we received surrounding the implementation of Arty was positive.

Overall, the Table of Elements was a valuable tool to help us remember the range of options that were available when we were creating the HoloStudio.



9

Final Thoughts & Insights

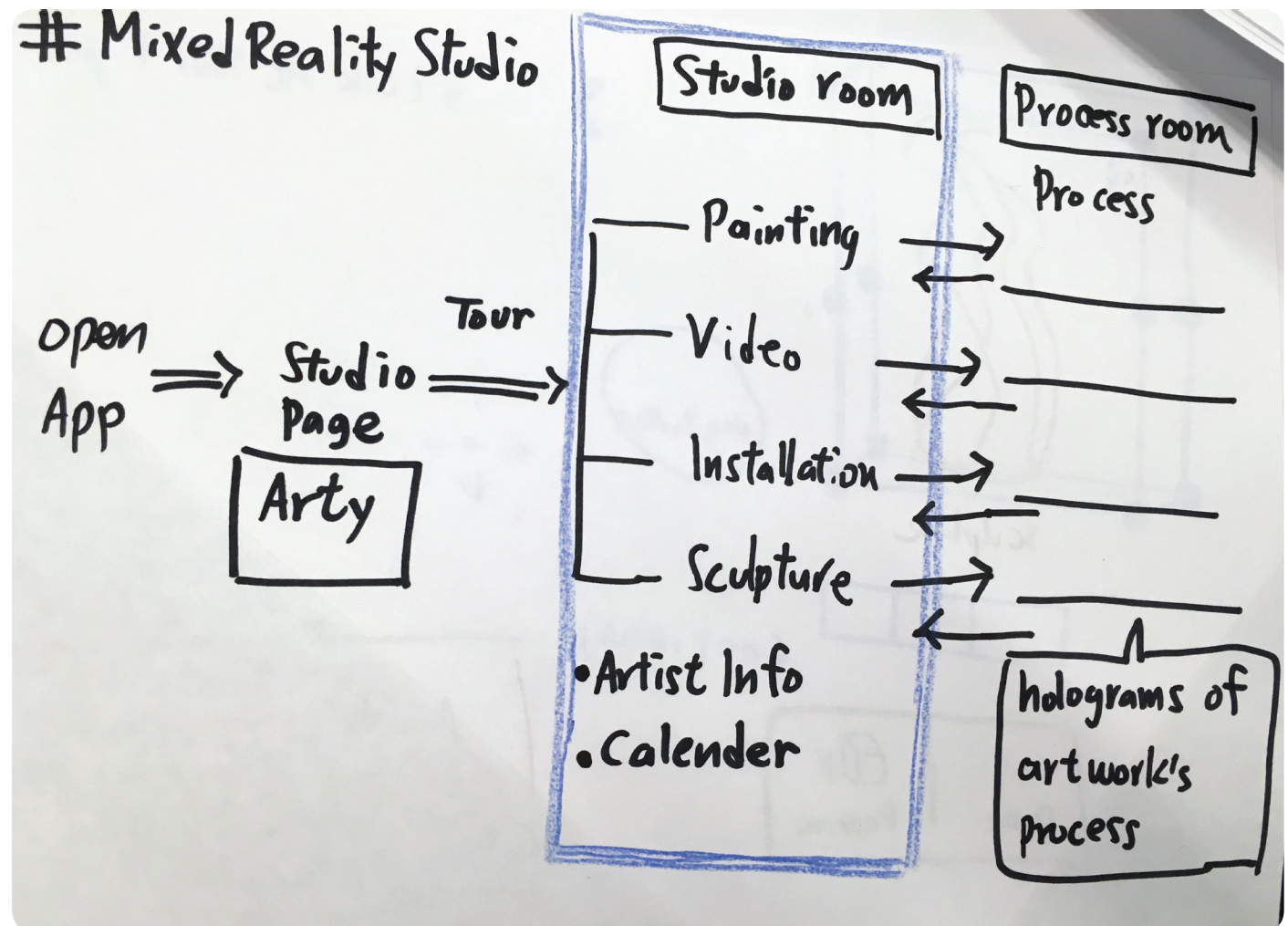
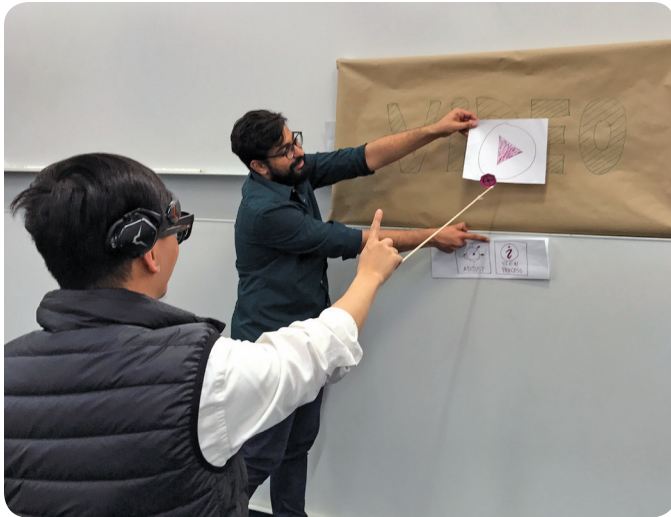
Working with the HoloLens proved to be an incredible learning experience in terms of developing a intuitive and simple interface, developing in Unity, as well as creating our own mixed reality design process. Since our project timeline was fairly short, our phases overlapped a lot. We were frequently prototyping and conducting user research to inform our prototype at the same time. Given the short timeline, our team could not fully flesh out some of our ideas as well as we wanted to, but we believe our final prototype conveyed enough information to get our point across.

The mixed reality design process we utilized can be summarized as follows:

1. We sought to understand the HoloLens to get a better idea of how we should develop for it. What could it do? What were its capabilities and limitations? How could this computing form factor change how we interacted with the world?
2. Once we had some answers to these questions, we began to create a map of interactions to conceptualize how users could interact with the art pieces.
3. From there, we sketched examples from our interactions map to get an idea of how it would look. This helped us convey our ideas to gather feedback.
4. Afterwards, we would begin user research to better address the needs of our users while simultaneously developing a prototype.
5. After some user feedback as well as more user research, we were able to develop the concept for ArtDroid-82, or “Arty” as we call it.
6. After more feedback, we refined how Arty would interact with the user. Our team got a lot of positive feedback for how we conceptualized Arty.
7. Finally, we would bring Arty into Unity to develop and deploy a proof of concept for the HoloLens.

Left:
Testing our second prototype

Right:
One of our close-to-final user flow diagrams



With the creation of the concept of Arty, the digital assistant for the holographic studio experience, we sought to bring a more human connection to the mixed reality experience. We took assumptions that humans wanted to connect with other humans and translated it into the creation of a digital assistant. In a way, we had come full circle in terms of how information was disseminated to people. Before the invention of the Gutenberg press, information was largely disseminated by people through word of mouth⁸. When humans could print books in large volumes, books became vessels of information. With the rise of the internet and smartphones, information once again reached a broader audience. Now, in mixed reality, we are utilizing a digital assistant to disseminate information to the user.

Overall, we thought that these tools, techniques, and insights were very helpful to us throughout the various stages of the design challenge. We hope that these insights will be helpful to you as well:

- Defining project goals and vision at the beginning.
- Developing a concept interactions map to figure out the possible types of interactions.
- Sketching a few of these interactions to see how one could complete simple tasks.

- Creating a draft Table of Elements to help determine what you want to include in your experience, including what design techniques for Mixed Reality you intend to use. You can follow-up by creating a final Table of Elements once your project is near completion.
- Constructing holograms from available materials to create low fidelity prototypes. This is a great way to bodystorm and see what will work and what won't in the mixed reality world. This could even help you break away from thinking about designing for 2D surfaces.
- Defining simple user flows for prototyping and then developing more complicated user flows as the prototyping progress.
- Creating concept visualizations in Photoshop to better articulate your ideas to stakeholders.

- Being able to quickly prototype in Unity is a big benefit. Things won't be perfect all the time, but this will allow you to produce real holograms and get an idea of scale during development.
- When prototyping in Unity, remember that perfect is the enemy of good. The goal isn't to create a complete HoloLens application but rather to prototype specific interactions in mixed reality space.

Our team hopes that this book and its contents were helpful to you. Mixed Reality is a great new form of computing that has as much utilitarian use as it does for entertainment purposes. Team HelloLens is thrilled to have been a part of this design challenge. We're excited to see what the future has in store for mixed reality and the HoloLens.

⁸ Grayson, Lee. "How Did People Communicate Before the Printing Press Was Invented?" Synonym. Accessed April 02, 2017. <http://classroom.synonym.com/did-people-communicate-before-printing-press-invented-8169.html>.



Below:
Visualization of adjustment interface with a sculpture



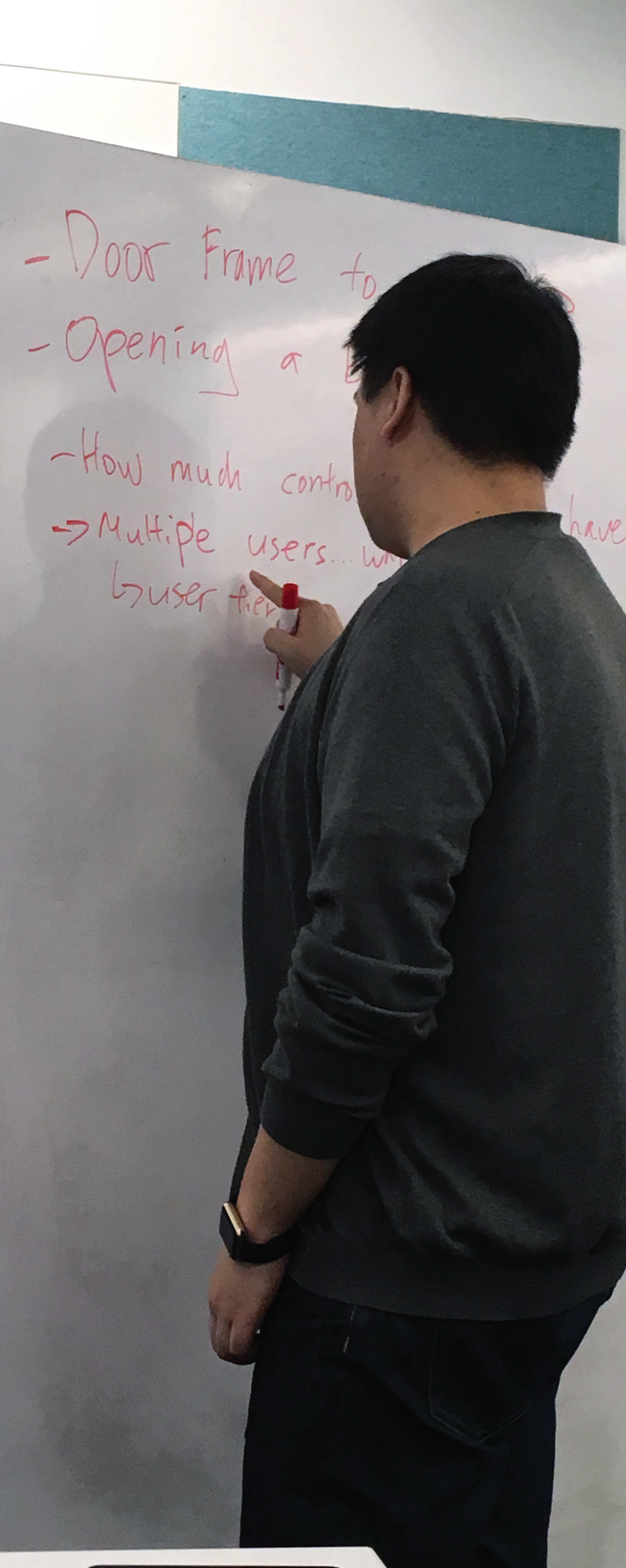
Below:
Visualization of piece of video art along with a
photograph in the same space



Below:

Visualization of a silhouette interacting with an interactive installation





Special Thanks

This project would not have been possible without:

Subigya Basnet for headshots - Graduate Student, Integrated Digital Media, New York University

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Joshua Walton for support and feedback - Principal Interaction Designer, Microsoft HoloLens

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Allison Berkloy - Artist, Interactive Installations

Toni Dove - Artist, Interactive Installations

Mark Scala - Chief Curator, Frist Center for the Visual Arts

Lee Glazer - Associate Curator of American Art, Freer and Sackler Galleries

Acknowledgments for assets from various diagrams, icons, and renders:

Iteration Diagram based on a chart designed by new7ducks / Freepik

Design icon by Gregor Cresnar

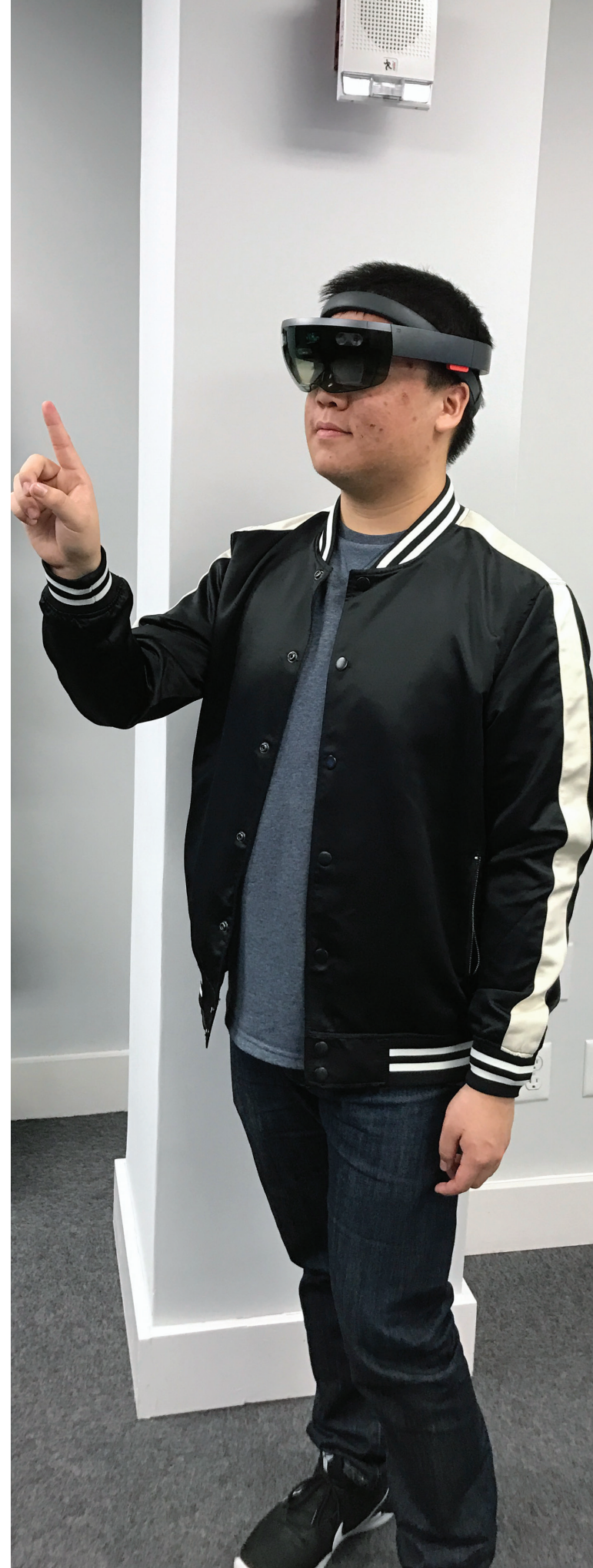
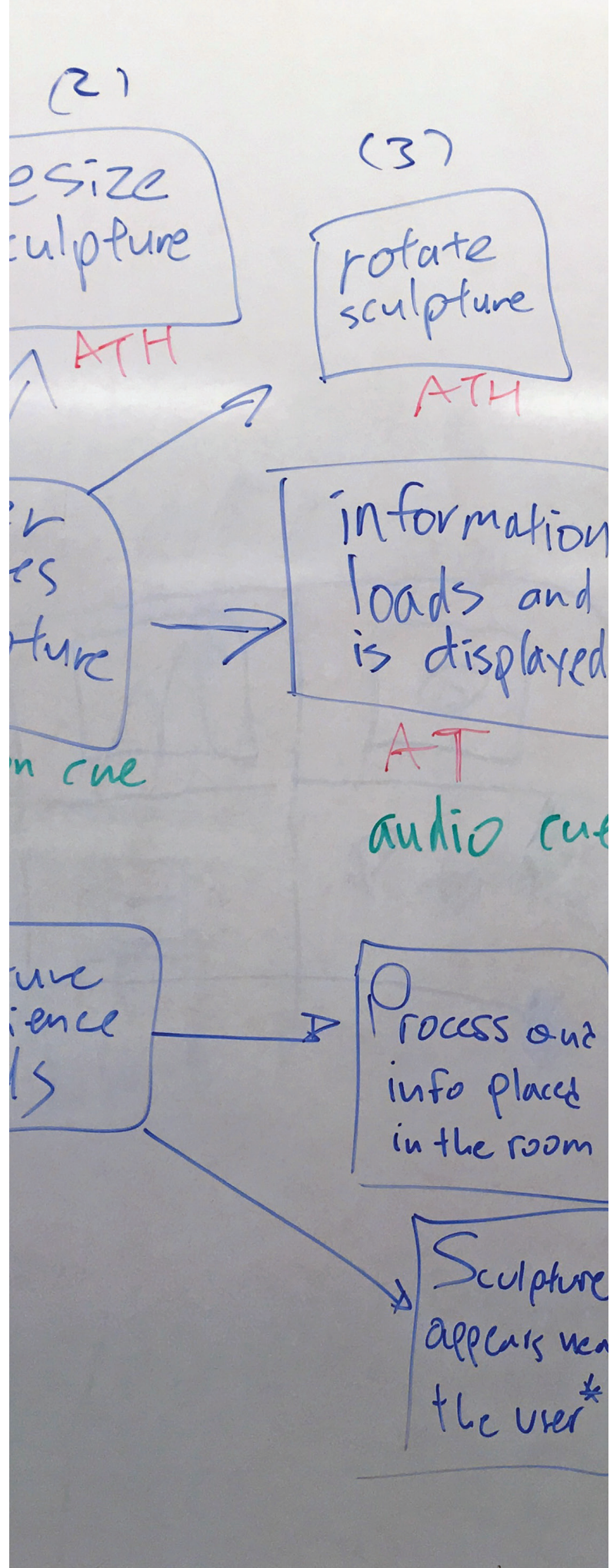
Adjust, Process, Play, Pause icons in renderings and Unity prototype by Freepik

Other Iteration Diagram and Comparative Analysis icons by FontAwesome and licensed under CC BY 3.0

All iconography from the various charts are from Freepik, Flat Icon, or Noun Project

Stock images from Pexels and Shutterstock







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