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AdvocaSea

Emily Dang

SANTA CLARA UNIVERSITY

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Emily Dang

ENTITLED

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Thesis Advisor

N. Ling

Department Chair

AdvocaSea

by

Emily Dang

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AdvocaSea

Emily Dang

Department of Computer Science and Engineering
Santa Clara University
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Plastics and pollution in the ocean pose a tremendous threat to the world's biodiversity and human life on the planet. However, this issue is characterized by a lack of visibility and urgency. People do not understand the importance of this pollution because they do not sense an immediate or tangible impact on their lives. AdvocaSea is a virtual reality experience that teaches people about plastics in the ocean in a more immersive and engaging way, and by doing so, gives them more motivation and agency to make change in the world. This experience was delivered at Santa Clara's Senior Design Conference in 2020.

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Chapter 1

Introduction

1.1 Problem

The world's oceans are filled with plastics, toxins, and pollution due to human negligence. This problem has been well-documented by global media and organizations, but the emphasis and publicity has always been centered on large "islands" of trash floating in the ocean. These huge masses of trash are concerning, but a more invisible and insidious form of plastic pollution, microplastics, also exists. When pieces of plastic break down in water, they form what are called microplastics - small particles that float invisibly at every depth of every ocean. These particles also absorb toxins from the water, making them dangerous to eat. Their ubiquitous presence in the ocean and their toxicity have earned microplastics the nickname the "smog of the sea". Small microplastics get caught in structures such as seaweed clusters, and the fish that eat the seaweed ingest these particles. As other fish eat those fish and the plastics travel up the food chain, their toxicity concentrates, eventually poisoning predators, including humans. [1]

A major hurdle in addressing and solving this issue is invisibility, both physical and metaphorical. An unfortunate truth about activism is that publicity and optics play a major role in attracting attention and resources; people are more inclined to care about issues that hit closer to home and feel relevant in their everyday lives. Many people do not feel like pollution in the ocean immediately affects their everyday lives, and are likely to care only when something with visual impact and pathos enters their awareness. A news article featuring islands of plastic is more likely to gain a response, while something regarding imperceptible microplastics is not. Additionally, there are a lot of politics and organization involved with working to solve this problem, and the average person might feel overwhelmed and helpless to make changes, even if they are aware of this issue.

1.2 Solution

AdvocaSea is a short form virtual reality experience and game created to address the issue of visibility and education about sustainability. As a narrative and game, AdvocaSea seeks to educate users on the presence and impact of microplastics, as well as the more sociological aspects of environmental activism. Users are asked to run an environmental advocacy organization that gains public attention, involvement, and funding in order to save a local reef. In doing so, the player will learn about the nature of microplastics ”face to face”, along with aspects of beach cleanups, research, and lobbying. The way a player interacts with the reef and the public will show them how publicity, ecological impact, and money all play roles in activism. In making decisions on how to gain and spend resources, the player themselves gains a sense of motivation and agency, and will leave with a greater sense of knowledge about pollution in the ocean and methods that can be used to help the environment.

AdvocaSea was created as a virtual reality project because VR is the most current form of immersive media. Users playing traditional video games in front of a screen experience a separation between themselves and their characters, while playing games in virtual reality blurs that barrier. Players find themselves more immersed and engaged in the experience, and develop a greater emotional response. Studies have found that learning about social issues through virtual reality as opposed to other methods, including traditional video games and oral narrative, result in users leaving with higher empathetic responses toward that issue, both in the short-term and the long-term. [2] Virtual reality is the most effective medium to use to tackle a social problem characterized by public apathy and a lack of visibility.

AdvocaSea was started in Winter 2019 with a team of four consisting of Emily Dang, Victoria Lim, Magdaline Schulte, and Isabel Wu, but is being updated and continued by Emily Dang for the 2020 Senior Design Conference.

Chapter 2

Requirements

2.1 Critical Requirements

In no particular order, the following is a list of requirements our project must meet or exceed.

- Users should be able to play a complete game experience with clear end states.
- The project should be updated to the most current stable version of Unity.
- The project's code should be refactored to be more readable and organized.

2.2 Recommended Requirements

In no particular order, the following is a list of requirements our project should meet or exceed.

- The game's user interfaces (menus, informative windows) should be redesigned to be more intuitive and readable.
- The game should be expanded to include more in-game options and upgrades that teach about different aspects of activism.

2.3 Suggested Requirements

In no particular order, the following is a list of requirements that would be nice if our projects meets or exceeds.

- Users should be able to go through a tutorial level that thoroughly explains game controls and goes through the mechanics of the game.
- Instructions and lessons should have voice-over narration in addition to text.

2.4 Design Constraints

In no particular order, the following is a list of design restraints for our application.

- The experience must be delivered before the end of Spring Quarter 2020.
- The solution should be a virtual reality experience compatible with Oculus VR products.

Chapter 3

Concept

3.1 Use Cases

The use case diagram in Figure 3.1 illustrates the possible actions a player can take in the game, on a high level. AdvocaSea is a single-player player game with no online components, and thus the use cases for the project pertain to

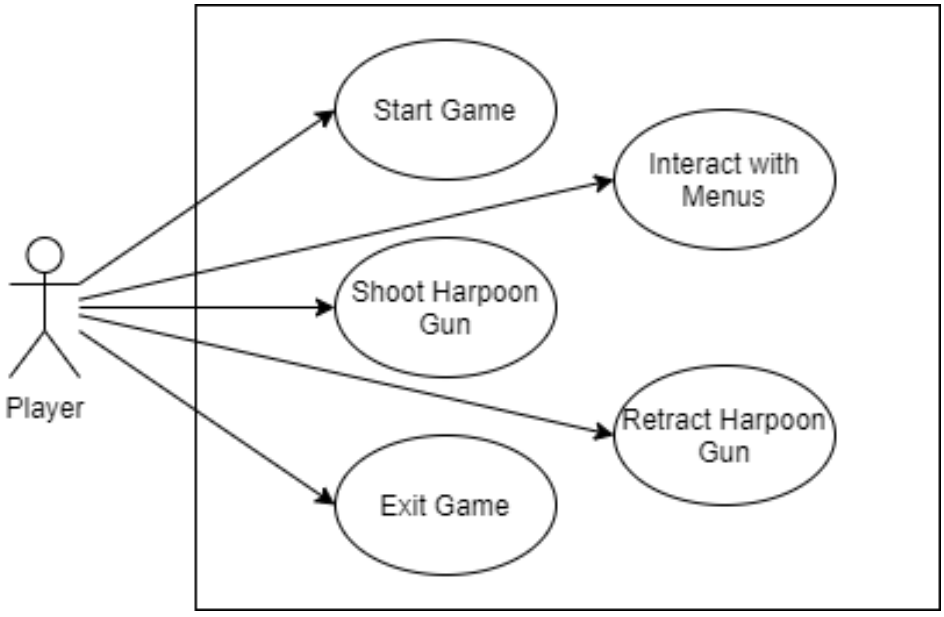

Figure 3.1: Use Case Diagram

actions that the single player can take while playing the game. At a very high level, the user must be able to start the game, interact with various elements within the game, and exit the game. The player is able to interact with the game with two modes of operation: a laser pointer and a harpoon gun. The laser pointer is attached to the player's right hand, and is used to point and click at menus and buttons. The harpoon is used to interact with "physical" objects in the virtual space. The user is able to shoot and retract their harpoon to catch and reel in trash while underwater.

3.2 Activity Diagram

The activity diagram in Figure 3.2 illustrates the gameplay loop that a user will go through until they have completed the game.

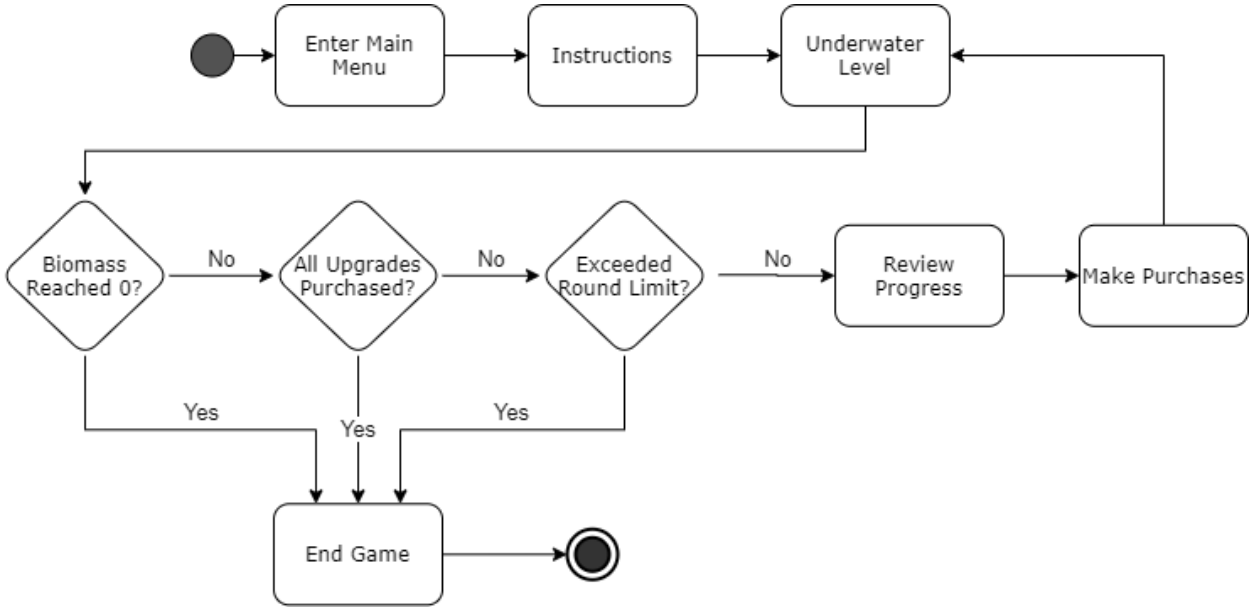

Figure 3.2: Activity Diagram

3.2.1 Starting the Game

First, the player enters the main menu, where they will be able to start a new game. They will be taken to an instructions level, where they receive a space to learn about how the controls work and how to interact with objects, either through shooting a harpoon or pointing and clicking a laser pointer.

3.2.2 Gathering Resources

Once the player feels comfortable, they will continue into the first round of gameplay, the resource gathering level. This timed level takes place underwater, and there is an object in the scene that is programmed to spawn trash for a certain time frame. This time frame is a variable, but is set to twenty seconds for the demo build of the game. The pieces of trash slowly float towards and past the player, who shoots the harpoon at the trash in order to collect it. The level ends once the player runs out of time or collects all the pieces of trash. This level is meant to reflect the beach cleanups initiated by many environmental organizations.

3.2.3 Making Decisions

Once the player has collected all possible trash or has exceeded the time limit, the game evaluates all of the growth functions that take place on the back end, and checks to see if the player has reached an end point in the game. If the biomass of the reef has reached a number from which it cannot recover, the organization has run out of money, or the player has purchased all of the upgrades necessary to save the reef, the player is taken to the game over scene, which informs them why the game has ended and allows them to exit to the main menu. The demo in the final build has an additional end state condition, which limits the player to seven loops of gameplay.

If the player has not reached an end state, they are transported to the decision-making level, which takes place on a small boat floating above the reef. On this boat are several menus, which the player can interact with to learn about their progress and the decisions they can make. The player is able to view a chart of the reef's biomass levels and carrying capacity, a breakdown of how their organization's reputation has been affected by their performance underwater, and the organization's monthly finance report.

After reviewing their reports, the player is presented with different investment choices. They are able to invest in making their harpoon gun shoot faster and straighter, to invest in research on how to combat microplastics in the water, or to invest in lobbying for preventative measures that help the reef. Each of these purchases have different incentives and effects, which then shape the environment of the underwater resource gathering level and the health of the reef. Once the player is satisfied with their purchases, they may continue back to the resource gathering level. This loop continues until the player reaches an end state.

3.3 Architecture

The diagram in Figure 3.3 illustrates the underlying software architecture of AdvocaSea.

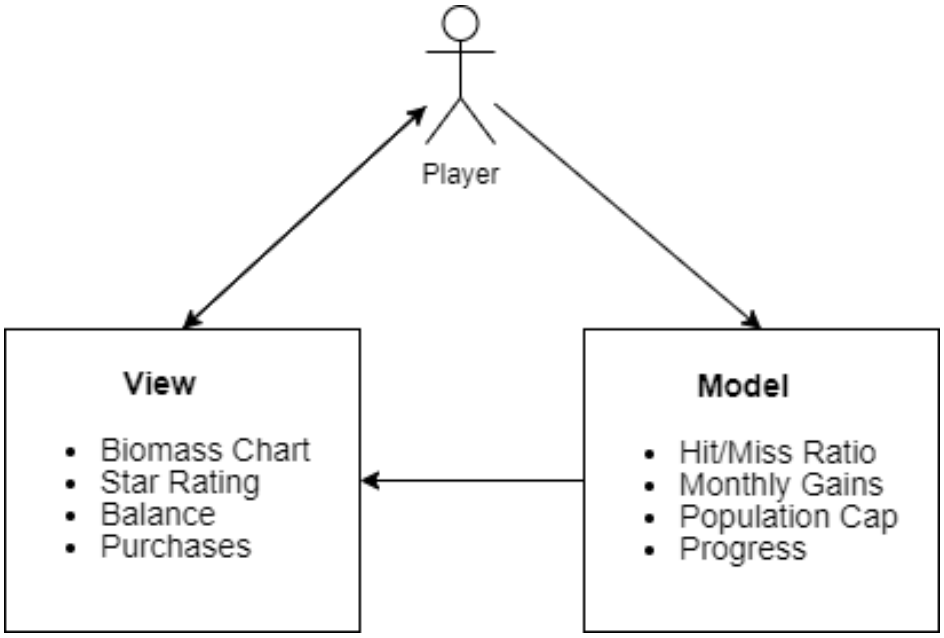

Figure 3.3: Architectural Diagram

The architecture chosen for AdvocaSea is a Model-View-Controller (MVC) architecture. The controller is the player, who is equipped with a laser pointer and harpoon gun to interact with their environment. In doing so, the player changes the model, which is stored on a Unity scriptable object. The scriptable object acts as a save file, and carries data that needs to persist over multiple scenes while the game is being played. The data points stored on the model is then reflected through the views, which in the game are the UI and the underwater environment of the resource gathering level. The UI spells out progress using charts, graphs, and reports, while the environment uses subtler cues to show the health of the reef. The player is able to gauge their performance and game progress by observing these views, and can make informed decisions.

Chapter 4

Technologies Used

4.1 Unity

Unity is a game designing software with realtime graphics rendering, a physics engine, and support for building for Oculus. Unity operates using a combination of dragging and dropping 3D assets, adding pre-made plugins, and scripting using C#.

4.2 Autodesk Maya

Autodesk Maya is a 3D modeling and animation software, used to design, create, and texture 3D assets which were used to create the props and environment for AdvocaSea. Maya is the industry standard for 3D modeling, and provides high quality assets that can seamlessly be exported, imported into Unity, and textured.

4.3 Oculus Rift and Quest

Oculus Rift and Quest have high performance, high quality graphics, and touch controllers that allow users to interact with the game more fully. Oculus provides a free plugin on the Unity store that jumpstarts developing in VR. Additionally, Oculus headsets were also available for development purposes at Santa Clara's Imaginarium VR lab, which made development and testing cost effective.

4.4 Github

Github is an online repository and version control service. It was used throughout the development process, allowing for remote work and saving multiple working versions of AdvocaSea so that reverting faulty changes was easy.

Chapter 5

Design

5.1 Scenes

AdvocaSea runs on a partial loop through several scenes.

5.1.1 Main Menu

Figure 5.1: Main Menu Selection

The player enters the game in the main menu, which presents as a large floating panel that a player can interact with using a laser pointer, as seen in Figure 5.1. When the player selects ”Demo”, the game’s scriptable object is reset to the default initial values.

5.1.2 Instructions

Once the player begins a new game or demo, they are taken to the instructions page. The instructions include a graphic

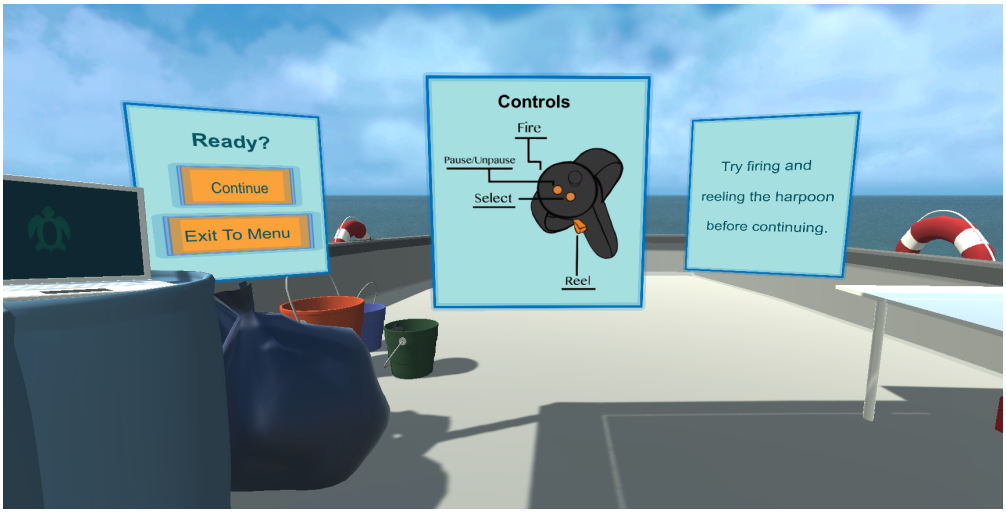

Figure 5.2: Instructions Scene

on how the controls and buttons operate, and a message suggesting the player try out each control before moving on to the next round.

Figure 5.3: Instructions Scene Harpoon

The player is holding the harpoon gun, and is able to try shooting and retracting the spear in order to get comfortable with the controls. Off to the side, there are also pieces of garbage on the boat that the player is able to shoot as practice.

5.1.3 Underwater

The Underwater scene consists of a section of the ocean floor, with coral and seaweed on the ground. The coral and water color will depend on how far the player has progressed in the game. The water starts out at a dark brown-green, and eventually clears up to a clear blue. The coral similarly starts as white, and regains color.

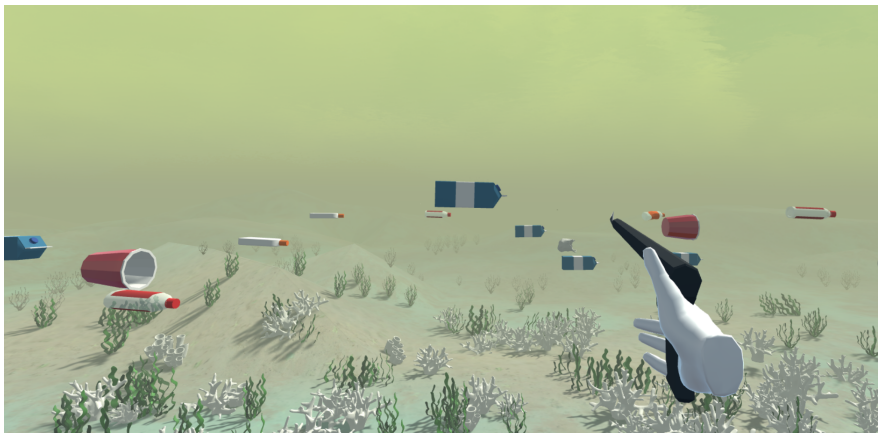

Figure 5.4: Collecting Trash

The player is responsible for shooting the harpoon and collecting as much trash as possible in the limited amount of time that they have underwater. Eventually, after the player invests in lobbying and research, the reef will be restored to a healthy state.

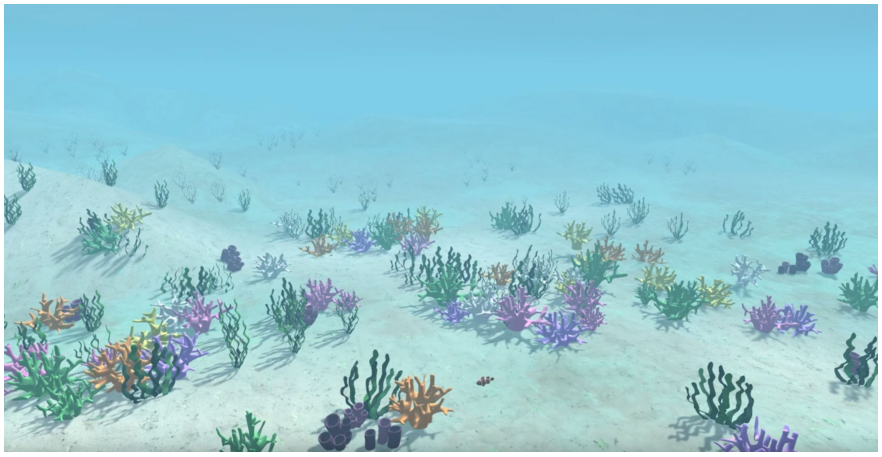

Figure 5.5: Healthy Reef

5.1.4 OnBoat

After each Underwater scene, the player is taken to the OnBoat scene, where they are able to review their monthly report, consisting of a graph of the biomass in the reef, as shown in Figure 5.6, their performance review and public popularity ranking, as shown in Figure 5.7, and their financial report, as seen in Figure 5.8.

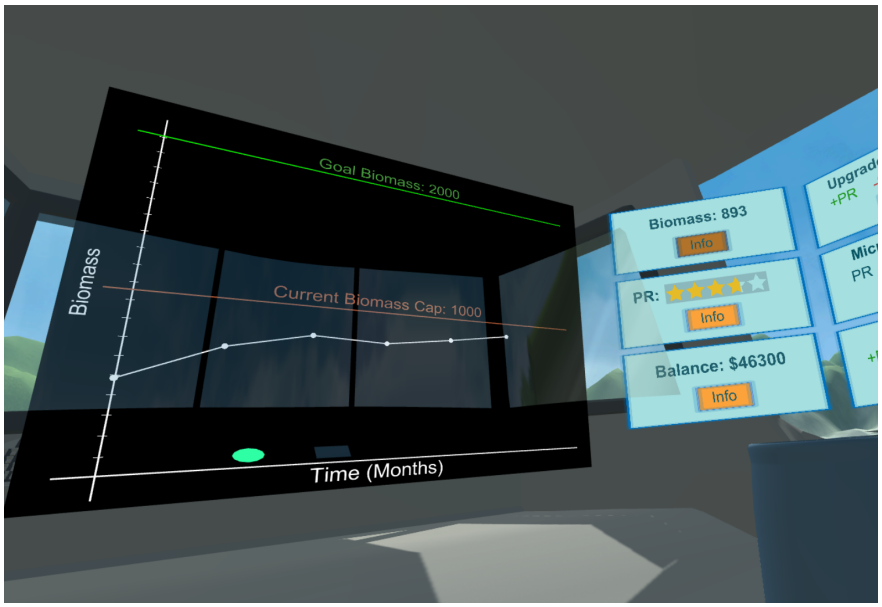

Figure 5.6: Biomass Chart

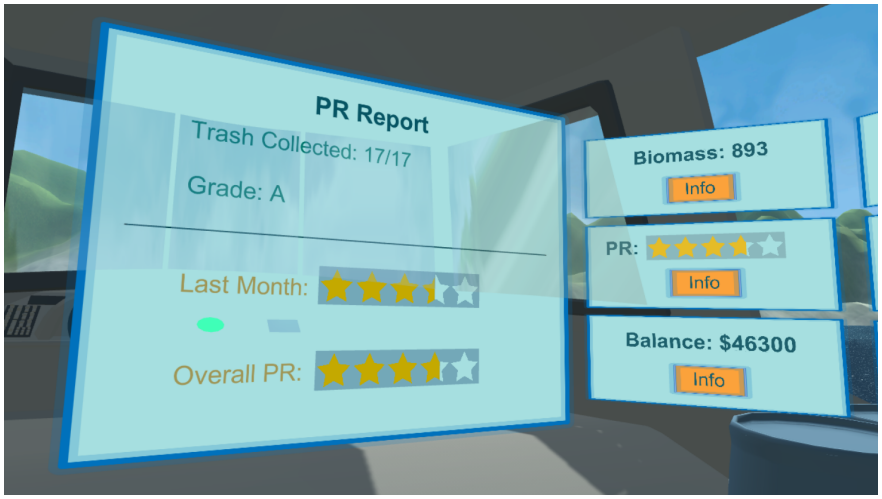

Figure 5.7: Public Relations Report

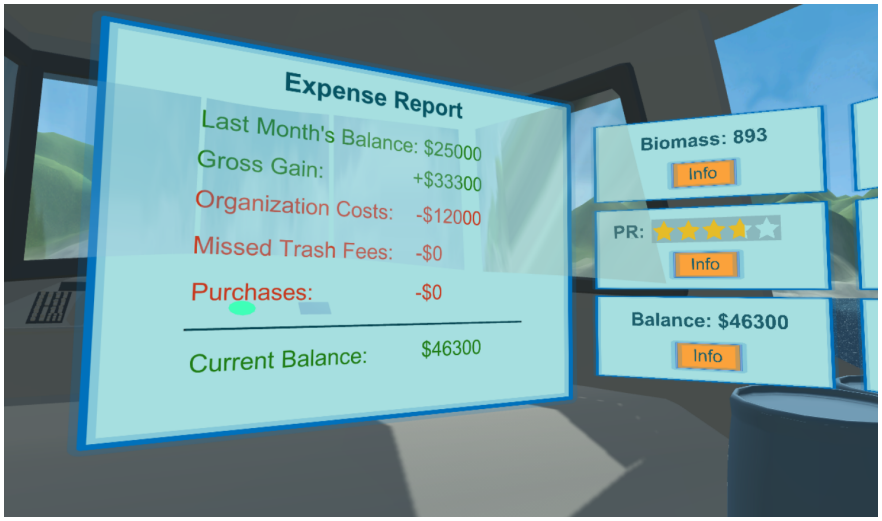

Figure 5.8: Financial Report

Once the player has reviewed their progress, they are able to take their funds and invest in different upgrades, such as the harpoon upgrade shown in Figure 5.9

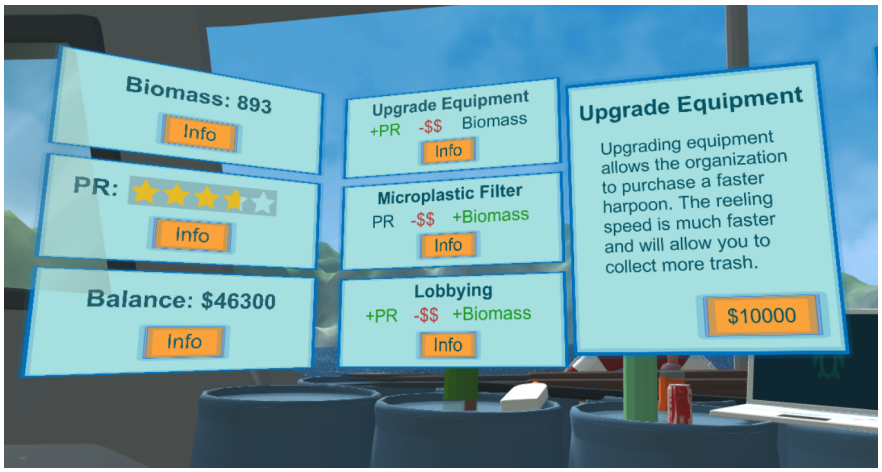

Figure 5.9: Equipment Upgrade Option

5.1.5 GameOver

Once the player reaches an end state, they are brought to the GameOver scene. The message in this scene lets the

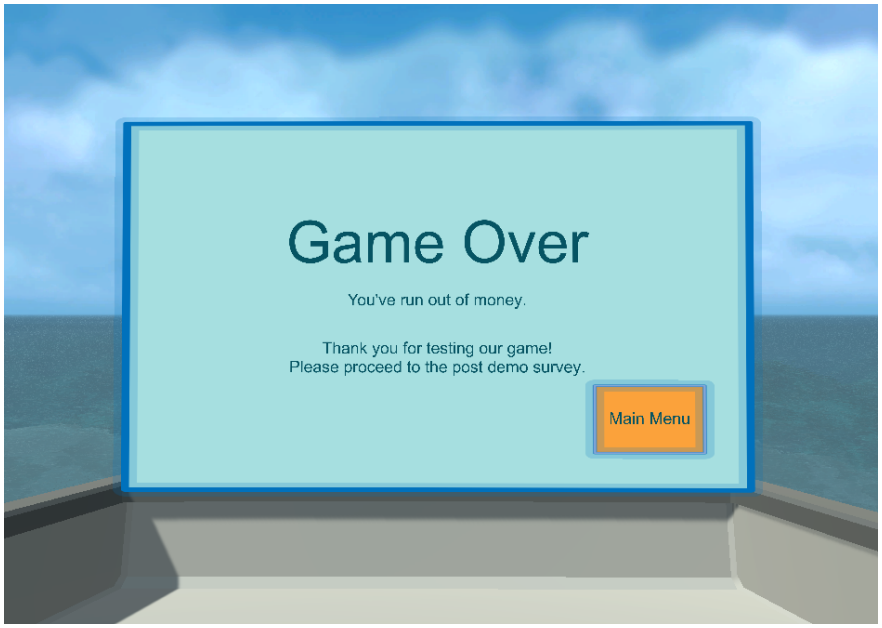

Figure 5.10: Game Over Scene

player know the reason the game has ended, whether it be because the player has saved the reef, the reef has died, the player has run out of funding, or the player has run out of time.

5.2 Working Models

Data points and game progress while a player is playing AdvocaSea are stored on a Unity scriptable object class, which holds this data across all scenes in the project. Each Unity scene file has a scene manager script that loads these data points and uses them in certain functions to determine, among many things, growth rates for biomass, the organization's popularity in the community, and the amount of money the organization gains or loses.

5.2.1 Scriptable Object

The scriptable object holds the following data points:

- Points: A list of the past biomass data points, to be used for creating a graph
- Round Count: The amount of rounds that have passed
- Biomass: The current biomass of the reef
- PR: The current public rating

- Money: The funds currently available to the organization
- Harpoon Index: The counter of purchases made to upgrade the harpoon gun
- Research Index: The counter of purchases made to invest in research
- Lobby Index: The counter of purchases made to invest in lobbying for legislation
- K: The current carrying capacity of the reef
- R: The maximum possible growth rate of the reef
- D: The steady death rate of the reef
- Income: The maximum amount of money a player can gain in one round
- Costs: The amount per round the organization must pay to stay active
- Round Time: The time limit for the player to collect trash in underwater rounds
- Total Trash: The total number of trash produced in the last underwater round
- Trash Collected: The number of trash that the player collected in the last underwater round
- Trash Missed: The number of trash that the player did not collect in the last underwater round
- Harpoon Speed: The velocity at which the harpoon gun launches the spear
- Water Saturation: The index of how far between green and blue the color of the water is
- Coral Saturation: How saturated the color of the underwater coral is
- Trash Spawn Time: How much time in an underwater round is dedicated to spawning trash
- Game Over Reason: The string that is set upon end state evaluation that informs the player why the game has ended.

5.2.2 Growth Functions

The different growth functions determined using variables, and can be changed through downloading AdvocaSea's Unity project and changing the different values. The manager uses the **ratio variable**, which is the ratio of how much trash out of the trash produced that the player collected in the last round to determine how much the resources grow or decrease.

Biomass is determined using a logarithmic growth function with a carrying capacity, defined as:

$$rN(\frac{K-N}{K}) \tag{5.1}$$

where N is the current biomass, K is the carrying capacity, and r is the growth rate - the death rate, multiplied by ratio variable.

PR is determined using the ratio variable, and takes an unweighted average of all previous ratios to determine the organization's rating, on a range of 0-1.

Budget is determined by multiplying the ratio variable by the maximum possible gross gains, which are set as a variable in the scriptable object. The organization's monthly costs, ten dollars per piece of trash not collected by the player, and any purchases made by the player in the OnBoat round are also subtracted from this total.

Chapter 6

Testing

6.1 Unit Testing

While developing in Unity, AdvocaSea was split into multiple scene files, each with different game managers, scripts, and objects. The scenes used in the final build of AdvocaSea were the Menu, Instructions, Underwater, OnBoat, and GameOver scenes. These separate scenes were made to compartmentalize the game into distinctive representations of the activity diagram. As such, each scene was unit tested separately, using artificial game data inserted into the scriptable object, in order to determine if each step in the gameplay loop could be executed successfully. Within these scenes, scripts attached to objects would also be thoroughly tested when added or changed in order to make sure the rest of the scene was functional. The testing would consist of running the scene in question using Unity's editor and interacting with objects with scripts, testing out the performance and robustness of the scene.

6.2 End-to-End Testing

AdvocaSea was designed with the intention to pass data from one scene to another, and each scene was designed to receive and manipulate the scriptable object that all of the game's progress is saved on. End-to-end testing consisted of playing the game from beginning to end using different decisions and outputs, ensuring that the data passed through each scene was clean and handled correctly by the managers.

Chapter 7

Societal Issues

7.1 Ethical

As an experience based in educating users and encouraging users to learn more about actions they can take the help the environment, AdvocaSea was created in an effort to make users more informed and prosocial.

7.2 Social

AdvocaSea's message is one of social change and championing environmental causes. Users do not learn about these causes in a vacuum; they learn about the social systems that perpetuate these issues, as well as strategies communities can take to address them. Users should leave the experience more conscientious about the sociological structures surrounding environmental issues.

7.3 Political

A large part of AdvocaSea's narrative explicitly discusses the politics involved with environmental regulation, and covers many channels that activists must take in order to make long-lasting change. In fact, of the achievements a player must make in order to win the game is to successfully lobby to ban sunscreen from beaches. However, AdvocaSea also recognizes the large role that money and publicity play in the political arena, and presents these realities for users to make judgements on. AdvocaSea's ultimate goal is to encourage users to take political action, as well as to educate users on the different methods they can use to make a difference.

7.4 Economic

AdvocaSea's lessons very strongly emphasize the role that funding, volunteering, and sustainable business models all play a part in environmental activism. Creating a movement to support the ecosystem requires financial support, as well as a restructuring of communal economies to accommodate those changes. AdvocaSea is free to play in the Santa

Clara University Imaginarium as an educational tool and a showcase of student work at Santa Clara University.

7.5 Sustainability

AdvocaSea is, at its heart, a project about sustainability, in many definitions of the word. While the foremost mission is to teach users about the impact of single-use plastics and microplastics, AdvocaSea also aims to teach about how to run sustainable businesses and organizations, as well as leading communal change to promote sustainable habits and initiatives.

7.6 Usability

AdvocaSea's user interfaces and controller schema was designed to make the game experience as smooth, informational, and intuitive as possible. User testing and feedback was a part of designing and redesigning the menus. The harpoon mechanic of the game was developed to offer an experience of cleaning up a beach while accommodating users with limited mobility and users prone to motion sickness.

7.7 Lifelong Learning

Creating AdvocaSea was a massive learning experience, from researching issues surrounding sustainability, designing the gameplay, designing the user interfaces, and adapting software engineering practices. AdvocaSea as a project also promotes lifelong learning, as it educates users on different environmental issues.

7.8 Compassion

Video games have been long regarded as purely entertainment, not as art or as useful tools for promoting prosocial behavior. AdvocaSea seeks to defy this believe, merging the best of art and engineering to provide an experience that is educational and that encourages users to think critically and compassionately.

Chapter 8

Conclusion

8.1 Obstacles Encountered

The majority of obstacles encountered while making AdvocaSea were a result of losses of development time. AdvocaSea was originally proposed as a solo continuation project, but this course of action was initially discouraged by advisors. Development on AdvocaSea only started in earnest after Emily Dang was placed on an alternative team project and made the decision to leave after contributing work for half of the academic year. Thus, development on AdvocaSea as a Senior Design Conference project did not begin until mid-February of 2020, a severe delay. Additionally, AdvocaSea's Unity project file had to be updated so that it was compatible to the latest stable version of Unity, but doing so rendered many aspects of the game, including UI elements and many aspects of the game manager, obsolete or unusable. This update and the time it took to remake preexisting elements totalled up to approximately four weeks. Additionally, shelter-in-place in Santa Clara was put into effect in March 2020, and access to SCU's Imaginarium VR lab was restricted in the interest of public health. Finding alternative hardware to develop and test with, as well as setting up an Oculus headset at home, delayed the project an additional three weeks. These setbacks led to fewer ambitious requirements being fulfilled, but AdvocaSea remains a playable and complete game.

8.2 Lessons Learned

The takeaways from this project are the importance of backwards compatibility, a good working environment, and user experience design. If updating the project file to Unity's latest version had not broken Oculus's virtual reality plugins, a lot of development time could have been devoted to expanding AdvocaSea more, instead of debugging and repairing existing features. Additionally, if AdvocaSea's legacy code had been designed with readability and resilience in mind, perhaps the stage manager would not have been rendered unusable either. In a similar manner, a work environment with functioning equipment and peers who can offer constructive critique are things that one cannot take for granted. Lastly, working on AdvocaSea was a learning experience in UX design; making sure that a user can comfortably and easily learn from and interact with a game is a much more difficult task than it seems. Working with a model with a

lot of information and condensing it so that a user can digest that information without being overwhelmed or missing out on parts of the game is a skill that is only apparent when it is missing. The workflow of designing an education experience, receiving feedback from testers, and redesigning was invaluable.

8.3 Future Work

In the future, AdvocaSea could be expanded to include, among other things, an interactive tutorial level, voiceover for instructions and lessons about sustainability, and more chapters. Additional chapters could highlight ecosystems of more than one reef, and unique challenges that come with activism in communities with different economies, cultures, and ecological challenges.AdvocaSea's UI should also be changed to be independent from Oculus's input module, which would make the system less likely to malfunction with a new Unity update. The UI's layout can also be redesigned so that it is more intuitive and learnable for users. Finally, once shelter-in-place is lifted in Santa Clara, volunteers should be brought in for user studies to analyze how educational, usable, and effective AdvocaSea is.

Chapter 9

References

[1] Cheney, Smog of the Sea. 2017.

[2] M. Christofi and D. Michael-Grigoriou, ”Virtual reality for inducing empathy and reducing prejudice towards stigmatized groups: A survey,” 2017 23rd International Conference on Virtual System & Multimedia (VSMM), Dublin, 2017.