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LA/AR

GAME NATURALLY

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INTRODUCTION

As technology has become increasingly more advanced in the past fifteen years, the face of gaming has changed drastically to follow. Our team is dedicated to providing the next step in gaming to suit both our users and the latest technology, augmented reality (AR). LAZAR is an AR laser tag game system aiming to provide seamless interaction between people in an immersive and natural way. Our goal is to compete with other gaming systems and introduce gaming that suits the 21st century user's needs yet is more interactive than current options. We think it is important to go back to more traditional gaming methods but include new technology to connect our community. At LAZAR, our mission is to bridge the gap between virtuality and reality through hands-on interaction that integrates gaming and real-life (see Appendix B).

OUR PROBLEM

INTRODUCING THE PROBLEM

In an increasingly technologically advanced society, technology has brought new convenience especially to the realm of gaming. Virtual games on phones, computers, or gaming consoles have dominated the gaming world, replacing physical games with appealing technological aspects. The problem with these games is that they remove the social experience of gaming. They are usually played alone with other players only visible online or played in groups where physical interaction still does not occur. We specifically targeted laser tag as a more traditional style of game that requires social interaction and is not as convenient as most video games. In order to target the lack of social gaming, we will focus on three specific facets of the problem: physical interaction, environment, and technology.

PHYSICAL INTERACTION

Our goal to increase social gaming is reliant on the physical interaction of players. Laser tag generally requires planning between a group of players to get together in order to play. At LAZAR, we want to keep this element of laser tag, though we will also give the option to play alone. Because we are concerned with the lack of social interaction currently involved in popular

gaming devices, making a game that requires teamwork and has elements of competition will influence our users to play with friends.

ENVIRONMENT

One of the current issues with laser tag is that it must be played in a specific environment; the game can not be transported to any environments. In order to make laser tag more accessible, we want to make it able to be played regardless of location. By doing so, it would increase the convenience of laser tag to be more comparable to modern video games and give gamers more reason to play a social game versus playing alone.

TECHNOLOGY

The last focus is on technology. At LAZAR, we believe improving the technology of laser tag will be important in increasing interest in playing. Our goal is to implement AR technology to bridge the gap between video games and physical games, combining them into one interface. We believe that having cutting edge technology will be an attraction point for current gamers to switch to our interface. We believe our technology is perfect fit to solve these problems and to further advance real-world activities with video game type of experience.

THE IMPORTANCE

Our technology is important to create a well-connected society focused on physical interactions rather than virtual ones. Our goal is for our users to be physically interacting with their real friends, similar to how they would be playing games like tag, soccer, or basketball. Our technology will allow video games to be more interactive and immersive for a realistic, natural experience. We want to break the conventional way of playing video games and promote social interactions as well as physical activity for an overall healthier user. We are confident that our technology will help the upcoming generations be more socially interactive and physically active while still allowing them to be involved in gaming and the popular technological culture that surrounds it.

SUPPORTING RESEARCH

AUGMENTED REALITY

The major goals of LAZAR was to bring the best of both video games and physical sports together. In order to do this, we decided we want to leverage the latest technology in the computer interface technology called Augmented Reality or Mixed Reality. To support our solution to the lack of social interaction while gaming, we first centered on what AR is and how we can use it to promote our cause. We defined AR as requiring the following three elements [6]:

- It must combine real and virtual objects in a real environment
- It must run interactively in real time
- It must register real and virtual objects with each other

The concept of augmented or mixed reality is to be able to create virtual objects in our real world. In the digital age, there are things that do not need to exist physically in the real world (e.g. text documents) that could live digitally on hard drives. We can extend this idea to three-dimensional objects that are only required to exist digitally in virtual world, which is referred to as virtual reality. AR is when these virtual worlds are augmented on top of our real world, allowing us really build software tools that exists in the same dimensions as we exist in, making it a much more immersive experience than virtual reality. Another major advantage of virtual objects that exist in AR is that they do not necessarily have to follow the laws of nature that real objects do, allowing space for creative thinking and building unique experiences.

EXISTING SYSTEMS

Our next step was to understand the AR systems are currently out there, so we could learn what we are adapting to. Microsoft's HoloLens and Meta are currently two of the most prominent and widely distributed systems, but there are also other successful AR projects like Pokémon GO by Niantic Labs, which brought world-wide attention to what AR has to offer [1][2]. Pokémon GO's widespread success also encouraged us that a large audience is interested in using AR over other

gaming systems. We decided our product should be integrated in already existing technology rather than be a standalone system.

We also were interested in the current implementation of AR with shooting games. HTC Vive and Oculus have made a great deal of progress in the realm of virtual reality (VR) shooting games, which gave us an idea about what an immersive shooting game experience should look like in terms of giving complete control to user movement and avoiding traditional keys and buttons [3]. Observing current VR games shaped our design process in thinking of how natural movements could be used to interact with our system, such as gestures or head movements.

By observing current AR systems, we observed multiple ways that AR can be displayed to a user. A popular version captures video through cameras worn on the head which create a background to display virtual objects. Other ways include a transparent display with an AR overlay or images displayed directly on the eye's retina with low-powered lasers. We also researched handheld display types and projection displays but found wearable headset displays to be the best option to free the user's hands and make the experience as immersive and complete as possible [6].

After we understood the concept of AR as well as what immersive first person shooting games looked like, we wanted to find current systems that exist combining both of them. We found a study conducted on soldiers that tested using AR to help them practice entering a potentially dangerous room, holding their weapon, and working as a team in combat conditions. The study found that AR technology makes showing and teaching these techniques to soldiers both easier and more efficient, confirming our belief that AR is the right experience for immersing users in our laser tag gaming experience [7].

The final step in our background research on existing systems were to specifically search for examples of AR laser tag already in existence that we could build off of. What we found was called Father.io, which implements AR laser tag on an iPhone with a small add-on [5]. Though an upgrade from current laser tag technology, which requires a specific indoor environment and

expensive gear, it is still not immersive, customizable, or socially interactive, which is what we plan to change with our product [4].

SURVEY OF USERS

To supplement our background research, our next step was to survey potential users in order to consider their needs during our design process. We created a short five question survey to learn more about the opinions of prospective users about our idea and what they would expect to see in our system. Our survey questions were as follows:

- Would you be interested in playing an augmented reality laser tag game? (Yes or No)
- How much would you pay for hardware that allows for augmented reality laser tag? (Short Answer)
- Of the following features which is most appealing? Information about self and others (health, status, commands, etc.), Locate team members, Display virtual opponents, or Display virtual obstacles (Select One).
- If this system allows you to play anywhere, where would you be most likely to play? (Short Answer).
- Have you used Microsoft HoloLens? If so, what are your thoughts on it? (Short Answer).

From our survey, we found that all of our participants were excited about playing an AR laser tag game, but they were not willing to pay for it. Only one would pay more than $60 for it. In order to keep our price point low, we decided not to develop an entire AR system but instead just a software on a pre-existing system. We also learned that users valued the ability to display virtual opponents and information about players (e.g. health, stamina), solidifying our decision to include both virtual opponents and objects in our eventual design, which we were previously unsure about, as well as health and status information using AR technology. We also found that users would be interested in playing in diverse locations, so we especially wanted to make sure that our design accommodated many locations, both indoors and outdoors (see Appendix C).

USERS

TARGET AUDIENCE

We chose our target audience to be high school and undergraduate college students, around the ages of 14 to 22. We chose this group because of their tendency to be up-to-date with current technology as well as the large amount of gamers included in this group. Because most students do not work full-time jobs, they also have an ample amount of free time to spend gaming with friends compared to the employed population. Our game also relies on ability to be active, which is more common in a demographic that is younger (see Appendix B).

PERSONA

To represent our target user population, we made a persona called Jesse R. Johnston, our archetypical user. We tried to analyze every aspect of our personas life including personality, family life, activities, work life, and goals. We also imagined scenarios of Jesse's life after implementation of LAZAR, as well.

ABOUT JESSE

Jesse is a 20-year-old college student who loves gaming and nature. He grew up in the suburbs of Detroit, where he was born. Jesse is now a third-year design student at the University of Michigan. Jesse has never been out of the country but has been to 20 different states in America and enjoys traveling.

Jesse's mom works at Dell. She brings home new technology prototypes that she receives at work for Jesse and his 16-year-old-brother Dylan to play around with. Jesse's dad is a sports writer who loves being active in the outdoors. The family loves to go to baseball games together and stay active by hiking, biking, or running.

Though Jesse loves being active, when he's not he plays video games with his friends. Jesse is an open-minded person and is up to try new things. He'll play games at least once before he

decides if he likes it or not. His hobbies include ultimate frisbee, hiking, playing videogames, watching sports, and hanging out with friends.

Jesse prioritizes people and relationships over his professional achievements. His dream is to be a game designer working on user experience at a company that encourages creativity and activity (see Appendix D).

AN AVERAGE DAY

After his alarm goes off five times, Jesse is running late to his AR laser tag team practice in the morning. Soon after the product has been introduced, Jesse and few of his friends started a laser tag club in his school. Now, Jesse is the leader of his laser tag team called, "Team Lazar Lamar." The team practices against each other to prepare for upcoming competitions against other teams (see Figure 1).

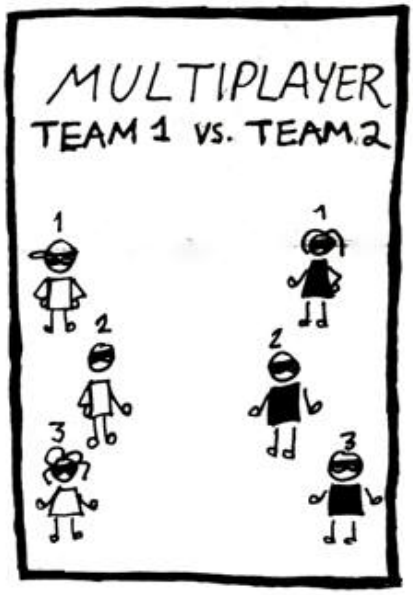

Figure 1. *Our storyboard depiction of Jesse's team practicing LAZAR with each other.*

During the game, a teammate gets a phone call and has to leave the game. He is replaced by a virtual opponent for the remainder of the game (see Figure 2). After a few rounds, the team breaks and heads off to school.

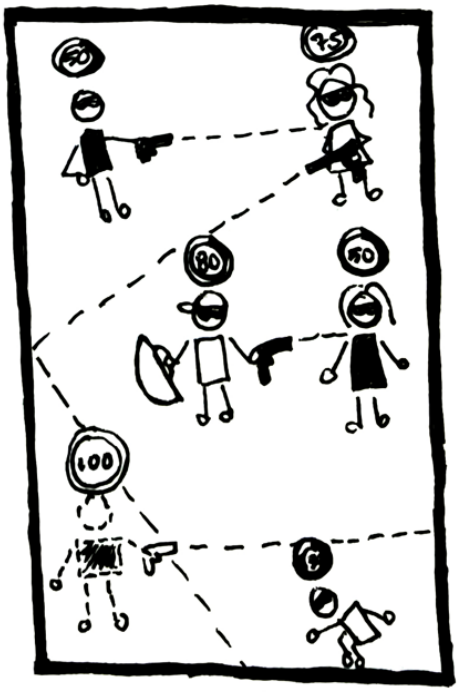

Figure 2. A virtual opponent (bottom left) takes the place of a player who left the game.

After school, Jesse goes home for a family dinner, and he and his brother eat their food as fast as they can in order to get a few rounds of laser tag in after dinner. He unlocks a new weapon and wins the game (see Figure 3). He heads to bed after midnight, ready to wake up the next day for practice (see Appendix F).

FIGURE 3. A SLIDE FROM OUR STORYBOARD DEPICTING JESSE AND HIS BROTHER PLAYING LAZAR.

AUXILIARY AUDIENCE

We also expect the secondary audience group who will range from the late twenties to mid-thirties and will also be interested in playing our game. Though this is a user population that tends to play games less frequently, it is still a population that is active in the gaming community and active physically in outdoor activities, which makes it a great secondary group to target. We found that the average age of a Minecraft player was 29 years old, which supports that this age group is integrated into virtual gaming. Furthermore, that generation is familiar with playing laser tag before the creation of video games, which may increase their interest in a more technologically advanced version of laser tag (see Appendix B).

DESIGN SPECIFICATIONS

In designing our interface, we first had to consider a variety of design issues as well as our design priorities and features we wanted to include. We also had to consider the non-functional requirements of playing our game.

DESIGN ISSUES

In order to solve our problem, we had to consider design issues that we might run into relating to the environment, technical constraints, appearance, and safety.

ENVIRONMENT

In order to design for any environment, we had to consider several issues that could impede our progress. These included scanning the current environment, public disturbances, and the portability of our hardware. Because we want our game able to be used in a wide range of environments, we need to account for various obstacles and size constraints of each individual environment. We decided to have the user walk around following projected arrows so that the software can calibrate to their current settings.

Furthermore, an ability to use our game in a wide range of environments means that some of these environments could be public settings. It is our goal to make our game as unobtrusive as possible to avoid public disturbances.

Lastly, it is important for us to make our hardware as portable as possible in order to make it accessible in many environments and not affect the gameplay of our users. That is another reason why we decide headwear implementation of AR would best suit our design.

TECHNICAL CONSTRAINTS

Another group of design issues centers around the current technical constraints that we face with AR. Current AR devices such as HoloLens are not yet suited to host our gaming system. However, we are assuming that as technology advances in the future, we will be able to implement our design on existing devices.

Other technological considerations include providing haptic feedback when shot, distinguishing players from non-players in the gaming environment, and providing accurate information about players during gameplay.

APPEARANCE

When it comes to appearance, our issues lie around making our game more attractive than traditional laser tag and how to design for a three-dimensional space. We find it important to update the look of laser tag to be more modern, especially with the increase in technological aspects.

We also want to consider that our design will be project in a three-dimensional space, which does not conform to the same design standards as a two-dimensional space. Instead of interacting with a mouse or controller, we want to incorporate gestures and possibly voice recognition capabilities to make interaction more natural and seamless.

SAFETY

Our last design issue to consider is the safety of our players. It is important that our device keeps our users safe as well as those who are not playing. Our main concern is that users will be unaware of their surroundings, whether it be other people, noises, or obstacles. Our calibration of the system before gameplay will be vital in identifying natural obstacles within the current environment as well as identifying players versus non-players during gameplay. This will alert users of physical obstacles in their setting as well as keep non-players safe from being brought into gameplay.

Furthermore, we are opting to keep the sound effects and/or music to a minimum so that players can communicate with their teammates better and be aware of noises around them. Again, our goal is to make our game natural while incorporating technology. We instead opt to use haptic feedback to cue users that will not intrude on their ability to communicate with other players or distract them from real world auditory cues.

DESIGN PRIORITIES

Though we have many design issues to solve with LAZAR, we are prioritizing making a three-dimensional gaming interface, incorporating physical elements, and creating self-contained gameplay.

THREE-DIMENSIONAL GAMING INTERFACE

Our main priority for our design was to stay away from the traditional two-dimensional gaming interfaces. It is easy succumb to a design that involves clicking on buttons and menus. In order to avoid adopting a style that would not best fit our interface, we wanted to focus on making our product intuitive for AR. To do so, we wanted to focus on physical movement and large-scale gestures, such as swiping with one's arm to move through a carousel of selections to choose a game. This would allow our interface to be interactive and immersive rather than a stationary experience.

PHYSICAL ELEMENTS

Our next design priority was including physical elements to our gameplay in order to make it more realistic. Since our game involves shooting lasers at other opponents, we wanted to make the shooting more real than just a visual effect projected on a player's surroundings. We opted to have a physical gun handle that can be triggered by the user, providing feedback to the device that then shows the projected laser. Not only would this base success off of the skill of the user at aiming and shooting, but it would immerse the user more into the game by feeling like the real thing, not just looking like it. The gun handle would also provide haptic feedback when the user was hit to give physical indication of an attack.

SELF-CONTAINED GAMEPLAY

We also wanted to make sure that our design would not be disruptive to people who were not involved in the game being played, therefore creating a self-contained gameplay. Though our experience is interactive and flexible to the environment it is in, it is impossible to remove all the unpredictable variables from gameplay, such as outside people walking around, moving obstacles like cars or bikes, etc. We found it a priority to find a way to indicate to users who is in the game so their experience can remain immersed and so others who are not involved in the game will not be disturbed or targeted.

SIMILAR SYSTEMS

In our background research, we found various systems that were attempting to solve similar aspects of our initial problems. Arcade game was one example. These are more interactive video games with context based input devices (guns, joysticks, etc.) Though they do not involve any form of mixed reality by any means, the interactivity of arcade games as well as their emphasis on different interaction modalities (touch, sound, etc.) make them a similar system. The Nintendo Wii is another system that is not identical by similar in specific aspects. It is a moved based video game system that relies on physicality, which makes it similar to the movement based system we are creating for immersive laser tag. Virtual Reality systems are also similar to what we are using. Though what we are doing is AR not VR, systems like PlayStation VR are also immersive and have many virtual elements. Lastly, another similar system is the mobile AR game Pokémon Go, which is similar in that it is a form of "play anywhere" AR.

FEATURES

From our research, we have identified several key features that we plan to include in our final design (see Appendix C). These are as follows:

- Play in a variety of environments
- Play with both virtual and real players
- Use both virtual and real obstacles during gameplay
- Connect to existing games
- Display laser beams
- Display information about players during gameplay
- Facilitate communication between teammates
- Use a variety of weapons

NON-FUNCTIONAL REQUIREMENTS

Though we want our users to have the ability to play LAZAR in any environment, it is preferable for the user to have a large enough space to move around with minimal traffic of other people through the area. This decreases the risk of harming themselves or others. In order to compensate for perhaps less physical obstacles being present, our virtual objects can replace

real world objects in order to still give users places to hide or objects to interact with. Users should also not play in weather conditions that may lead to accidents such as ice, snow, hail, sleet, and fog. Though the devices we use for augmented reality laser tag are waterproof, these weather conditions can lead to accidents like running into dangerous objects or slipping and falling.

OUR DESIGN

We created our design to best follow our design priorities and finish our tasks in the most user-friendly way. We centered our core functionality around game setup and our auxiliary features around add-ons that improve gameplay but do not necessarily affect the playability of the game.

TASKS

The three main tasks we identified were as follows (see Appendix H):

- Complete a tutorial of the game
- Create a new game with both virtual opponents and obstacles
- Join a game created by a friend nearby

CORE FUNCTION

The core function of LAZAR is to set up and play a game of AR laser tag (see Appendix). Some specific features that assisted this function were as follows (see Figure 4):

1. Calibration with the environment
2. Health indicators
3. Physical trigger system
4. Team identification
5. Virtual obstacles/opponents

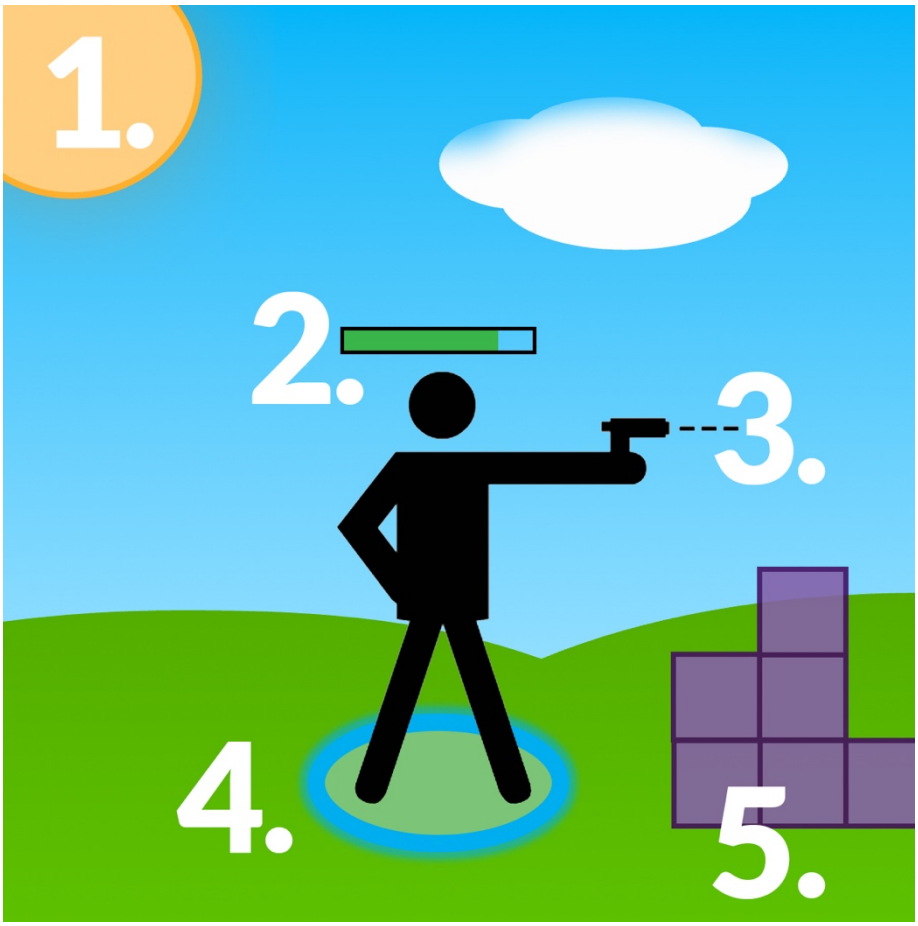

FIGURE 4. THE FIVE COMPONENTS ESSENTIAL TO THE CORE FUNCTIONALITY OF LAZAR.

AUXILIARY FUNCTIONS

The auxiliary functions of LAZAR that are not necessary for gameplay are features such as the weapon shop, user profile, and achievements. These features are all a way of adding individual competitiveness or a ranking system to the game in order to influence users to play for longer; however, the game can exist perfectly without them.

ORGANIZATION

Our goal was to decrease the need for menus and features outside of gameplay to the best of our abilities. Because we decided to build on an already existing platform such as HoloLens, we did not need a lot of system settings such as volume or brightness because they would already be developed onto the actual device.

The main organization of our interface involves two menus--one for the general options when you first open the game (e.g. playing a game, checking your profile, going to the shop) and one for the game play options (e.g. tutorial mode, creating a game, joining a game). Originally we included all of these options in one larger menu (see Figure 6), but dividing them into more specific menus helped users be more specific with where they want to go and avoid unnecessary gestures to search for the correct option (see Appendix F).

ITERATIONS

During our project, we made three iterations of our design in order to test our interface design and overall concept.

FIRST ITERATION

Our first iteration was relatively low fidelity first attempt at creating our interface design for a three-dimensional game in a two-dimensional form. We presented each screen on paper and flipped between pages while holding them in front of our users to emulate an AR experience (see Appendix ????).

Some notable screens from our first iteration are the calibration screen, the menu screen, and the create game screen. On our first attempt at the calibration screen, we wanted to suggest that users should explore their surroundings. We used arrows to indicate that the user should do so; however, our users only turned their head side to side instead of turning all the way around (see Figure 5).

FIGURE 5. THE CALIBRATION SCREEN FROM OUR FIRST ITERATION.

Our original menu screen implemented a carousel-style scrolling system (see Figure 6). As mentioned before, we eventually divided into a main menu and submenu to lessen the amount of scrolling needed by users. We also realized that have buttons below the menu options was pointless as the actual menu options could act as buttons themselves, minimizing our design and making it easier for users to use.

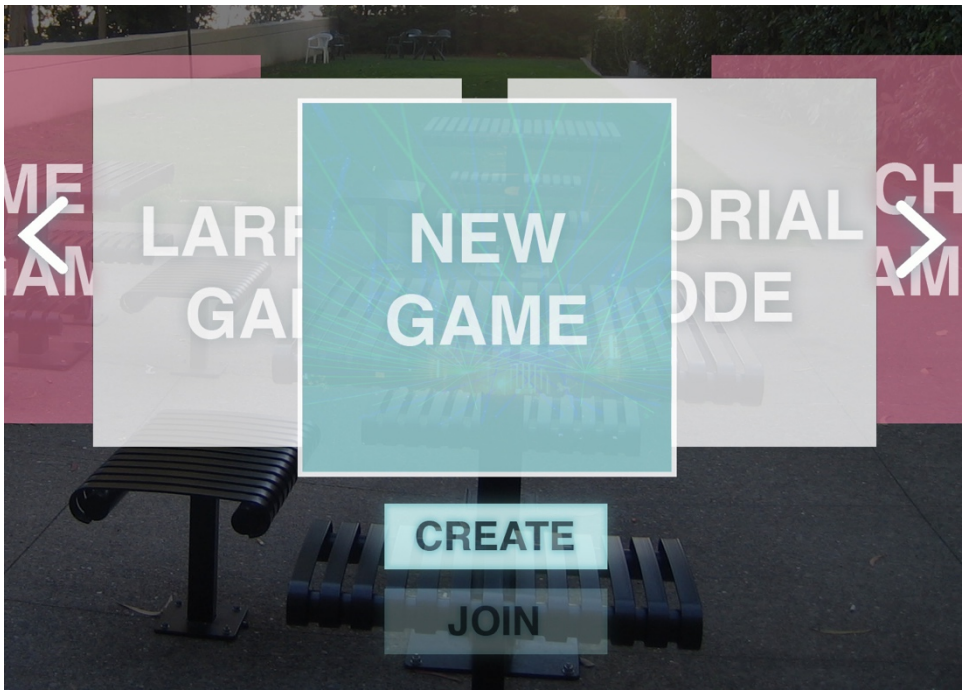

FIGURE 6. ONE MENU FOR ALL OF OUR FEATURES FROM OUR FIRST ITERATION.

The last screen we focused on was our 'Create Game' screen. We had the original idea use buttons to set the amount of players, but we realized this did not fit with our priority to avoid common gaming interface design (see Figure 7). Furthermore, our users found it confusing whether to press the buttons or the icons next to the buttons. Lastly, they were not sure there should be different amounts of virtual obstacles rather than just either virtual obstacles or no virtual obstacles.

FIGURE 7. THE 'CREATE GAME' SCREEN FROM OUR FIRST ITERATION.

SECOND ITERATION

For our second iteration, we attempted to make a higher fidelity mockup of our final design in order to give users a better feel for using AR (see Appendix H). However, we were met with technical restraints that made us difficult to make a full prototype using the AR technology. We were able to make the menu and the 'Create Game' screen as well as a way to add obstacles and virtual opponents (see Figure 8). Though there were buttons on our mockup, they were meant to represent gestures though we could not do so with the technical constraints of Tango.

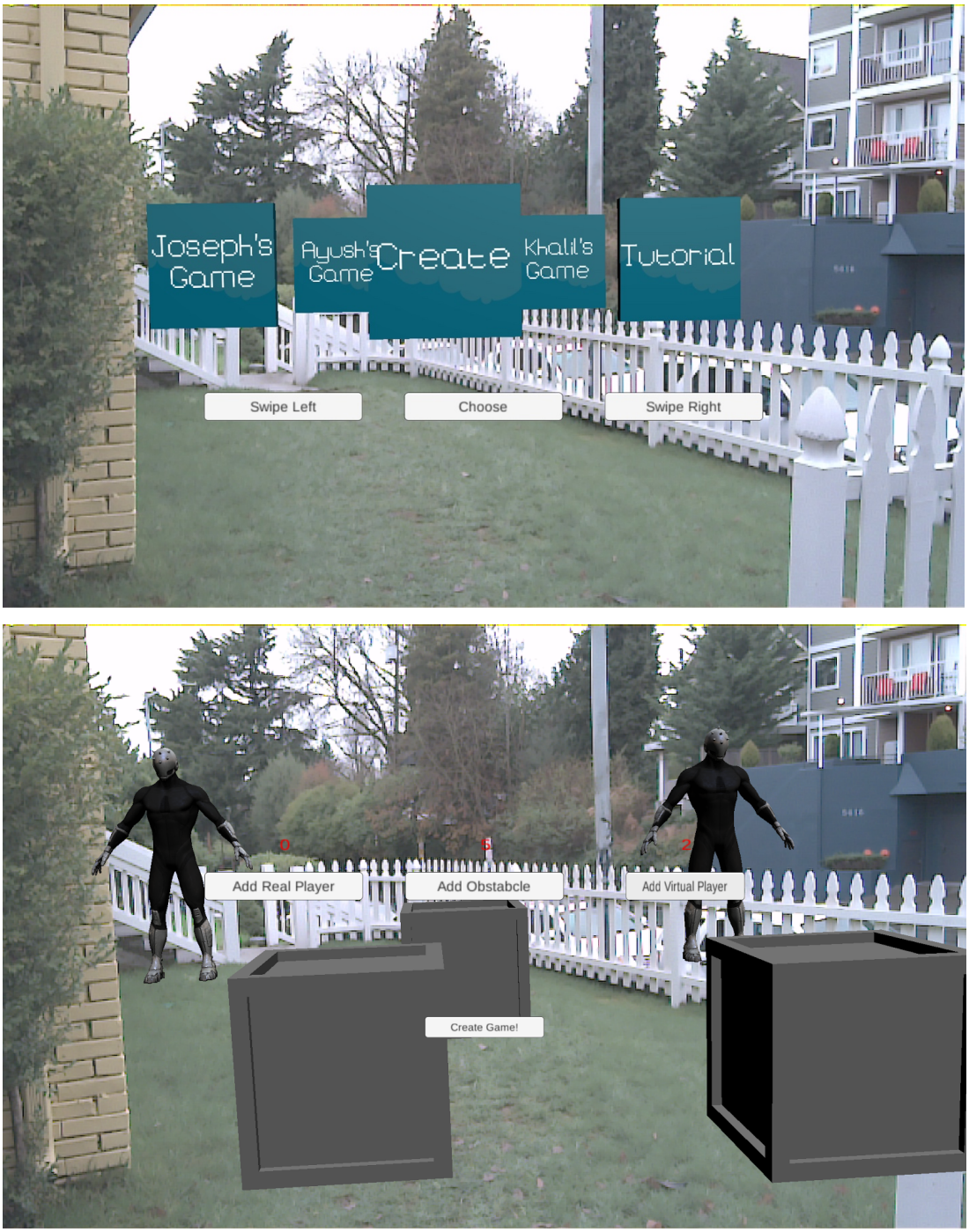

FIGURE 8. THE MENU AND 'CREATE GAME' SCREEN FROM OUR SECOND ITERATION.

Though this mockup had less functionality than our previous one, it articulated more clearly to the users what we were trying to achieve, and they found the system more interesting to use than our previous iteration. However, in order to get more useful feedback, we decided that

showing our users this iteration along with a low fidelity third iteration would be most helpful in getting specific advice of what to change about our prototype.

THIRD ITERATION

Our final iteration was a low fidelity paper prototype application. We paired this with our second iteration in order to give our users a feel of AR so that they could understand our paper prototype better (see Appendix K). The fully functional paper prototype can be accessed at http://bit.ly/2gF8YlS.

Some important changes we made were changing specific wording to inform our users of when the game was starting as well as dividing the menu into two smaller menus and adding auxiliary features such as the user profile and the shop (see Figure 9). Other changes we made to make obstacles a feature that turns on or off and a way to switch teams when joining a game.

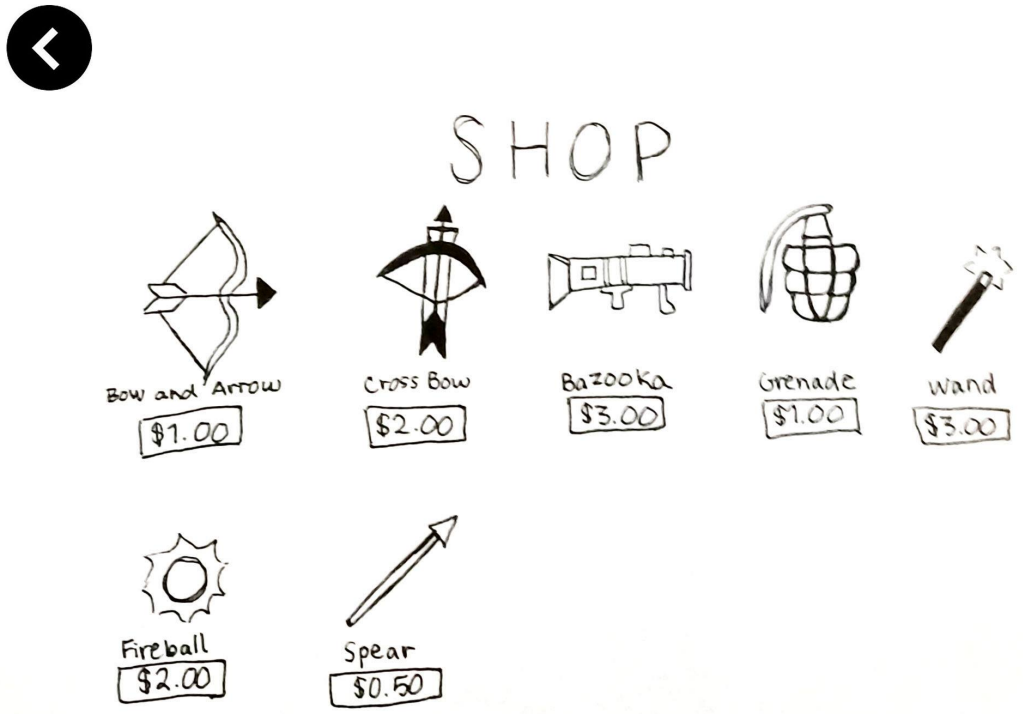

FIGURE 9. THE MENU AND 'CREATE GAME' SCREEN FROM OUR SECOND ITERATION.

USER TESTING

TASKS

From our design process, we identified three tasks to test that were as follows (see Appendix H):

- Complete a tutorial of the game
- Create a new game with both virtual opponents and obstacles
- Join a game created by a friend nearby

We opted for these certain tasks because they best encompassed the most important features of our game. By having a user complete a tutorial of the game, we could make sure all of our features of the game worked as well as teach our user how to play. By testing how to create and join a game, we could make sure this process was seamless up until the point of playing the game.

THE PROCESS

It was critical that we test our technology with potential users to get a sense of how our design is functioning. We did two rounds of testing, with each round also having a pre-testing period to fix any major issues before officially testing. We tested five people per round for the official testing. Our first testing round was with the first iteration of our design and the second was with our second iteration (see Appendix F, H). While testing we measured the time it took to complete each task, the likability on a scale to 10, and the difficulty on a scale to 10 (see Table 1).

RESULTS

Our results were divided into two sections—quantitative data we collected and qualitative data from conversations with our subjects. We also recorded various suggestions our subjects made.

QUANTITATIVE

After our two rounds of testing, our second testing results improved from our first testing results because the users were less confused, quicker at completing our tasks, and more satisfied as far

as what the technology was capable of doing (see Appendix I). The average time per task went down by about a minute in our second iteration (see Figure 10).

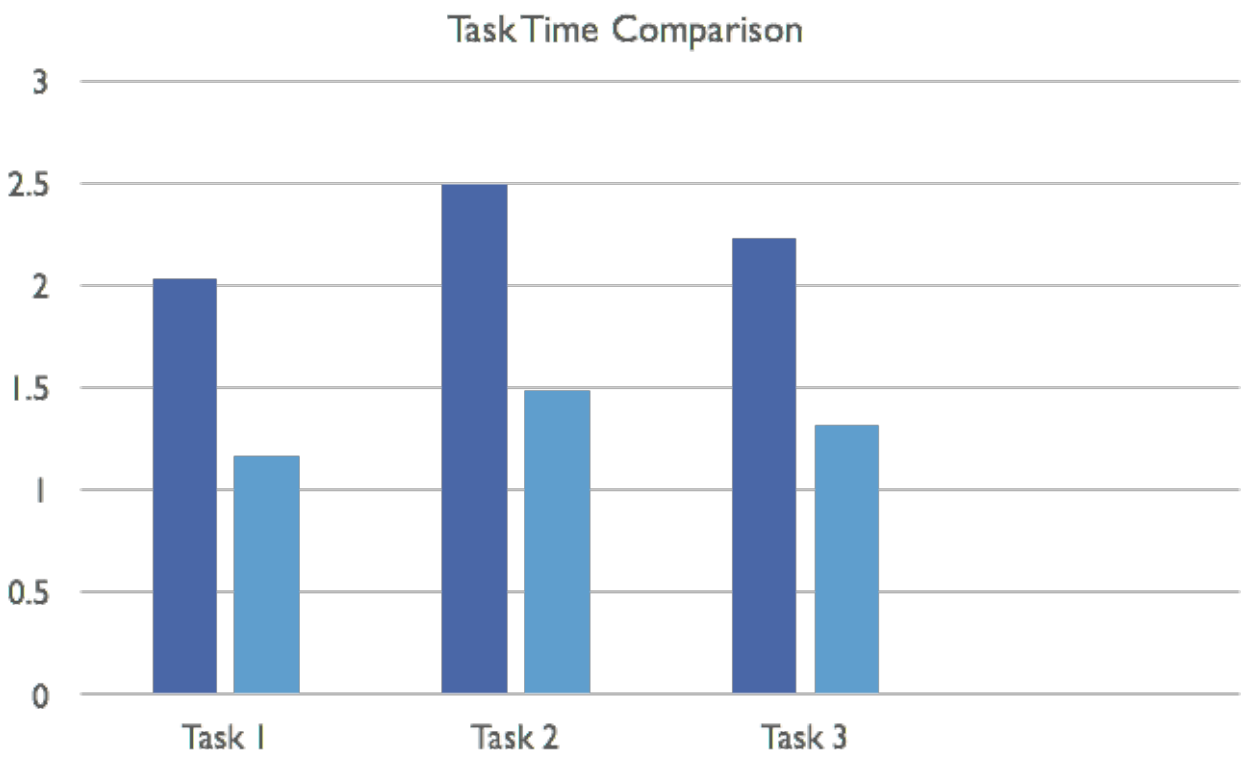

FIGURE 10. A GRAPHICAL COMPARISON OF THE TIME FOR EACH TASK, WITH DARK BLUE REPRESENTING OUR FIRST TESTING ROUND AND LIGHT BLUE REPRESENTING OUR SECOND TESTING ROUND.

Our second iteration was more likeable partially because many of our testing subjects were impressed with the implementation of AR technology in our mockup. They also found it easier to complete tasks when flipping through paper pages was not necessary (see Table 1).

FIRST ITERATION TESTING RESULTS

	Average	Standard Deviation
Task 1 (Time)	2:03	0.12
Task 2 (Time)	2:49	0.53
Task 3 (Time)	2:23	0.42
Likability – 1 (Dislike) to 10 (Like)	8.6	1.02
Difficulty - 1 (Easy) to 10 (Hard)	4	1.48

SECOND ITERATION TESTING RESULTS

	Average	Standard Deviation
Task 1 (Time)	1:16	0.13
Task 2 (Time)	1:48	0.16
Task 3 (Time)	1:31	0.18
Likability – 1 (Dislike) to 10 (Like)	9	1.1
Difficulty - 1 (Easy) to 10 (Hard)	2.2	1.6

TABLE 1. TWO TABLES SHOWING THE RESULTS FOR OUR FIRST AND SECOND ROUND OF TESTING.

QUALITATIVE

Absolutely. Fortunately, all the users were amused by the concept of minimalist way of playing the game. As far as specific design goes, users thought the carousel in the main menu was likable. Overall, we found out that we were mostly going in the right direction as far as what we were trying to accomplish but the design and layouts needed several tweaks in order to perfect the design to our satisfaction.

SUGGESTIONS

From our conversations with our testing subjects, we were given suggestions for what to keep and what to change about our designs. In both testing rounds, our users liked the carousel menu because it was easy to navigate and more interactive than a dropdown menu. However, during our second testing round, users voiced concern over how to navigate the single carousel menu if a lot of options were in the menu. They also pointed out confusing word choice such as our initial calibration screen that said 'Start' even though the game was not starting yet (see Figure

11). They were similarly confused by the wording ‘Go’ to create a game, even though the game would not begin yet (see Figure 7). Though the iteration with the implementation of AR amused our users the most, it was not the most functional iteration. Users suggested we pair our mockup with a more functional paper prototype to make changes easier to test without the technological constraints of making an AR mockup.

CHANGES MADE

With the suggestions from our users, we made several changes for our third and final iteration. To make tasks more clear, we made the ending calibration screen say “Continue” rather than “Start,” so that our users know the game is not starting yet (see Figure 11).

FIGURE 11. COMPARING OUR MOCKUP OPENING SCREEN TO OUR FINAL ITERATION SCREEN.

We split the “Create Game” screen into two screens—one that sets the parameters for the game and one that shows who is on what team while waiting for other players to join (see Appendix K). We also made it so that if spaces were not filled by real players, they were automatically filled by virtual players. We split the menus one for a general menu and and one for the game play menu to make our menus easier to scroll through (see Figure 12). We also added back buttons so users could navigate easier if they made a mistake when first navigating (see Figure 9). Making these changes added extra directional options to give more clarity to users as far as what to do in order to proceed to the next step, and the users were able to proceed with different tasks much quicker.

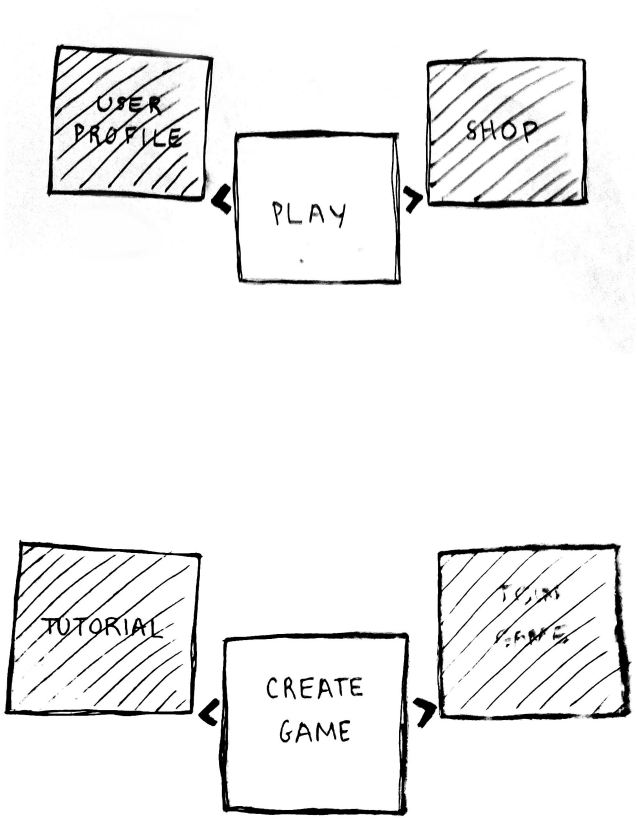

FIGURE 12. OUR TWO MENUS IN OUR FINAL ITERATION.

FUTURE GOALS

Since we only had ten weeks to work on this project, there is a lot more progress that we can make in the future to turn our prototype into reality, or maybe I should say augmented reality. The immediate next step in our process is to ideate on how to move our design prototype to an actual AR system such as Microsoft HoloLens while taking technical constraints into consideration. Since HoloLens is a common, well-developed, accessible, and successful AR system, we will likely use that system. We then plan on building a physical prototype for the given system and testing with users. This class has made it clear to us that we are not the user, and that testing can only make the design of an interface better and better. We then will iterate into higher fidelity designs and expand user tests until test results are consistently excellent regardless of sample size. The next part of the design process will be to replicate our high-fidelity design in code that meets requirements of the system. Finally, given the success of all the previous steps, we will dive into implementation, small scale marketing, and production platforms for the product.

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REFLECTION

Our group, Team LAZAR, learned a great deal this quarter and feel very fortunate we got the chance to work through the full user-centered design process and tackle a very cool project. One of the most important things we learned was how to move through the UCD process in general. For the HCDE majors in our group (Khalil and Brynn), we had the chance to work through the process of building personas, designing prototypes, etc. on a very complicated project that we typically don't get exposure to, in this case, augmented reality laser tag. It also gave us the chance to learn a lot more about augmented and virtual reality to move through the process of the project successfully.

For the non-HCDE majors in our group (Ayush, a Computer Science major, and Joseph, an Industrial Engineering major), we got the chance to learn the UCD process in detail for the first time. As a result of not being totally familiar with this process, some of us wanted to jump right into design from the start. It took understanding who an archetypal user is for our interface as well as doing user research survey, interviews, and background testing among many other processes to learn that gaining background information on who we are designing for is the most important part of design.

We also learned how to work with different types of engineers. In our previous classes, our teams have only consisted of people from our own majors. This project was extremely interdisciplinary in that we had the privilege of working with other engineers from different fields. This proved difficult at first, because we all had completely different perspectives. Khalil and Brynn started out being very focused on the users. Joseph wanted to understand how people interact with augmented reality. Ayush wanted to understand the technology behind augmented reality systems and interfaces, and what makes them work. These different perspectives eventually became an asset to our team. With all these different perspectives, we were able to come at augmented reality laser tag from so many different angles. This is thoroughly reflected in what we have produced along the way. For example, the design of the moving carousel in our interactive prototype is a great example of Brynn and Khalil's knowledge

of what kind of interface a user would be able to use most effectively, Joseph's knowledge about how users interact with systems, and Ayush's knowledge of how to build and code to bring the interaction to life.

Working in our group was also a great team building experience in general. Many times we had a great deal of work to do, especially with user testing, that we could not just accomplish in our Friday meeting sessions. We had to be cooperative and willing to compromise in order to arrange meeting times and location that worked for all members of the group, which was difficult considered we are all busy students! There were also many times when none of us could meet but work still needed to get done, and we had to learn how to accomplish work on google docs, google slides, etc. We even had a weekend Skype brainstorming session which led to a bunch of great ideas!

Our favorite part of this entire process has definitely been trying to use what Tom has taught us in class and apply it to our project. Many times this can seem daunting, especially because of the immensely high bar Tom has set in mixed reality. But it proved to be an inspiration for design, specifically the examples he gave in class about fighter pilot cockpits. He talked about how in one of the newer "more improved" versions of one of these cockpits, there were many more buttons and functionalities, but this made it even more hard to use even though it looked prettier. We used this knowledge to remove excessive buttons and "accessories" to our interface that we realized would only make things more confusing. One thing that we didn't like was our method of timing users as they ran through both our paper prototypes and our improved interactive prototype. This may just be the nature of user testing, but many times users would start talking about unrelated things, stop prematurely, or get distracted during testing, and it was very tough to time users successfully when these things happened and we weren't able to stop and restart the timer fast enough.

As far as whether we will use these techniques that we have learned this quarter, we definitely will. These techniques are not something you forget easily. I think the one that was most

impactful was approaching design with the mindset that we are not the user. Even the HCDE members of our group said that they had never heard that before, which is very surprising since it plays such an important part in design. Also using thinking hats! Though we can't always remember which cap to use in which situation, it gave us the idea that when we are having a difficult time solving a design or research problem, the best idea is to come at the problem from a different perspective. The greatest part of the thinking hat idea is that not only are you coming at a problem from a different perspective, but it is one specific perspective, which allows for a great analytical mindset. When you only have one element that you are thinking about, it is much easier to figure out how to be creative thinking through that one specific lens.

There are a couple things that we would definitely want to do differently as a group and as individuals. As a group, we would want to try what would happen if we approached our persona differently. Our persona was focused on someone who was a teenager or young adult, which did really fit our goal to immerse a video-game loving generation into the outside environment for a healthier and more sustainable future. But we would like to try changing the age of the persona to see if that would change our design. Though our currently archetypal is the most likely user of our interface, we think it would be really interesting to approach much older and much younger individuals as the focus of the product to see if that would give us some interesting ideas as how to focus on our target user but still accommodate important needs of other age groups. One thing that Khalil wanted to change specifically was to do some more statistical analysis on user tests. He thought it would be very interesting to take a large enough sample size of users so that we would see if a normal statistical distribution could be formed, and maybe some data visualization could be done on the results to present some more exciting results. Joseph wanted to get rid of the obstacles feature that we created where users could not only add virtual opponents, but could also add virtual obstacles with our augmented reality laser tag software. He thought that adding small objects was impractical and did not have much purpose. Brynn wanted to prototype the effect of the gun which we were not able to do, which would be to give the user a 3D printed handle of a Nerf gun, which when in augmented reality would become a full laser gun with a barrel. Lastly, Ayush wanted to see if we could have added more to our

flowchart, like a way to switch to different types of laser guns or use different types of “attacks”.

For what we would want to keep the same, we are a group were very happy with most of what we accomplished together. We definitely would want to keep our core approach to our idea. We did a great deal of background research and user research, and we know that our product is something at least our small sample of users really like. More user research can always be done though, especially in different areas and with different populations. On the individual level, Ayush said that he likes the fact that we used virtual opponents, especially because then the user can play even if they don’t have any friends or peers around to play with. Brynn really liked our paper prototype design, and Khalil was a big fan of the logo design. Joseph really liked the rotating carousel that we used since it was so interactive and perfect for augmented reality in that it was a clearly more effective way of scrolling that manually pressing buttons.

Each of our group members had slightly different personal experiences throughout the process of this project, and it also related differently to each of our lives and ambitions. For Joseph, this was the first time he has gotten to do a project like this, and it was a completely new experience for him. He felt that it was a really great growing experience for him, and he got a sense of the design process that was unlike anything he has previously been exposed to. He has approached his classes and academics in general with the attitude that the user matters, but never really thought of how important to user is and how the user really needs to be in the forefront of design thinking. Saying that, “I am not the user” is now a saying that he quotes often, not just in academics but also in general when thinking about any interface he is interacting with.

For Khalil, he personally is very thankful that he got practice working with different types of people. He has many times found himself working in groups with a “groupthink” mindset, where everyone thinks the same and it leads to a singular and sometimes dangerous escalation of singular ideas. In this group with many different perspectives and experiences, he feels he learned how to actually work in a real-world team. This relates to his life because he feels like in applying for jobs and internships since he is graduating, he will be able to function really well in a

team with different types of individuals and accomplish design tasks at a high level.

For Ayush, he is really happy with exposure to this project because it has given him a chance to get thorough user research experience. As someone who has done a lot of app development work, he has had a great deal of experience in app programming and design, but this research experience gives new techniques to make apps as effective as possible. It relates to his own life because as a result of this class he realized how important it is to understand the background before approaching a problem of any sort.

For Brynn, she had great personal experience doing paper prototyping. She has had multiple experiences with it in other classes such as HCDE 318, but she really liked doing paper prototyping and seeing immediate results from user tests on the prototypes, instead of classes just requiring low-fidelity mock-ups be done right after paper prototypes are finished. As far as how it relates to her life, it has made her realize that just because you hear something from one class or from one source in general, that doesn't mean it is applicable to how you should approach something, in this case, interface design.

We really liked this course, and can all agree that it was one of our favorites. That being said, there are always elements of any course that can be approved, and we came up with a few ideas of what could make the class even better. One thing is that we wish we had more time to do user research, since we found it so impactful. It may be a stretch, but having three weeks to do research would give us a chance to do interviews, field observations, surveys, and then make affinity diagrams/card sorts based on our research. Another thing that could make the class even better would be walk through some of the specifics of Toms war stories! We loved learning about those real life industry stories, and wish we could spend more time learning about the process behind them so we could try and imitate those things! Sometimes, many things like building a super cockpit suit seem so crazy and cool, that it would be really neat to learn more about the process behind how those things came about from a technical level and the user-centered design process behind those things. Lastly, we also wished there was a quiz section.

Chun was an awesome TA, and we think it would have been very valuable if we had allotted time to work one on one with him to walk through our ideas. Sometimes we as inexperienced designers would go in directions that were not ideal, so working through the process with Chun would be very helpful. Thank you both so much for an amazing class!