



HCDE CAPSTONE 2015

VIRTUAPLUSH

PROCESS BOOK



Special thanks to:

Brian Espinosa, Yihsiu Chen, and Angela Sharer of HTC
Corporation

Jared Bauer, John Porter, and Michael Grazewski of the University
of Washington

Professor Thomas A. Furness III of the University of Washington

Dani Sandoval, our honorary sixth member

htc

W

HCDE Human
Centered
Design &
Engineering

HCDE CAPSTONE 2015

VIRTUAPLUSH

PROCESS BOOK

TABLE OF CONTENTS

5	Executive Summary
6	Organization
8	I—Research
11	II—Ideation/Design
18	III—Development
25	IV—Presentation
30	Reflection
30	Citations
30	Appendix



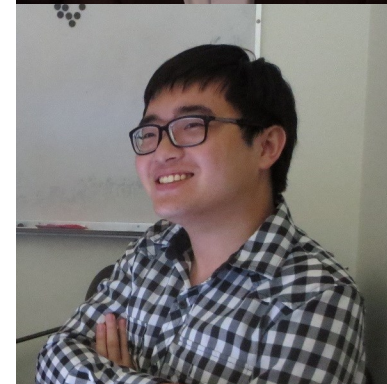
John Allen
Lead researcher and historian



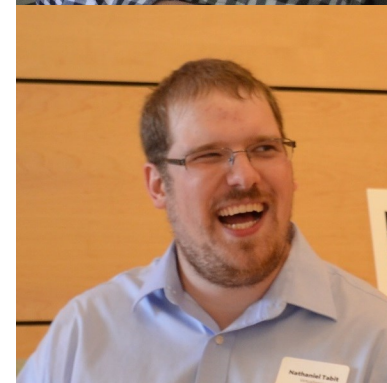
Erika Berlin
Co-lead designer and researcher



Derek Lee
Project manager, historian, researcher



Alan Qiu
Lead Q/A evaluator, co-lead designer, developer

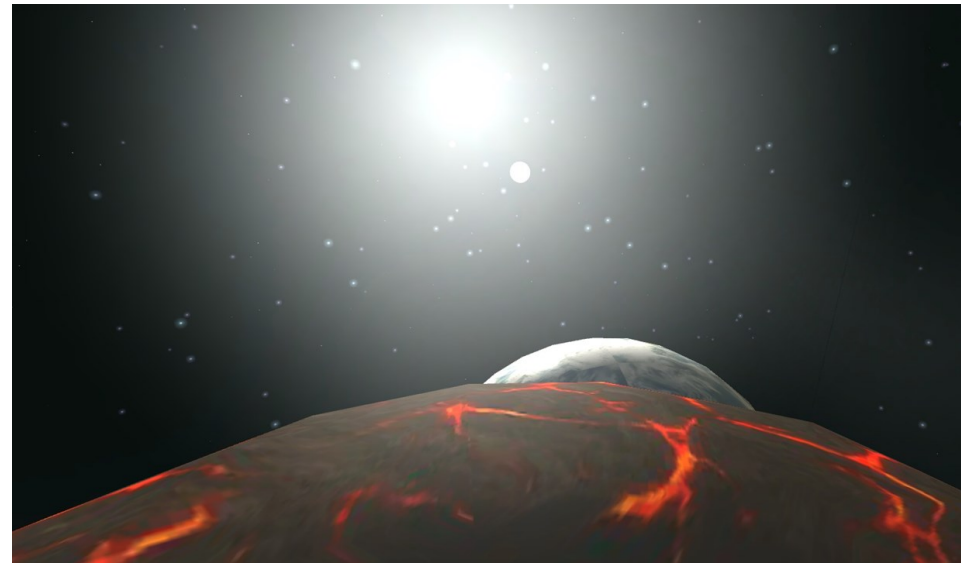


Nathaniel Tabit
Lead developer, public relations

EXECUTIVE SUMMARY



Discussion of research (date: April 1, 2015)



Screenshot from the VirtuaSpace VR app



Pilot testing of usability test (date: May 4, 2015)

VirtuaPlush came together in February 2015. We formed around the opportunity presented by HTC in the form of their mobile virtual reality (VR) project. The project within mobile VR was largely open-ended, but we quickly identified areas that we wanted to focus on.

VR is a quickly-growing field, due to a marked decrease in hardware costs and thanks to decades of previous research. However, in this crowded space, the focus has been creating a mind-blowing experience on hardware-heavy platforms like the Oculus Rift and Steam Vive.

Mobile VR operates off mobile phones, hence the name. We saw the vast opportunity that having a VR device in your pocket could provide. Although the capabilities of mobile VR are less than that

of other VR systems, mobile VR provides VR to a much-larger audience. The power of VR can reach more people with mobile VR.

VirtuaSpace, the final app created by VirtuaPlush, is an interactive mobile VR program built for Google Cardboard. It is a VR music visualizer that is set in an imagined space environment.

The production of VirtuaSpace fulfilled several key objectives for the VirtuaPlush team:

- 1) Develop mechanisms that are purpose-built for mobile VR and applicable to all VR
- 2) Validate our mechanisms by applying it in a marketable

app

- 3) Increase the prominence of mobile VR
- 4) Build a fun and exciting app or game
- 5) Create a project incorporating music

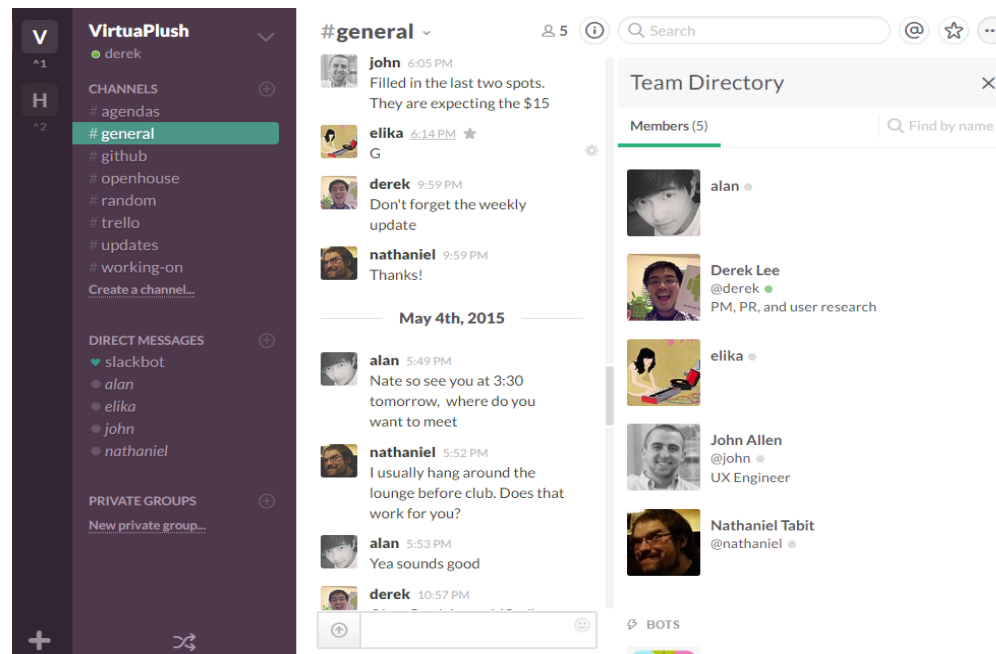
To this end, we created a robust framework for completing this project over the five month period of our capstone course. The work was divided into three stages: Research, Ideation/Design, and Development.

Each stage was capped off with a specific milestone relevant to the stage's content. This process book covers these stages and the process taken to complete them.

ORGANIZATION



ORGANIZATION



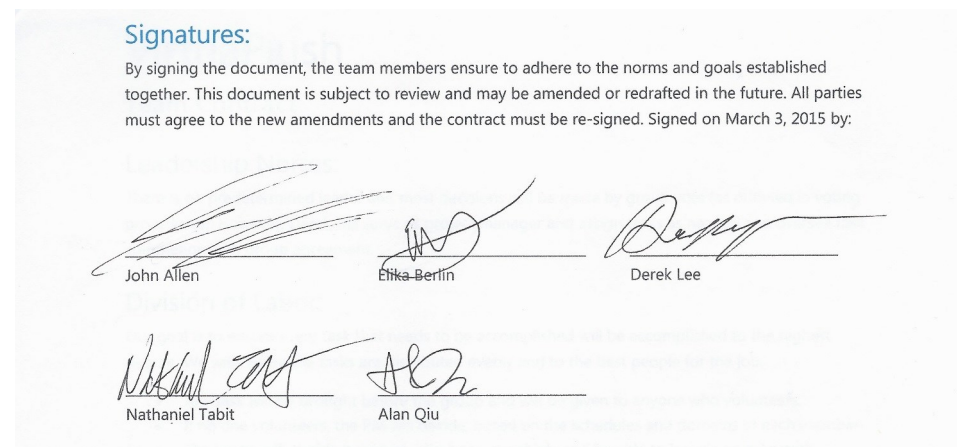
Slack message app

In order to perform at our best, we established various norms for our project. We set meeting times and establish a Slack configuration to keep communications. We drafted a team contract to keep everybody accountable to themselves and the rest of the team.

We quickly assembled timelines and proposals to set up our objectives for the five month project term.

We created several deliverables from this setting-up phase, including our project vision, work breakdown, timeline, and proposal.

We proposed three stages: Research, Ideation/Design, and Development.

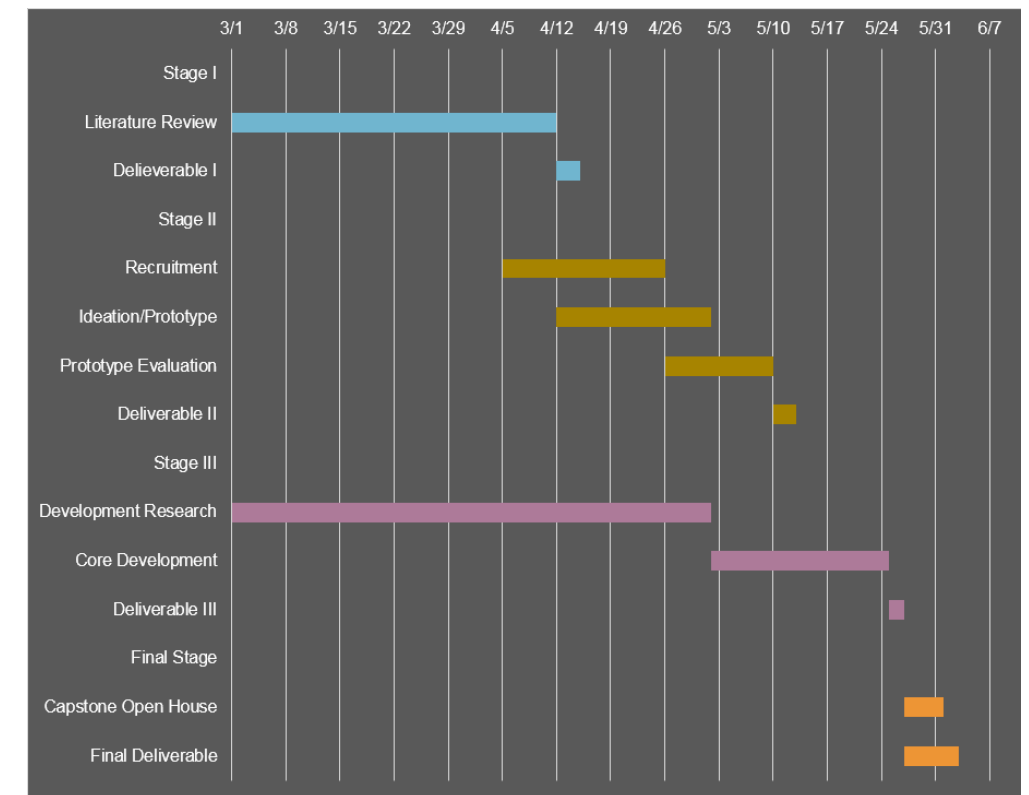


Team signatures on the contract

Stage I included our primary research into the world of mobile VR. Since we as a team did not have extensive knowledge about the world of VR, we needed to do a survey of current world of VR. From there, we found missing gaps in applying this knowledge to mobile VR, and finally wrote a paper about it.

Stage II took place once our paper was completed. From the gaps in mobile VR, we designed solutions and tested them on ourselves and on users. This rapid iterative cycle allowed us to be confident when moving to the finished app.

Stage III was our core development. It actually began at the same time as Stage I, and consisted of the developers configuring the programming environment and learning about the various platforms. Once Stage II finished, they began work



Gantt Chart for our project

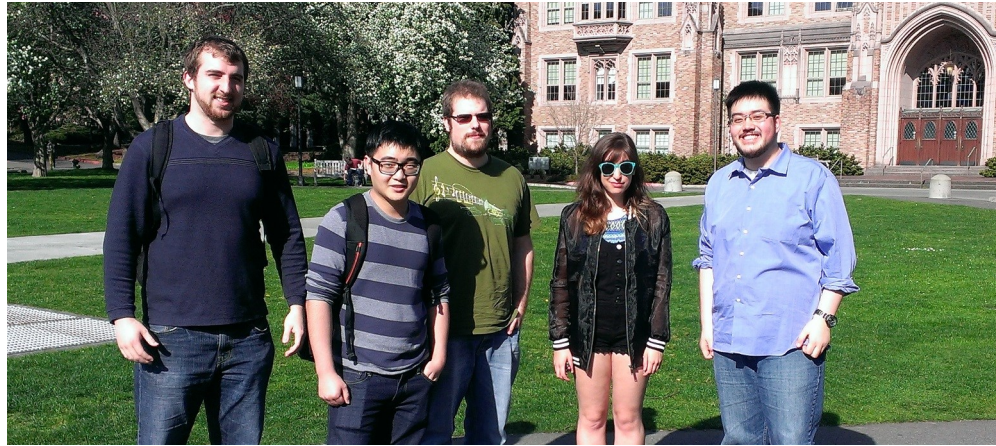
on the development of VirtuaSpace, incorporating the body of knowledge gained during Stages I and II.

A final, informal stage existed, and this was to complete deliverables associated with the course requirements, rather than with VirtuaSpace itself. This included preparations for the Human Centered Design and Engineering (HCDE) department Open House, the project poster, video, and this process book.

RESEARCH



STAGE I: RESEARCH

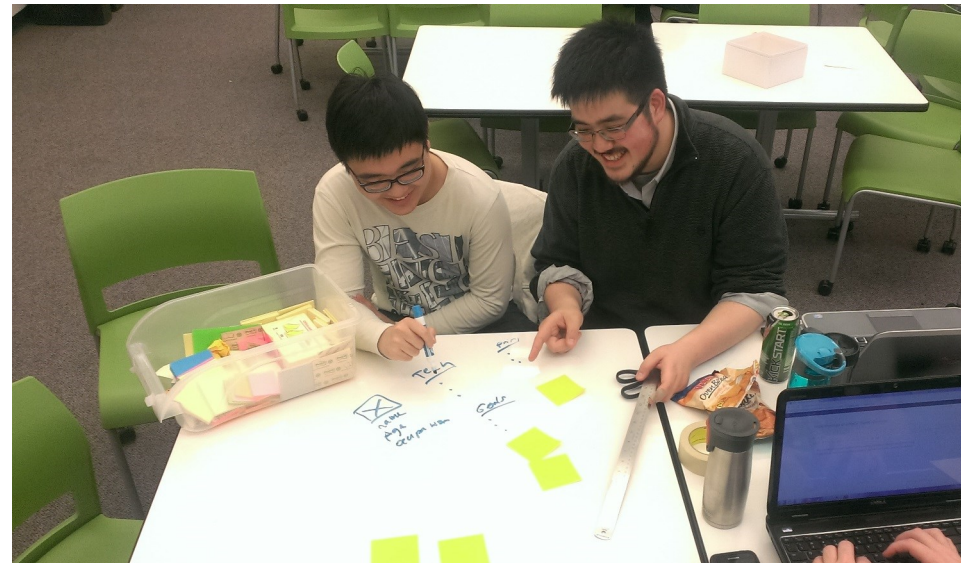


Team meeting (date: March 30, 2015)

Our research phase spanned six-and-a-half weeks, from our team kickoff date established on March 1, 2015 to April 14, 2015, the date of our research presentation. However, work began slowly, since we were still completing work from the previous quarter and had spring break travels.

Research involved reading literature on the VR space, specific research into mobile VR, conversations with prominent VR experts, analysis of the Google Cardboard, and competitive analysis of competing platforms and apps.

Our research brought us to the conclusion that indirect manipulation was the best path for our app. This terminology, contrasts with terminology found in the human-computer interaction (HCI) field. In HCI, indirect manipulation excludes



Content analysis of technical whitepaper (date: April 13, 2015)

pointer tools such as computer mice. However, as defined in a paper titled "Direct Manipulation in Virtual Reality", we defined indirect manipulation as "an object in the environment [that] responds to controls generated by manipulating other objects" [1]. Although this confused some of our reviewers, we proceeded with this terminology, as we felt it best set up our research information.

A similar concept to indirect manipulation is a widget. Also defined by Bryson, a widget is a tool that allows for indirect manipulation [1]. Using this concept, we were confident that we could find a proper interaction for the mobile VR problem-space.

Another key step that we took during this research phase was



Team meeting (date: April 6 2015)

to talk to Professor Thomas A. Furness III, of the University of Washington. Professor Furness is the 'Grandfather of VR', having pioneered the field in the 1970s and with five decades of experience spanning from the military, to the private sector, and academia.

We met with him in his personal lab on March 10, 2015 to discuss our capstone project and to point our research in the right direction.

Important to Professor Furness is the ability for VR to excite and engage people in a manner not possible in the real world. In particular, he opened us up to the world of music in VR, by demonstrating a research project. This project used augmented reality to control music in a captivating and intuitive way.

STAGE I: RESEARCH—TECHNICAL WHITEPAPER

VirtuaPlush

Whitepaper

Mobile virtual reality and music visualization

John Allen, Erika Berlin, Derek Lee, Nathaniel Tabit, Alan Qiu



To convey our claims, we developed a technical whitepaper. The technical whitepaper covered our research, but was not as extensive as a research paper. The strength of a whitepaper is its ability to condense a large amount of research into a package for readers that is purpose-built for persuasion.

Widgets serve as the key to VirtuaSpace and our research—they provided us with four key advantages over other possible solutions:

- 1) Lowered Learning Curves
- 2) Affordances
- 3) Visualization Grouping
- 4) Unchanging Spatial Position

Our whitepaper covers our relevant body of research to VirtuaSpace and presents three major points to the direction of our project:

Relevance of Mobile VR

Our sources argued that mobile phones are highly capable of delivering VR, stating that “the emphasis on smartphone VR is not altogether surprising, given that most of the ingredients to turn your phone into a virtual reality wonderland are already

there;”[2] smartphones have enough processing power, an accelerometer and compass for head-tracking, and generally have good screens. In fact, Ed Tang, founder and Chief Strategy Officer at Avegant, stated that “if you want a short-term, really high uptick in VR, the phone is the way to do it,”[2] given the wide distribution of smartphones and the cost accessibility of cardboard and plastic VR phone containers.

Therefore, initially incorporating VR with a mobile platform is the method of choice for fulfilling the VR industry’s top goal: engaging the mass general public with VR.

Indirect Manipulation

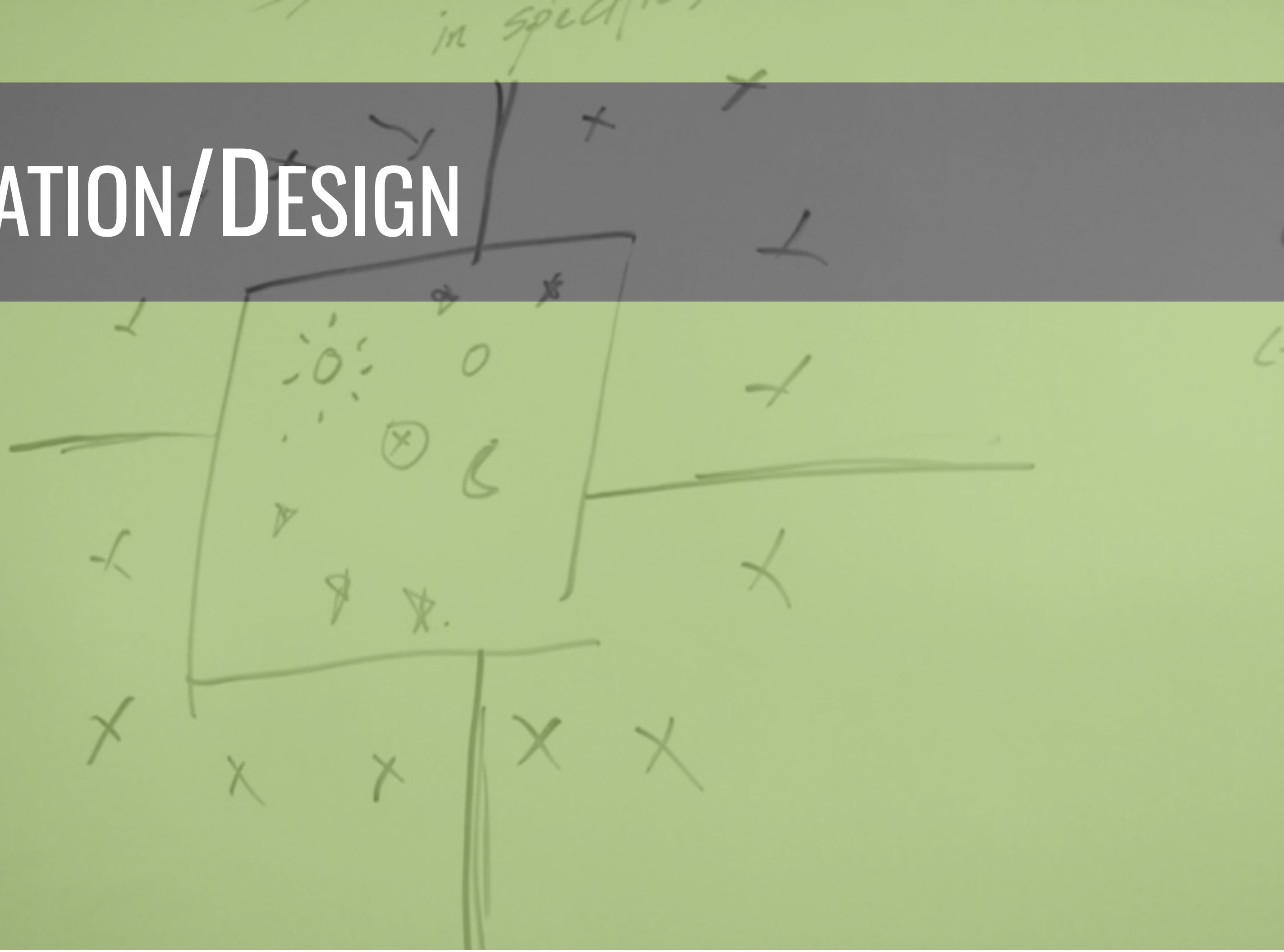
As previously discussed, indirect manipulation provides the most promising mode of interaction for mobile VR, given the platform’s lack of support for additional controllers and input modules.

Music Visualization

Music visualization provides an environment that properly fits our use-case of short-term VR use with mobile VR. Music visualization is a captivating and immersive application of VR technology and opens up the possibility to being a tool for calming users down or getting them excited.

Technical whitepaper cover page

IDEATION/DESIGN



STAGE II: IDEATION/DESIGN



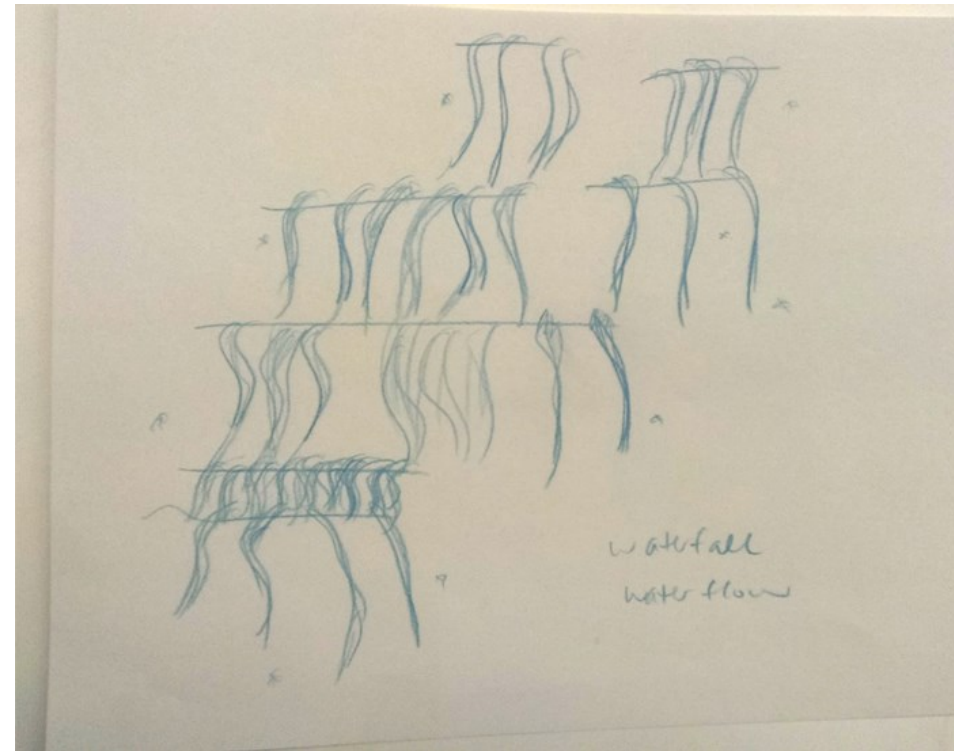
Widget designs (date: April 15, 2015)

The main topic of Stage II is our prototyping and ideation phase. At the end of Stage II, we had no formal deliverable, unlike the whitepaper for Stage I.

Stage II took place from April 14, 2015 to May 11, 2015. We had several key meetings and ideation sessions to design the VR environment, interaction methods, and usability tests.

Our focus during this phase was to create and refine the design of our VR final product. Using the knowledge gained during the research we made during Milestone #1, we solidified designs, then moved to evaluate those designs.

During our semi-weekly meetings, we created several designs for interaction, then performed usability tests on these designs. We also created designs for our environment and the general

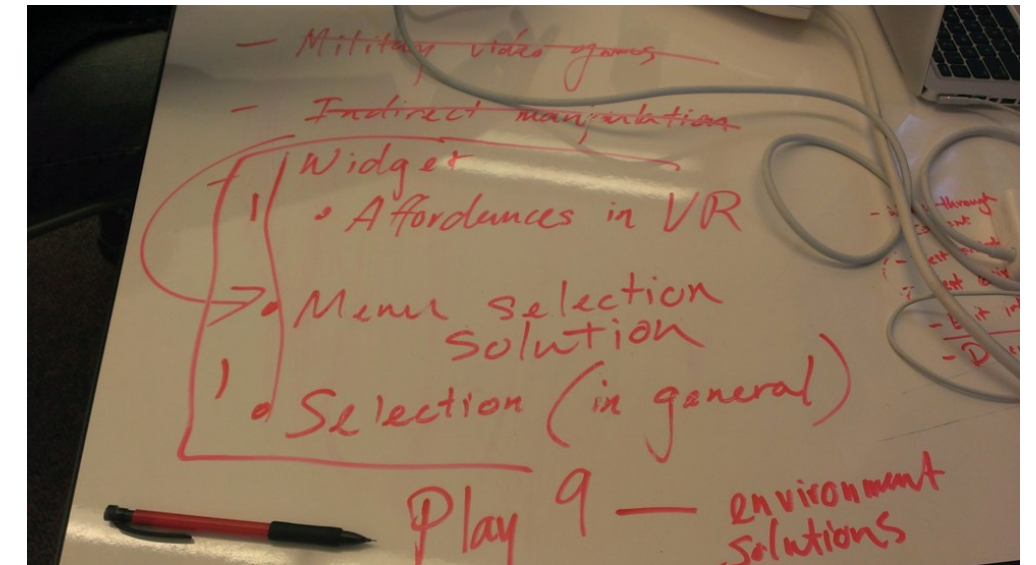


Waterfall environment design (date: April 15, 2015)

maneuverability in the environment. We brainstormed space, underwater, and poolside locations as possible, but space won out, due to its uniqueness (unlike poolside, which we had seen some examples of), and ease of programming (unlike underwater, which involved vision distortion due to refraction).

Having settled on the basic design and overview, we were able to begin the division of work, in anticipation of Stage III, our development phase. Our developers were able to begin work on the VR space environment, as the designers and testers were able to begin work on the interaction methods.

Our major focus during this phase was our efforts to design a new and usable form of indirect manipulation in VR. As the form-factor of mobile VR and Google Cardboard was a major



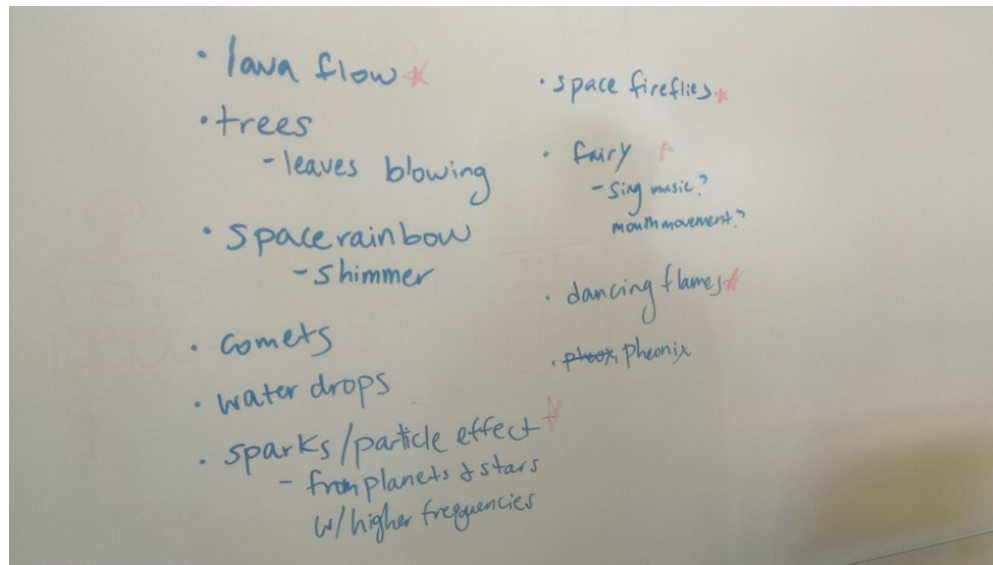
Discussion of widget definitions (date: April 15, 2015)

factor to the success of our project, we spent a lot of time on getting the indirect manipulation aspect right.

We attempted to create an expandable methodology to interact with objects in a mobile VR space. The goal would be to create an interaction method that could be scaled up to multiple interaction uses, including (but not limited to) state changes, movement, selection, and manipulation.

We began brainstorming interaction methods and exploring different environments and methods for testing and showcasing our proposed solutions. We explored a multitude of interaction methods, but settled on the two we thought could best solve the issues. This is based on the data that has come through our research regarding indirect manipulation in a mobile VR space.

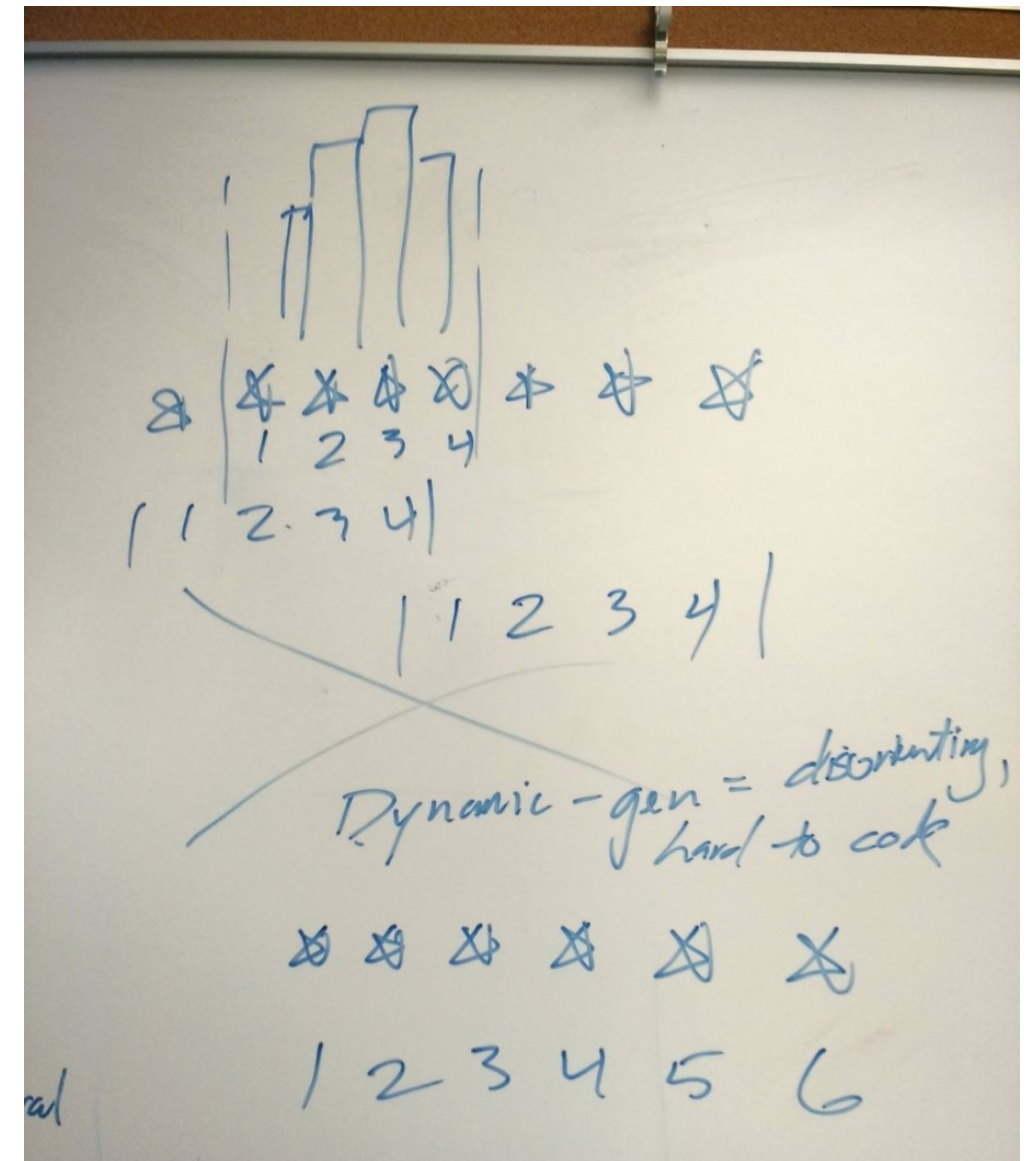
STAGE II: IDEATION/DESIGN—ENVIRONMENT DESIGN



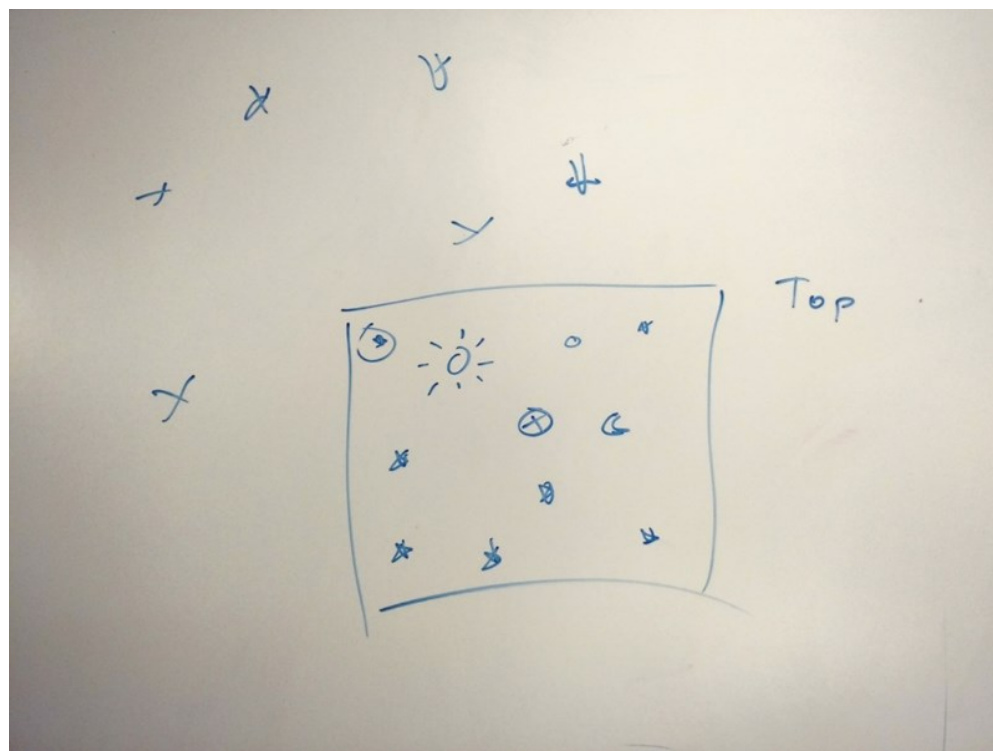
Potential visualization choices (date: April 15, 2015)



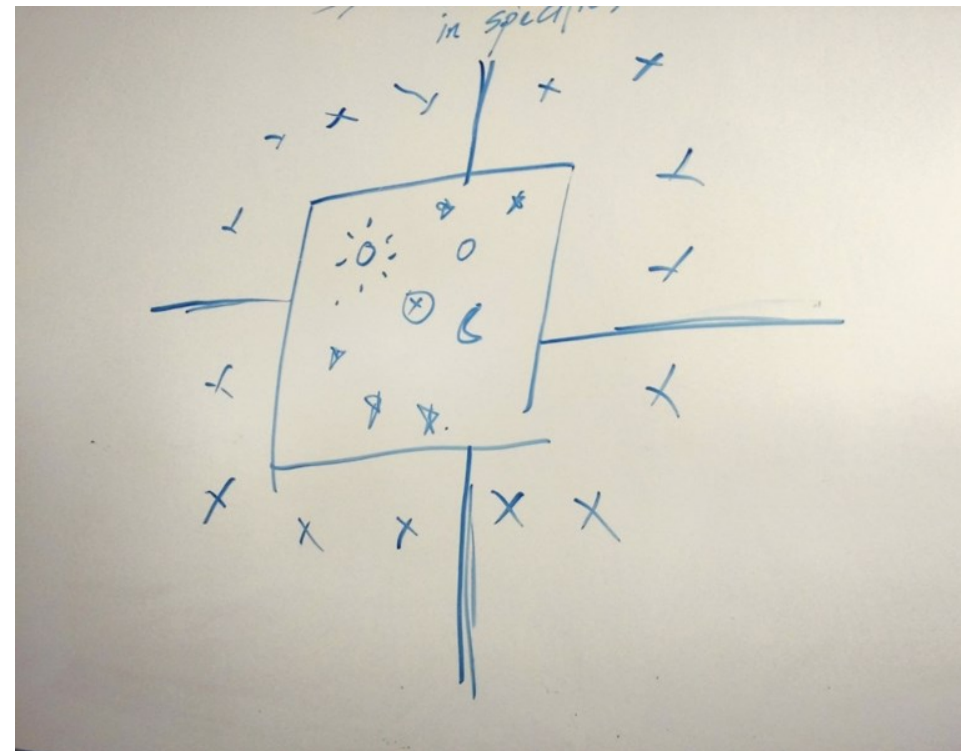
Sketches of proposed visualizations (date: April 15, 2015)



Layout discussion for creating the music visualizer (dynamic generation means it adjusts the visualization based on head-bearing)

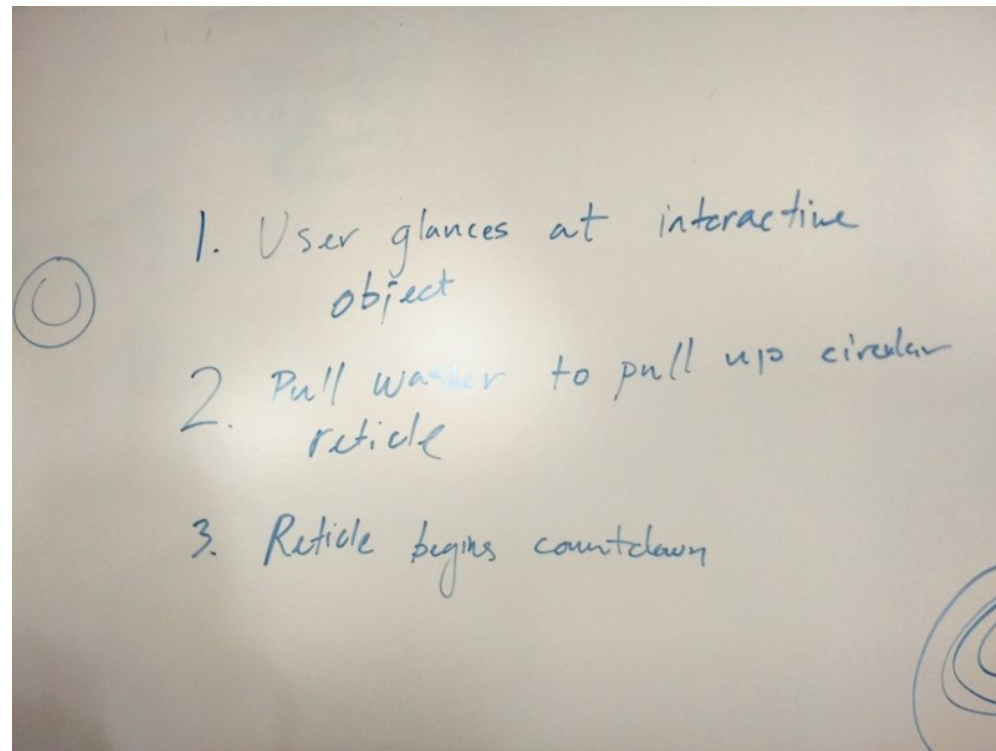


Top-view diagram of the VR space, using the space environment theme (date: April 20, 2015)



Creating a grid design was critical to setting up how the environment allowed for the music visualization in a circular pattern (date: April 20, 2015)

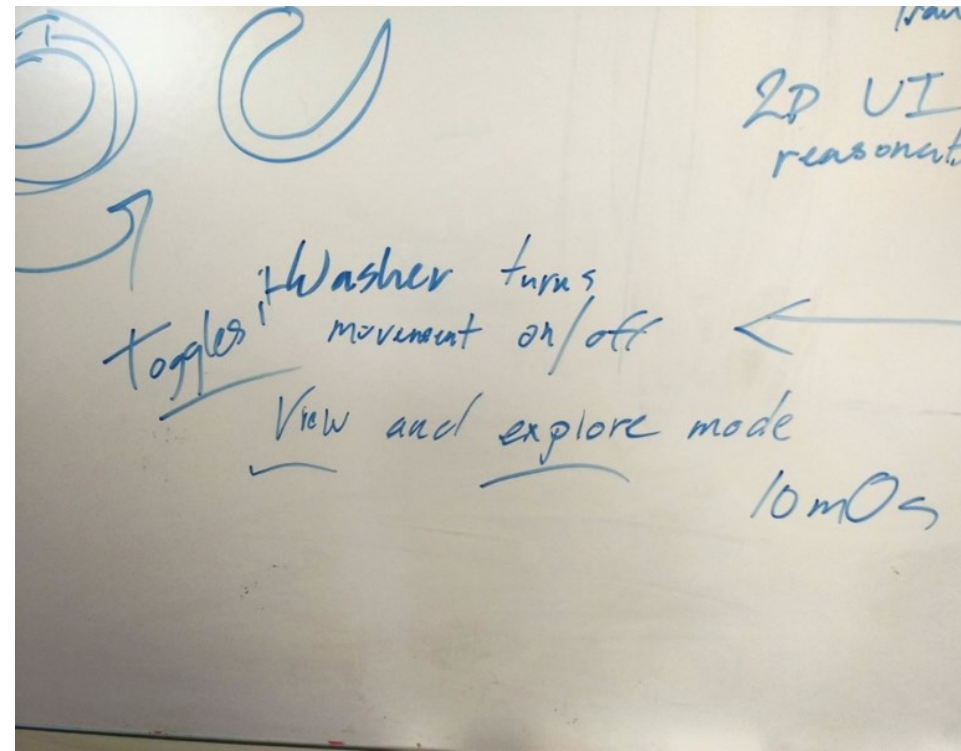
STAGE II: IDEATION/DESIGN—GLANCE AND CLICK



Glance interaction conceptualization (date: April 20, 2015)

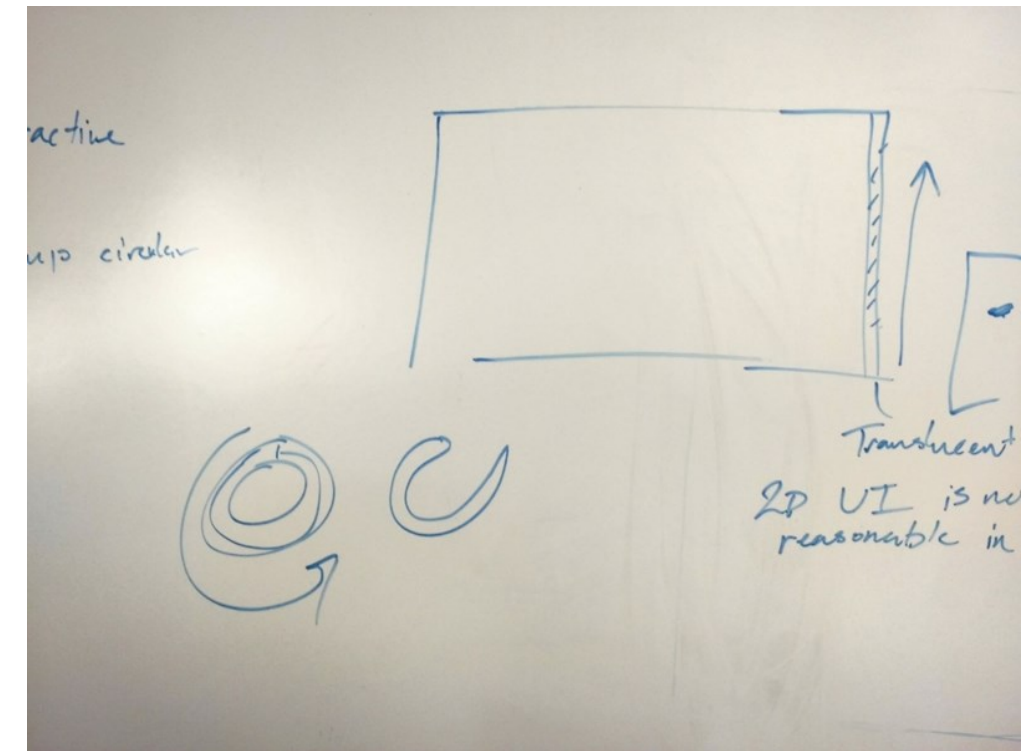
We have termed the first interaction method as 'Click'. Using the Google Cardboard washer, users simply click the washer to move the location that their view is focused on. We believe this could be a powerful solution because of method's instant response time and familiarity to users.

Our second proposed solution is termed as 'glance'. Glance maps the button to a toggle that controls two settings, explore and observe. The two settings determine which actions are possible. Under glance, users simply look at an object for a set period of time to move to or select an object. Our design uses a reticle above objects to show the time remaining until selection. During explore mode, users can move by simply looking at an object for the set time. In observe mode, movement is locked and users are

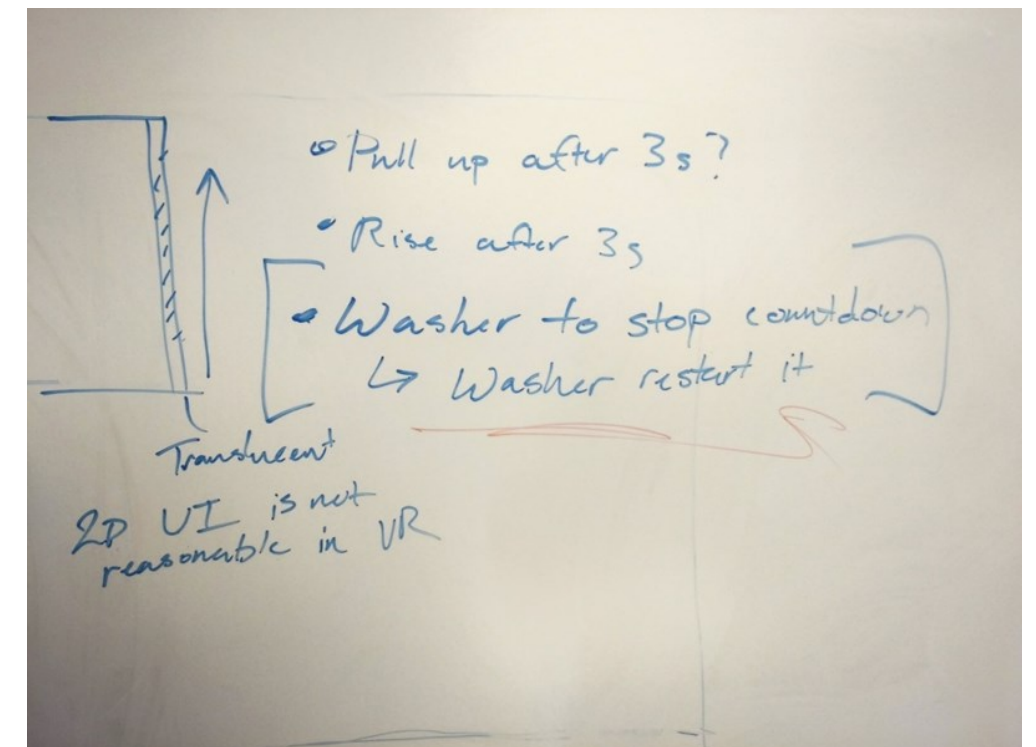


Toggle modes (date: April 20, 2015)

free to look around without having the countdown reticles appear or inadvertently moving to a new location. This interaction method is powerful because it allows for seamless interaction without constantly using the physical button.

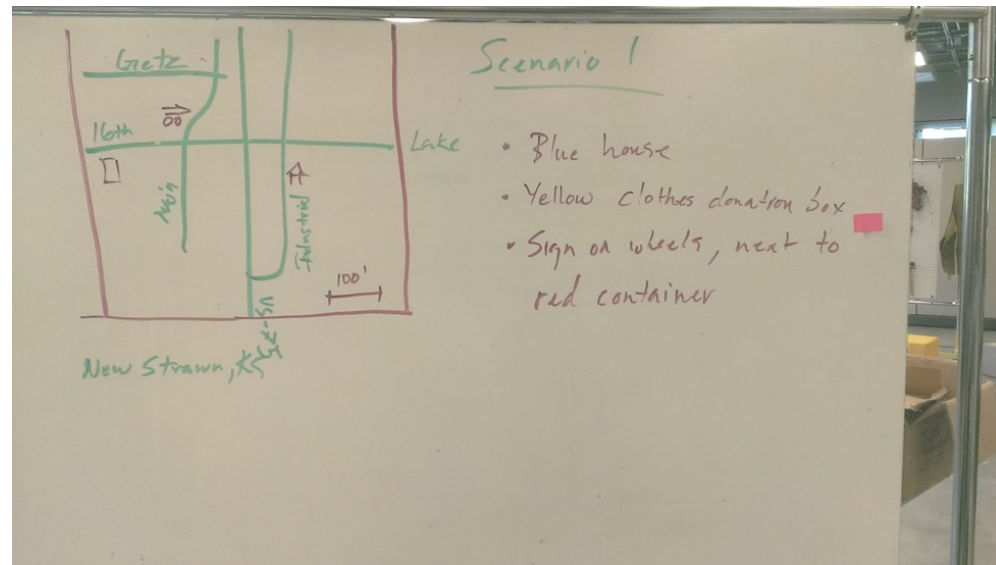


Reticle design options (date: April 20, 2015)

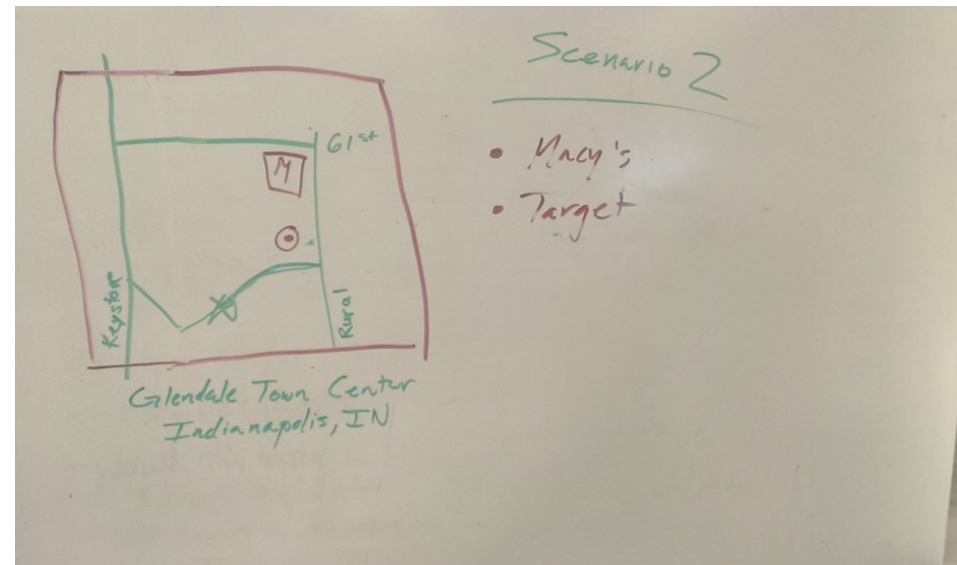


Timing options (date: April 20, 2015)

STAGE II: IDEATION/DESIGN—USABILITY TESTING



Scenario 1 setting map (date: April 26, 2015)



Scenario 2 setting map (date: April 26, 2015)



Pilot test (date: May 4, 2015)

To evaluate the Click method, we explored simulating our interaction methods in both physical and virtual environments. Constructing a virtual environment for interaction testing would have been too time-consuming for designing and iteration—too much time would have been wasted building a mere option for interaction. By creating a rough prototype, we were able to properly limit user interactions and simulate a virtual environment space using Google Maps Street View and a laser pointer to track head movement.

During the test, the participant was seated at a table facing a large screen with Google Maps Street View up. We provided them with a modified Google Cardboard device with a laser pointer attached to it, and the phone holder removed. We instructed the

participant through a set of tasks while looking through the device as if they were using a real mobile virtual reality device. The test was recorded by two cameras, one in front of the participant to record their facial reactions and a second behind them to record their interactions with the virtual reality space.

As the users' heads moved across the Street View screen, the view adjusted based on head movement, following the laser pointer's movements. The Click action was responded with a movement to where the laser pointer was directed. All of this contributed to the Wizard of Oz-style prototyping method, of creating a "VR setting" without actually having to develop it.

We had initially planned on testing the glance method during this round of usability testing, but during pilot testing, we

discovered that our methodology would not be compatible with it. The operator's actions were too slow to suspend the user's state of belief—constantly having the reticle appear and countdown before movement was too taxing and did not happen instantaneously.

STAGE II: IDEATION/DESIGN—USABILITY TESTING



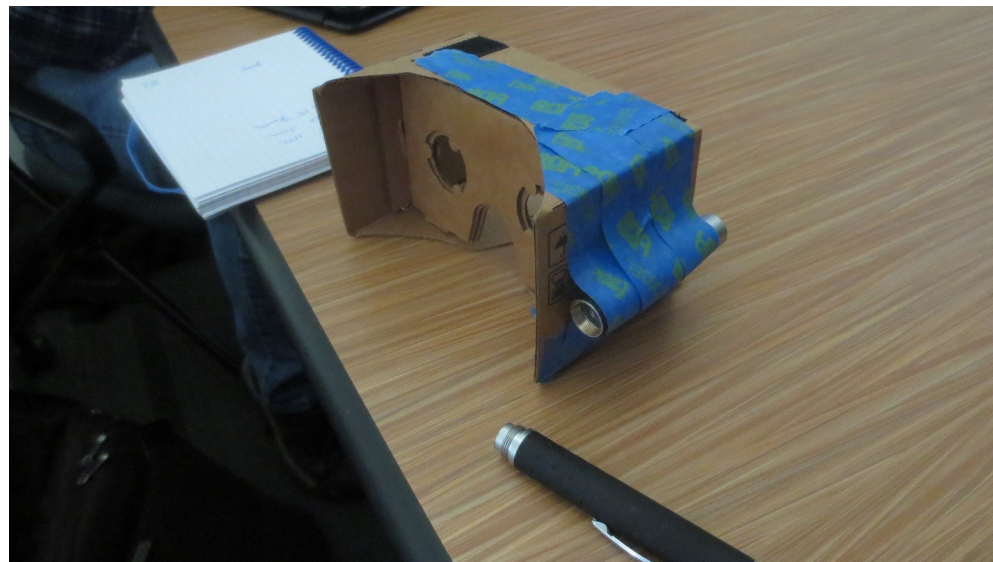
Wizard of Oz usability test (date: May 6, 2015)



Participant evaluating Click method (date: May 6, 2015)



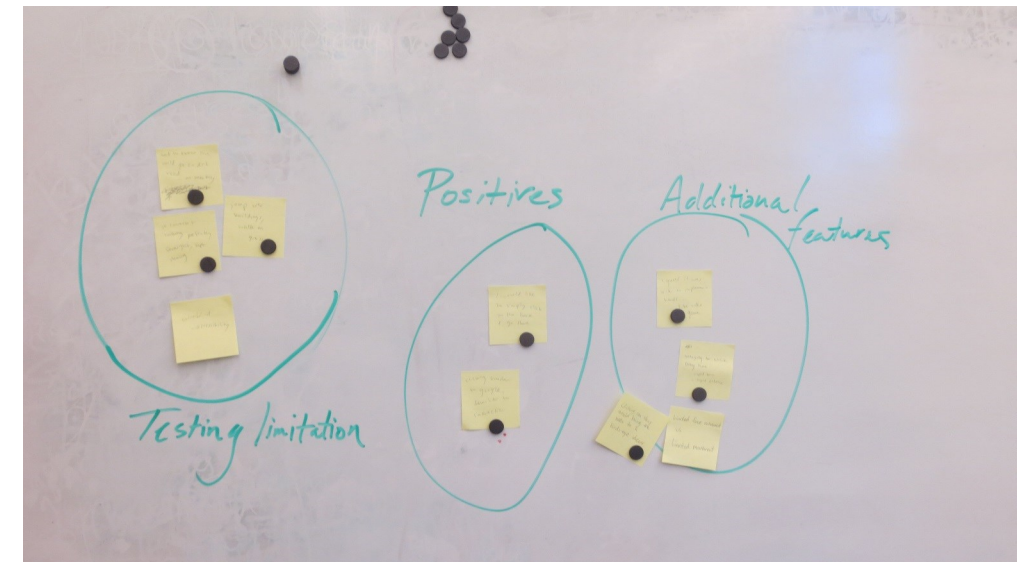
Nathaniel as moderator (date: May 6, 2015)



Cardboard holder with laser attachment (date: May 6, 2015)



Object with laser point for head tracking (date: May 6, 2015)



Post-test affinity diagramming (date: May 6, 2015)

STAGE II: IDEATION/DESIGN—FINDINGS



Click, as it appeared during the usability tests

With the Click interaction, we discovered two major findings with our first method:

- Participants were susceptible to getting lost after clicking to move.

We deemed that if we showed a marker to where the participant was selecting we would be able to ensure that they knew where they were going to end up and if we were to slow down the transitions they would be able to follow their path and lower the risks of becoming lost in their virtual reality space.

- Choosing a location to move to could be imprecise

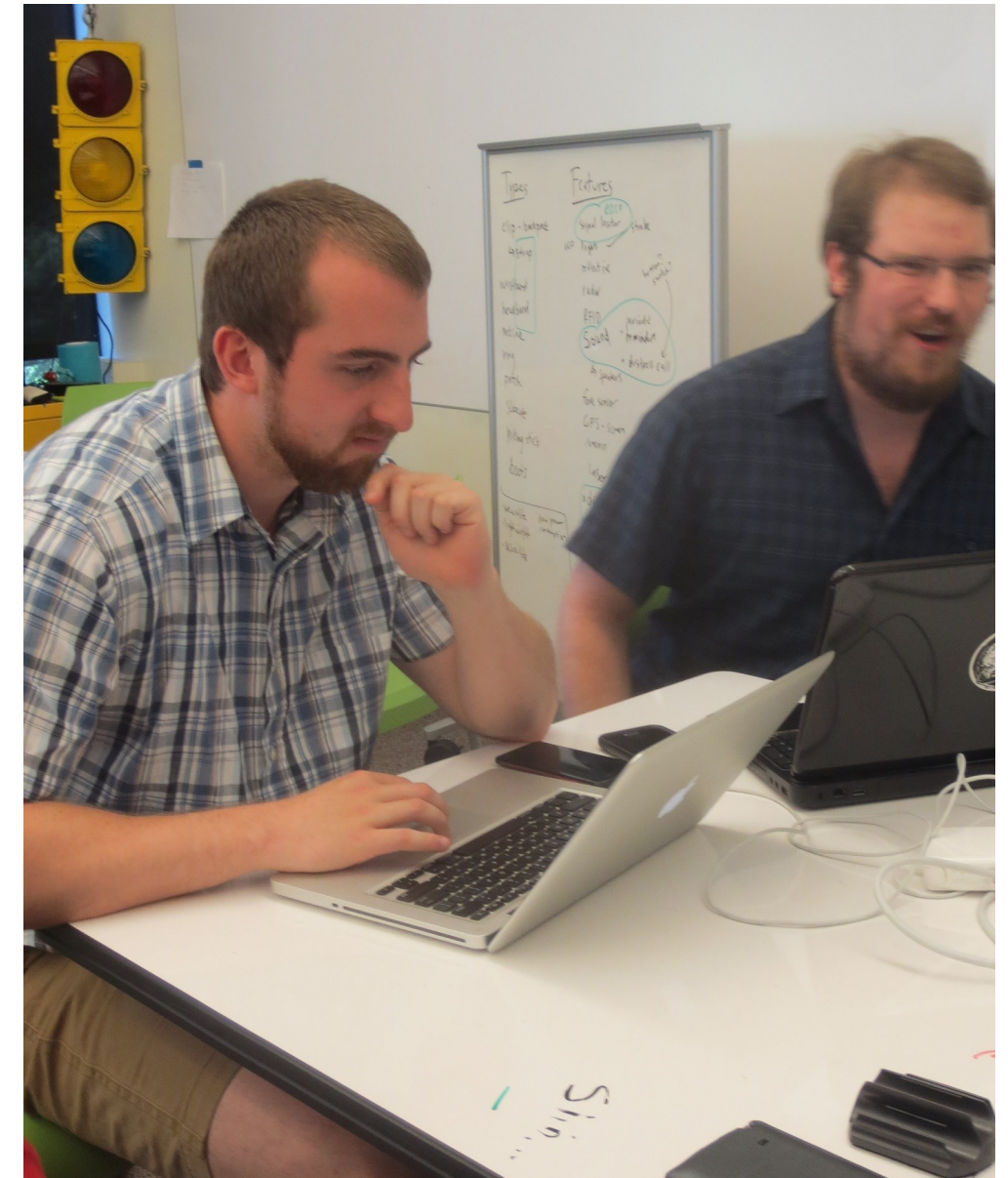
During one instance, we had a user try to make a movement, but the location of where he was looking was further than he



Proposed changes to Click

intended. The vanishing horizon affected how precisely he could move. What this means for us is that there can only be a “limited free movement”. Limited free movement allows for free movement throughout the VR space, but is limited by the open area—in this case, we will be only allowing movement between objects.

- Need markers to show where users will travel to (show endpoint)
- Need transitions to be slower so users can follow their path (minimize chance of becoming lost)



Usability test preparations (date: May 4, 2015)

DEVELOPMENT



STAGE III: DEVELOPMENT



Development status meeting (date: May 11, 2015)



Development discussion (date: May 11, 2015)



Demo of early-build of VirtuaSpace (date: May 18, 2015)

Milestone #3 represents the culmination of our third and final project stage. Stage III, Implementation focuses solely on our virtual reality app, VirtuaSpace. It took place between May 11, 2015 and June 1, 2015.

VirtuaSpace by VirtuaPlush is our musical visualization VR app on Google Cardboard. The app has an imagined outer space theme. The app is available as an .apk file and may be installed on Android phones running Jellybean 4.2.2 or higher. It was developed in the Unity physics engine.

Our implementation and development was spearheaded by our two developers, Nathaniel and Alan, with logistical support from PM Derek. Nathaniel was head developer, and was responsible for setting up the development environment. Alan was involved

in the previous stages by both contributing to the whitepaper and being heavy in the interaction design, so he joined Nathaniel once Milestone #2 was completed. Derek set up several services to keep track of development, including a Trello board for project tracking and WorkingOn for micro status updates. Following the completion of Stage II, Nathaniel and Alan focused on building the app.

The first task of Stage III was the research and configuration of the development environment for VirtuaSpace. The development research task coincided with Stage I, our research phase, spanning nine weeks through the end of the design phase of Stage II, our ideation and design phase.

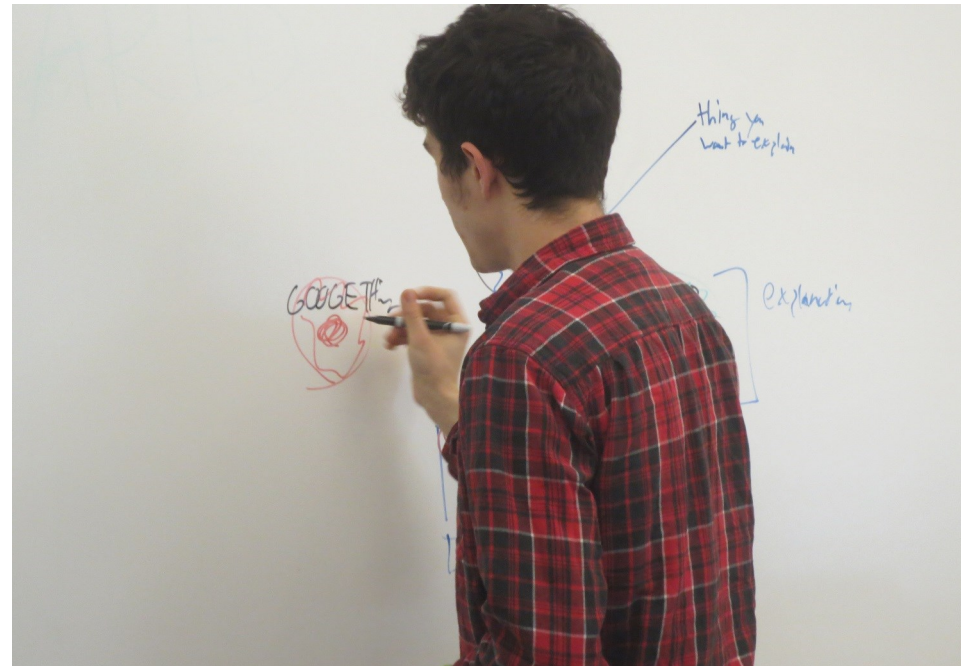
Led by head developer Nathaniel, we researched virtual reality

and interactions while researching information about how to develop for Google Cardboard. Thanks to some pointers in the right direction by our sponsor HTC, we set about setting up our programming environment in the Unity game engine and read up on the Google Cardboard SDK documentation.

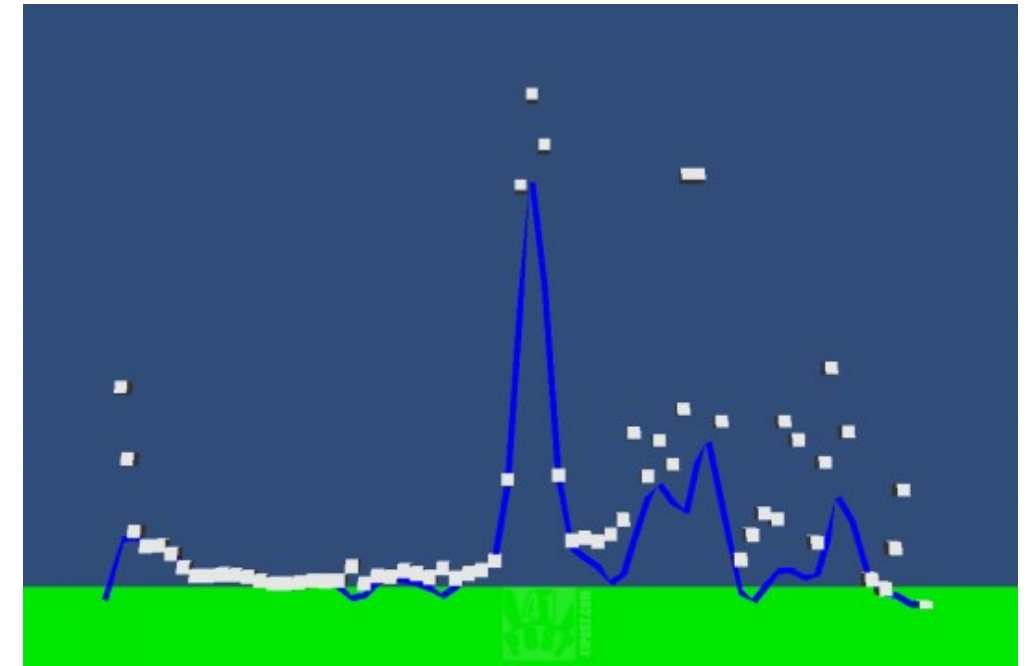
STAGE III: DEVELOPMENT—RESEARCH



Development meeting (date: May 18, 2015)



Some help from Dani Sandoval (date: May 18, 2015)



Simple music visualization waveform screenshot

To run the app, we needed a game engine to provide the basic framework of it. Game engines provide the core functionality for interactive digital programs, including graphic rendering, sound, and realistic physics among other things.

The Unity engine was a simple choice for our development. Nathaniel's previous experience with the engine was a key factor, as well as the engine's straightforwardness and robust community and documentation. Other engines, like the Unreal engine, were deemed more difficult to use and to have much steeper learning curves than Unity. Furthermore, our discussion with Professor Furness led to him independently advocating Unity as our game engine.

Configuring Unity was straightforward. Unity Personal is free for

use in apps when the developer generates less than \$100,000 per year from the Unity-based app [3], which applies to our team members and to VirtuaSpace. Nathaniel already had Unity Personal configured and was able to simply adjust settings for use with VirtuaSpace.

Given our team's relative inexperience with the Unity game engine, finding community help and documentation was important. At the University of Washington, we found the Game Dev Club. The Game Dev Club is a student organization on campus that met on Tuesdays [4] during our development. Nathaniel and Alan attended these meetings with other students who have a passion for game development. Although none of them had programmed for Google Cardboard or

virtual reality, we were able to go to them for pointers and tips for Unity.

The music visualizer required a good amount of programming research. Music visualization in Unity had been done previously, but the how-to guides and documentation were sparse. Eventually, we found the function that would make the visualization possible: `getSpectrumData`. However, there were no available examples of programs that used this function and it was unclear how to use it.

Around week 3, Nathaniel found a blog about building waveform music visualizers in Unity [5]. This post from 2012 helped us to build a simple waveform within a week. From there, we had the tools to get the basic audio-to-movement translation done.

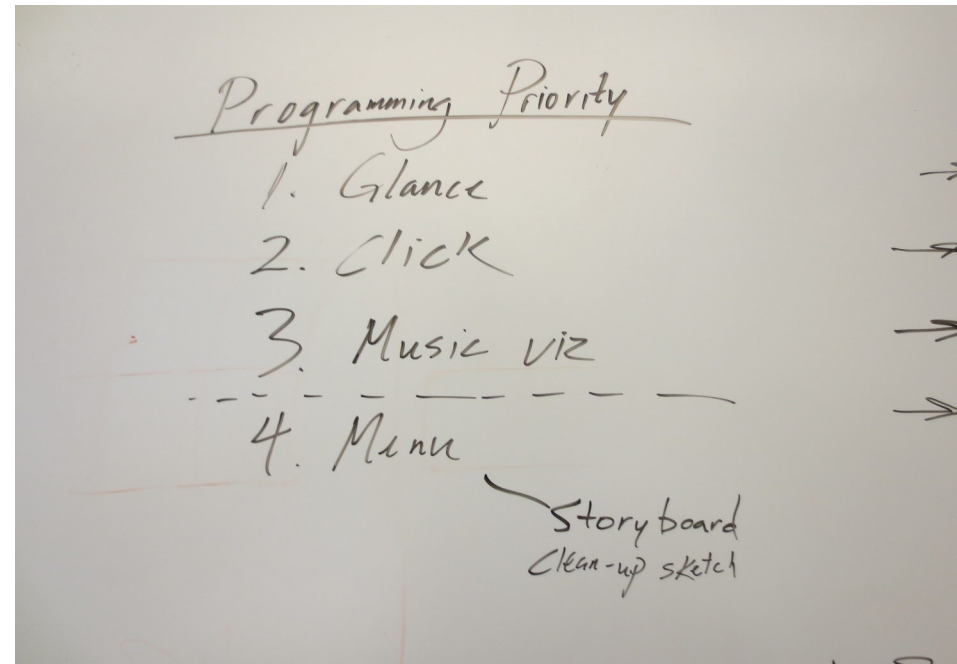
STAGE III: DEVELOPMENT—MENU



Screenshot from Harmonix demo video

During our Stage II Ideation/Design, we discussed the idea of a menu over movement. Our Click and Glance interactions would have easily worked with menus, menu navigation, and selection mechanisms. Menus navigation is complex and is highly applicable to all VR apps. Initial plans included menu navigation, with the menu being pulled up when the user moved their heads down; looking down is a weak spot in VR, as it can induce motion sickness, as covered by Harmonix in their demo video and discussed in our whitepaper.

However, the decision of movement over menu navigation for development by VirtuaPlush in VirtuaSpace came down to the time to develop a menu navigation, the relative lack of excitement a menu would have compared to movement in an

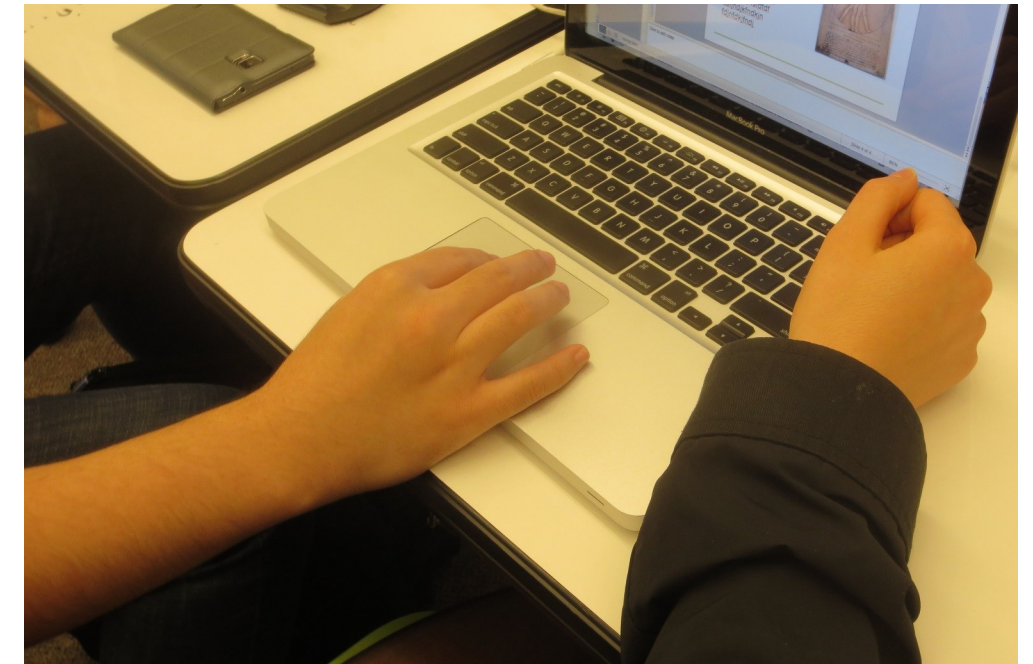


Prioritization of development (date: May 18, 2015)

app, and the fact that VirtuaSpace is a proof-of-concept.

A menu navigation system required much more programming time and resources than what we had available. As Nathaniel completed his programming research, he concluded that designing a menu user interface (UI), creating a fake app to have the menu overlain, and information architecting the hierarchy and submenus, in addition to the work needed for movement-based app would have been too much additional work for the month allotted for core development.

Furthermore, creating an app whose focus was on menu navigation, would not have been interesting for the user or our team. In keeping with our music visualization theme, we envisioned that the most interesting way to implement menus



Design work (date: May 27, 2015)

would be to have a menu that allows users to change the music and adjust settings like music volume, visualization intensity, visualization colors, etc. Developing this simple visualization may have been okay for our team, but we would not have a particularly interesting app for users. We felt that building an app that consisted entirely of moving between menu options would betray the ability that VR has to engage and excite users.

We considered developing both the movement and the menu navigation, but given the amount of work required for menus, we put it as a lower-priority item. Instead, we felt that since Glance and Click could easily be used for developing menus, we needed an exciting movement-based app to demonstrate the utility of Glance and Click for mobile VR.

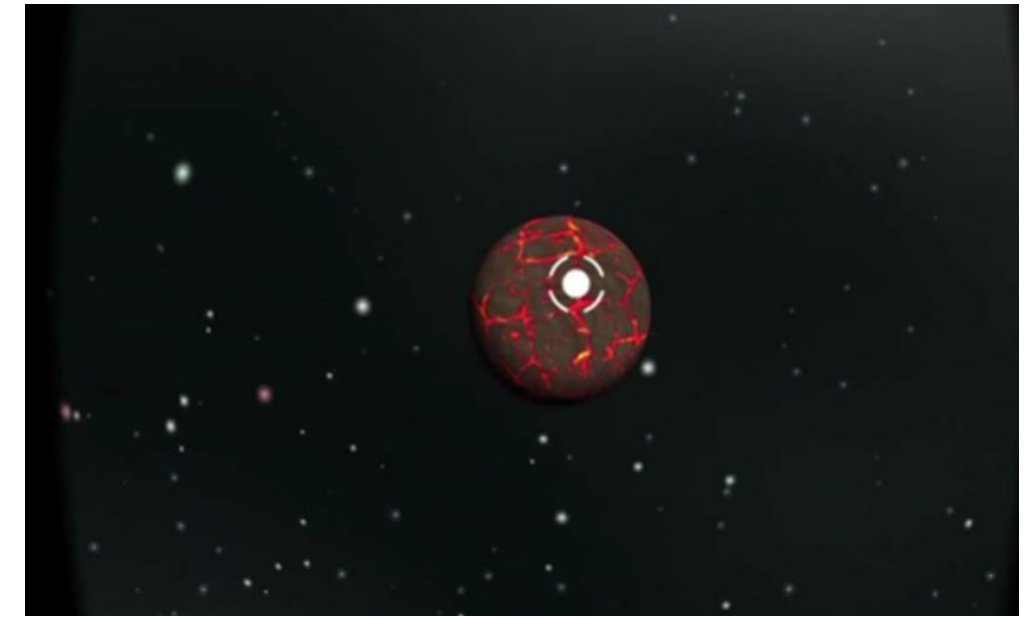
STAGE III: DEVELOPMENT—GLANCE



Circular timer reticle design (conceptual)



Empty crosshair reticle



Filling crosshair reticle

Glance was our top priority for development. We decided that since we were unable to test Glance using our Wizard of Oz methods that we used for Click and that we didn't have enough time to create a different prototyping method for Glance, VirtuaSpace would serve as our testing method for Glance.

Glance works with a UI reticle that appears on-screen during the Explore mode. When the user's view direction moves and the reticle moves over an object that can be interacted with, the reticle begins to countdown. Once the countdown is complete, the action takes place (in VirtuaSpace, this is movement to that object). The washer interaction on the Google Cardboard switches between Explore and Observe mode. Explore mode allows for this interaction. Observe turns off interaction and the

UI reticle, which allows users to look around in their environment without inadvertently moving to a new location.

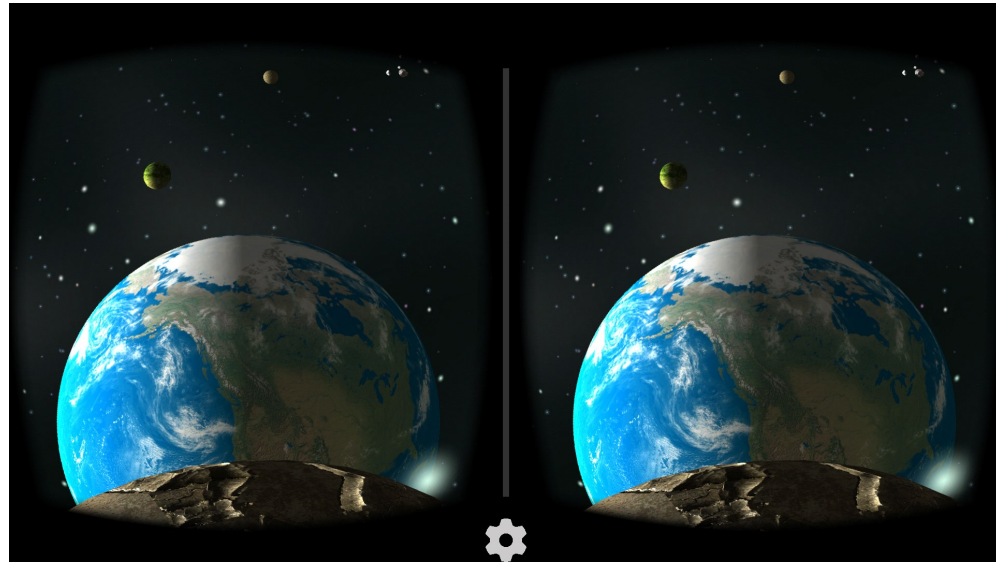
Our initial designs during Stage II had the reticle as color-changing based on whether it was over an object that could be interacted with. When it was not over an interactive object (and the reticle was not counting down), it would be blue. When the reticle moved to an interactive object, it would become red and begin the countdown.

Ad hoc testing uncovered that this color-changing reticle solution would not work. Users thought it was ugly and intrusive—the reticle was too salient for the environment and was distracting. Furthermore, it worked in our space environment, but relying on color was not good practice for

inclusive design (colorblindness) and was not universal (it worked in space, but would not easily translate to other environments or menu navigation).

Instead, Alan decided to try a crosshairs reticle. Inspired by the video game analogy that we had uncovered during the usability testing of the Click method, the crosshairs were a success. When not over an interactive object, the crosshairs do not distract users. Unlike the large circular countdown timer, it has less occlusion. As the reticle counts down, the crosshairs fill from the center. It is a gentler action than a countdown revolution and is more visually appealing.

STAGE III: DEVELOPMENT—ENVIRONMENT

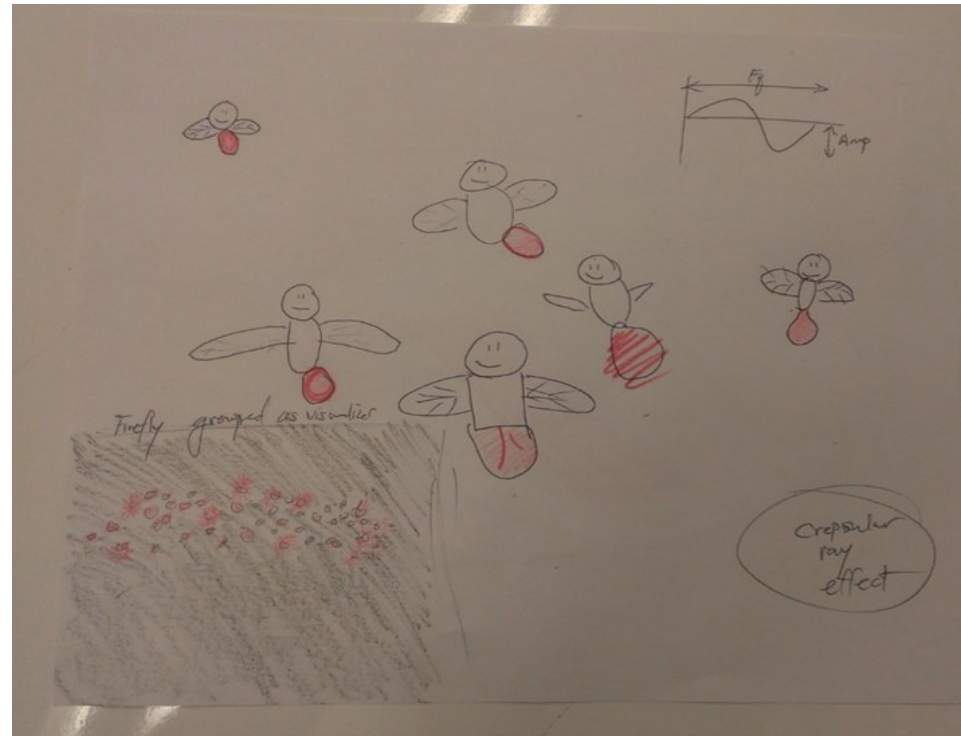


Earth representation in VirtuaSpace

As soon as we completed our environment ideation in Stage II and chose the space environment, Alan and Nathaniel got down to building the environment in Unity. The space environment was relatively simple, conceptually speaking. In Unity it is spheres (the planets) in a skybox (the space environment) with gravity effects removed (to prevent the planets from falling).

This simplicity allowed us to add flourishes that added to the realism to VirtuaSpace. We were able to add planet rotation and focus on the music visualizer setup during development.

Our current version of VirtuaSpace includes a representation of planet Earth. This introduced an interesting issue during the ad hoc testing we performed while developing and at the HCDE Open House: users wanted to explore the Earth more. Users

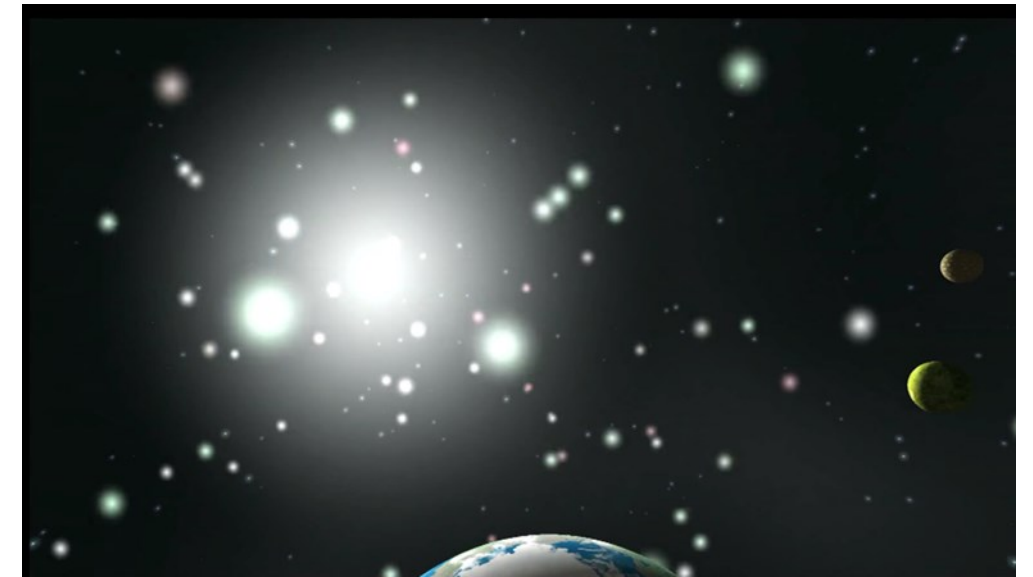


Firefly environment design (date: April 15, 2015)

were disappointed by the inability to do more on Earth than simply be located on the North Pole. Although exploring the Earth was an interesting feature that we would like to implement, it would require a new series of movements and it is a bit outside the scope of our project. Future iterations would have us figuring out how to make this a possibility.

From our design and ideations in Stage II, our 'firefly' design for the music visualizer was our chosen idea. The firefly design entails free-floating fireflies that twinkle to the beat of the music. Using the firefly metaphor allows a mechanism for them to move with the view (azimuth and elevation) of the user.

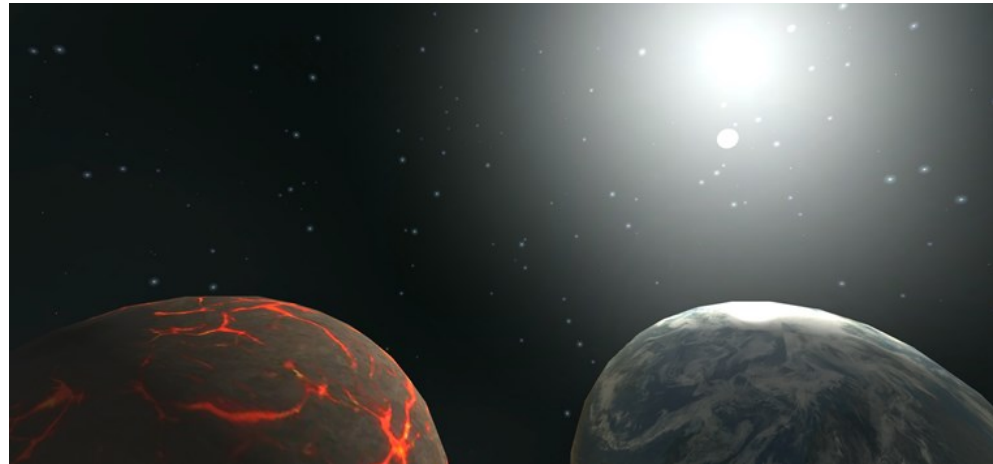
Since fireflies don't exist in space, we translated the idea to twinkling distant stars. Since stars will exist in any direction one



Twinkling stars pattern

looks at in space, we came up with the stars "moving" because other stars are being highlighted as the view changes. That being said, the view does not change that much—they're designed as free-floating particles.

STAGE III: DEVELOPMENT—MUSIC VISUALIZATION AND CLICK

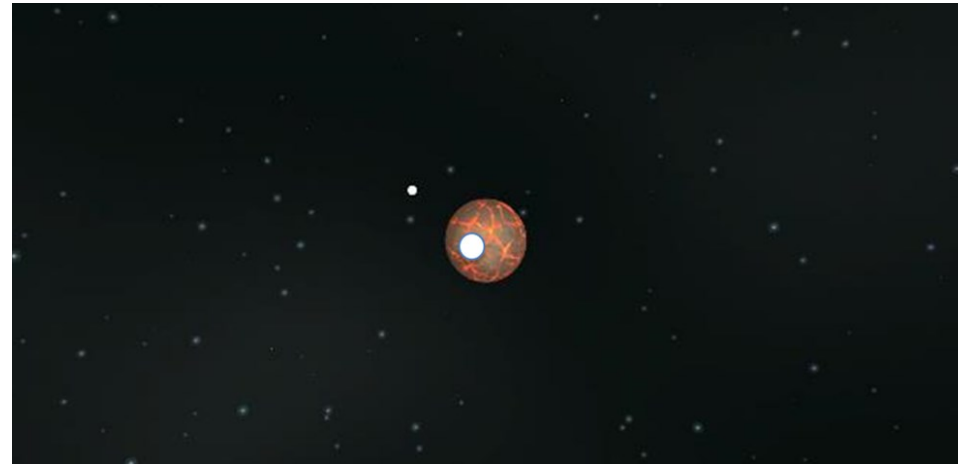


Space environment design

The music visualization blog post that Nathaniel found during the development research phase made developing the music visualization mapping straightforward while developing VirtuaSpace.

In order to create the firefly in space effect, Nathaniel devised an algorithm that provided, what we've termed, limited-free and partially-random movement. The twinkling stars float around in a controlled view space (the user's view), but have a limited range of motion, as to prevent stars from moving too much and being distracting. Furthermore, the movement is random, but weighted against the user's head movements—the stars move randomly, but are highly influenced by the user's view.

Nathaniel devised this algorithm by using the RootMeanSquare



Click design (conceptual)

calculation function on the sum of music playing. The music is fed into VirtuaSpace in bits, and VirtuaSpace sorts the bits into a float array of samples. Numbers representing each bit comprises the float array, and these numbers are then used to make the visualization dynamic.

In order to create the movement ability for Glance, we had to first develop Click. Developmentally, Glance is simply an automated version of click, with an added reticle and toggle between Explore and Observe mode. Point-to-point movement is common between Glance and Click, and this required some clever programming.

Since VirtuaSpace is built for Google Cardboard, we took



VirtuaSpace start screen

advantage of the Google Cardboard Software Development Kit (SDK). This SDK gave us the tools to take VirtuaSpace from the Unity game engine and make it usable with VR.

The Google Cardboard SDK has its reticle framework that maps a cursor or reticle to the programmed environment. Unfortunately, this method that the SDK provided was broken. In response, we had to develop our own selection methodology. Alan was able to do this himself, using a concept called ray casting.

PRESENTATION

Approach for an Out of This World Context

u Mohajerjasi, Mark Starnes, Jessica Wong

most potent milestone of (SMEs). Our literature review gave us the very

most direct influence on the prototyping technology for the use of a glove used in a simulated environment. Our interview with a designer was particularly insightful, as it gave us a window into the process of designing a space

iterations of our glove during the prototyping phase. We began with the use of a fabric restraint layer, and covered with a thermal micrometeorite-resistant latex glove. The restraint layer was seen from lightweight microclimate temperature (The surface of Mars can be as cold as -120°F) to preserve dexterity, as we learned from our research (particularly in the area of hand motion) and iteration we are experimenting with different materials for

questions!



BS15

SPACE Exploring Mobile Virtual Reality Interactions

Virtual Reality (VR) has rudimentary interaction and selection methods. We explored two different selection methods and created a VR app for mobile phones. Analysts believe VR will have a \$150B revenue by 2020 (Digi-Capital 2015).

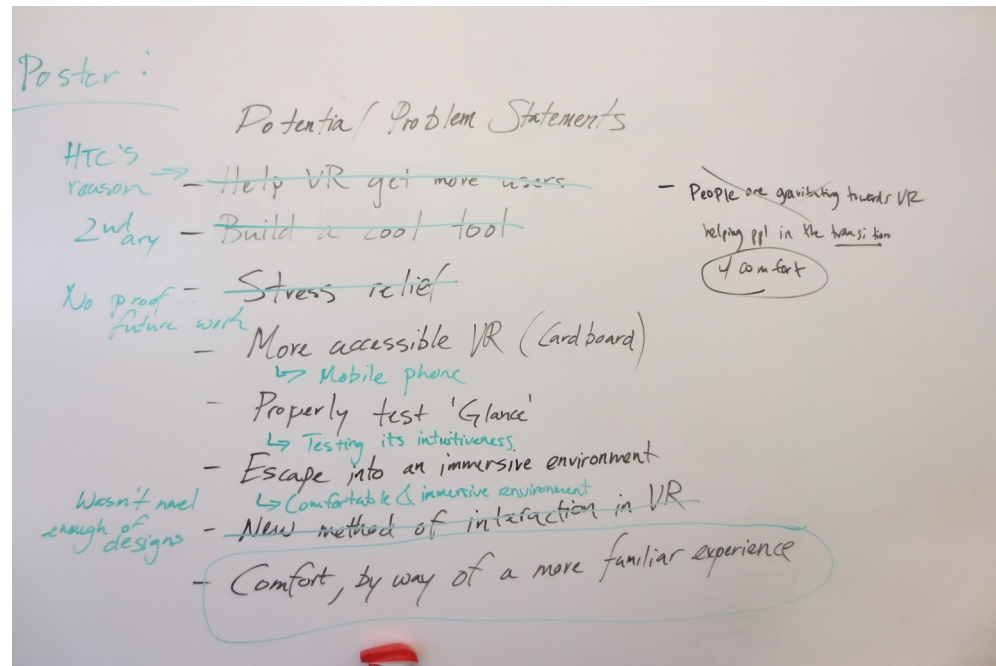


Music

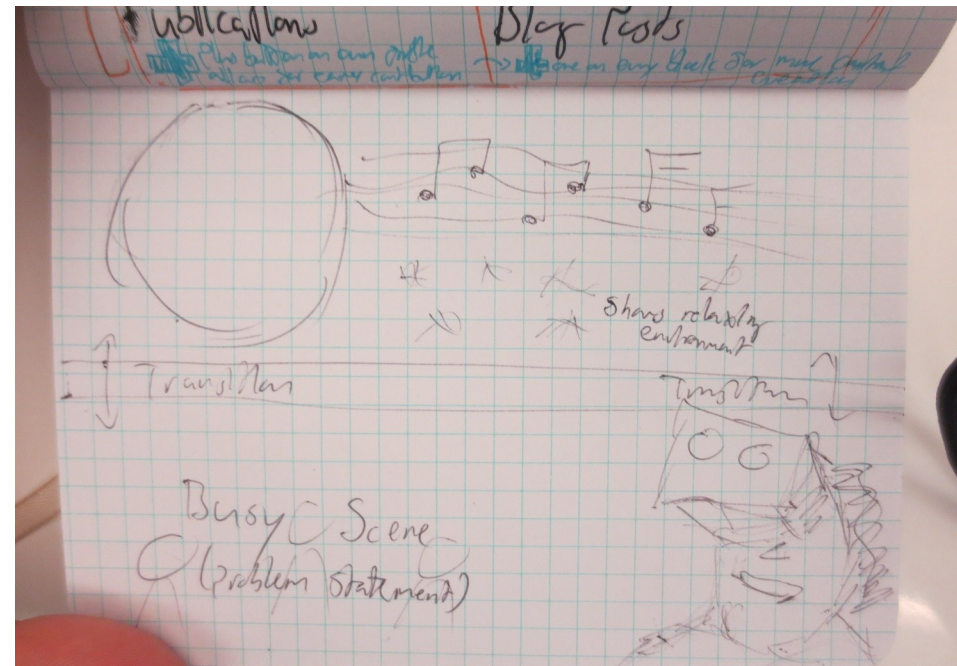


ment translates your motion. The plane moves with your

STAGE IV: PRESENTATION



Problem statement construction (date: May 20, 2015)



Poster conceptual design (date: May 20, 2015)

Once we completed the research development and Milestone #2, we transitioned into full development mode. John, Erika, and Derek transitioned to creating the poster, video, and this process book, while Alan moved into developing VirtuaSpace with Nathaniel. As per requirements from HCDE, we had to present our research at the department Open House. Additionally, as a sponsored group by HTC, we had to present our findings to selected developers and VR professionals.

These various presentations and deliverables, while not directly related to the completion of VirtuaSpace, represented a large amount of additional work and processes, and therefore comprise a fourth, informal stage.

The bulk of the work towards Stage IV overlapped with Stage III, but progress had been made going as far back as April.

The first task was the project poster. We began by reclarifying what we had learned over the course of this project and redefined our purpose. Many of the reasons that we originally

had for pursuing VirtuaSpace had morphed over time and needed to be reasserted. We had several different problem statements at different points in our project, and we needed to determine which were still relevant and powerful.

The most difficult aspect was conveying VR on a static, 2D board. During other points of the project, we found that it was difficult to succinctly explain VirtuaSpace—not knowing what VR or Google Cardboard was common. However, we didn't want to spend precious space explaining this.

To circumvent this problem, we created the poster to work in tandem with live demos of VirtuaSpace. Our poster explains our design choices and findings, but we simply encouraged those unclear about more foundational aspects to try VirtuaSpace.

John was primarily responsible for designing the poster, with wireframing assistance from Erika, models from Nathaniel, and proofreading by Derek.

VIRTUASPACE

Exploring Mobile Virtual Reality Interactions


OPPORTUNITY

In its current form, Virtual Reality (VR) has rudimentary interaction and selection methods. We investigated and improved two different selection methods and created a VR app for mobile phones to showcase our findings. Analysts believe VR will have a \$150B revenue by 2020 (Digi-Capital 2015). We want to emphasize the user VR.

ADVANCEMENT

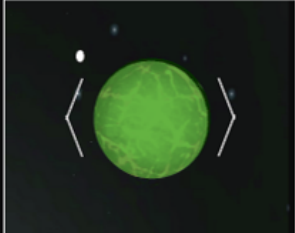
We evaluated the effectiveness of two interaction techniques: washer manipulation (Click ●) and reticle glance (Glance ◁) interactions. Our app demonstrates the interaction techniques using Google Cardboard to provide a fun, immersive, and accessible environment.

Glance ◁



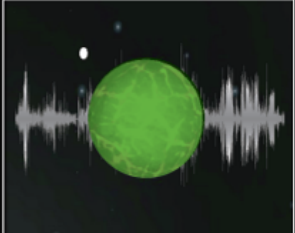
Glance ◁ is a method of interaction where you locate an object to interact with, hover over it, then wait for the reticle to hit 0 and you will automatically interact!

Click ●



Click ● is a method of interaction where you locate an object to interact with, hover over it, the click to interact!

Music



Our environment translates your music into motion. The planets and stars move with your music!


ANALYSIS

The findings from our usability tests showed the Click ● method of interaction to be effective at movement, but we believe Glance ◁ could perform even more effectively.

Click Interaction Ease of Use

Very Easy	<div style="background-color: #00FF00; height: 10px; width: 100%;"></div>	15
Easy	<div style="background-color: #00FF00; height: 10px; width: 90%;"></div>	9
Moderate	<div style="background-color: #00FF00; height: 10px; width: 30%;"></div>	3
Difficult	<div style="background-color: #00FF00; height: 10px; width: 5%;"></div>	1
Very Difficult	<div style="background-color: #00FF00; height: 10px; width: 0%;"></div>	0

John Allen, Erika Berlin, Derek Lee, Alan Qiu, Nathaniel Tabit
<http://virtuaplus.hsb.co>



VirtuaPlush poster for VirtuaSpace

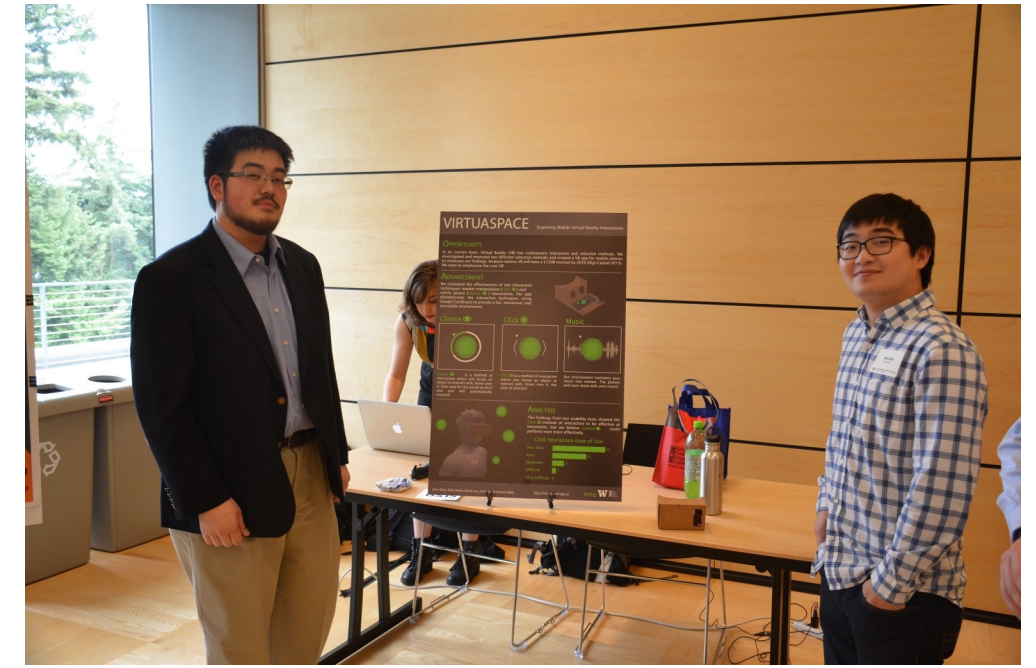
STAGE IV: PRESENTATION—OPEN HOUSE



Demonstration of VirtuaSpace



Team photo



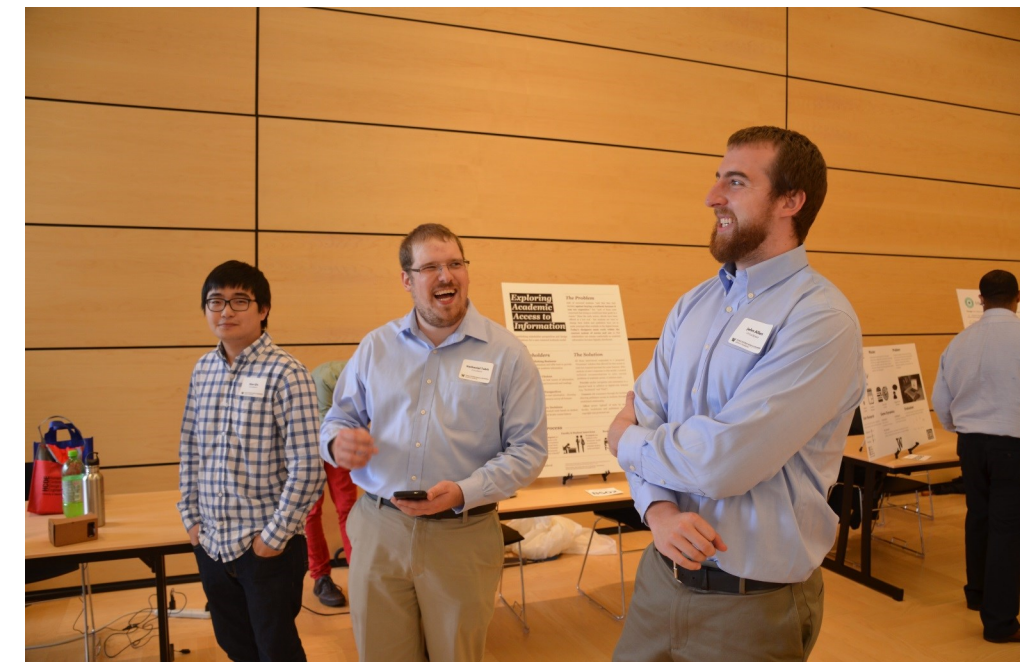
VirtuaPlush booth

The project poster was made for use at the HCDE Open House. The HCDE Open House took place on June 1, 2015. It was open to students, family, and friends of the department. Each capstone team, Bachelor's and Master's, presented their projects.

VirtuaPlush enjoyed a high level of traffic, as the lure of a live demo of our own VR app enticed visitors. We provided two sets of Google Cardboards and phones running VirtuaSpace for visitors to experience.

With the number of participants that we anticipated, we took the opportunity to do some ad hoc usability testing. Since we were unable to perform low-fidelity usability testing on Glance, we realized that by incorporating Glance into VirtuaSpace, we could use VirtuaSpace to evaluate the effectiveness of Glance.

We found that Glance took a bit more work for users to understand. Unlike Click, users needed a bit of explanation for them to use Glance properly. Once we explained the purpose of the washer, users found it easy to use and immersive.



Early stages of the Open House

STAGE IV: PRESENTATION—PROJECT VIDEO



Filming on the light rail (date: May 25, 2015)

The project video was created to demonstrate the features of VirtuaSpace. Our main goal was to illustrate the need for VirtuaSpace, and we did so by creating usage in a crowded and uncomfortable situation. Our value prop for VirtuaSpace is its ubiquitous form of escape—unlike heavier VR systems like the Oculus Rift, VirtuaSpace on Google Cardboard is easily transported and accessible.

The video shows the story of our main character who rides public transportation and has to deal with loudmouths, seat sprawlers, and obvious people. He finds relief from his stressful and uncomfortable commute in VirtuaSpace, where he can enjoy the wonders of space set to a beat.

Elika was in charge of the video, and she produced storyboards



At the University Street Station (date: May 25, 2015)

and designs for the video. The use-case of public transit fits the both the need for the comfort that VirtuaSpace provides and the relatively short (5 to 10 minute) burst that we see mobile VR being best suited for.

We had primary filming on May 25, 2015. We enlisted Elika's brother, Keon, to act as our protagonist, with Eilka, Alan, and Derek filming and acting as the inconsiderate other passengers. We filmed our scenes on the Seattle metro Sound Transit Link Light Rail, between the University Street Station in downtown Seattle and its southern terminus at the Seattle-Tacoma (SeaTac) International Airport, 15 miles away.

On the light rail, we occupied a section of train articulation, which allowed us to film with two rows facing each other, with



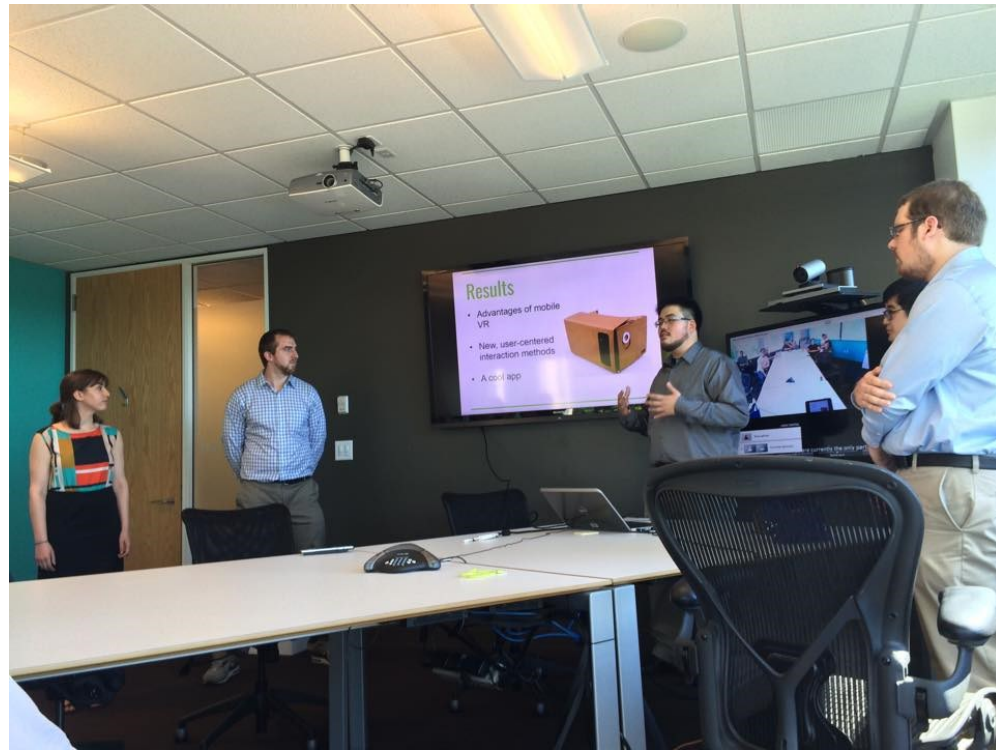
At the SeaTac Airport station (date: May 25, 2015)

the least amount of interruption to other passengers as possible.

Most filming took place on the initial southbound journey. However, the trip up north was too crowded to continue filming, so we got off at SoDo to take the train back south and complete filming.

Elika took care of the editing and incorporated footage from VirtuaSpace in action.

STAGE IV: PRESENTATION—HTC PRESENTATION



VirtuaPlush presenting



Before the presentation in the conference room



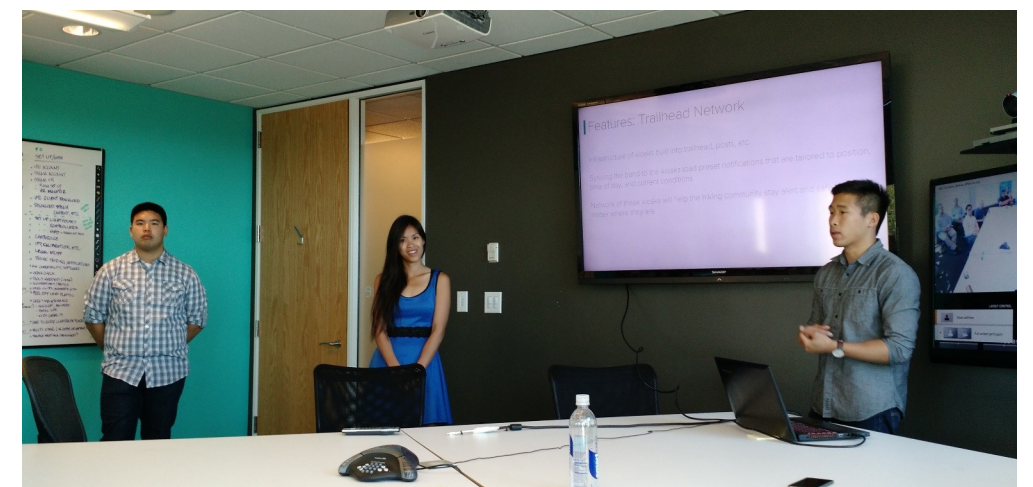
Team happy hour at Lunchbox Laboratory afterwards

In accordance with our sponsor agreement with HTC, we presented our findings to stakeholders at their Bellevue office on June 8, 2015. Along with another HCDE Bachelor's capstone team that was sponsored by HTC, Beacon, we gave a 15 minute presentation and fielded questions about our project, processes, findings, and applications.

We gave a well-received presentation to our stakeholders and impressed them with our ability to answer questions succinctly and thoroughly. They asked questions about our research methods, our perceived applications of VirtuaSpace, and about what we learned.



Combined group photo in mirrored elevator ceiling



Our friends, Team Beacon presenting

REFLECTION

Teamwork

Forming VirtuaPlush, performing our research, creating and evaluating our designs, and developing VirtuaSpace was not easy. However, we are satisfied and confident with our body of work. We had some hiccups and disputes, but it was all out of our mutual passion for our project and the desire to exhibit our best work.

We learned that teamwork and coordination with five people is difficult. Derek acted as practically a full-time project manager, by setting up protocols and norms, dividing the work, and combining the different sections of VirtuaPlush into cohesive documents and presentations.

Communication

Coming into this project, we all relied on our shared technical and design expertise. However, we learned that even the best-built product needs to be understandable to outside observers. By virtue of doing VR, we had a difficult topic to convey to the layman. We learned that it is easy to get lost in the world of VR (perhaps fitting) and come up with things that can't be easily described.

Good communication and design mitigates the complexities of our subject matter. Our most elegant solution came during the Open House—instead of trying to explain everything VirtuaSpace did, we showed them and answered questions as they arose.

A common design language throughout our project conveyed a sense of continuity and gave insights to our vision.

Virtual Reality

Having spent five months working with VR, studying its foundations, and meeting with experts in the field, we have

completed this capstone with excitement for the future of mobile VR and VR in general.

Be it by us and VirtuaSpace, HTC and Vive, or some up-and-coming player in VR, we are confident that VR will take off. As hardware prices continue to drop precipitously and even mobile phones can power apps like VirtuaSpace, VR's future is sound.

We believe that VR stands to take escapism and entertainment to the next level, and as such, the user and usability must be at the forefront. We've already established VR's ability to engage and captivate the user, so we need to ensure that poor UX doesn't force them to disengage.

Future Work

We have designed new interactions purpose-built for VR in the mobile space and applied them in the fun and interactive VirtuaSpace. Our interactions are not only for movement, but as we demonstrated, Glance and Click are perfectly applicable to UI menus. This may usher a new branch of UI design and engineering.

The health-related aspects of VR and specifically mobile VR cannot be understated. Professor Furness' seminal work into using VR to treat severe burn victims has shaken up the field of pain treatment [6].

To a lesser extent, we believe that short bursts of calming or exciting environments with both sound and vision (like VirtuaSpace) can serve as mood affectors. With mobile VR apps like VirtuaSpace, we could possibly provide key stress-relief or excitement in a convenient, non-medication manner. To test this hypothesis, we will need a true medical research study. At this point, we are unconfident to make these claims part of our main value proposition.

CITATIONS

- [1] Bryson, S. (2003, January 1). Direct Manipulation in Virtual Reality. Retrieved March 1, 2015, from <http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20030054521.pdf>
- [2] Pierce, D. (2015, March 6). The Future of Virtual Reality Is Inside Your Smartphone. Retrieved March 1, 2015, from <http://www.wired.com/2015/03/future-virtual-reality-inside-smartphone/>
- [3] <http://unity3d.com/legal/eula>
- [4] <http://gamedev.cs.washington.edu/>
- [5] <http://www.41post.com/4776/programming/unity-making-a-simple-audio-visualization>
- [6] <http://www.hitl.washington.edu/projects/vrpain/>

APPENDIX

All referenced milestone deliverables, contracts, videos, posters, and apps are available on our team website:

<http://www.virtuaplush.5gb.co/>



VIRTUAPLUSH

