

Dyadic Unity MQP

A Major Qualifying Project Report
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Abstract

Dyadic Unity is a whimsical fantasy 2D RPG that examines themes of morality surrounding player choice. The player controls two characters that live in parallel worlds that make up a greater whole. Gameplay involves collection, puzzle solving, and navigating social interactions. The team used Unity to create the game, and the finished product contains two puzzles: one dynamically generated, and one hand-made. The team followed a playtesting driven iterative design process that focused on improving communication with the player.

Executive Summary

To explore player choice as it affects non-player-characters (NPCs) within the microcosm of a video game based world, the team worked on a 2D side scrolling game: Dyadic Unity. This game tasks players to navigate puzzles taking place in between two parallel, mirrored worlds by negotiating both physical objects and conversations with NPCs. Throughout the game, players are able to swap between these worlds at will. Conversations with NPCs directly affect the physical objects around the player, creating a gameplay loop where the player must alternate between planning how to manipulate the world and speaking with nearby NPCs. With a focus on diversity of gameplay and replayability, Dyadic Unity also incorporates a procedurally generated puzzle in addition to its other, hand-crafted puzzle.



Figure i: Interactable objects from the hand-crafted puzzle (left) and the procedurally generated puzzle (right)

In making this game, it was our mission to create an interactive digital game world where we explore the effects of player choices on non-player-characters and objects within the game world, the generation of new unique puzzles in this game world, and how to communicate the complex game features to the player within the space of the game. To accomplish this goal, we outlined 3 key objectives to guide us through the team's three academic terms of dedicated development:

- 1) **Plan an initial design** with specific **puzzles** and game **mechanics**
- 2) **Prototype** various puzzle designs in Unity, with a focus on creating **functional and iterable** content that could be **tested by users to obtain feedback**.
- 3) **Expand and refine** puzzles to implement the basic mechanics upon a wider range of objects. Include new usability features and add complexity to puzzles, then test this expanded game one more time to discover whether the changes we implemented were effective.

By the end of the team's development time, Dyadic Unity had a tutorial segment and two fleshed out puzzles. One of these puzzles utilized procedural generation to make its content for players to experience. Throughout the development time, the team had successfully conducted 3 playtesting sessions. The first occurred during Alphafest and provided us with feedback on early puzzle designs. The next round of testing occurred in an ad-hoc format throughout B Term. The feedback from this testing inspired the group to create a tutorial segment to start the game in, to ease player understanding of the basic mechanics they had access to. Finally, the testing performed in D Term was an evaluation of the quality of our iteration through the development process and the effectiveness of our tutorial segment.

The art for Dyadic Unity consists of modular assets, rather than cohesive single images. This is to support individual hitboxes, as well as procedurally generated content. After the creation of an array of modular assets, the artist arranged them within scenes to form the landscape of the game. These assets exist on various layers, which determine at what location in the foreground or background the renderer draws them.

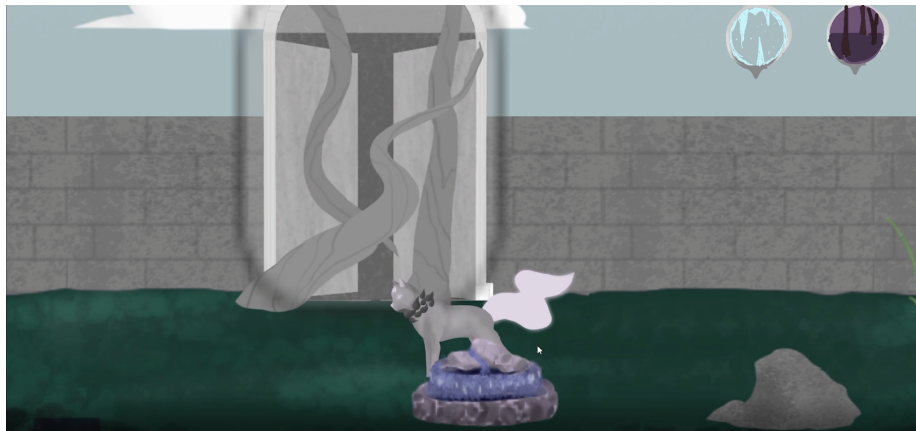


Figure ii: Scene from the procedurally generated puzzle

Dyadic Unity has an emotional system for NPCs to abstract and evaluate their current feelings. These feelings are the parameters which change the physical aspects of the game space around them. The dialogue options the game presents players with alter these values based on the content of the choice and character they are speaking to. These values do not instantly change based on the most recent option selected, rather, dialogue options adjust the current weightings between the emotions, influenced by previous choices.

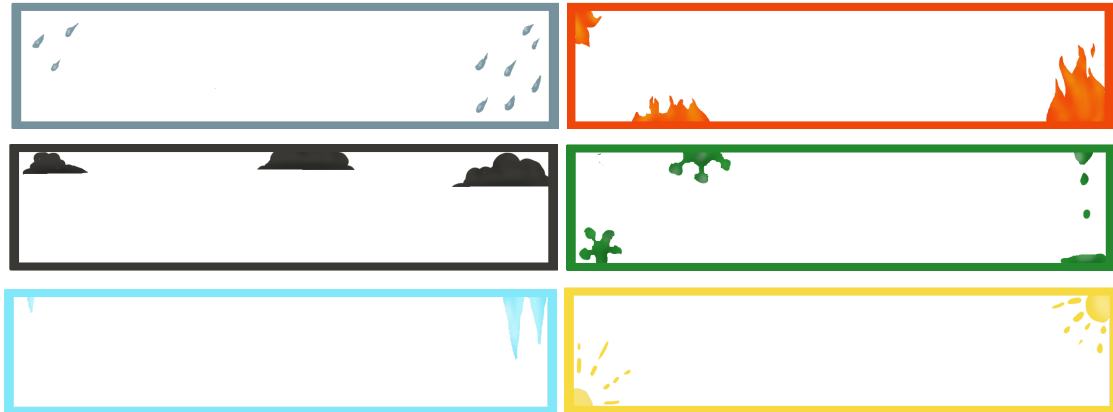


Figure iii: UI elements for the emotionally toned dialogue options

The procedurally generated puzzle within the game, the Garden Puzzle, first begins with two handcrafted puzzles to ensure players understand the mechanics and rules of the puzzle. After progressing past these, players must navigate through procedural content. To generate this procedural content, the algorithm involved generates many potential candidates, then has an agent perform iterative-deepening random walks through the candidates to determine both: which candidates contain a valid solution, and which solution, if any, took the most steps to reach. Though not guaranteed to return the most optimal answer, the team used this approach because of the intractability of the puzzle format. The team deemed this a valid evaluation of difficulty for any given puzzle of this type.

Acknowledgements

The team expresses its recognition and thanks to its advisers, Joshua Rosenstock and Gillian Smith. Throughout the project, they provided the team with advice, direction, and help on anything brought to their attention. We also extend our thanks to all of those who participated in our playtests, granting us useful feedback and allowing us to iterate upon the design of this game.

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Authorship

Each team member edited and reviewed every section of the paper and wrote sections based on their own personal specialization. The team collaborated on general sections such as the Introduction and Conclusion. Daniel wrote all of the procedural-generation sections, Sarah wrote the art sections, and El wrote the gameplay experience sections.

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1.0 Introduction

In an effort to make a game focused on replayability and introspection, our team created Dyadic Unity (DU). DU is a highly replayable 2D sidescroller role-playing game (RPG) and puzzle experience that targets teens and adults who enjoy non-violent puzzle games and whimsical fantasy. The game takes place within two mirrored worlds, known as the light side and the dark side, that the player can switch between at will. One is a world of order and its counterpart is a world of chaos. Players control two mythical creatures in a whimsical setting where they must gain the favor of the local creatures. Though the lands and characters may seem to be opposites at first glance, they are actually two halves of the same whole. As the player explores the world, they will navigate a series of social interactions that will influence the state of the game world.

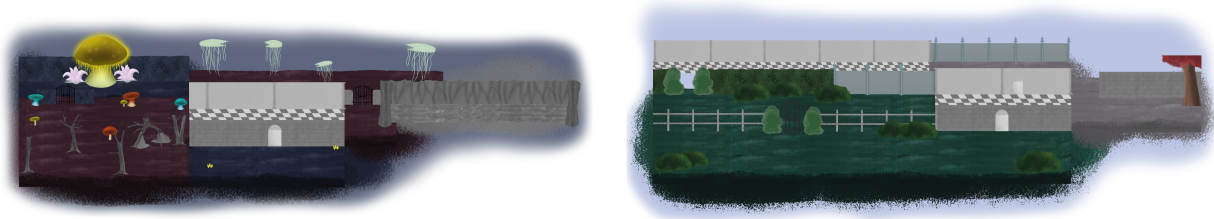


Figure 1: Chaos (left) and order (right) worlds.

There is one ending the player can achieve at this time, which is completion of both puzzles. However, to complete the game, the player must choose one of two NPCs to assist along the way. The world of the game is affected by the emotional states of the NPCs, so players must navigate social interactions to complete puzzles. They must also consider how each side of the game world affects the other in order to navigate and complete each puzzle. Our initial goal of developing complex and interesting puzzles evolved into a challenge of portraying these complex systems to players. Throughout development we explored many avenues of portraying this information to players.

Ultimately, our team's goal was to create a captivating world for players to navigate puzzles driven by social interactions. We developed interesting systems for our puzzles that we adapted over time to make them more intuitive for players. The game overall is meant to be a laid-back experience, so much of our development was spent striking a balance between puzzle challenge and providing enough information to the player to make sense of our puzzles without making them too easy.

The team's development period was three terms of seven weeks - for two of the team members, this first term of seven weeks was a prep term. The team used the first term to build a strong design and do preliminary testing, so in the remaining terms the team could immediately jump into production phases. The team's schedule can be found in Appendix C.

2.0 Background

2.1 Artistic Inspiration

The original inspiration for the game's art style came from vector-like art. This initial idea has evolved to become more painterly and mimic a style reminiscent of *Ori and the Will of the Wisps* (2020). It remains firmly cartoon-like yet simultaneously a beautifully rendered style that intentionally draws the player's eyes to the high contrast characters in comparison with their environments.



Figure 2: Ori (2020)'s two main characters.

Our two main characters have similar palettes to *Ori's* main characters, and derived inspiration from all the handcrafted environments of *Ori*. The art style of this game should be able to draw proper player attention to the characters, which are the main means of player interaction in the world. The art team had to take into consideration the modular aspect of DU while creating assets like this, as *Ori* is not a modularly generated game.



Figure 3: Dyadic Unity's main character designs - roughly based on a fennec fox and a domestic cat.

DU draws from a plethora of area types, as each dyad pair corresponds to a particular area. For instance, the Custodian and the Host are located in a series of outdoor and indoor rooms. On the light side, everything is dramatic and imperial. On the dark side, everything is wilder and fun. The Gardener and Apothecary share a garden space, and so on. The art team tailored each space

to the corresponding character's design and purpose. Architecture appears to be built in a modern style with a touch of grandeur on the light side, and wildness on the dark side.

A lot of inspiration for the world's design came from whimsical fantasy games like *Legend of Mana* (1999) and *Undertale* (2015). We wanted to inspire a sense of wonder and encourage players to explore the world and discover fascinating new places, characters, and objects.



Figure 4 (left to right): *Legend of Mana* (1999)'s Birdcage Lighthouse location, *Legend of Mana* Dudbear species, *Undertale*(2015)'s Dummy Battle.

These games have interesting worlds for players to experience, with activities like rescuing a siren from a birdcage made of plants and selling lamps to a species called Dudbears that have their own unique language within *Legend of Mana* and fighting living dummies and going on a date with a skeleton in *Undertale*.



Figure 5(left to right): *Dyadic Unity*'s Cattail Fireworks, *Starlight Disco*, and *Tutorial Dummy*.

Dyadic Unity attempts to capture a similar sense of whimsy with objects such as cattail reeds that look like actual cat's tails and shoot cat shaped fireworks, natural disco balls that light up from

small glowing insects trapped in a webbed natural cage, and a talking tutorial dummy that guides the player through the game’s mechanics, among many other things.

2.2 Design and Mechanics Inspiration

In order to create a successful and compelling experience, the team did research on a variety of comparable games and experiences. This aided in the brainstorming and creation process, as it allowed the team to see what kinds of methods are already successful and work well.

2.2.1 Dialogue and Character Interaction

A large inspiration for the dialogue came from the well-received JRPG *Persona 5*. Within this game, players must progress in relationships with characters they meet within the game world, each with distinctive personalities, goals, and an arcana to match. To bond with these characters, the player is given a limited amount of ways to respond to them. The characters respond well to options that are attuned to their heavily defined personalities. *Persona 5* rewards the player based on how their responses correlate to each NPC’s personality.

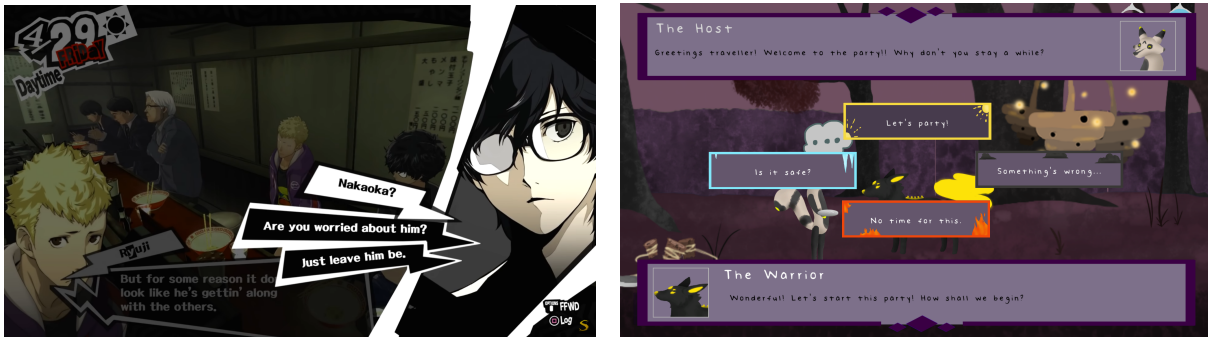


Figure 6(left to right): *Persona 5*'s Dialogue System, *Dyadic Unity*'s Dialogue System.

Another important part of the team’s research was looking through other completed MQPs and trying to find analogous systems. One MQP the team researched is called *Quest*, which is a 2D single-player (with multiple controllable characters) RPG experience. Although most of the mechanics are based on combat (Graedler et al. 2014), the programming half of the game was focused primarily on developing AI.

2.2.2 World Switching

DU’s genre is an RPG puzzler, with a variety of mechanics that can be compared to other games. One of the primary mechanics of gameplay is switching between two worlds, and there are a few games that have a unique take on this. There is the type of system that *Degrees of Separation* (2019) uses that has both characters on the screen at once that can change the world state from winter to summer, depending on which part of the screen each character is on (Noisy Pixel Staff, 2018). Although the puzzle aspect of the *Degrees of Separation* still stands with DU, it is entirely

composed of environmental puzzles as opposed to including social puzzles. Furthermore, DU does not show both sides on screen at once. Further exploring the world switching mechanic, the team came up with the comparable *Spider-man: Shattered Dimensions (2010)*, that explores four different “spider-verses.” The player navigates through a series of different chapters with the different Spiderman characters. However, the game limits world switching based upon the completion of the chapter or plot as opposed to DU, where it can happen instantaneously from player input (*Spiderman: Shattered Dimensions, 2020*).



Figure 7: Degrees of Separation’s separate world mechanic.

2.2.3 NPC Relationships

Another important mechanic of DU is keeping track of NPC interactions with the player. A comparable system the team found for that is *Xenoblade Chronicles’ Affinity Chart*. For this mechanic, interacting with NPCs through quests changes the state of their relationships and feelings towards each other (although usually not with the player themselves, which makes this system different). Party members have more direct relationships with the player (*Affinity Chart (XB1), 2020*). In DU, the player will have direct relationships with all the NPCs.

The second comparable is an MQP called *Broken World*, which is a non-violent game like DU (Thorn et al., 2012). *Broken World* is advertised as a social experience, which is similar to DU’s whimsical social puzzle solving. The *Broken World* team also used the Unity game engine to develop their game.

2.3 Procedural Generation

The team decided that procedural generation for various puzzles within DU would be appropriate. This would enable the users to have differing experiences and add to the replayability of the game as a whole.

Puzzle generation is a diverse and well researched field in both game design and, more generally, algorithms. There are a variety of ways that an algorithm can approach generating a puzzle for a

user. A **constructive** puzzle generation algorithm has a logical progression for puzzle generation that guarantees solvability, while **generate-and-test** relaxes its restrictions, yet must be verified post generation (Kegel).

The next step is to evaluate the quality of a puzzle. For computational methods, there can either be a **direct** evaluation of features, or a custom-made AI can play through a **simulation** of it to determine its complexity (Kegel).

Finally, the next consideration is when will the puzzle be generated. The first option is **offline**, in advance of the game. This would allow testing of a set of puzzles that could be randomly chosen from on any given player-playthrough. It would also give us more direct control and cut computational times. With **online** generation, however, each player would have a unique experience that more closely matches their progress through the game (Kegel). While the team would have less control over the content the player would see, in addition to using more computational resources of the player, this diverse and tailored experience is core to how the puzzles fit into our game.

The **generative space** of a procedural content generator describes the potential range of artifacts that can be produced by the algorithm. To avoid catastrophic failure in generation, e.g. an unsolvable puzzle, this generative space needs to be pruned through adjustments to variables and additions to the algorithm being used. As a generative space becomes smaller, more viable candidates potentially become excluded from what the procedural content generator can create. For DU, the team wished to maintain a wide range of generative space, as the candidates generated for a given puzzle were separately checked by a solver to see whether they were valid.

It is important to track overall metrics from the generative space across iterations of the procedural content generator. This can be done through **data visualization** techniques. One such technique involves sampling discrete properties of each artifact produced in a batch and generating multidimensional heatmaps that plot these values on various axes. This way, a developer can better understand the relationship between the changes that they have made and the relations between key variables in the generative space at large. The team used data visualization techniques while developing key parts of the procedural generation found within Dyadic Unity.

2.4 Unity Development

The Unity Engine has been around since 2005 and has gained quite a bit of traction amongst the game development community. This comes with heavy online support, as well as several publications to refer to. In addition, to best serve their users, the developers of Unity made it a point to provide “extensive documentation and support for the users” (Haas). With these

resources, the team was able to more quickly utilize the APIs provided by Unity, while quickly debugging content.

Overall, Unity is a general-purpose game engine with several years of user-feedback and updates, as well as an extremely active community. While it may not present the fidelity of creating a custom game engine for this specific game, as it has a bulk of features the team had no use for, the team has deemed the time saved from utilizing it is well worth this trade-off.

The team decided to build the game in the Unity Engine because it has a lot of flexibility to offer with 2D art. It has a useful plugin available called Dragon Bones that allows rigging of 2D sprites and importing them into the software. Additionally, one of the programmers associated with the project had significant prior experience with Unity as opposed to other available engines to use. This familiarity ensured a more informed approach from the planning phase. Additionally, there would be far less time incurred in navigating learning curves associated with implementation specifics. This would grant the ability to add more refined mechanics, prototype and test ideas more quickly, as well as implement more stretch goals.

3.0 Methodology

With this MQP, the team's mission was to create an interactive digital game world where we explore the effects of player choices on non-player-characters and objects within the game world, the generation of new unique puzzles in this game world, and how to communicate the complex game features to the player within the space of the game.

This mission involved providing a way for players to drive the emotional development of a series of characters taking mirrored forms called "dyad pairs." To this end, the team created a system that allows NPCs to adapt emotionally based on player choices. This system influences the state of various objects in the world, allowing players to navigate puzzles in the game world. We also explored procedurally generated puzzles and implemented new indicators and features to explain these systems to the player. In order to achieve these goals, the team established three main objectives:

1. **Plan an initial design** with specific **puzzles** and game **mechanics**
2. **Prototype** various puzzle designs in Unity, with a focus on creating **functional and iterable** content that could be **tested by users to obtain feedback**.
3. **Expand and refine** puzzles to implement the basic mechanics upon a wider range of objects. Include new usability features and add complexity to puzzles, then test this expanded game one more time to discover whether the changes we implemented were effective.

Dyadic Unity's development was an iterative process. At each stage of development, we collected user feedback and used this to further improve and refine the game. To collect this feedback, we held several playtesting sessions over the course of the project. There were three major playtesting sessions, where multiple playtesters would test the same build of the game, as well as several smaller playtest sessions with one or two people playing intermediate builds of the game.

Before playtesting, we required potential testers to sign the informed consent document (Appendix G). This is standard procedure, compliant with guidelines set forth by the IRB here at Worcester Polytechnic Institute. By reading and signing the consent document, potential testers became more informed on their rights related to playtesting Dyadic Unity, including their anonymity, safety concerns, and benefits related to the testing.

The first playtest occurred during Alphafest. Observing player behavior within the game allowed us to identify and then fix minor bugs. The feedback from this initial playtest indicated that the game needed a lot more UI. Players overall felt they were not aware of their current progress

within individual sections and the game as a whole. This criticism encompassed the need to: make the map clearer, make a map for the Garden Puzzle, and add a means of keeping track of a player's progress within the UI.

To address these concerns, the team implemented several features in the following weeks. The team cleaned up the map, as well as added a map for the Garden Puzzle. Additionally, the team placed UI elements over many of the interactable objects within the world, to better signify what a player could and could not interact with.

The next playtesting occurred in ad-hoc sessions throughout B and C term. This test came with a survey (Appendix H). This survey addressed the player's comprehension on navigation, core mechanics, and puzzles. It also checked the player's satisfaction with visual elements, as well as the experience as a whole.

According to the results, maps and UI added still were not preventing players from becoming rapidly lost in the game world. Moreover, a majority of the results showed that players were not aware of key mechanics, including dialogue having impacts on physical objects within the world. This was particularly problematic, as without awareness of this mechanic, players could not progress through puzzles or make meaningful decisions whilst navigating them. Overall, players seemed to be satisfied with the visuals provided by the game in this stage, a majority tending to give the visuals a $\frac{3}{4}$ or higher on the provided Likert scale.

4.0 Design

The world of Dyadic Unity is made up of two parallel worlds populated by pairs of creatures called dyad pairs. Every character has a counterpart in the opposite world. Inside the game, there are three dyad pairs: two pairs of NPCs and one pair made up of the two playable characters. A character's name is their role within the world. The Pilgrim is on a special journey to gain the experience needed to step up as the new guardian of his land, while The Warrior is journeying to gain enough power to fight a corrupt guardian. However, the names hint at their vices as well. For instance, The Custodian spends so much time cleaning that she never has time for self-improvement. Her analog is The Host, who over-invests time and energy into other people while neglecting himself. As the player journeys through the world, they will sometimes have to choose one half of a given dyad pair to assist.



Figure 8: Locations in Dyadic Unity.

As they begin the game, the player will first enter a tutorial level meant to teach them basic game mechanics. In early versions of Dyadic Unity, players struggled with understanding mechanics like world switching and the emotion system. To resolve this, we created a simple level that required players to switch between worlds to get past a physical obstacle, after which they must interact with a pseudo-NPC dummy to change the emotional state of the world and acquire an item needed to proceed. This tutorial helps players get their footing and reduces the bar of entry to play and fully enjoy the game experience.

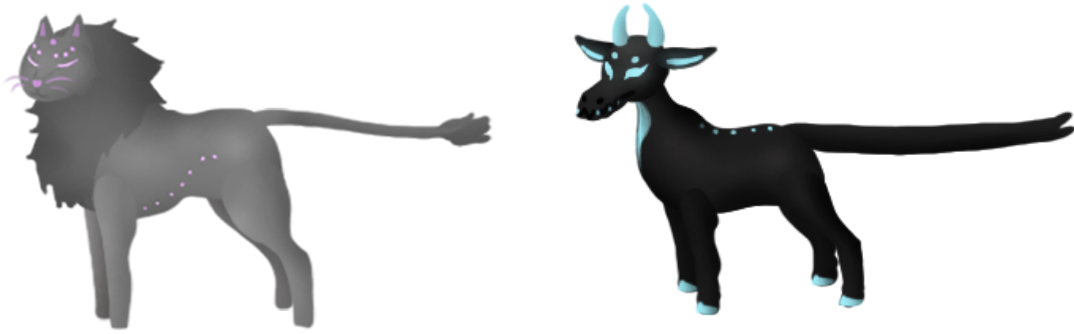


Figure 9: The Gardener and The Apothecary.

The Gardener and The Apothecary, located in the light and dark sides respectively, are a dyad pair defined by their extreme self-image relative to how others view them. The Gardener wishes to maintain their award-winning garden to always be the same- under the belief that it can be no better. Conversely, the apothecary is never satisfied with the plants they maintain, feverishly cultivating new harvests.



Figure 10: The Custodian and The Host.

The Custodian of the light side and The Host of the dark side manifest as people pleasers. It is The Custodian's job to keep the Land of Order clean and organized, especially within the garden. She fears The Empress and worries about being punished should she fail to keep the land to her standards. She is often worried and anxious, as there are always more messes to clean up. Despite these worries, she often tries to conceal her fear to avoid worrying others. The Host, on the other hand, is responsible for entertaining guests during parties in the grove. He feels pressured to maintain a fun and relaxed persona, considering anything less to make him a failure

of a host. To this end, he neglects his own personal responsibilities. See Appendix A1 for details on the associated puzzle.

4.1 World Switching

One major feature of Dyadic Unity is the player's ability to shift between worlds. This shifting does not move the player character however, it simply changes the player's perspective to the view of the playable character in the opposite world. Players may shift at almost any time by pressing either of the shift buttons on their keyboard. Shifting is only restricted when the player is actively speaking to an NPC or when the player's position on the opposite side would be obstructed by an object.

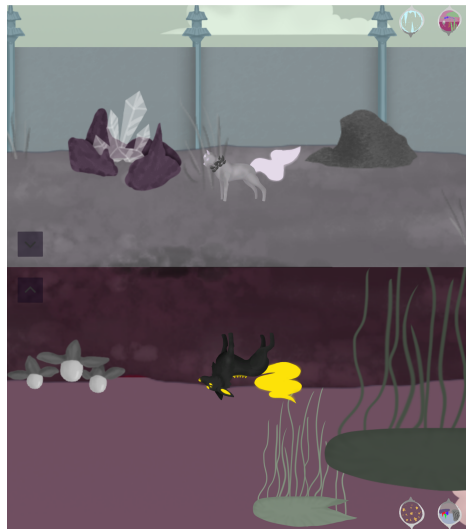


Figure 11: Visual example of parallel locations between worlds.

Player actions are mirrored between worlds. As the player navigates one world, the opposite world's playable character will move the same way in their own world. Speaking to and influencing one NPC will also affect that character's other dyad half. For example, calming down The Custodian will make The Host depressed. Fixing something in one world will break it in the other. Similarly, growing plants in one world will trim them in the other, and vice versa. These are all things that players must keep in mind as they navigate both worlds using the power of shifting.

This ability to shift is required to solve the puzzles of Dyadic Unity. While helping The Custodian or The Host, collectable items used for fixing objects are often located in the opposite side's world. While helping The Gardener and The Apothecary, both the growing and cutting of

plants is necessary to navigate their maze, so players must shift in order to interact with a plant in the correct way.



Figure 12: The tutorial area in Dyadic Unity.

Functionally, we achieve the effect of ‘shifting’ in different ways depending on where the player is currently located in the game. In the tutorial and the areas associated with The Custodian and The Host, the current scene is changed, and the armature used for the player is swapped to the other playable character, but the player object itself is never moved. Objects that are connected to each other have shared stats in the GameManager object that persists between all scenes within the game. Changing the state of any object will affect the corresponding object on the opposite side. The areas connected to The Gardener and The Apothecary are actually contained within a single scene, with both shifting and moving between ‘rooms’ just changing the currently visible objects within the scene, in addition to switching the player armature.

4.2 Emotional System

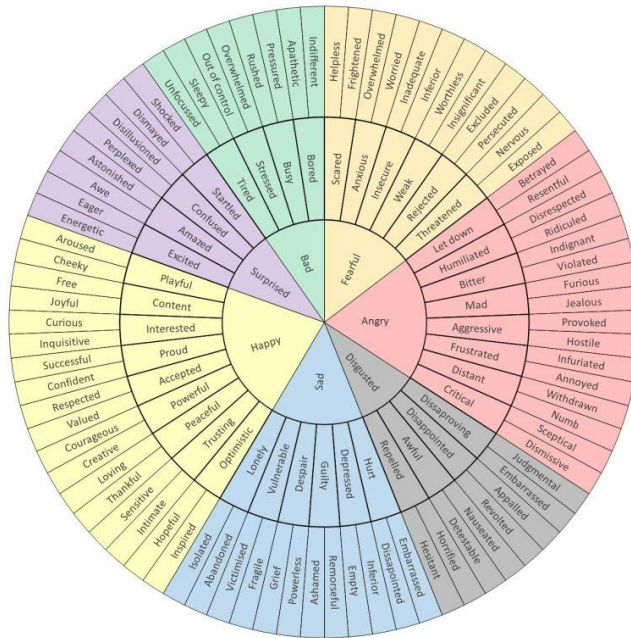


Figure 13: Geoffrey Roberts' Emotion Wheel.

Dyadic Unity makes use of an NPC emotion system that was inspired by Geoffrey Roberts' emotion wheel. As players interact with NPCs, their dialogue choices will be based on each of the emotions in the center of the wheel except for 'surprised'. These essentially determine the tone that the player character is speaking with. Within the game, each of these emotional tones are represented by elemental symbolism.



Figure 14: Elemental symbolism (left to right): Angry, Sad, Bad, Happy, Fearful, Disgusted.

The Custodian and The Host each have three main emotional states they can be in, based on their personalities. Within the code of the game, each emotional state has a score attached to it, and the state with the highest score will act as that NPC's current emotional state. The Custodian's 'annoyance' score is tied to The Host's 'excitement' score, fearful is tied to 'playful', and 'calm' is tied to 'depressed'.



Figure 15: The Custodian’s emotional states of annoyance, fearful and calm (top) and The Host’s emotional states of excitement, playful, and depressed (bottom).

Each time the player speaks to an NPC with an emotional tone, the NPC’s emotional state scores will be updated based on weighted values of the tones in addition to weights based on the prior emotional state scores. Though only one dyad pair currently uses this emotion system, it is intended that each dyad pair would have their own unique weights for these calculations based on their personality.

$$\text{Sun} = 0.75 \text{ Sun} + 0.25 \text{ Water} - 0.25 \text{ Fire} - 0.5 \text{ Ice} - 0.5 \text{ Wind} - 0.25 \text{ Cloud} + \text{old Sun}$$

Figure 16: Example of weights used in updating The Custodian’s calm emotional score

While the primary emotional state does affect NPC dialogue, its most important effect is its ties to the states of various objects in the game world. There are many objects the player can collect items from, but these items are only available when the object is in the correct state. These changes are connected to the elemental symbolism of the current emotional state. A fearful state, which is represented by ice, will cause a fountain to freeze and snow to fall. A playful state, represented by glowing stars, causes glowing bugs to leave to hive and glowing sap to drip from a tree. The items collected from these objects can then be used to fix items for The Custodian or party with items for The Host. The puzzle is considered solved once either all items are in a fixed state for The Custodian or all party objects are in an active state for The Host. It is impossible to assist both NPCs as puzzle objects are connected to each other and activating an object on one side deactivates it on the other side.

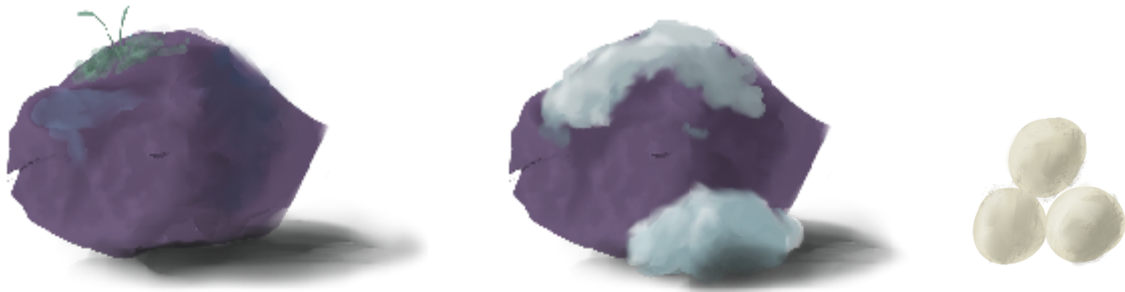


Figure 17: The two forms of a puzzle rock: calm/annoyance form (left) and fearful form(center). Snowballs collected from the fearful form of the rock (right).

4.3 Dialogue Wheel and Conversation Logic

The dialogue system of Dyadic Unity is tied heavily to the game’s emotional system. As a player engages an NPC in conversation, they will have up to four emotional-tone-based dialogue options to choose from. Each option has a frame representing its emotional tone and each contains an abbreviated version of what the player character will actually say. A textbox below the dialogue options contains the full text of a dialogue choice, and this text updates as the player hovers over each dialogue option. The upper textbox contains the NPC’s dialogue.



Figure 18: Dyadic Unity’s dialogue interface.

After the player chooses a dialogue option, the NPC will respond with a modular two-part response. The first half of their response will be a direct response to the player’s choice, while the second half will be based on the NPC’s emotional state.

4.4 Puzzle Generation

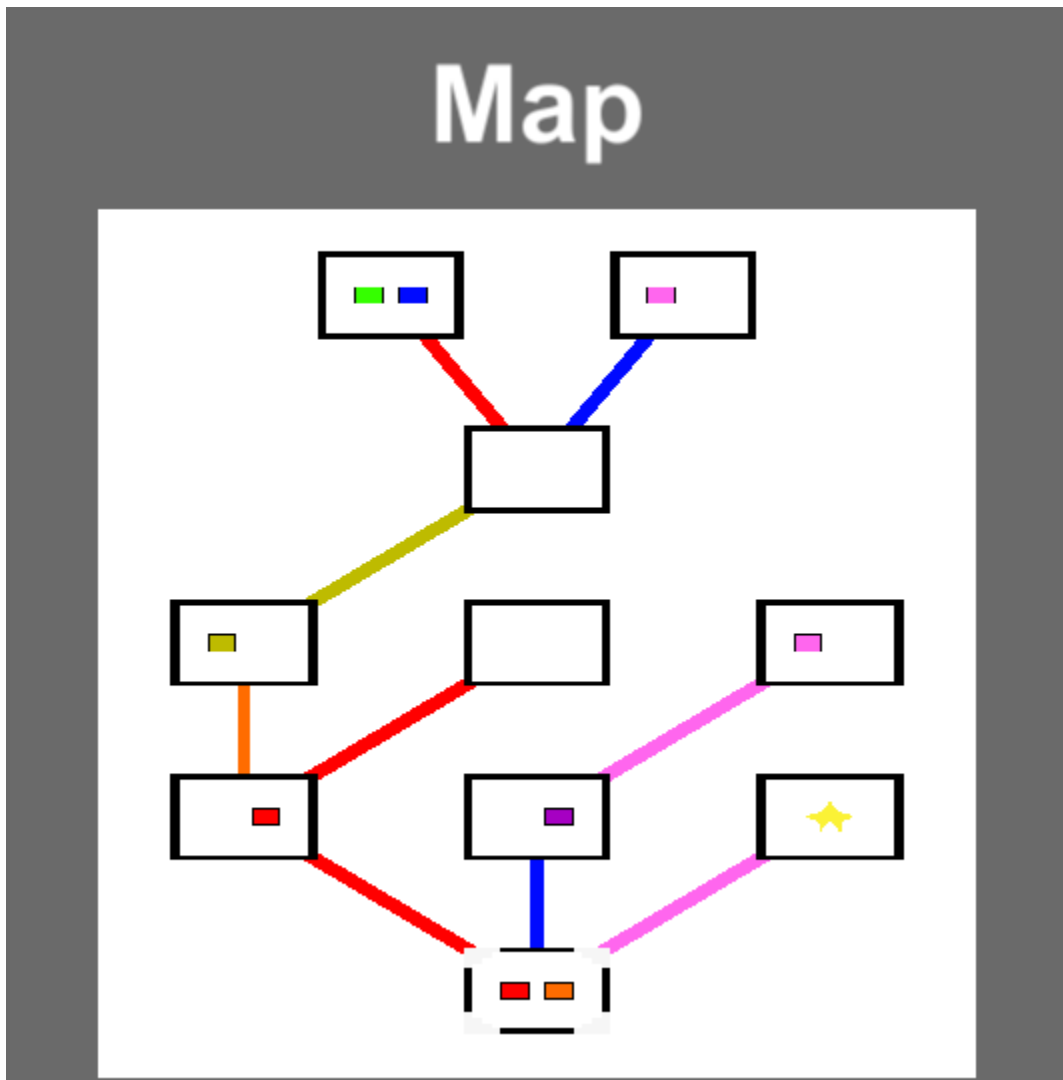


Figure 19: Example of a procedurally generated map.

In the final product, puzzle generation solely exists within the Gardener/Apothecary puzzle. This puzzle had clearly defined rules which could be used to generate puzzles given an array of related parameters. The rules of the Gardener/Apothecary puzzle are as follows:

- 1) Only 1 plant may be grown per room
- 2) Plants contain various colors
- 3) Doors may only be traversed when their corresponding color is grown somewhere in the maze.
- 4) Multiple plants of the same color can be grown at once.

In generating a puzzle, the algorithm uses some heuristics to trim solutions that are immediately unsolvable from the generative space. The most important is simply not allowing a door to generate which requires a color not yet found within the puzzle. For color placement, the algorithm sets a number of empty plants and repeat plants, and then randomizes the order in which the solver will encounter the plants.

Once the generator makes a puzzle, it attempts to evaluate the quality of the puzzle. The fitness of a puzzle directly relates to how many steps a solver would need to take to get to its goal. Because of the complex number of states in the puzzle, it is intractable to use a complete algorithm to determine the number of steps it takes to reach the solution. The state space is prohibitively large. Instead, the algorithm performs an iterative deepening set of random walks with a max depth, up to a limit, returning if any random walk gets to the end.

When the game state requires a new puzzle, then the corresponding scripts generate several new puzzles per frame and keep track of the best one generated thus far. This is done by simply comparing their fitness. When the player decides to go through the first door of the maze, then the current best puzzle becomes the puzzle they must solve, and the generation process stops until it is solved.

4.5 Modular Assets

Modular assets are one of the smartest ways to go about crafting what would ordinarily be large amounts of original assets for many different areas. Doing this drastically cut down production time, which was important because the art team was small. Making smaller pieces that can easily be added in and out of sprites was imperative, as well as adding color filters and small extra features.

Other pieces are rocks, bushes, and trees, which were made out of a root modular trunk, and have added modular foliage pieces. The team then placed these modular pieces and edited them in any fashion to give them a different look and feel while still staying within the same style. For instance, a large boulder on its own could be a separate piece and additive pieces could be pebbles surrounding it or little colored plants.



Figure 20: Example of some base grayscale recolorable assets. From left to right, tree trunk, fence piece, hedge, and rock.

Aside from creating small props, the art team made bigger props like sky backdrops. The team avoided the issue of parallax complexity by having a very small camera view, which reduced the need for parallax. Instead, most of the objects are located in the foreground, in line with the player, slightly behind the player, or very far behind (like clouds or the sky). All the art assets for the game can be found in Appendix F.

4.6 Artistic Process

The art team had a few different processes to create efficient and beautiful art assets for the game. The primary method for animated props and characters was to create them for the DragonBones animation and rigging system, and all of the game’s static props were simply rendered in Photoshop.

4.6.1 Character Creation

Each in-game character was first drawn in photoshop, with each limb or separate piece on a different layer. This allowed them to be imported into DragonBones with ease for animation purposes. Each character’s model in DU has a single makeup of limbs. After rigging and animating the character within DragonBones, the character is ready to be exported to Unity and used. An example can be seen below for the final version of one of the main characters. All of the NPCs are stationary, so they have an “idle” standing animation. The two halves of the player character have walking and idle animations.

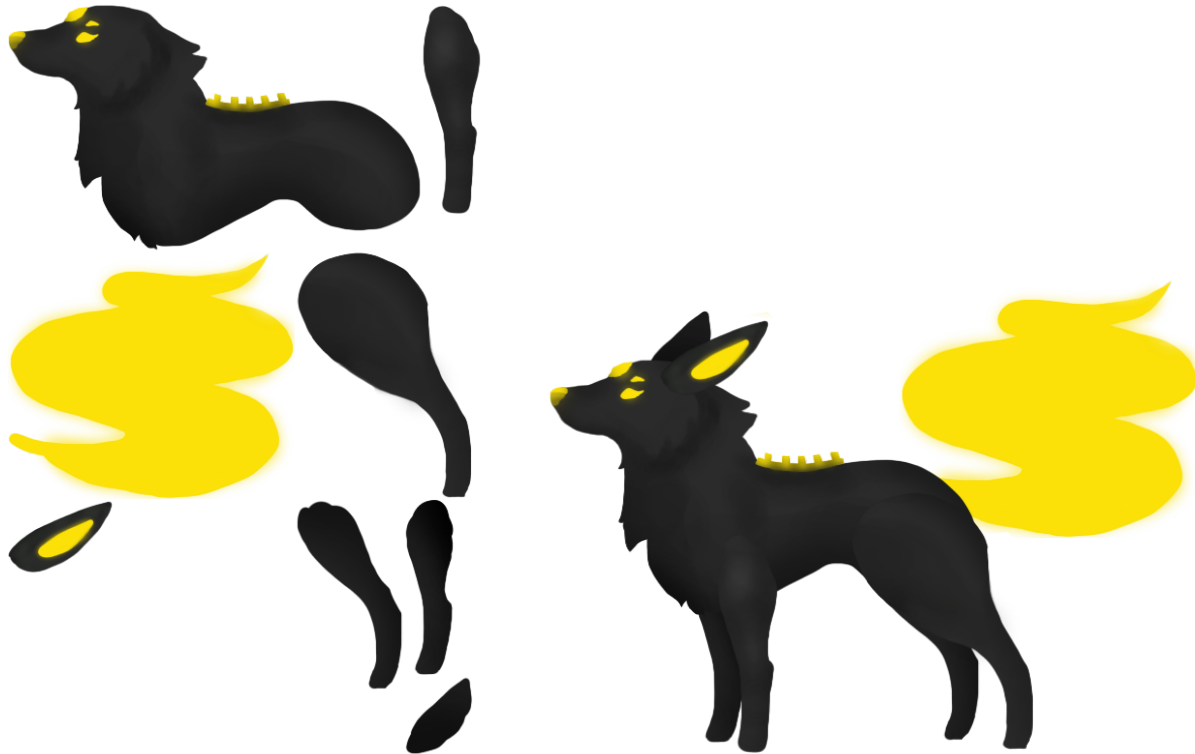


Figure 21: Example of a finished character breakout sheet for animation production vs what it looks like in game.

4.6.2 Color Choice

In DU on the chaos side, the color palette is high contrast and saturation with a colorful feel. The palette on the dark side includes oranges (enthusiasm, creativity), reds (passion, fleeting), and dark blues (to represent sloth). On the order side, the palette is a bit more restrained and desaturated. The primary color variants the player will find in the order world are colors close to white (to represent purity) and purple (to represent the luxury of royalty).

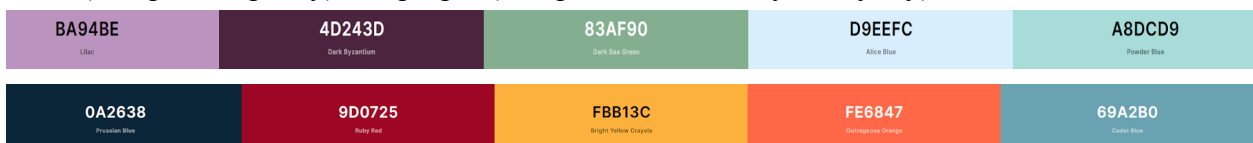


Figure 22: Example color palette for chaos side (below), and color palette for order side (above).

4.6.3 Asset Creation

The art team researched many techniques on how to build these assets in the smartest way possible, including using liquify editing, warping, color filters, and small pieces that make up greater wholes to stretch asset creation as much as possible due to the small art team. Another way was found during production, which required making grayscale assets and re-coloring them in the game engine. An example of small asset creation would be the creation of a tree: The

different “leaf bushes” that could be populated on the tree could also double as bushes, and if there were enough different looking leaf bushes they could be used for a variety of things. Regarding indoor spaces, the art team made individually generated walls with layers to add over them in order to add complexity and detail. An example is shown in the diagram below. The team gleaned this technique from the Reckoning: 2.5D Western Side-scroller MQP paper (Gaddis et al. 2020).

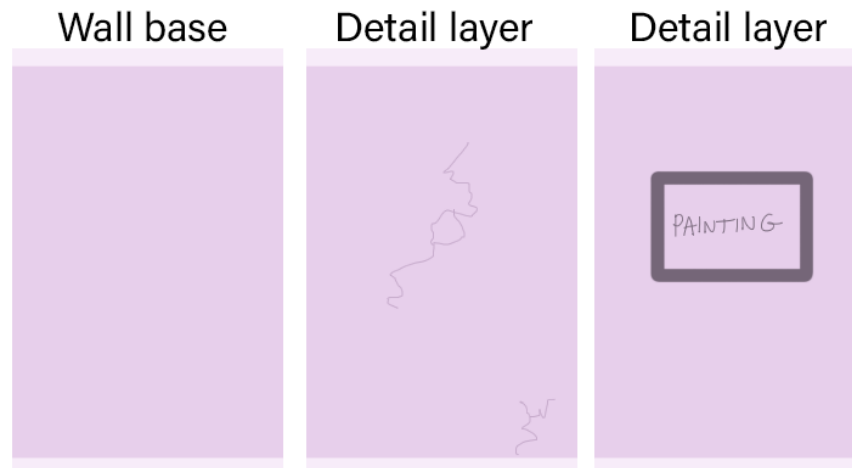


Figure 23: Indoor space generation basic example.

One of the largest problems with asset creation is issues with sizing. If the tree trunk asset is as large as a fencepost, that can cause visual confusion. Resizing assets in the engine in a significant way should be avoided, as it uses memory that could be directed to other functions. Optimizing assets, even for a 2D game, is very important for performance. Not doing so can exclude players with slower or older computers. The art team had a very simple solution for this challenge: asset sheets. Every asset in the game was drawn on a series of 16 squares, so that every asset had a comparison size before being exported into the engine. Examples of the art team’s size comparison asset sheets can be found below.

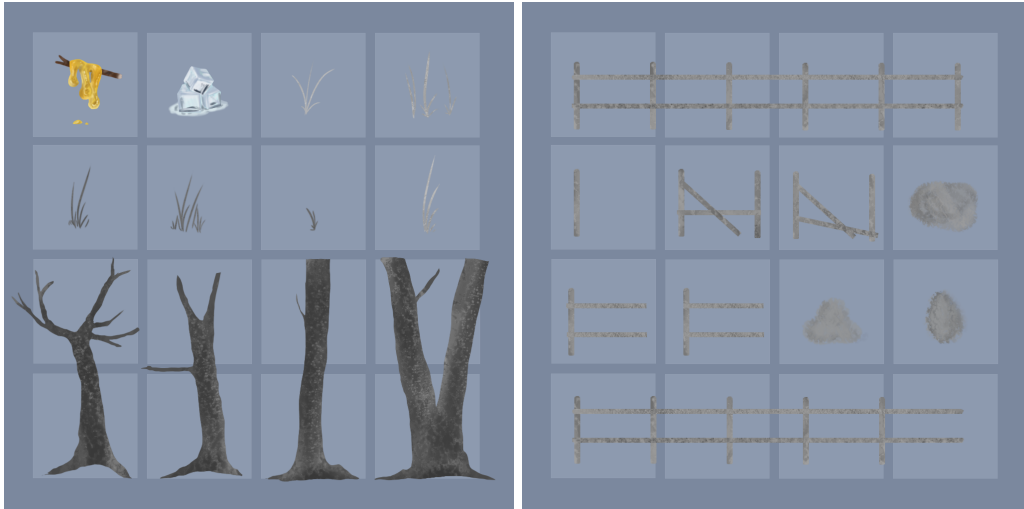


Figure 24: “Backpack” elements are compared to in-game grass and trees (left). Fences were compared to bushes, and to make sure there were matching modular pieces (right).

4.7 UI and Player Feedback

As the team developed Dyadic Unity, we discovered that communicating features to the player was one of our biggest challenges. To tackle this, we developed a variety of useful UI indicators. As the player walks past interactable objects, a bubble indicator will appear and hover over the object. Three dots within a bubble indicate that interacting will start a conversation. An image of an item inside a bubble indicates the item needed to fix an object.

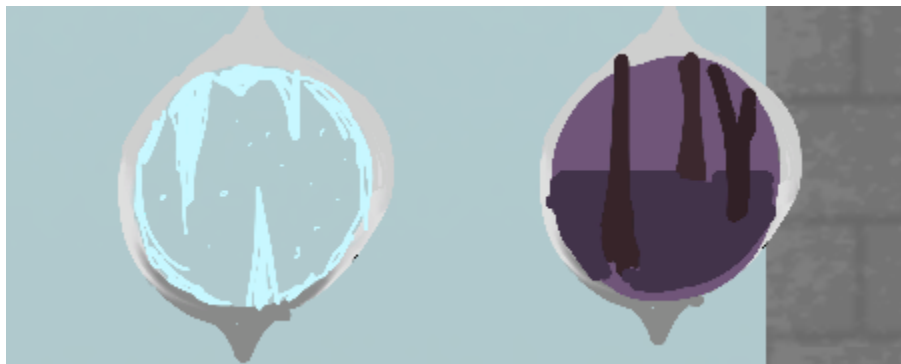


Figure 25: The emotional state indicator (left) and location indicator (right).

Two permanent indicators persist in the upper right corner of the screen. The first is an indicator containing elemental symbolism representing the local NPC’s current emotional state. The second indicator contains an image representing the location in the opposite world the player would shift to. In the bottom left corner, the player’s currently held item is visible. Additionally, each puzzle has its own map that may be accessed by pressing tab.

4.8 Sounds

To give auditory feedback to the player, as well as characterize the environments within the game to greater depth, the team included a set of background tracks and sound effects. These sound effects and background tracks play as players traverse through the game state and perform specific actions. The sounds were all mixed from creative commons sounds found on freesound.org, using Reaper.

Within this process, the team combined related tracks into one project and then trimmed/moved them to the appropriate temporal locations. The team adjusted volume and spatial balance. Finally, the team included various effects, including equalization, compression, and echoing.

5.0 Discussion

During the course of this project, there were quite a few challenges the team was presented with. Many of these challenges involved communicating the game systems to the player. Here there-in is a discussion of the problems the team encountered along the process of making the game, and how we fixed them.

5.1 Planning Initial Design

Plan an initial design with specific puzzles and game mechanics.

To start the project, the team spent time brainstorming potential mechanics for the game. These first seven weeks focused on coming up with UI designs, characters, locations, puzzle concepts, and game mechanics. Near the end of this period, we drafted our initial project proposal. The team met each week through their team Discord server and shared new ideas, and then adapted and built upon them so these ideas could form one cohesive design. Additionally, the team used Zoom to meet weekly with their advisors and update them on progress.

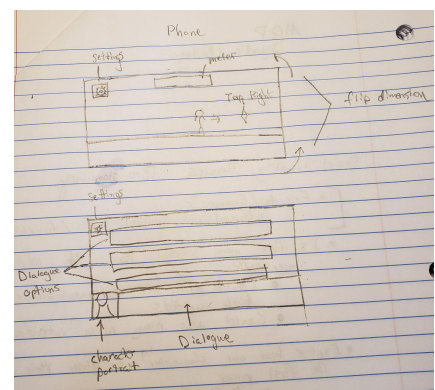
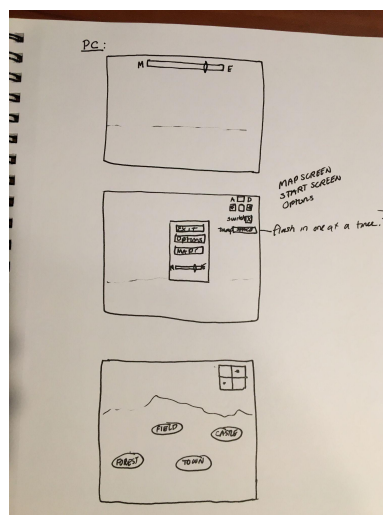
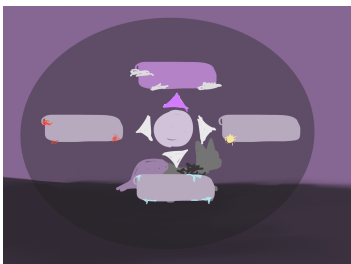


Figure 26: Early UI design concepts.

Each team member produced various drawings, diagrams, and write ups to develop their ideas. We stored all of these brainstorming documents in the team Google Drive, alongside meeting minutes, design documents, reports, presentations, and any other important files.

Ultimately, the team brainstormed seven “dyad pairs,” including the player characters, with locations and puzzles for each non-player character. We also determined our major game mechanics of switching between two parallel worlds, an emotional interaction system, and procedural generation, as well as the basic UI elements needed to go along with these mechanics.

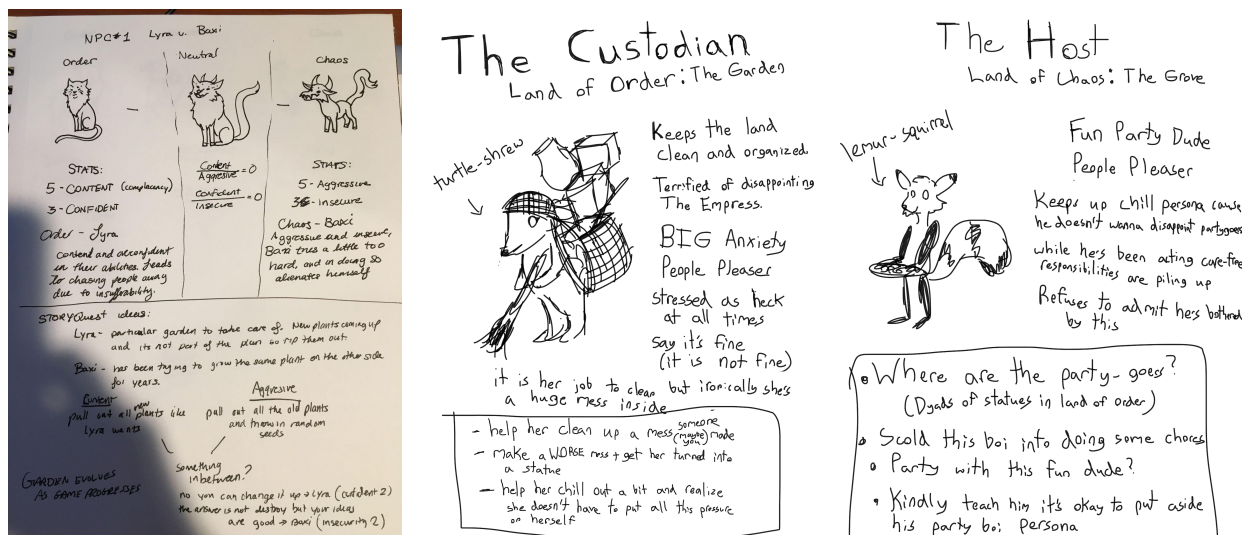


Figure 27: Character Concepts for The Gardener (Lyra), The Apothecary (Baxi), The Custodian, and The Host.

As the team entered development, this was narrowed down into three “dyad pairs,” including the player characters and two pairs of non-player characters with their associated puzzles. Initially we had planned for players to have the end goal of “fusing” the two parallel worlds, and designed puzzles with this end goal in mind, but we dropped this mechanic over the course of development. References to some unused characters remain in the dialogue of the final game.

5.2 Prototyping Initial Puzzle

Prototype initial puzzle designs in Unity. Create functional puzzles in their most basic forms. Test this prototype with players to discover which aspects of the game are difficult to understand.

For the next fourteen weeks of the project, our team worked on developing the game in Unity. Each programmer focused primarily on one of the two main puzzles (The Custodian/Host puzzle and the Gardener/Apothecary puzzle) while the team's artist produced assets for both. While in production, Unity Teams worked very effectively as version control for our small team. We found it easy to push game updates to each other with the push of a button, and merge conflicts were rare as it was unlikely any two team members to be editing the same file at the same time. Collab History was a valuable feature that helped in tracking down the source of bugs. We could easily jump between previous versions to locate exactly which code changes introduced bugs that were not immediately obvious.

Our basic puzzles consisted of a maze in which players unlock doors by growing and trimming plants for The Gardener and The Apothecary, and another puzzle involving helping either The Custodian repair all of her ice sculptures using ice or partying with The Host and lighting up giant mushrooms through the use of glowing sap.

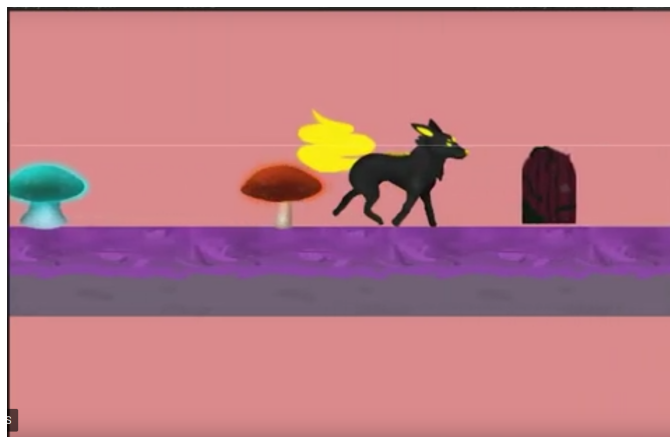


Figure 28: Dyadic Unity AlphaFest Build.

During AlphaFest, we were able to playtest these early versions of our puzzles. The feedback we received provided many valuable insights and it allowed us to identify the major challenges we needed to overcome.

5.2.1 Challenge 1: How should players interact with the world?

Our initial design of the Custodian/Host puzzle involved players clicking on objects to fix them and jumping onto (or otherwise entering the hitbox of) items to party with them. However, we realized it was necessary to narrow the focus of gameplay in order to meet our true goals for the tone of this game. Platformer mechanics requiring players to jump around and dodge objects did not fit into our vision of a relaxed whimsical world. The next version of the puzzle simply

required players to click on an object while possessing the required item in their inventory. This version of the puzzle was truer to the team’s vision of the game.



Figure 29: Examples of items the player character can pick up to solve the Custodian/Host puzzle.

As we began to fill the game world with new assets, we discovered a new challenge: players did not know what could be interacted with. To solve this, we added a new UI element: a bubble that hovered over objects of interest when you approach them. While this certainly helped identify interactive objects, it also became the source of additional problems. Players often first encountered this bubble hovering over an NPC that they could talk to. In future encounters of this bubble, they began expecting a conversation to take place.

The confusion surrounding ‘interaction bubbles’ necessitated new bubble designs. Our new designs not only differentiated ‘conversation bubbles’ from ‘puzzle object bubbles’, they also explained to the player what was needed to proceed in the puzzle. Now, objects that needed to be ‘fixed’ or ‘partied with’ would have a bubble containing an image of the item required for that interaction. These bubbles each had three different forms, based on the current state of the puzzle object.



Figure 30: Interaction bubbles for: (a)speech, (b)unsolved objects where the player is missing the item, (c)unsolved objects where the player has the item, and (d)solved objects.

Despite the new interaction bubbles, players remained uncertain about how they should interact with item source objects (objects that players can collect items from). Our solution involved connecting NPC dialogue to these objects, with a colored and bolded emotion word (calm, excited, anxious, etc.) to identify the required emotional state for the item, and a second bolded word identifying the type of object that the item was to be used on. With this addition, players

could now identify what they needed to do in order to interact with an object, and why they needed to interact with it.

5.2.2 Challenge 2: How will players navigate the world?

Another challenge involved the way players navigated our world. In early versions of the game, players quickly and frequently found themselves lost. They cited a myriad of reasons including the world being too big, the rooms all looking the same, and a general lack of understanding of how rooms connected to each other.

While several changes were made to aid player navigation, the most important addition was a map. By simply pressing ‘tab’, players could open a map containing a hovering indicator over the current room in the Custodian/Host puzzle, or find their location represented by a highlighted box in the Gardener/Apothecary puzzle.

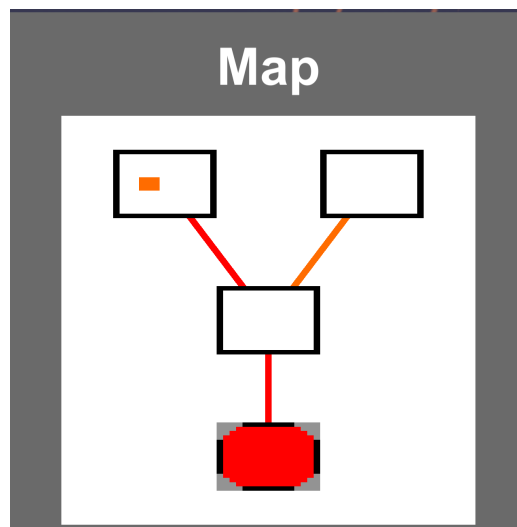


Figure 31: The Gardener/Apothecary puzzle map.

As the Gardener/Apothecary puzzle consists of a maze, the map and its included features were especially important. On this map, colored lines represent the colored doors connecting rooms, colored squares represent the colored plants found in each room, and the overall color of a room on the map represents the current plant color grown inside, indicating to the player that doors of that color are unlocked.

As each room in the game became filled with art assets, they began to gain distinct identities from each other. Two rooms that were once identical platforms could now be identified as a forest or a cave. Artistically unique rooms greatly improved players’ sense of the world.

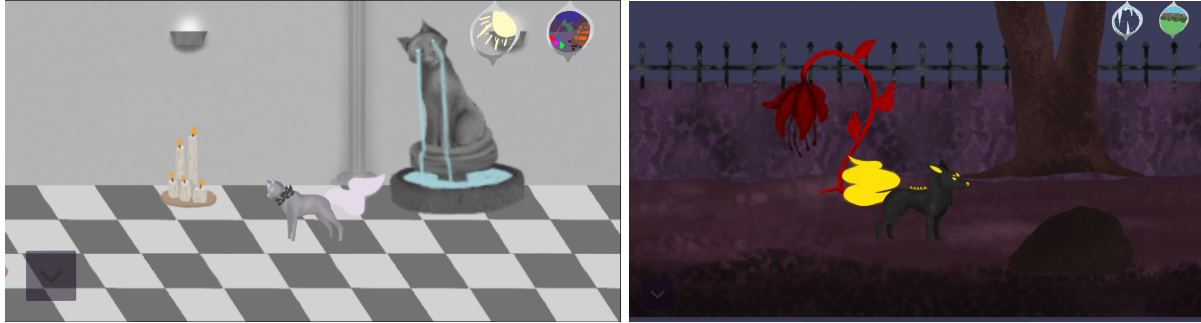


Figure 32: Examples of decorated rooms within the game.

Asset placement also played a role in player navigation. In initial builds of the game, doors were all located behind the player character. Players had no sense of what direction they were moving as they travelled from one room to another. After placing some doors in the foreground, players could then tell if they were moving ‘forward’ or ‘backward’ in the world.

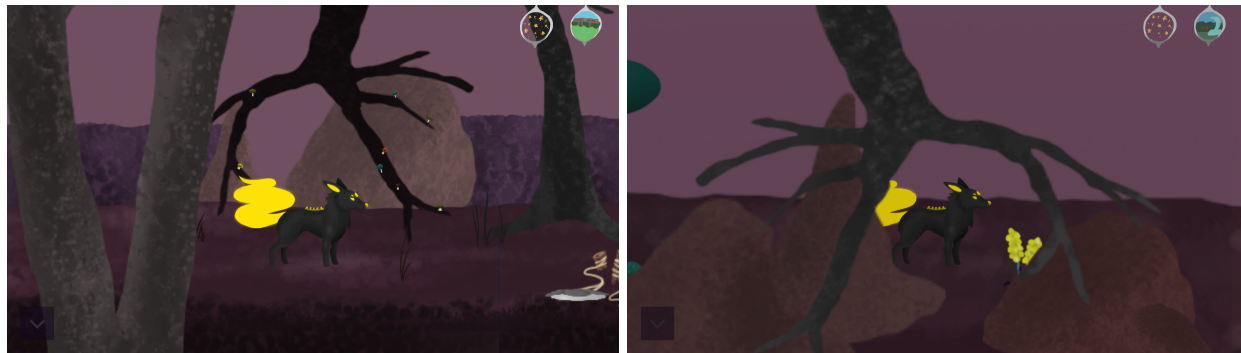


Figure 33: Examples of door behind (left) and in front (right) of the player.

A second and greater challenge concerning navigation was shifting, or more specifically, players’ lack of shifting. Despite the existence of two unique game worlds to explore, players often spent all of their time in one, seemingly forgetting about their ability to shift between them. We ultimately did not solve this challenge until much later in development, where we created a tutorial level explicitly explaining the mechanic and forcing the player to use the feature.

5.2.3 Challenge 3: How will players perceive their impact on the world?

Our final challenge involves how players perceive their impact on the game world. In the Custodian/Host puzzle, the player’s relationship with each NPC is a central mechanic to solving the puzzle, but in early versions of the game, this mechanic is not obvious.

The first step to solving this challenge was to indicate to the player that talking to NPCs was indeed ‘doing something.’ Through a combination of stylized dialogue boxes and a new element-themed indicator, we could signal to players that each choice had a different effect. The resulting emotional state from their choice would be symbolized in the indicator.



Figure 34: The “Annoyed” indicator and two objects that are set on fire during this state.

Players also needed to know that these choices were affecting the physical state of the world. To display this impact, the team designed multiple versions of game objects, with their alternate versions only displayed during the correct emotional states. We designed these other versions to match thematically to the indicator images.

These features each work together to show the player their impact on the world as they navigate this puzzle.

5.3 Expanding and Refining Puzzles

Expand and refine puzzles to use the basic mechanics on a wider scale. Include new usability features and flesh out puzzles into more complex forms. Test this expanded game one more time to discover any remaining areas of confusion for the player and any major issues with game mechanics.

During the latter half of our fourteen development weeks, we expanded the scope of each puzzle and fleshed out the game world with additional art and sound. The Gardener/Apothecary puzzle was transformed into a series of smaller procedurally generated mazes, while the Custodian/Host puzzle was adapted to make use of the emotion system by tying item access to the emotional states of NPCs. An additional five pairs of objects to fix/party with were added to the light side and dark side respectively along with the sources for the required items to interact with each of them.

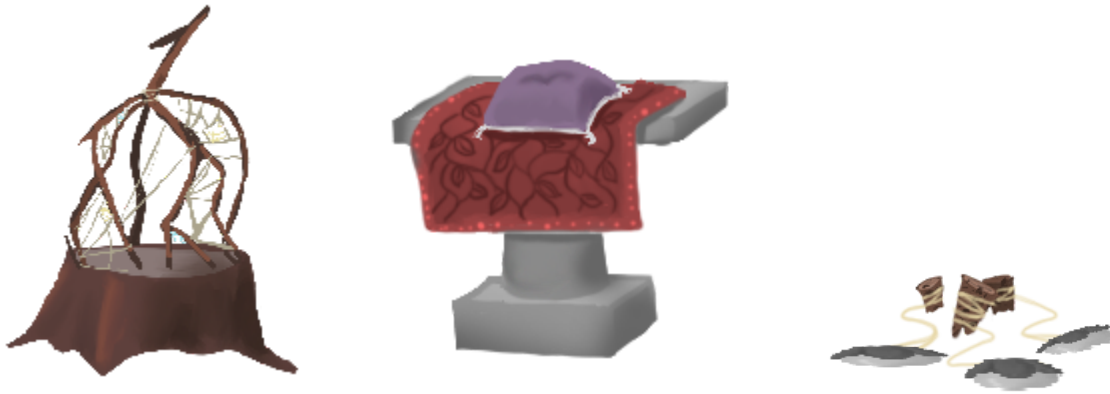


Figure 35: Objects the player can fix/party with.

We spent the next seven weeks polishing and finalizing our game. During this time, we also created a brand new tutorial level, which guides players through the basic mechanics of world switching, interacting with NPCs to change their emotional state, changing objects in the world through changing an NPC's emotional state, and picking up and using items.



Figure 36: The tutorial level teaching the player about the impact of emotions on the world.

Over the course of two days, we ran additional playtesting sessions on this expanded version of Dyadic Unity. Through these sessions we discovered lingering bugs, ranging from temporary assets accidentally being left in the game to game breaking issues causing players to get trapped in a room. We also discovered which aspects of the game were still confusing to players and made plans for further improvements, implementing as many as we could during the time remaining.

The team performed one final round of playtesting to assess the impact of these changes. Further potential game improvements are present in our postmortem.

6.0 How to Play

The team's aim in creating a control scheme for Dyadic Unity was to keep it simple and intuitive. Through user feedback in playtests, as well as the advice of our advisers, we believed we achieved this desire.

The player can move left by pressing A or the left arrow key. The player can move right by pressing D or the right arrow key. By incorporating both, we hoped to accommodate for players accustomed to either set of controls. There is no button for jumping, as we knew such a mechanic served no functional purpose and would add unnecessary complexity to the game.

To shift between realms, players may press either left or right shift. Originally, the team only used the left shift button, however, playtesting feedback informed us that some players wanted to use the other shift key, so we incorporated that as well.

To interact with objects, pick them up, enter doors, and initiate dialogue: a player can press F or the left mouse button. These all fall under the simple notion of "interact". The team chose the F key because of its proximity to the A and D keys. Whilst in dialogue, players may use WASD or the arrow keys to select different options (W for up, A for left, D for right, and S for down respectively). Alternatively, they may click dialogue options to obtain the same effect. To navigate various menus, such as the title screen, a player can drag their mouse over the options presented to them and click the one they choose.

As playtesting and development went on, the team integrated several maps to guide the player through the game. To access the map, a player can press the tab key. To hide the map, the player can press the tab key again.

Overall, there are not many different buttons to keep track of whilst playing this game, for the team felt it was important to prevent the controls from being distracting and/or overwhelming.

7.0 Postmortem

7.1 Accomplishments and Success

Overall, Dyadic Unity has succeeded in its goal of creating a whimsical and visually pleasing world for players to explore with several interesting gameplay elements. The game successfully makes use of procedural generation and its emotion-system to provide unique puzzles for players to explore. The team overcame several player communication challenges through the use of additional UI elements and game features. Ultimately this resulted in two complete and polished puzzles.

7.2 Areas for Improvement

There are things that the team could have improved throughout this Major Qualifying Project. First, the team could have performed more testing throughout the course of the project. The team took many weeks to get IRB approval, and only ran three testing sessions across three terms. These sessions generally had a small turnout, and while the team found the data gathered useful, more feedback can only strengthen a game development project. The team ended up vastly overscoping what we wanted to achieve, which was a design weakness for Dyadic Unity. There was a myriad of Dyad pairs planned, each one moving the player closer to the end of the game. In the final build, however, there were only 3 pairs, one of them being the player. Because it comes from a plan that ended up being over scoped, the content in the final game ended up feeling incomplete, and more like a sample than the complete experience.

7.3 Recommendations and Future Work

Given additional time, the team would develop more of the initially planned content. The next step for Dyadic Unity is telling a complete and cohesive story while further investigating the novel limits of its mechanics. The team would incrementally add more content so the game felt like a more complete experience. This would include a clear-cut ending, as well as more information on how various Dyad pairs and locations relate to one another.

For procedural generation, more sophisticated heuristics could be used to evaluate puzzles. Currently, the only heuristic used to evaluate a puzzle is how many total actions an agent needed to take to get through the puzzle. This assumes that every action should be considered as interesting or complex as other actions, which is a false assumption. This leads to many puzzles being generated that do not require all of their components to be used to reach a solution. Furthermore, the agent takes a random path through the puzzle until it is solved. There is no guarantee that this is the optimal path, so in future iterations of this game, the team would like to

save a list of the best generated candidates. These candidates would then be weighted based on the agent score, so that an arbitrarily long path taken does not dominate the judging process.

As the last round of playtesting demonstrated, the player still ends up being perplexed by what their objectives are. This is a major problem the team would fix if we had more time. This fix would be replete with a more in-depth tutorial as well as clear in-game explanations for what the player needed to do within the game world. Further UI elements would be added for clarification on how to interact with things, and small animations when nearby interactable objects would distinguish them from decorations. The UI itself would also receive more noticeable animations, to further reinforce its presence to players. One major UI element change we would include would be to replace the emotional state indicator with a pie or bar chart so that players can visually gauge the impact of their dialogue choices. Overall, our improvements would center around crafting a player experience that enables more autonomy and motivation for the player to explore and experience the game.

8.0 Conclusion

The team strived to use a blend of interactive mechanics to construct a dynamic experience that is responsive to player choice. To further this goal, the team focused on both an emotion based interaction system and the field of procedural generation. This required players to think and explore solutions to the challenges presented by both dialogue and the game's accompanying puzzles. There were many unexpected challenges involving communicating the goals of the game effectively to players. Some examples of this include the inability to discern which objects were interactable, or becoming hopelessly lost in the large maps. The team vastly improved upon communicating the game systems to players, though there still remains room for improvement. However, the end project goal was reached: a polished and re-playable digital game experience that playtesters found both enjoyable and contemplative.

9.0 References

Affinity Chart (XC1). (n.d.). Retrieved from

[https://xenoblade.fandom.com/wiki/Affinity_Chart_\(XC1\)](https://xenoblade.fandom.com/wiki/Affinity_Chart_(XC1))

B. De Kegel and M. Haahr, "Procedural Puzzle Generation: A Survey," in *IEEE Transactions on Games*, vol. 12, no. 1, pp. 21-40, March 2020, doi: 10.1109/TG.2019.2917792.

A fantastic source to begin brainstorming various puzzles using. It presents a catalogue of different types of puzzles, and explains various methods that have been used to generate them. It provides a lot of useful terminology and technical insight, as well as thought provoking examples.

Gaddis, W. S., Grim, M. T., Riley, J. M., & Trottier, K. J. (2020, May 8). *Reckoning: 2.5D Western Side-scroller* [Scholarly project]. In *WPI Electronic Projects Collection*.

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10.0 Appendices

Appendix A: Original Puzzle Concepts

A1: Custodian/Host Puzzle



Upon entering the area, the player will pass ice sculptures(Order side) and mushrooms(Chaos side). As the player passes, they will be prompted with a button to click to interact with it. (“Press ‘E’ to jump on”) The player can carefully avoid them, so the ice sculptures aren’t destroyed, or jump on top of them, destroying the ice sculptures, but bounce on the mushrooms and make them chime and glow. The Custodian/Host will initiate a conversation with the player. (Note: while these initial objects are set, other interactable objects for later in the puzzle will be generated with the puzzle dice system)

IF PLAYER BOUNCES/DESTROYS SCULPTURES:

The Custodian will be very distressed and upset about your destruction of the ice sculptures, then complain/vent about all the messes she needs to clean up. Her emotional stats will start out being more stressed, fearful, and angry towards the player.

The Host will be happy to see you enjoying yourself, and will welcome you to the party. He will start the conversation with emotions leaning towards playful and excited.

IF PLAYER AVOIDS SCULPTURE AND MUSHROOMS:

The Custodian will be relieved that the sculptures are safe and admit she was worried she was about to have another mess to clean up on top of everything she's needing to do. Her emotional stats will start out slightly more happy and less fearful.

The Host will be sad that you aren't partying and enjoying yourself, and will encourage you to join the party and have a good time instead of avoiding all the fun. He will start out slightly more sad and disappointed.

NOTES:

- The Player can still go back and bounce/destroy the sculptures afterwards, for double the emotional stat effect that doing it in the first place would have.

-The Player can partially destroy the sculptures before initiating the conversation. The Custodian will only be half as angry and The Host will be half as disappointed.

MAIN PUZZLE BASE DESCRIPTION:

The Custodian wants all of the messes in the area to be clean. There will be 4-5 distinct "rooms" in the area that need to be cleaned. Cleaning will involve interacting with objects that are "broken" or "dirty". (These will be generated with the puzzle dice system and distributed among rooms) The player may become a nuisance by interacting with "breakable" and "clean" objects and changing them to their broken and dirty states. She will not unlock the path to proceed forward until the areas are **fully clean(light path)**, the player is too much of a **nuisance(dark path)**, OR her **stress is low** enough and she is feeling more calm and the area is **partially clean (neutral path)**

Avoid letting her see you make new messes on neutral path. Do this by ensuring you are not in the same room as her when you are making the mess.

The Host insists on you having a good time at the party. The Grove will similarly have 4-5 distinct rooms with fun activities that will correspond to new messes being created in The Garden. The action of Cleaning (in order to help The Custodian) will make The Host feel like he is being a bad host. He will not let you proceed until you have **partied enough(dark path)**, the

player makes him depressed and feel like a bad host by **rejecting his activities(light path)**, OR his **stress is high** enough to make him pursue his own needs after you've established a bond by **partying a little bit(neutral path)**

The Host Must See You Partying to Progress Dark Path.

The player can party by interaction with "Party" objects

RESULTS OF EMOTIONAL STATS ON MAIN PUZZLE:

Custodian/Host Primary emotions: (Stress on each considered a secondary emotion on this puzzle)

Annoyance/Excitement: They will follow you to every room you enter. They will refuse to allow you near any messes, however you are able to party/make new messes

Fearful/Playful: They will change rooms randomly. They will not stop you from cleaning.

Calm/Depressed: They will remain in one room and not move. Partying will not progress dark path until you make him not depressed.

A2: Praetorian/Companion Puzzle

The Praetorian and The Companion each guard the entrance to the Palace and the Cave Respectively. Each one completely loyal to the guardian of their land, they will not let you proceed to see them. The Companion is sad and lonely because no matter what he does, he can never please/be close to The Heir. The Praetorian thinks very highly of himself and his position, and takes great pride in serving The Empress.

There are three paths to proceed:

Dark Side path: **Give gifts to The Companion/Bribe the Praetorian** - As the Companion is sad about his lack of closeness with The Heir, you can instead befriend him yourself, by giving him presents of items found in other parts of the land. This action results in bribing the Praetorian. The type of item each desires depends on their current main emotion. By befriend/bribing enough, they will allow you to pass without trouble.

Light Side path: **Help each do tasks for the Empress/Heir** - More than anything, The Praetorian takes pride in working for the Empress. Doing such tasks will raise your rank in his eyes. When you've done enough, The Empress will request he does a task on the opposite side of the land, and he will trust you enough to ask you to stand guard in his place. Meanwhile as you do tasks alongside The Companion for the Heir, none will please The Heir, and The Companion will feel worse and worse, as he sees that his attempts to help The Heir are not working. Eventually The Heir will say "Please, just leave me alone. Leave me here" and The Companion will sadly walk away, leaving you free to proceed.

Neutral Path: **Encourage a confrontation** : Help them realize that they have their own worth that does not depend on their value to The Empress/The Heir. The Praetorian will confront The Empress about how wrong her excessive punishment is. The Companion will confront The Heir, telling him that he must stop hiding and be an actual leader. The Empress will turn The Praetorian into stone and The Companion will be banished by The Heir.

This triggers the start of the Neutral Ending of the game (if you've met other requirements) and The Empress/Heir will freak out and petrify/banish every dyad pair in the game except the player characters and themselves.

A3: Empress/Heir Puzzle

If playing is leaning towards the light side at start of quest:

PLEASE THE EMPRESS:

If you've done the dark side path for anyone, you must rat them out, they will be petrified (on the dark side, they come to help cheer up The Heir, The Heir refuses their help, unintentionally banishing them)

Part 1: conversation: talk the Empress into a state where she is pleased with you. Pick conversation options based on what you've learned about the empress from all the other NPCs.

POTENTIAL BAD END: Make the empress hit a certain level of anger with you, she will petrify the player.

Part 2: Prove your worth by finding the land's hidden treasure, that is only revealed in a state of perfect order.

Mechanically:

There are randomly generated objects around the whole map, that are not where they belong (they will visibly fit in better with one of the other areas, and you can talk to still existing NPCs to receive a hint about where something belongs)

Some objects are in multiple pieces that must be combined to restore them to their original state first before being moved to their correct location.

When the land is in order, a secret location opens up, this area contains a special item to bring back to The Empress

If player is leaning towards dark side at start of quest: (Unfinished)

COMFORT THE HEIR:

The Heir banishes dyads you did the light side path for, because they are depressed and the Heir feels that he failed them and they'd be better off elsewhere. (Meanwhile, The Empress is feeling super insecure this route and petrifies the equivalent halves of those dyad pairs because 'they act like they're so much better' than her and she's also kinda paranoid of a coup)

Neutral Path: (unfinished)

See end of gatekeeper puzzle. Everyone but the player and Empress/Heir is petrified/banished.

Appendix B: Dialogue

Conversation in the Statue Room (Garden)

Player:

(Happy) What lovely statues these are, you must take great care of them

(Fear) Don't you find those statues to be a bit frightening?

(Surprised) Wow! I almost thought those were real.

(Sad) It must feel lonely, with no one but these statues around...

Custodian:

Modular Responses >

[I always do my best to please The Empress!]

[Not as terrifying as The Empress.]

[ha ha ha... Well, the Empress wouldn't have anything less!]

[Oh, I'm fine, dear. The Empress certainly keeps me busy taking care of them.]

- (Anxiety/Stressed) She'd have my hide if anything happened to them...
- (Annoyance) Now, you'd better not touch them, there are enough messes in here already!
- (Calm) They're really quite lovely though, it's too bad...
- (Amazing Low Stress) What she's done to them is so awful though...

Example Full Responses:

"I always do my best to please The Empress! They're really quite lovely though, it's too bad..."

"Oh, I'm fine, dear. The Empress certainly keeps me busy taking care of them. She'd have my hide if anything happened to them..."

"Ha ha ha... Well, the Empress wouldn't have anything less! Now, you'd better not touch them, there are enough messes in here already!"

"Not as terrifying as The Empress. What she's done to them is so awful though..."

"I always do my best to please The Empress! Now, you'd better not touch them, there are enough messes in here already!"

Player:

(Frustration) What's so important about them anyway! They're just statues.

(Curiosity) Is there something special about them?

(Disgust) It's awful how she treats you. You shouldn't have to worry this much over statues.

(Unlocked) What exactly did she do to them?

Custodian:

Modular Responses >

[Just statues?! These aren't simply statues!]

[Special is one way to put it....]

[My worry has left me much better off than I can say for others.]

(Anxiety/Stressed) All you need to know is that you don't want to end up like them...

(Annoyance) I have half a mind to send you to The Empress to find out yourself!

(Calm) These statues are warnings, and you best stay out of trouble.

Special Unlocked Response:

- Do you see those engravings? Those are crimes, not titles. Each "statue" you could say, is a prisoner, and their frozen form is a punishment... We all do our best not to end up like them.

Appendix C: Scheduling

In A term, the team's schedule was thus:

One meeting on Monday at seven where we assigned major tasks and reported last week's findings.

One meeting on Thursday at noon where we checked in on progress

One meeting with the advisors on Wednesday at four where we checked new ideas with the advisors.

First week - UI

Second week - character

Third week - quest logic

Fourth week - planning puzzles

Fifth week - planning puzzles

Sixth week - playtesting setup

Seventh week - proposal and IRB submission

In B term, the team's schedule was thus:

One meeting on Thursdays at two where we checked on progress and planned for the following week.

One meeting on Monday at two-thirty (post advisor meeting) where we assigned new tasks based on advisor feedback.

One meeting with the advisors on Monday at two where we discussed our finished tasks and what was planned for this week.

First week - Start of development

Second week - IRB fixes, continued development

Third week - working towards a playable/testable game

Fourth week - preparing for Alphafest

Fifth week - incorporating feedback from Alphafest

Sixth week - Continued development on two puzzles

Seventh week - Cont'd development

In C term, the team's schedule was thus:

One meeting on Wednesday at three-thirty where we assigned tasks.

One meeting with the advisors on Friday at two where we reviewed progress.

First week - Cont'd development

Second week - Cont'd development

Third week - Cont'd development

Fourth week - Cont'd development

Fifth week - adding sounds to the game

Sixth week - finishing adding all the puzzle elements

Seventh week - all the major assets are completed and polished

In D term, the team's schedule was thus:

One meeting on Friday at four to assign final tasks and report findings.

One meeting with the advisors on Tuesday at one to report findings and final progress on the project.

First week - development week

Second week - last development week

Third week - playtesting week

Fourth week - playtesting week/paper writing

Fifth week - paper writing and revisions

Sixth week - revisions to the game from playtesting results

Seventh week - final polish and submission

Appendix D: Screenshots



The Custodian

Ah yes, our garden's beautiful entrance fountain. Oh my, not again! The water is completely frozen! I've not a clue of how it keeps happening, though it does have use in touching up the **ice sculptures**.



Okay



The Pilgrim

...

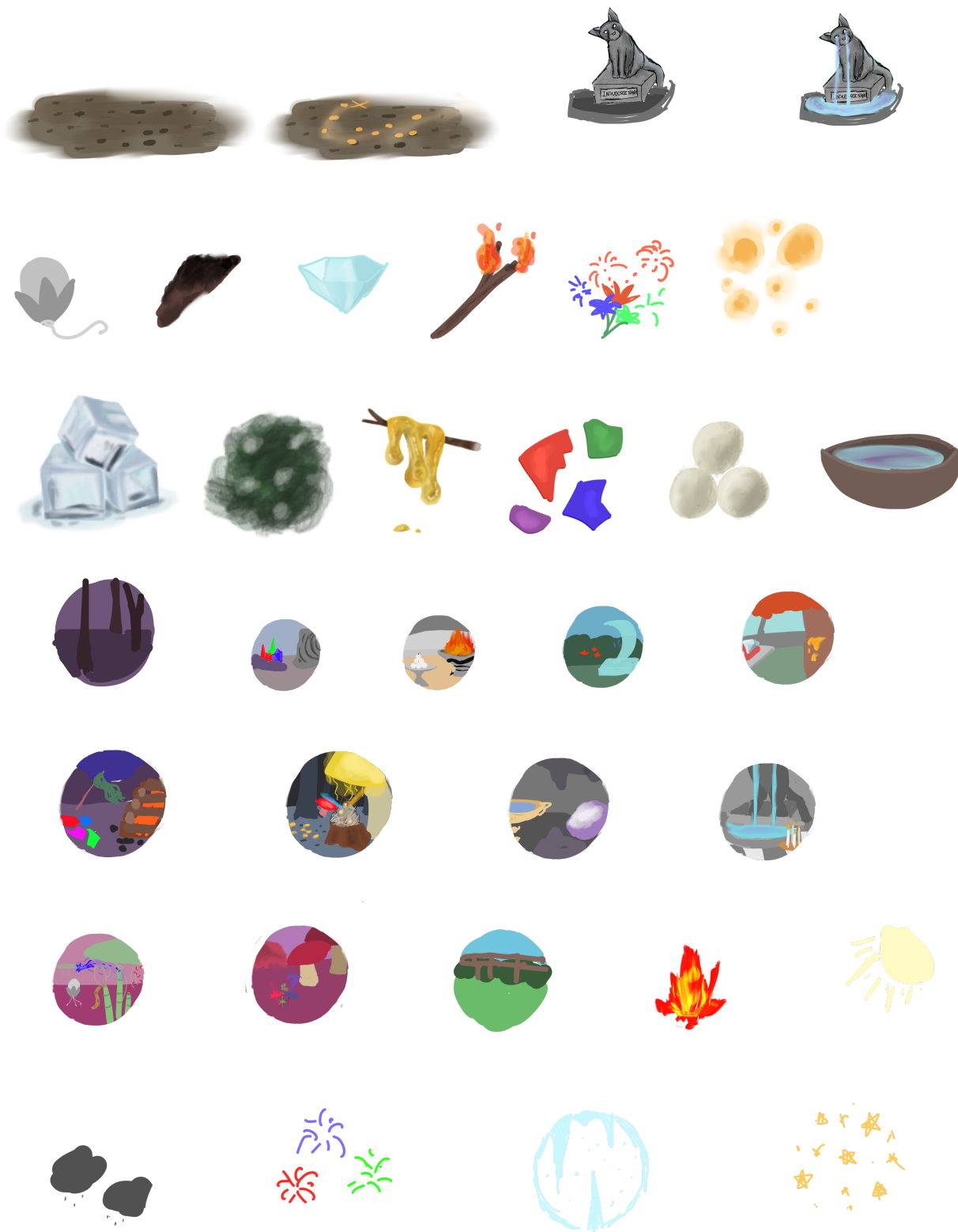
Appendix E: Sample XML for dialogue trees

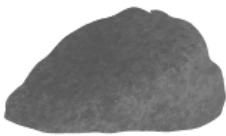
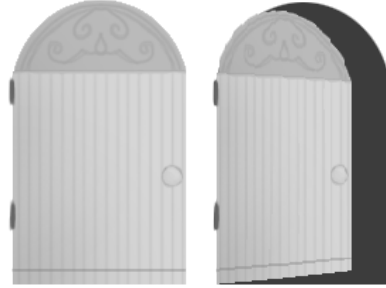
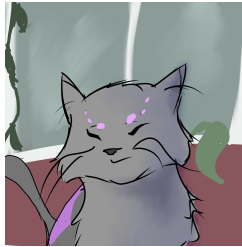
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        <Emotion>-999,0,0</Emotion>
      </Transition>
      <Transition>
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        <Display> True </Display>
        <Emotion>0,5,0</Emotion>
        <State>2</State>
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            <Text> Thanks! </Text>
          </Node>
        </Nodes>
      </Transition>
      <Transition>
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        <Display> True </Display>
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        <State>2</State>
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          </Node>
        </Nodes>
      </Transition>
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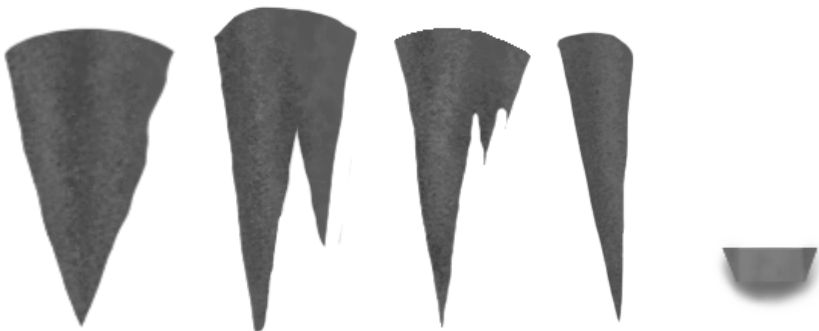
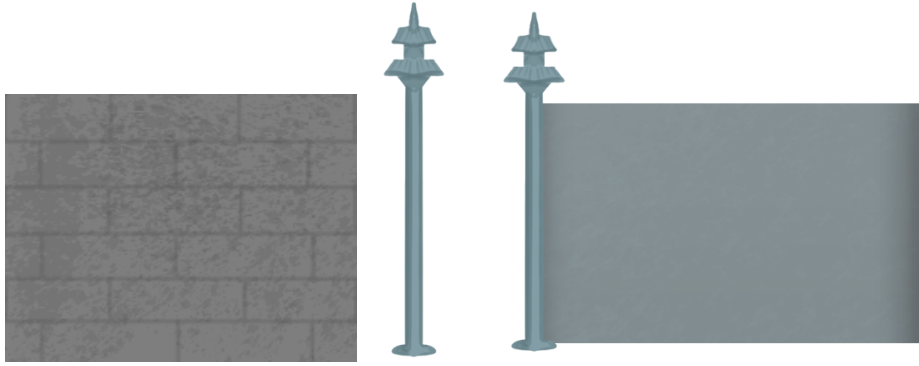
Appendix F: Game Assets

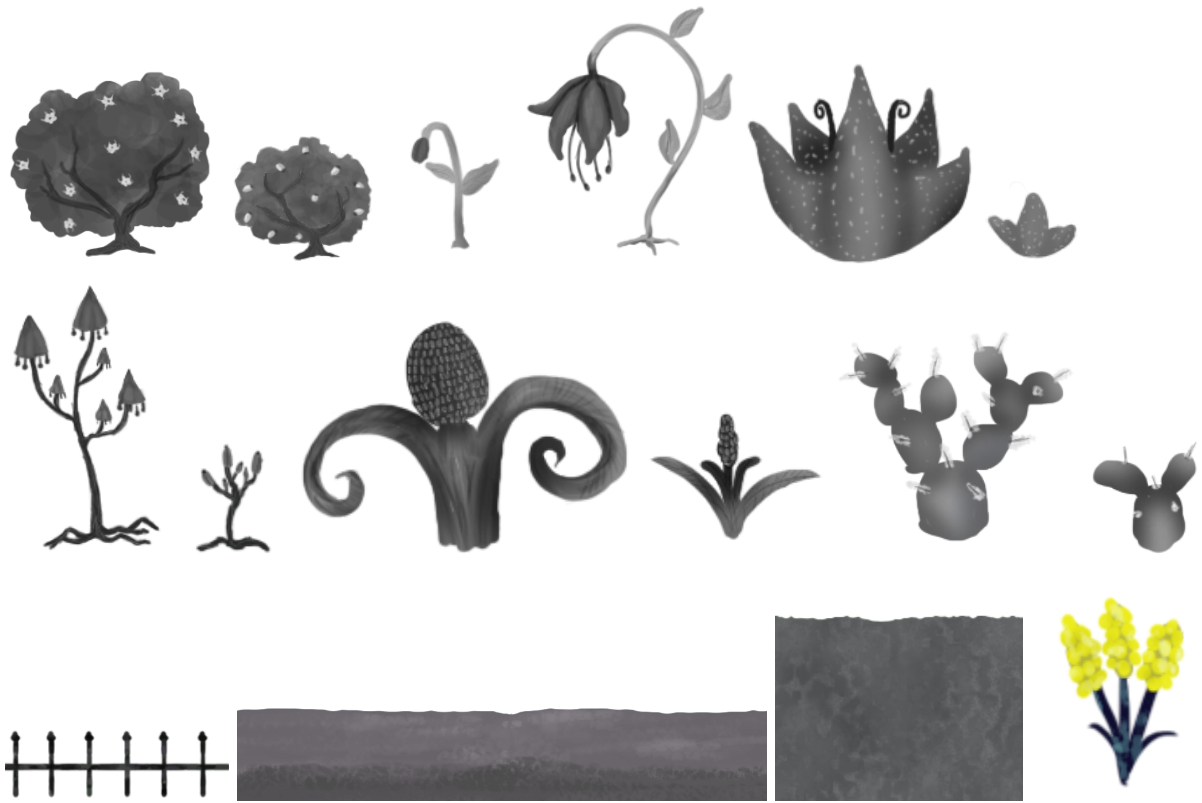


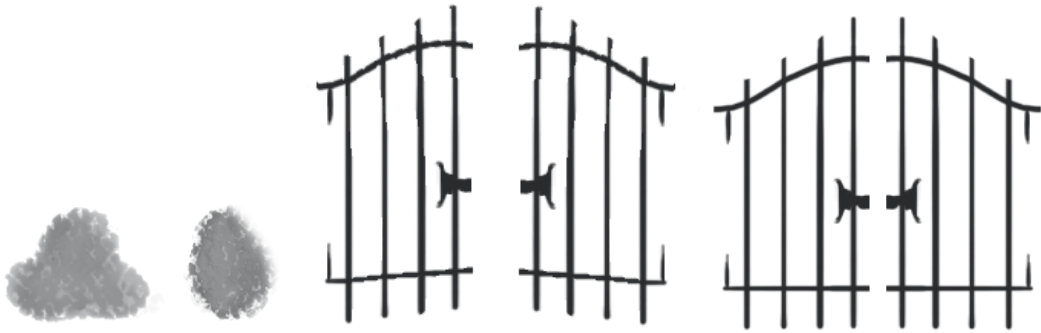
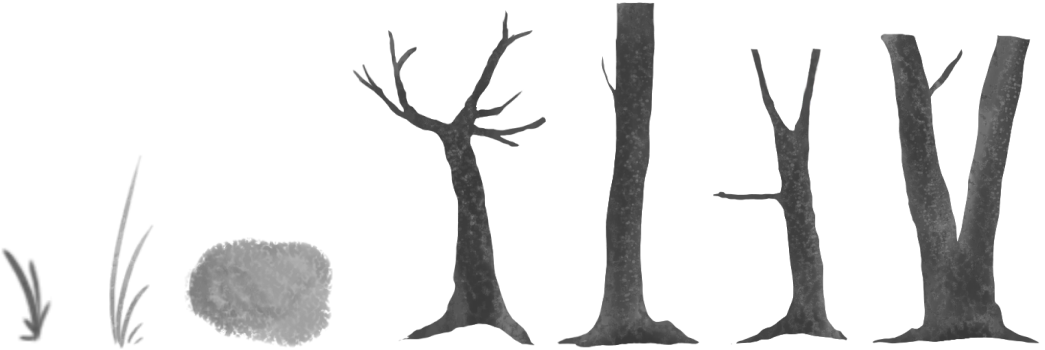
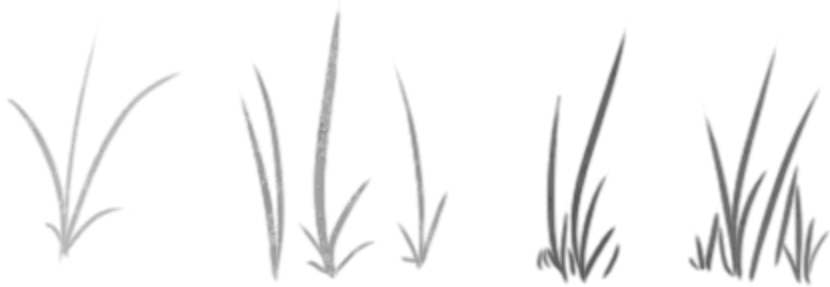


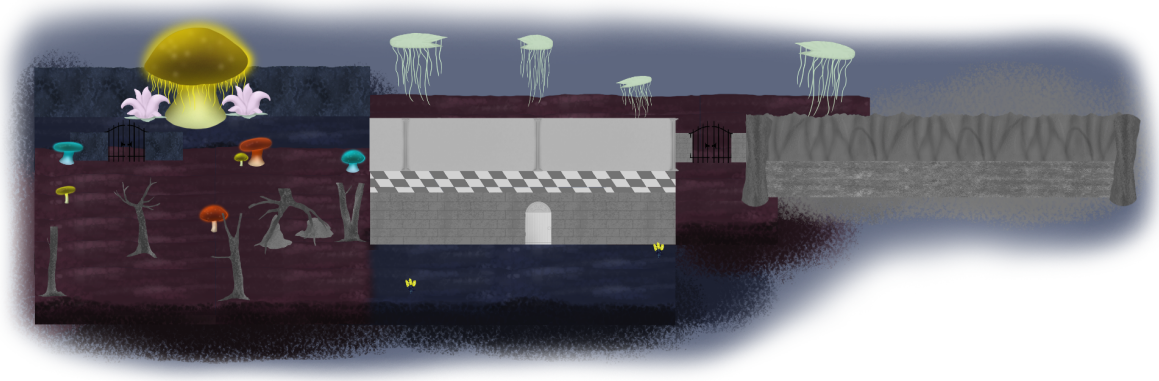
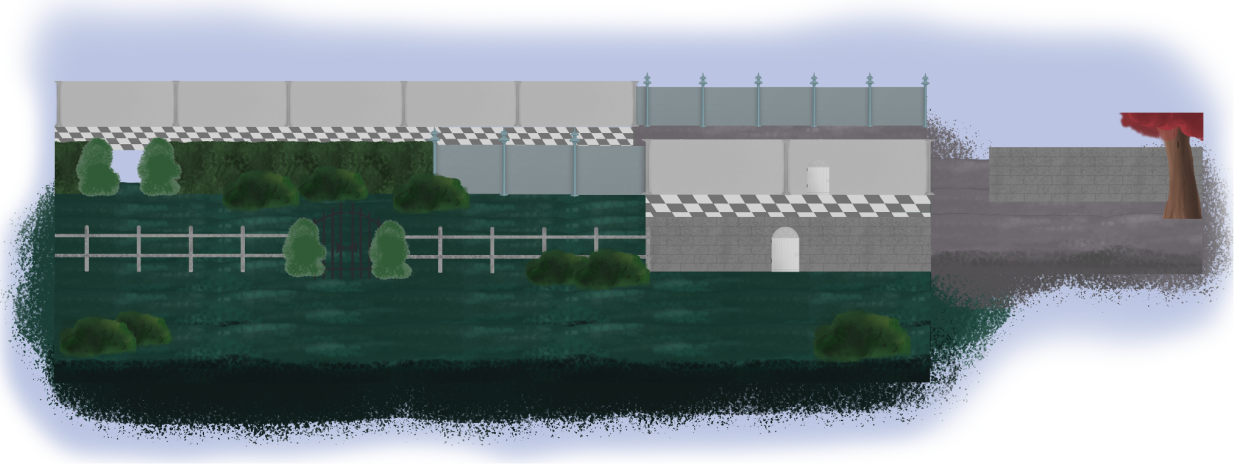
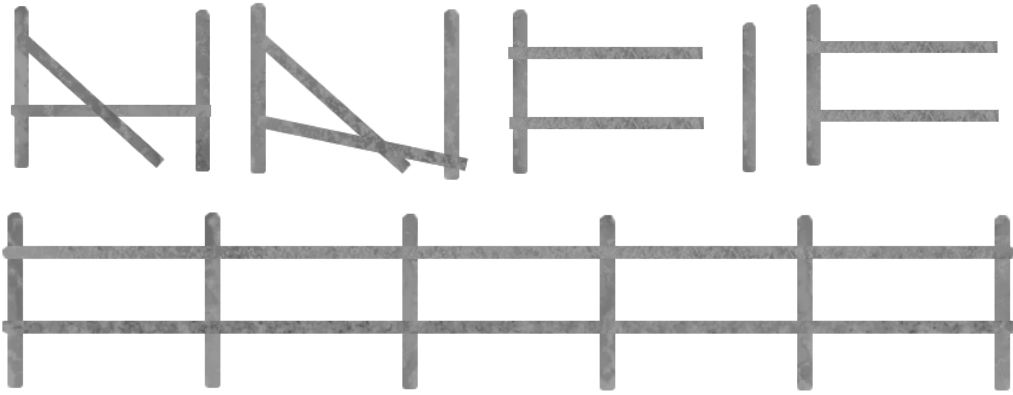


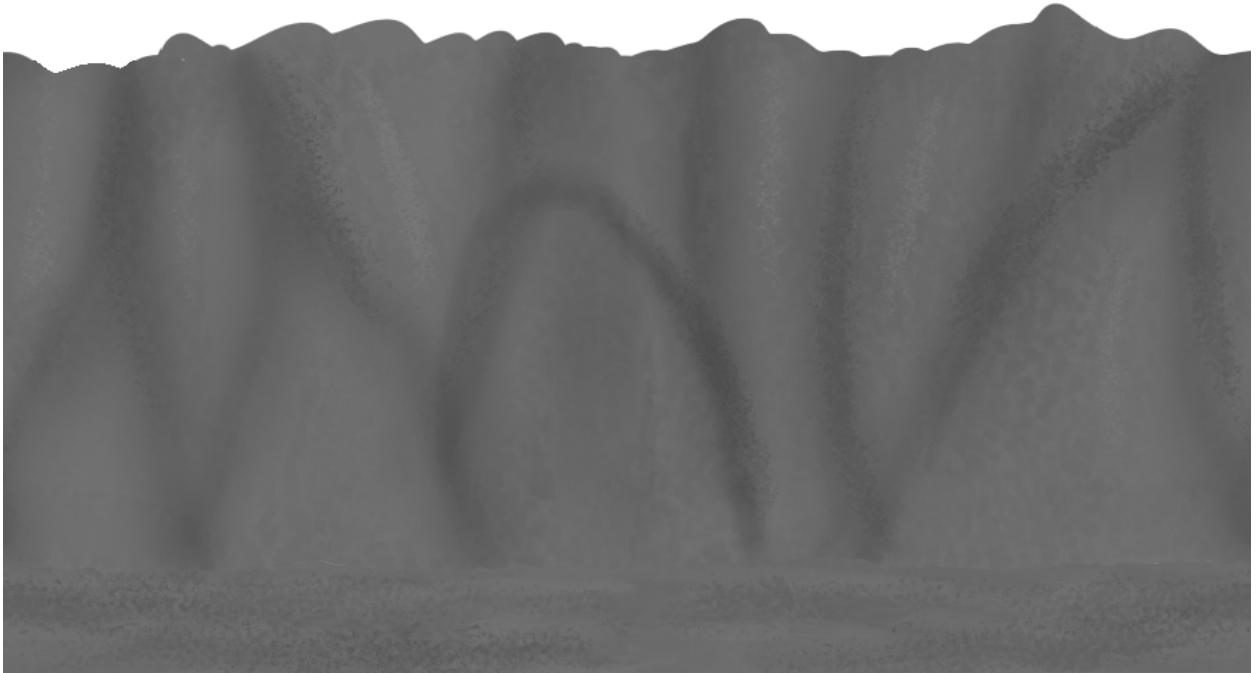
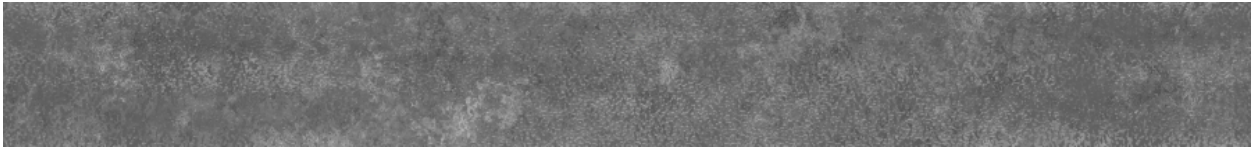
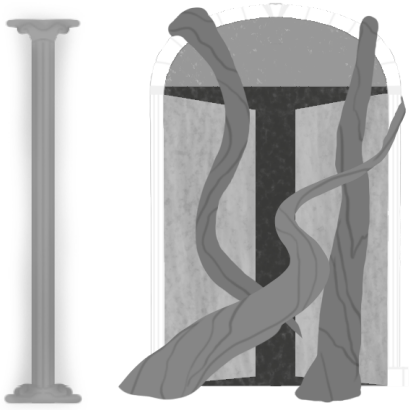


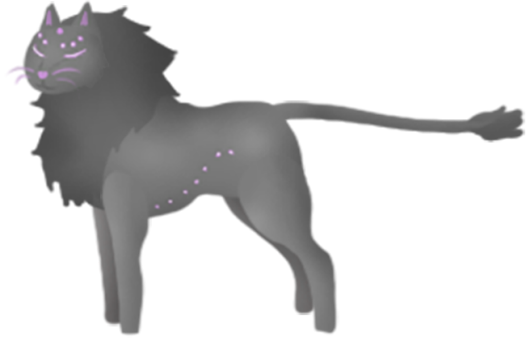












Appendix G: IRB Consent Form

Informed Consent Agreement for Participation in a Research Study

Investigators: Daniel Ribaldo, Sarah Love, Rachael Sallie

Contact Information: dcribaudo@wpi.edu, smllove@wpi.edu, resallie@wpi.edu

Title of Research Study: Dyadic Unity Testing

Sponsor: Not Applicable

Introduction:

You are being asked to participate in a research study. Before you agree, however, you must be fully informed about the purpose of the study, the procedures to be followed, and any benefits, risks or discomfort that you may experience as a result of your participation. This form presents information about the study so that you may make a fully informed decision regarding your participation.

Purpose of the study:

The purpose of this study is to determine the effectiveness and understandability of the features of our game Dyadic Unity. Data collected from this study will be used to improve the clarity and predictability of the features while encouraging future players to be engaged with the mechanisms of the game.

Procedures to be followed:

This session happens once (with possible repetition to test future features of the game) and should last no longer than 30 minutes. Participants will play through features of our game to test the feature's effectiveness. After completion of this task, participants will fill out a survey implemented in Google Forms, containing no identifiable participant information.

Risks to study participants:

There are no foreseeable prospective risks or discomforts to participants.

Benefits to research participants and others:

The subject may receive a playtesting credit for participating in this study. If the subject does not require any playtesting credits for current courses being taken at Worcester Polytechnic Institute for the term, there are no other benefits for participating.

Record keeping and confidentiality:

No identifying information will be collected or recorded during this study. This form, if signed, will not show up to any degree in any findings presented or otherwise acted upon.

Compensation or treatment in the event of injury:

There is no risk of injury involved with this study.

For more information about this research or about the rights of research participants, or in case of research-related injury, contact:

Dyadic Unity MQP Team: dcribaudo@wpi.edu, smlove@wpi.edu, resallie@wpi.edu

Advisor Joshua Rosenstock: jrosenstock@wpi.edu

Advisor Gillian Smith: gmisth@wpi.edu

IRB Manager Ruth McKeogh, Tel. 508 831-6699, Email: irb@wpi.edu

Human Protection Administrator Gabriel Johnson, Tel. 508-831-4989, Email: gjohnson@wpi.edu

Your participation in this research is voluntary. Your refusal to participate will not result in any penalty to you or any loss of benefits to which you may otherwise be entitled. You may decide to stop participating in the research at any time without penalty or loss of other benefits. The project investigators retain the right to cancel or postpone the experimental procedures at any time they see fit.

By signing below, you acknowledge that you have been informed about and consent to be a participant in the study described above. Make sure that your questions are answered to your satisfaction before signing. You are entitled to retain a copy of this consent agreement.

Study Participant Signature

Date: _____

Participant Name (Please print)

Study

Signature of Person who explained this study

Date: _____

Appendix H: Survey Questions

Section 2 of 4

General Questions

Description (optional)

Did the presence of various maps in the game help navigate the world?

1 2 3 4 5

They did not aid in a meaningful way They were very helpful for navigation

Did you get lost?

1 2 3 4 5

Frequently Never

Was it clear when you could swap between worlds?

No

Yes

Did swapping between worlds feel relevant to the moment to moment flow of the game?

No

Yes

How did movement speed feel

1 2 3 4 5

Too slow Too fast

Was the animation for walking fluid and appealing?

1 2 3 4 5

Disjointed and unappealing Fluid and appealing

When talking to other NPCs, was it clear that giving different answers changed the game state and world state?

1 2 3 4 5

I was not aware of this mechanic I was keenly aware of this mechanic

Was it apparent that different imagery and colors used in dialogue boxes corresponded with different emotions for the NPCs?

1 2 3 4 5

Not apparent Very apparent

Try to match what you feel is the relation between imagery, color, and emotion

	Gray clouds	Light blue ice	Blue raindrops	Yellow suns...	Orange fire	Green webbi...
Anger	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Unhappy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Disgust	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fear	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Happy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sad	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Did you feel as though you knew what you were supposed to be doing?

1 2 3 4 5

Not at all I understood completely

How would you rate the overall experience?

1 2 3 4 5

Did not enjoy the experience Enjoyed the experience

Write any suggestions here

Long answer text

⋮

How appealing were the visuals in the Host/Custodian area?

1 2 3 4 5

Not appealing Very appealing

Was there anything obstructive or otherwise distracting?

Long answer text _____

Was the way the inventory system worked (in that the player can only hold 1 item at a time, displayed in the bottom corner of the screen) clear?

Yes

No

⋮

Did you understand what the puzzle in this area asked you to do?

No

Yes

Did you complete the puzzle in this area?

No

Yes

Additional remarks about this puzzle here:

Long answer text _____

⋮

How appealing were the visuals in the Apothecary/Gardener area?

1 2 3 4 5

Not appealing Very appealing

Was there anything obstructive or otherwise distracting?

Long answer text

How much did the map aid in navigation?

1 2 3 4 5

None It was essential

⋮

Did you understand what the puzzle in this area asked you to do?

No

Yes

Did you complete the puzzle in this area?

No

Yes

Additional remarks about this puzzle here:

Long answer text
