UNIVERSITY OF TARTU
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Computer Science Curriculum

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Houseplant Care Simulator

Bachelor's Thesis (9 ECTS)

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Tartu 2021

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Abstract:

This thesis describes the design and development of a life simulation video game called *Houseplant Care Simulator*. The main goals of the game are providing educational value regarding plant care and showing the effect houseplants can have on people's stress. The thesis starts with an overview and analysis of similar games to get an idea of what value the new game can bring to the potential users. After that, game design and interesting parts of the implementation are described. Usability testing was conducted to find out if the game has reached the set goals, discover any potential issues, and gather general feedback from the participants. Some of the feedback was used to fix existing issues during the work on the thesis, and other ideas are planned to be developed in the future.

Keywords:

Computer game, simulation, game design, computer graphics, Unity, usability testing

CERCS: P170 Computer science, numerical analysis, systems, control

Toataimede hoolduse simulaator

Lühikokkuvõte:

Selles bakalaureusetöös on kirjeldatud toataimede hoolduse simulatsioonimängu „Houseplant Care Simulator" disaini ja arendust. Mängu eesmärk on anda mängijale uusi teadmisi toataimede hoolduse kohta ja näidata, et toadaimede eest hoolitsemine saab stressi leevendamisele kaasa aidata. Lõputöö alguses on välja toodud sarnased mängud, mida on analüüsitud, et leida, kuidas uus mäng saab täiendada olemasolevat arvutimängude valikut. Huvitavamad mängudisaini ja implementatsiooni osad on töös väljatoodud. Töö käigus viidi läbi mängu kasutatavuse testimine, et selgitada välja, kas „Houseplent Care Simulator" on suutnud hariduslike eesmärke täita. Samuti testimisest saadi väärtuslikku tagasisidet. Osa sellest kasutati, et parandada olemasolevaid probleeme. Ülejäänud tagasiside saab kasutada tulevikus mängu edasiarendamisel.

Võtmesõnad:

Arvutimäng, simulatsioon, mängudisain, arvutigraafika, Unity, kasutatavuse testimine

CERCS: P170 Arvutiteadus, arvutusmeetodid, süsteemid, juhtimine (automaat-juhtimisteooria)

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1 Introduction

Through the years video games have managed to grow beyond just a multi-billion-dollar industry that provides entertainment for the players around the world [1]. Games are letting people immerse themselves into different worlds created by game designers and developers. In those worlds, players have experiences through which they can learn [1]. This type of learning is effective, because players do not have to take in facts, but rather their way of thinking is affected [1]. For that reason, video games have the potential to be educational.

In this thesis a simulation game called *Houseplant Care Simulator* was created. One of *Houseplant Care Simulator*'s main goals is serving as a source of knowledge about care for a selection of houseplants. It tries to achieve it through various game mechanics like watering, light level, and in-game computer mechanics. Another important goal of *Houseplant Care Simulator* is mental health promotion and demonstrating how houseplants can affect mental health and stress levels of people.

The game tells a story about a doctor by the name Eric, who got into caring for plants as means of stress relief outside of work. The player can help Eric by acquiring new plants using the in-game computer, and by learning how to care for them using the Plantipedia – encyclopaedia of *Houseplant Care Simulator*. Then the player can apply that knowledge by playing as the game character, giving the virtual plants a sufficient amount of light and watering them according to instructions from the in-game computer.

In Chapter 2 analysis of similar games is provided. Chapters 3 and 4 contain descriptions of game design and implementation decisions made for *Houseplant Care Simulator*. In chapter 4 the usability testing process is described, the results analysed, and improvements suggested.

The Appendix has a Glossary, where the terms used in the thesis are explained. Furthermore, a link to the Project Repository, list of used Assets, The Event-driven Architecture Overview, recordings of the Test Sessions, description of Accompanying Files and the License can be found from the Appendix. The story introduction to the game can be seen from Figure 1. Screenshot of the game at the end of work for the thesis is provided in Figure 2. Executable of the game can be found and downloaded from the following link: https://kriskevel.itch.io/houseplant-care-simulator.

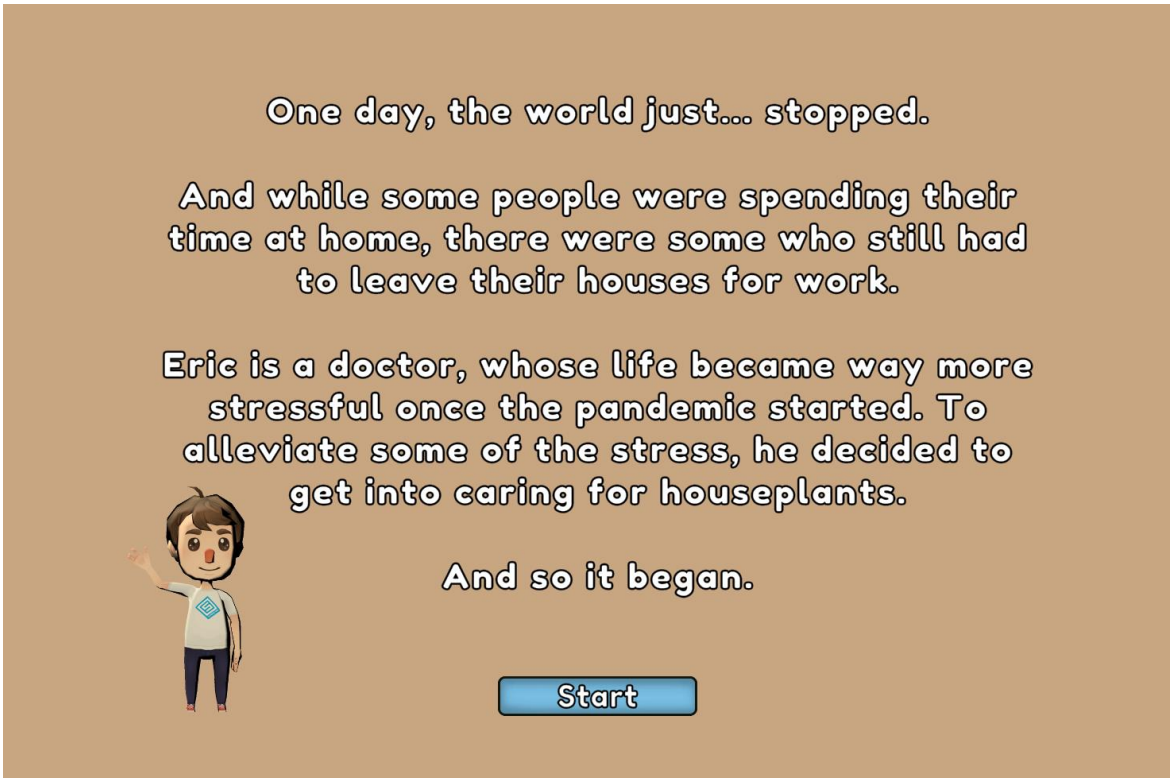

Figure 1. Introduction to the game

Figure 2. In-game screenshot of *Houseplant Care Simulator*

2 Similar games

Before creating a new game, it is vital to research the video game market and find games with similar goals and mechanics. In doing so, it is possible to ensure that the newly created game will not be a copy of an already existing video game and will provide additional educational value to the potential player base.

Houseplant Care Simulator has two main goals that it is trying to achieve (mentioned in 1 Introduction). First goal is to provide the players with educational information regarding plant care. Second goal is to introduce the players to one of the ways to relief stress. Based on those goals, two categories of games were selected for further research: games about growing plants and games about stress relief.

2.1 Plant Growing Games

As *Houseplant Care Simulator* is mainly focused on houseplant care, it was necessary to find games with similar mechanics (*e.g.*, watering plants) to those planned for the new game. The found games had to be analysed, their mechanics and main goals researched.

This subchapter analyses the two most similar games about houseplant care available to the players on the market. *Viridi* (available on both mobile and Windows platforms) and *Plant Tycoon* (available only on Windows) are those games. Corresponding subchapters list the strengths and weaknesses of these games with the purpose of either learning or improving from them in *Houseplant Care Simulator*.

2.1.1 *Viridi*

Viridi[1] (2015) is a gardening simulator published by Ice Water Games. The game is focused on the growth of succulents[2] as means of stress relief by providing the players with virtual ceramic pots and seeds, then letting them grow virtual plants. Every real-world Friday the players are given a new free virtual seedling and it is also possible to get new seeds and plants from a nursery through microtransactions (see Figure 3).

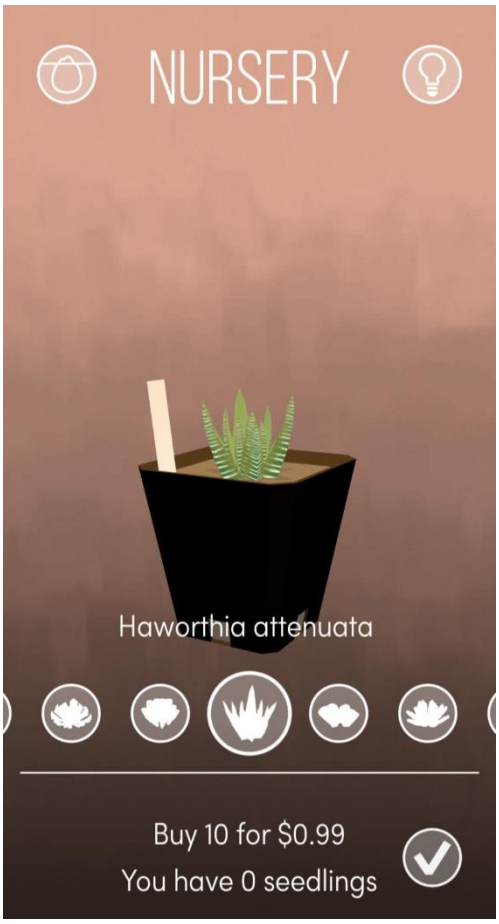

Figure 3. Succulent available from the nursery in Viridy

The plants present in *Viridi* are succulents. In the real world there are thousands of plant genera[3]. Including more genera that are commonly grown as houseplants (*e.g.*, cactus[4], sansevieria[5], monstera[6]) in *Houseplant Care Simulator* should provide richer educational information.

Care for succulents in *Viridi* consists of watering the plants. The player sees the status of a plant (*e.g.*, "Thirsty", see Figure 4) and can water the plant by clicking the "Spray" button once. Realistically spraying the plant once will not provide it with enough water to survive as water will remain on the surface of the soil. Water needs to reach the roots for the plant to obtain it. That is why houseplant enthusiasts pay close attention to the soil moisture at the root level (sometimes with the help of a moisture meter) and water their plants accordingly, taking each plant's needs into account. This can be simulated in *Houseplant Care Simulator* by designing and implementing a moisture meter (described in subchapter 3.3.1 Plant Care).

[1] http://www.icewatergames.com/viridi

[2] https://en.wikipedia.org/wiki/Succulent_plant

[3] http://www.theplantlist.org/1.1/browse/-/-/

[4] https://en.wikipedia.org/wiki/Cactus

[5] https://en.wikipedia.org/wiki/Sansevieria

[6] https://en.wikipedia.org/wiki/Monstera

The control over water levels given to the player in *Houseplant Care Simulator* can provide them with an additional challenge while also supporting the process of learning those needs.

Figure 4. Thirsty plant (left), sated plant (right)

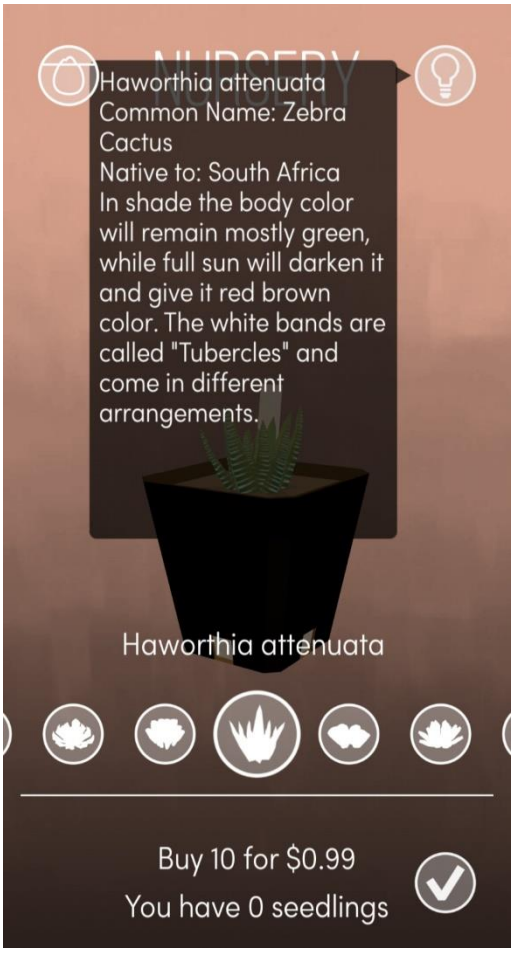

Figure 5. Plant information in *Viridi*

Viridi provides the player with some basic information about each plant in the nursery: the plant's Latin name, common name, origin, and some facts about the plant (see Figure 5). The summary, however, does not contain any care information (*e.g.*, water and light requirements) that could be beneficial to know how to grow the plant. Thus, *Houseplant Care Simulator* should provide essential background information about houseplants in the game. Besides, it should specify light and water requirements in more detail, as these are necessary for the care of the plants. That way, *Houseplant Care Simulator* should have more educational value when it comes to plant knowledge that can be used in practice outside the game.

2.1.2 *Plant Tycoon*

Plant Tycoon[7] (2003) is a gardening simulation game developed by Last Day of Work. The game's objective is to grow, pollinate, sell plants, and get new seeds to eventually discover the 6 Magic Plants of the island of Isola. The player can water, fertilize, prune, pollinate and spray plants with pesticides (all the tools can be seen on left side of Figure 6). It is also possible to put plants up for sale at the nursery to get in-game money that can be spent on new seeds, decorations, fertilizers, and grow substances that speed up the growth of the plants.

[7] http://www.ldw.com/plant_tycoon.php

Figure 6. The main scene of Plant Tycoon

While having multiple means of care for plants, the game does not focus on bringing educational value and does not provide any information on the plants apart from their names. Furthermore, all plants require the same care, and keeping each of them at a certain water level is enough for them to grow. For that reason, the game is easy to start playing but provides little to no increasing difficulty. Thus, it can be uninteresting for players who enjoy some amount of challenge in their games. As Jesse Schell wrote in his book *The Art of Game Design: A Book of Lenses*, it is essential to provide players with challenges as their skills are growing. Otherwise, players can become bored if the game is not challenging enough or become anxious if the game is too challenging. He also proposed some ways to make games adequately challenging [2], which will be considered when developing *Houseplant Care Simulator* (described in subchapter 3.5 Balancing).

The water level of each plant in *Plant Tycoon* is shown on the left side of the screen (see Figure 6) when one of the plants is selected. To water it, the player can choose the watering can and hold it over the plant while holding down the left mouse button, and this will raise the water level. This system provides a good overview of the plant's soil moisture levels and makes it convenient for the player since they know when to water the plant. *Houseplant Care Simulator* will use a similar system, except there each plant will have its own water

level requirements and sensitivity to over- or underwatering. This should provide a meaningful challenge to the player.

2.2 Stress Management Games

Research has shown that houseplants help relieve stress. For instance, Min-sun Lee *et al.* conducted a study with 24 young male adults, which lasted two days [3]. On both days, they measured the stress levels of the participants before the experiment. Then, on the first day, they asked them to repot houseplants. The next day, they asked them to complete a task on a computer. After both experiments, they measured stress levels again. As a result, they found that after performing repotting activities with plants, participant's stress decreased. In contrast, after doing tasks at the computers, the stress level increased compared to the initial value.

In another research, Masahiro Toyoda *et al.* found that the well-being of office workers can be affected by placing a plant on their table [4]. Workers watched the plants when they felt fatigued, and as a result, the authors found that only 3 minutes of plant watching was enough to affect the workers' mental health positively.

Based on the previous research, plants can positively affect the people who are tending to them or simply looking at them. There is no research confirming that virtual plants have a similar effect, and *Houseplant Care Simulator* does not claim to have that effect on the players. Instead, the goal of *Houseplant Care Simulator* is to show how houseplants can affect people's mental health via virtual plants' impact on the in-game character. Existing games that also bring up their characters' stress are analysed in the following subchapters.

2.2.1 *Stardew Valley*

Stardew Valley[8] (2016) is a simulation video game in which the main character inherited an old farm from their grandfather. They decide to move there to circumvent the burnout caused by work. During the game, the player cares about their garden (see Figure 2), spends their time in nature, and meets habitants of *Stardew Valley*, as a result improving the mental health of the player character. It is known that players seem to project themselves onto the game characters they control over [2]. This means that the player will empathize with the game character and be motivated to act in the character's interest (e.g., take care of their

[8] https://www.stardewvalley.net/

stress levels). Through narrative in *Stardew Valley*, the player can empathise with the character better. To motivate the player to care for the character in *Houseplant Care Simulator*, a similar approach is used (described in chapter 3.1 The Story). The player can help the character by using the game mechanics (described in 3.3 Game Mechanics).

Figure 7. Garden in Stardew Valley

Stardew Valley uses a watering mechanic where players need to water their crops daily (except on the rainy days) for them to eventually grow. Plants do not require special care as caring for plants is not the focus of the game. As plant care is the main focus in *Houseplant Care Simulator*, more advanced ways to care for a plant are designed (described in subchapter 3.3.1 Plant Care) where every plant needs different soil moisture and light levels. These additional requirements provide players with challenges and an incentive to learn more about each plant.

2.2.2 *Oxygen Not Included*

Oxygen Not Included[9] (2017) is a survival video game developed and published by Klei Entertainment. In the game, the player needs to manage a space colony, inhabitants of which

[9] https://www.klei.com/games/oxygen-not-included

are called *duplicants*. To do so, the player develops the settlement's infrastructure, assigns *duplicants* to jobs, and takes care of their health and well-being.

The well-being of *duplicants* is described by a stress factor, which is affected by multiple other factors. The game provides the player with daily reports that contain detailed cycle (in-game day) information, including changes in their stress levels (see Figure 8). As seen from the image, one noticeable factor is *duplicants'* morale – it is essential to keep inhabitants of the colony happy and dramatically affects their stress.

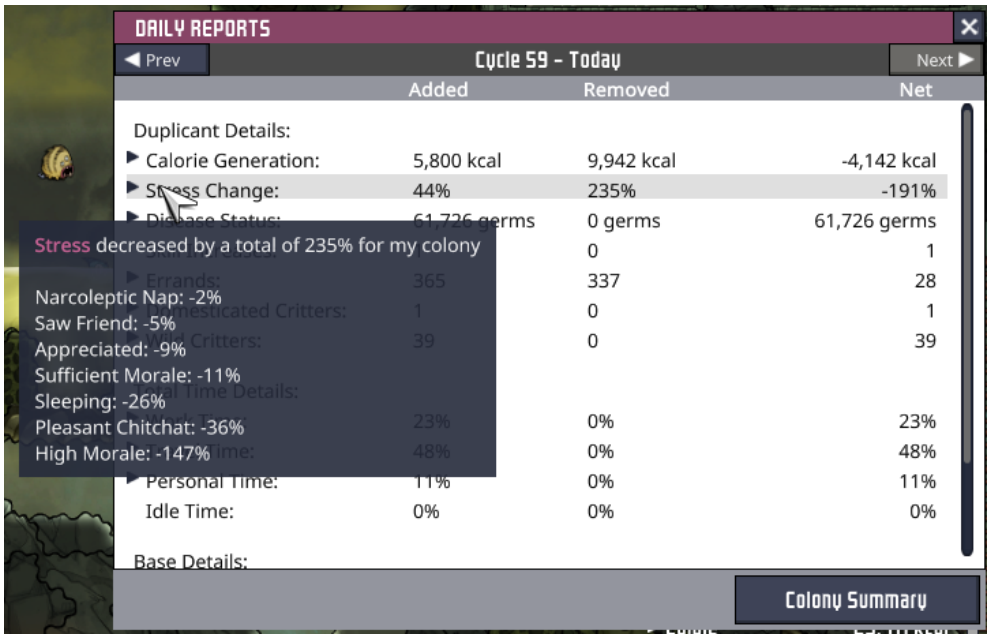

Figure 8. Daily stress change statistics

One of the main factors affecting morale is the decor. There is a decor overlay in the game for the player's convenience, which colours areas with the poor decor in red and regions with the good decor in green. It allows the player to quickly see which areas of the colony might be making duplicants unhappy and to be able to react accordingly. As can be seen from the Figure 9, the plants add to the decor in that cave. Thus, the area is coloured green, and duplicants visiting that cave will have higher morale at the end of the day, which will positively affect their stress level.

Another curious factor that can positively affect stress levels is smelling flowers. Unfortunately, not all duplicants will benefit from smelling flowers since some of them are allergic. Nonetheless, plants in *Oxygen Not Included* do generally positively affect the space colony inhabitants' stress levels and general well-being.

Figure 9. Effect of plants on decor

The analysis showed that there were several games with similar mechanics, some even tried to achieve similar goals as *Houseplant Care Simulator*. All the analysed games had strong points that gave inspiration for creating *Houseplant Care Simulator*, and some of the games had functionality that could be improved on. Results of the analysis were taken into consideration while designing *Houseplant Care Simulator*.

3 Game Design

Game design is an integral part of creating any game. Katie Salen Tekinbaş and Eric Zimmerman in their book *Rules of Play: Game Design Fundamentals*, mentioned that game designers are the people who design rules and structures. Those will later create experiences for the players [5], which means there would be no game without game design. Game design includes multiple important components that game designers need to think through and work on in the process of game development. Some of the main components are the story, game loop, and game mechanics. Another essential step in any game design and implementation is balancing, as it has a significant impact on the general feel of the game [6]. The following subchapters describe those components in the context of *Houseplant Care Simulator*.

3.1 The Story

Most games have a story that they convey. Jesse Schell in his book *The Art of Game Design: A Book of Lenses* brings an example of chess – even though it might seem abstract, chess still has a story about battles between two kingdoms. When games are too abstract to have a story, players themselves tend to come up with different scenarios to enhance the gaming experience [2]. Thus, the story is an integral part of any game, including the *Houseplant Care Simulator*.

As stated in the Introduction, one of *Houseplant Care Simulator*'s main goals is contributing to mental health awareness. Multiple pieces of research have shown that caring for plants reduces levels of stress, anxiety, helps burnout symptoms, and positively affects mental health in general (analysed in subchapter 2.2 Stress Management Games). The story of *Houseplant Care Simulator* is based on that research.

The main game character Eric is a pulmonologist in a local hospital whose life kept getting more stressful every day due to an ongoing global pandemic. Long work hours and an increased number of patients started to negatively affect Eric's mental health and lead to him experiencing symptoms of burnout. He always enjoyed caring for his only plant and found himself feeling better afterward. This gave Eric the idea of buying more houseplants to prevent his stress from becoming uncontrollable, at least until the end of the pandemic.

The ending of the story depends on the player's actions. In case the player succeeds at keeping stress levels low, Eric will get through the pandemic and go back to regular working hours while still maintaining houseplants as a hobby. If the stress levels become too high,

Eric will need to turn to a mental health professional and possibly step down from his work. The story of Eric is aimed to raise the player's awareness about one of the ways to reduce stress levels – taking care of plants. Furthermore, it should also further motivate them to learn about different houseplants present in the game. The general flow of the game is closely described in the next chapter.

3.2 Core Gameplay Loop

Core gameplay loop is at the base of every game. It is a loop that represents the core structure of a game, removing which is impossible without drastically changing the game [7]. In *Houseplant Care Simulator*, the core gameplay loop is built around the character's stress level. There are actions the player can take to impact stress, which will affect the outcome of the game.

In the previous subchapter, two endings of the game were described. One of them can be achieved by reaching the 8th in-game day with a stress level below 100%. This is the game's win condition. Another ending will be caused by reaching the lose condition – Eric's stress level is at the 100% mark after the character's sleep. The game loop with the win and lose conditions can be seen in Figure 10.

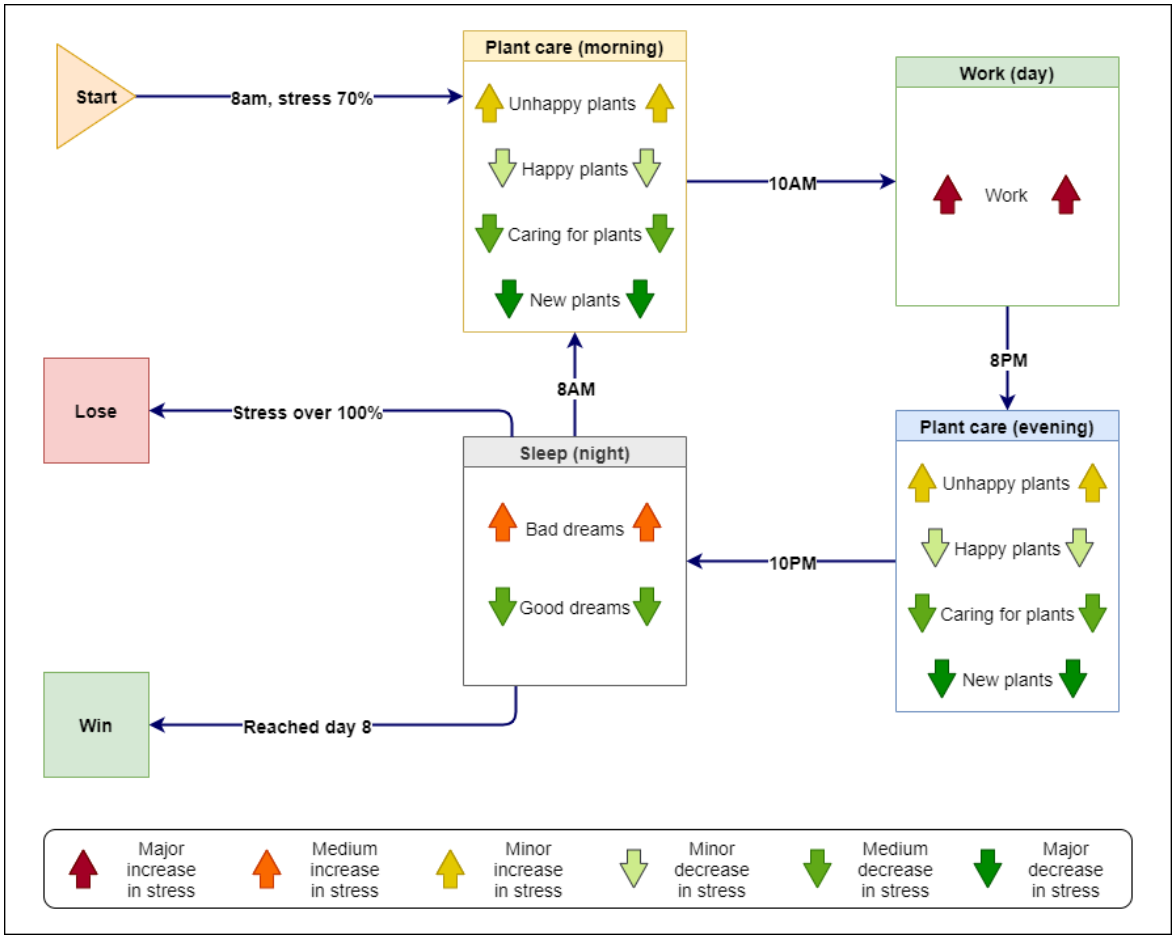

Figure 10. Core gameplay loop of *Houseplant Care Simulator*

Whether the player reaches the win or the lose condition depends on their in-game choices. Acquiring new plants and taking care of the plants in Eric's room will positively impact the character's stress (lowering the stress level). In the case of successful care, happy plants will also decrease the character's stress level throughout the in-game day. If care were not appropriate (over- or underwatering, too much or too little light), the unhappy plant would cause stress gain for the player's character until its water level or light amount returns to the plant's requirements. The amounts of stress that each plant can add or subtract from the overall stress level are provided in Table 1.

Table 1. Effect of houseplants on character’s stress

	Stress removed on delivery	Stress removed / h (happy plant)	Stress added / h (unhappy plant)	Stress added (plant died)
Fittonia	10	0.6	0.7	4
Monstera	15	0.6	0.7	6
Opuntia	7	0.3	0.4	5
Cylindrica	9	0.6	0.5	6

Two factors affect the character's stress independently of the player's actions – work and sleep. Work will always cause stress gain at the end of the workday in the evening. Sleep can affect the stress level either by increasing or decreasing it, depending on the sleep quality. Both work and sleep are assigned a range of values from which the game will randomly pick the amount of stress to add or remove. For sleep the range is from -10 to +14 units of stress (maximum stress being 100 units), for work the range of added stress is from +10 to +25 units. All factors affecting the character’s stress can also be seen from Figure 10.

3.3 Game Mechanics

Different game mechanics allow the player to affect the outcome of the game. Each plant can be taken care of by either being watered or giving it the right amount of light. Each plant has statistics that let the player know how it is doing. The player can also use the in-game computer to buy new plants or look up plant care information. All these mechanics are described closely in the following subchapters.

3.3.1 Plant Care

Each plant has light and moisture level data attached to it, and for the convenience of the player, it can be seen from the plant statistics panel (see Figure 11). The panel displays the plant’s name, current light and water information, and the plant’s health. An example of a plant statistics panel is in the image below.

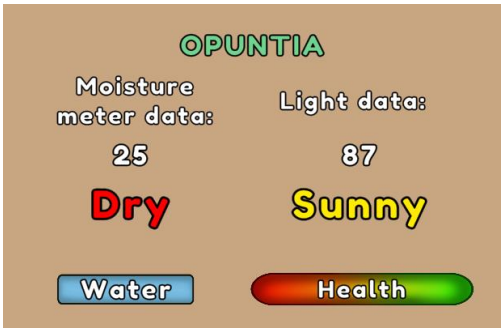

Figure 11. Plant statistics panel

Apart from the numbers showing light and water level, keywords describing those figures were added. For water level, those keywords, representing the moisture level of the soil, are *Dry* (0-33.3 moisture), *Moist* (33.3-66.6 moisture), and *Wet* (66.6-100 moisture). Similarly, for the light level, there are keywords *Sunny*, *Light*, and *Shadow*. These keywords are there for the player to better understand the state of each plant and whether it needs different care since, generally, plant care guides do not provide precise numbers. Instead, when describing light level requirements, the guides use terms like direct light, bright indirect light, filtered light that correspond to *Sunny*, *Light*, and *Shadow* keywords used in *Houseplant Care Simulator*.

The player can take care of their plant in 2 ways: watering it and providing it with sufficient light. To water a plant, the player needs to open the plant's statistics panel and hold the *Water* button until soil moisture reaches the desired level. The player can move the plant to another place in the room to change the amount of light the plant is getting. An idea for future development would be to add special LED grow lamps to the in-game store. Those lights could also impact the light each plant is getting.

3.3.2 The In-game Computer

In the *Houseplant Care Simulator*, two features can be accessed from the in-game computer: a plant shop (Green Pine Nursery) and a plant care guide (Plantipedia). When interacting with the computer for the first time, the player will be shown a welcome screen (see Figure 12) from where they can select the window to go to next.

Figure 12. Main screen of the in-game computer

To know how to care for a particular plant, the player can use the Plantipedia. Once selected, the player is presented with the selection of plants available in the game (see Figure 13). To see more information about a houseplant, the player can click the *Learn more* button. They will then be shown general information, water requirements, and light requirements of each plant (see Figure 14). Knowledge acquired from the Plantipedia can then be used to take appropriate care of the plant in character's possession.

Figure 13. Plant listing in Plantipedia

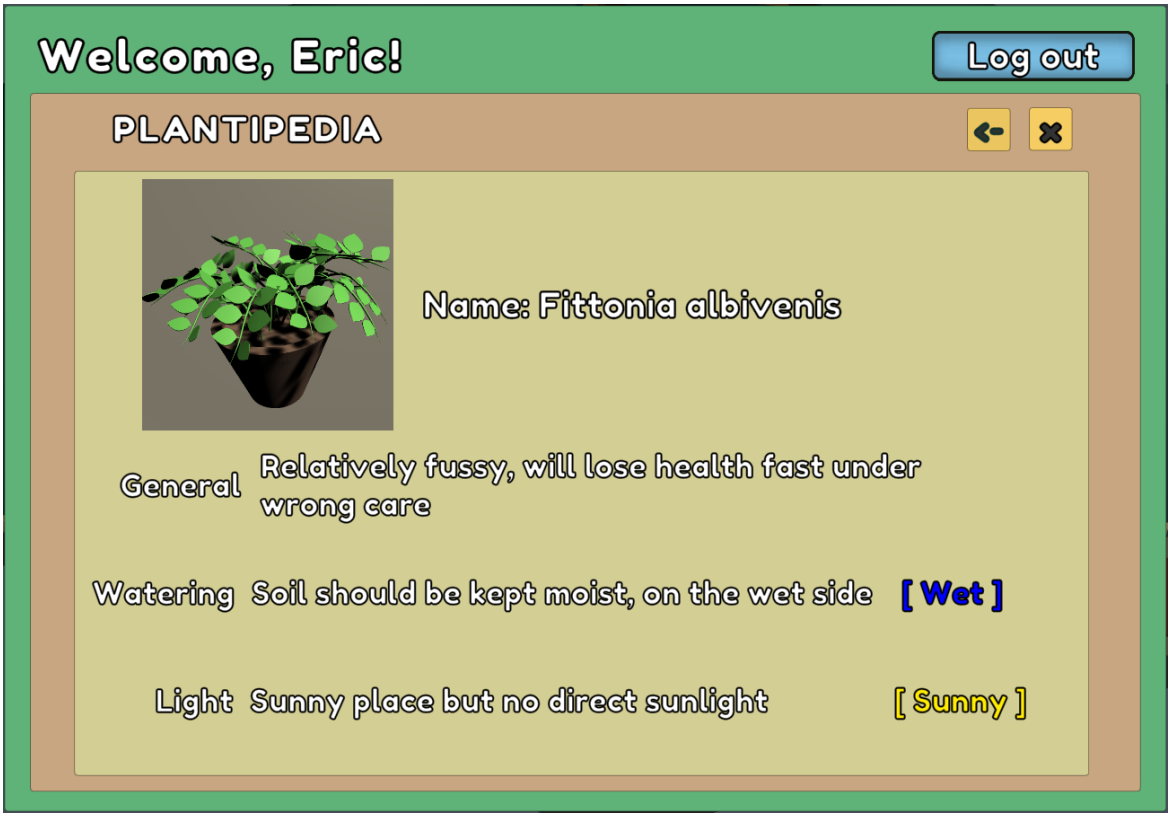

Figure 14. Plantipedia plant info page

Apart from Plantipedia, the in-game computer also has an online plant shop called Green Pine Nursery. In the shop, the player will be able to select from a variety of available plants. Each plant has its name, price, and number of in-game days that it will take to arrive once ordered (see Figure 15). By pressing the *Order* button, the player can order them to expand Eric's plant collection. Every plant will take several days to arrive – the delivery time depends on each plant.

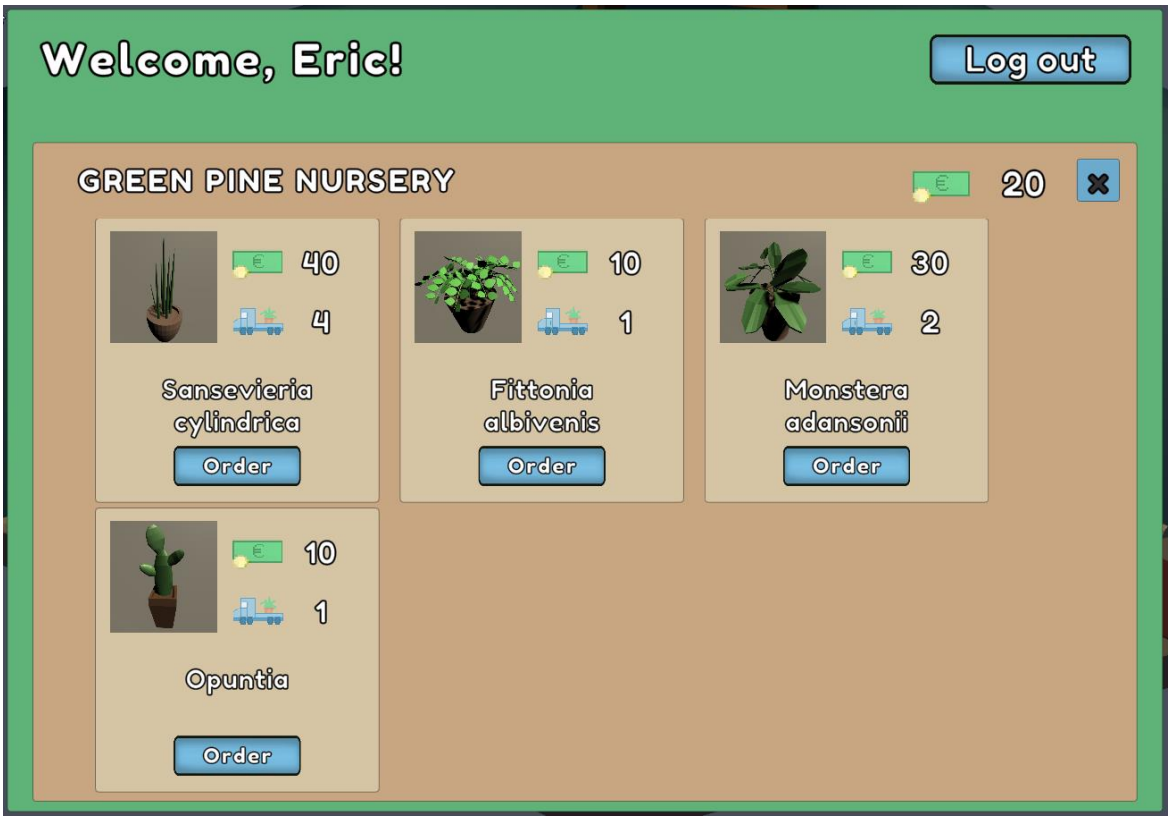

Figure 15. Plant listing in the nursery

The in-game computer is an important element for *Houseplant Care Simulator* in terms of user experience. It is one of the main mechanics that help the player acheive their end goal and it is important that the user interface of it is clear and easy to understand. There are more UI elements that are aimed to improve user experience.

3.4 UI/UX

As *Houseplant Care Simulator* is a management game, there are multiple resources to keep track of, which can get overwhelming even in the demo version of the game implemented in this thesis. To prevent the player from being disoriented, some auxiliary UI elements were added. Some of them are tooltips, a delivery panel, and resource statistics.

Adding tooltips to a game is a simple way of helping the player out with navigating UI elements, making sure the player understands what action they perform and their meaning. To prevent the tooltips from showing up when not needed, a coroutine was created to show the tooltip only if the player has hovered over an object for over 0.5 seconds. Tooltips are also actively used during the tutorial of *Houseplant Care Simulator* to introduce the player to some of the game's functionalities.

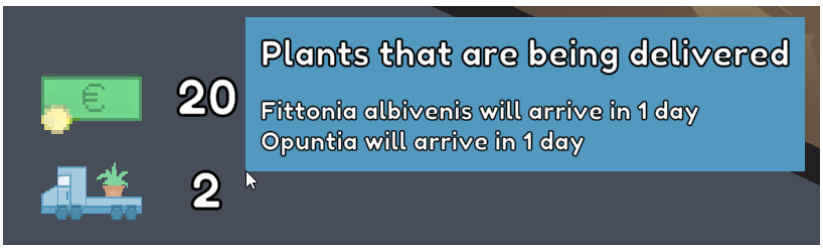

Figure 16. Plant delivery panel with a tooltip

Sometimes tooltips can also provide additional information that otherwise does not need to be visible all the time. This is done with the delivery panel – usually, it only shows the number of plants in delivery, but on hovering over the delivery panel, more information is displayed on a tooltip (see Figure 16). The delivery panel itself was also introduced for the player's convenience, so the player knows when to expect a new plant.

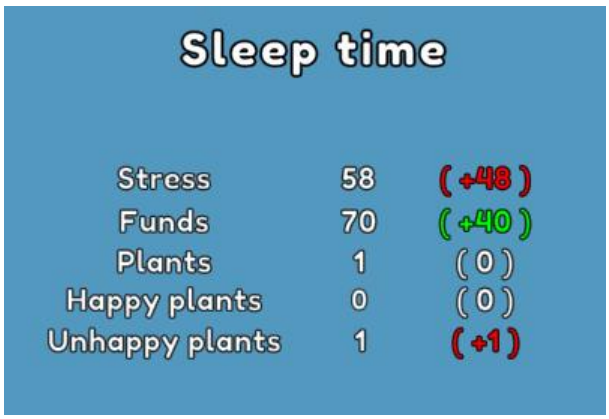

Figure 17. Daily statistics

Another element added to improve the player's experience in *Houseplant Care Simulator* is resource statistics shown to the player during the night when the character is sleeping (see Figure 17). The player can see changes in stress, funds, plant amount as well as the amount of happy and unhappy plants. The data is compared to the previous night's statistics or, on the first day, to the morning data.

3.5 Balancing

User experience is greatly impacted by how balanced the game is. Jesse Schell wrote in his book that if the game is too easy, the player will get bored and, if too challenging, the player

can become anxious [2]. He also proposed 6 questions a game designer should ask themself when designing the challenges of a game. These questions are as follows:

„What are the challenges in my game?“ The main challenge of *Houseplant Care Simulator* is figuring out and remembering the needs of each plant. Another challenge is keeping up with those needs by watering the plant and placing it in the correct amount of light.

„Are they too easy, too hard, or just right?“ The main challenge can get difficult, for that reason lables describing the requirements were added (see Figure 14). Caring for plants should be rather easy once the care is figured out, especially in the demo version of the game where there is only 4 types of plants. To know if the challenges are hard or easy, usability testing was conducted (results described in 5.2.2 Feedback).

„Can my challenges accommodate a wide variety of skill levels?“ The challenges are easy enough to be picked up by inexperienced players. The players with more gaming experience can still find challenge in figuring out the plant care needs.

„How does the level of challenge increase as the player succeeds?“ The more the player progresses, the more plants they get. With more plants the challenge raises as there is more plants to keep track of. However, if the player figured out how exactly to care for plants, there is a high reward making the game easier.

„Is there enough variety in the challenges?“ In the demo version the main challanges revolve around water and light requirements of the plant. This can get repetitive, thus more challanges will need to be added during the future development. The challanges present in the current short version of the game should provide enough variety for the amount of time played.

„What is the maximum level of challenge in my game?“ The maximum level of challenge is reached when the stress raises to critical values, then the player has to be careful to not lose as every unhappy plant can end the game at that point.

Overall, in theory demo of *Houseplant Care Simulator* should provide enough challenge to its players. However, to establish whether the game is indeed balanced, usability testing has to be conducted. Also, to make sure that the game is in balance, some additional components were implemented, *e.g.*, the tutorial at the start of the game.

4 Implementation

Another crucial part of any game development is the implementation process. In this chapter, technologies used for the creation of the *Houseplant Care Simulator* and alternative technologies will be brought out. Furthermore, the essential event-driven system of the game is described along with important UI/UX features and tutorial development.

4.1 Technologies

In Lens #92 of his book, Jesse Schell formulated an important question to think about when creating a game: "What technologies will help deliver the experience I want to create?" [2]. Before getting to the actual implementation, various technology options had to be considered, especially when it came to the core technology of the game – the game engine.

The main technology – the foundation of *Houseplant Care Simulator* – is the Unity[10] game engine. There were two main alternatives: Unreal Engine[11] and Godot[12]. All above mentioned game engines are powerful technologies that have support for user inputs, physics, scripting and many more functionalities, making them convenient tools for game development. Unity was selected due to the author's prior experience with that game engine.

Some of the 3D models and art were created during the development process of *Houseplant Care Simulator* (all the created assets are listed in Appendix III, Table 3). Simplistic models of the room, furniture, plants, computer monitor present in the game were created in Blender[13]. The main menu background, icons and buttons were drawn using Paint.NET[14].

Another essential tool that helped to deliver *Houseplant Care Simulator* is C# – a well-known object-oriented programming language that is supported by Unity game engine. Along with other useful functionality, C# also supports delegates[15], that serve as a base for

[10] Unity - https://unity.com/

[11] Unreal Engine - https://www.unrealengine.com/

[12] Godot - https://godotengine.org/

[13] Blender - https://www.blender.org/

[14] Paint.NET - https://www.getpaint.net/

[15] C# delegate type - https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/builtin-types/reference-types#the-delegate-type

events[16]. The events allow for communication between classes or objects. Using the events, an event-driven architecture was built for *Houseplant Care Simulator*.

4.2 Event-driven System

To make objects communicate with each other and react to certain changes throughout the game, an event-driven system was built using the observer programming pattern [8]. The system consists of numerous events that are being invoked by objects (publishers) to notify other objects (subscribers). Apart from being a way to notify other objects of changes in the system, events also allow passing data. Because of that, objects can send updated information to each other, making updating in-game resources (*e.g.*, funds) or information visible on the user interface (*e.g.*, stress level) a simple task.

In the case of *Houseplant Care Simulator*, one of the core objects of the game is `TimeManager`, which is responsible for the in-game time. To notify other objects of changes in time or time of day, it uses events `HourPassed`, `ToggleWork` and `ToggleSleep`. There are various objects that are listening to said events and acting upon the events being invoked - buttons appear or disappear depending on the time of day, sleep and work panels are being shown or hidden, statistics on the sleep panel updated (see Figure 18).

[16] C# events - https://docs.microsoft.com/en-us/dotnet/csharp/programming-guide/events/

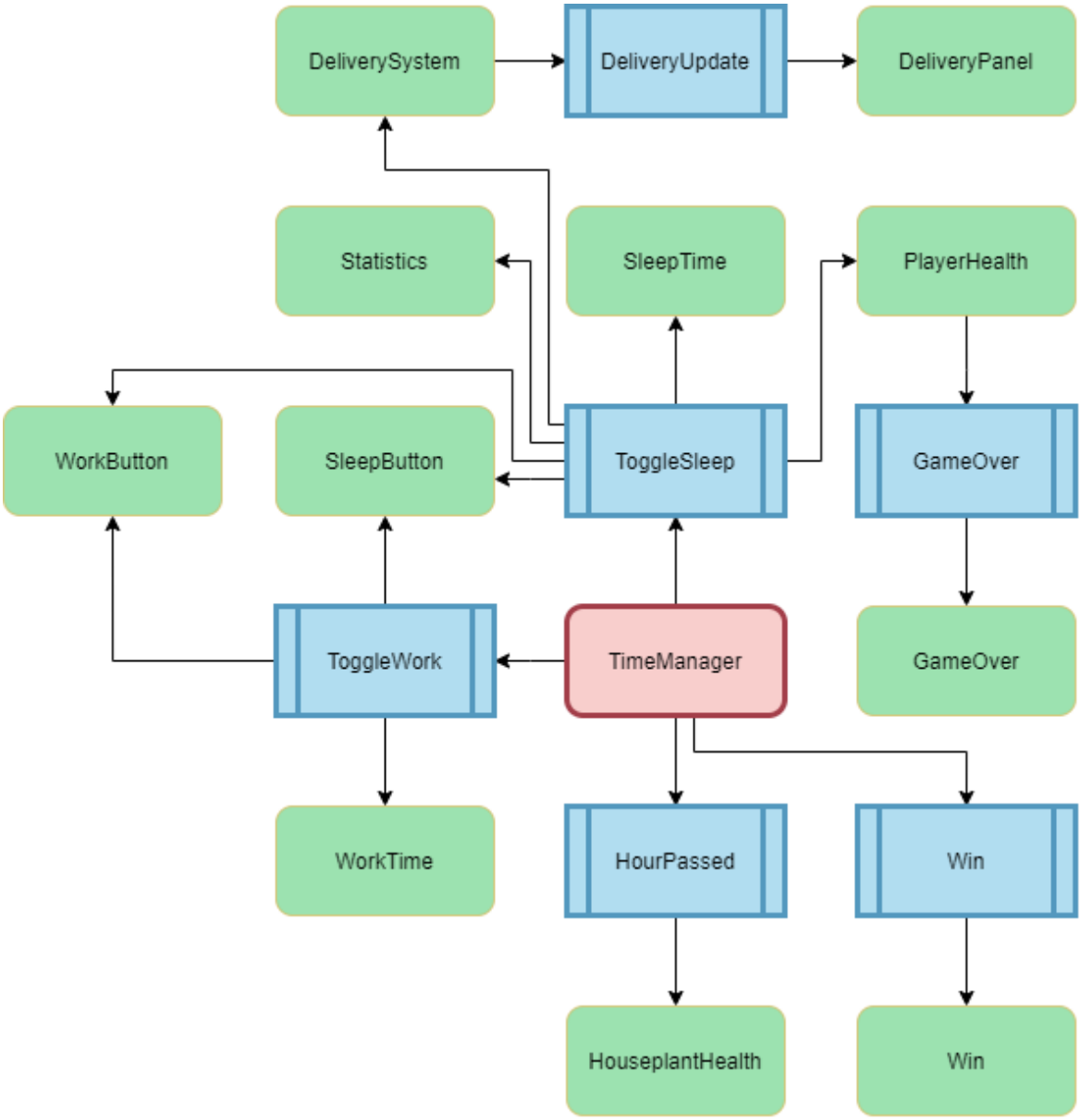

Figure 18. Part of the event architecture, managed by the time manager

Apart from the UI updates, other important updates are happening. `HourPassed` event notifies every `HouseplantHealth` object that it is time to check the plant's well-being. The moisture level and the light amount are checked, houseplant health updated depending on the check results. After that, the character's stress is updated through the `GameManager` – another essential object of *Houseplant Care Simulator*. Once `GameManager` has updated the character's stress, it invokes the `UpdateStress` event that `StressUIManager` listens to and once received, updates the stress bar for the player to see the change in stress levels (see Figure 19). Another object listening to `UpdateStress` is `SoundManager` that might need to change the music depending on the new stress level.

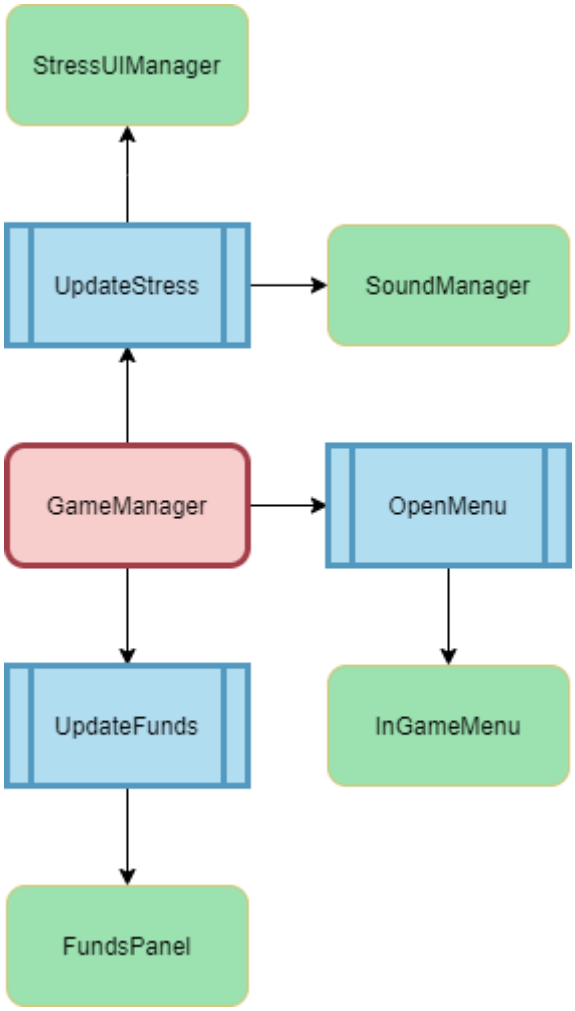

Figure 19. Part of the event architecture, managed by the game manager

More events are being invoked in *Houseplant Care Simulator* that can be found in a diagram (see Appendix IV The Event-driven Architecture Overview). All the events together make up multiple game mechanics that need to be introduced to the player. For that reason, a tutorial has been implemented.

4.3 Tutorial

The main issue that came up when developing the tutorial for *Houseplant Care Simulator* was scalability. Since the initial plan was to have a short tutorial, no game programming patterns were used for the tutorial at the beginning. The first version of tutorial manager contained a list of `Hint` objects that represented tutorial steps. The order of steps in the list was the order in which they would appear in the game. The next step would be initiated whenever a condition for the previous step was fulfilled. To check if the condition was

fulfilled, a `switch` statement was added to the `Update` method of the `TutorialManager`. Within the statement, based on the current step index, a verification method would be called. It meant that to add a new step, indexes in the switch statement would have to be updated, a new verification method added to the `TutorialManager` class, hints reordered in the inspector view of Unity. That is a lot of manual work and as the tutorial was expanding, the code was becoming less readable and maintainable. This led to `TutorialManager` refactoring.

During the refactoring of the tutorial manager, the state pattern [8] was implemented. Every tutorial step extends an abstract class `TutorialStep` and overrides its abstract method `CheckIfCompleted`. The method contains the step completion condition and is called in the `Update` method of the `TutorialManager`. To call the correct method, the `TutorialManager` keeps track of the current step.

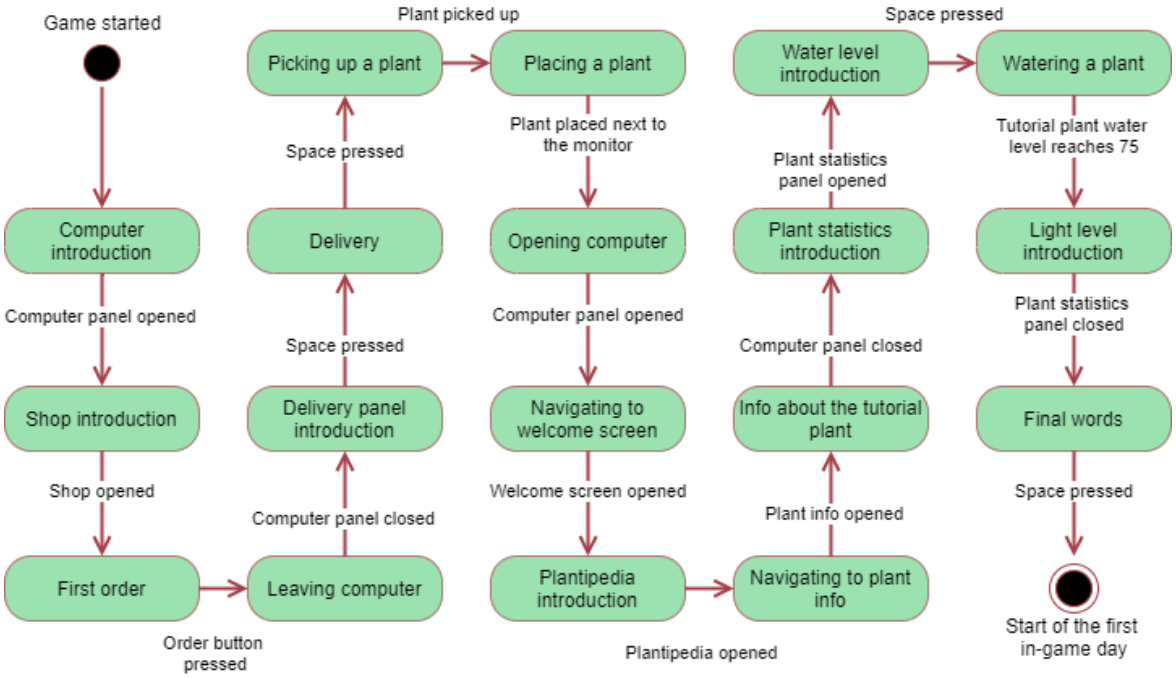

Figure 20. State diagram of the tutorial steps

Additionally, a dictionary was added to keep track of the steps' order (all steps in the right order can be seen from Figure 20). It takes the ordinal number parameter of the `Hint` object as its key and the `TutorialStep` as the value. This way the order of `Hint` objects in the inspector does not matter and there is no need to manually reorder all the steps to add a new one - changing the ordinal numbers is enough.

The implementations described in this chapter are just a part of *Houseplant Care Simulator*. There are multiple mechanics in the game that need to be working well together. To ensure that the core gameplay loop and all the implemented game mechanics are working as expected and find potential issues, the usability testing was conducted.

5 Usability Testing

Usability testing is an opportunity to identify problems and find aspects that can be improved on [9]. In this chapter the methodology on the usability testing of *Houseplant Care Simulator* is described and the results are analysed. At the end, the implemented fixes are brough out and the possible future improvements listed.

5.1 Methodology

The testing was conducted with five computer science students. Four of the testers ran the game on Windows, one on macOS. Testing sessions took place online via video-communication services, taking advantage of the screen-sharing features. Recordings of the playtesting sessions can be found in the Appendix V Test Sessions.

The participants were asked to run the game and share their screens. Testers were not given any detailed instructions, but they were informed of their objective to reach the 8th in-game day. Generally, the participants were playing the game without help, but they were provided with hints on instances of confusion. Those instances were also taken into consideration when analysing possible improvements (see subchapter 5.3 Improvements).

Before and after playing the game, the participants were asked to fill out a questionnaire that was put together for the usability testing. Questionnaire was composed of 2 parts. Answers to both parts are analysed in the following subchapter.

5.2 Results

First, the testers were asked to answer the first part of the questionnaire that contained general questions about their houseplant and stress knowledge and experience with video games. Results of the first part of the questionnaire are analysed in subchapter 5.2.1 Preliminary Information.

After the playtesting session, the participants were asked to answer the second part of the questionnaire. It contained questions about their experience while testing the game. The gathered feedback is analysed in subchapter 5.2.2 Feedback.

5.2.1 Preliminary Information

To know if the game has succeeded in its goals (described in 1 Introduction), gathering information about testers' previous experience and knowledge was needed. For that, in the first part of the questionnaire there were five questions.

The first questions were about the background of the testers. Most testers play videogames frequently, 80% of them play on average at least once a week. However, games of simulation genre are not played as often – the testers either had experience with them a while ago but do not play them anymore or play them rarely, up to once a month (see Figure 22).

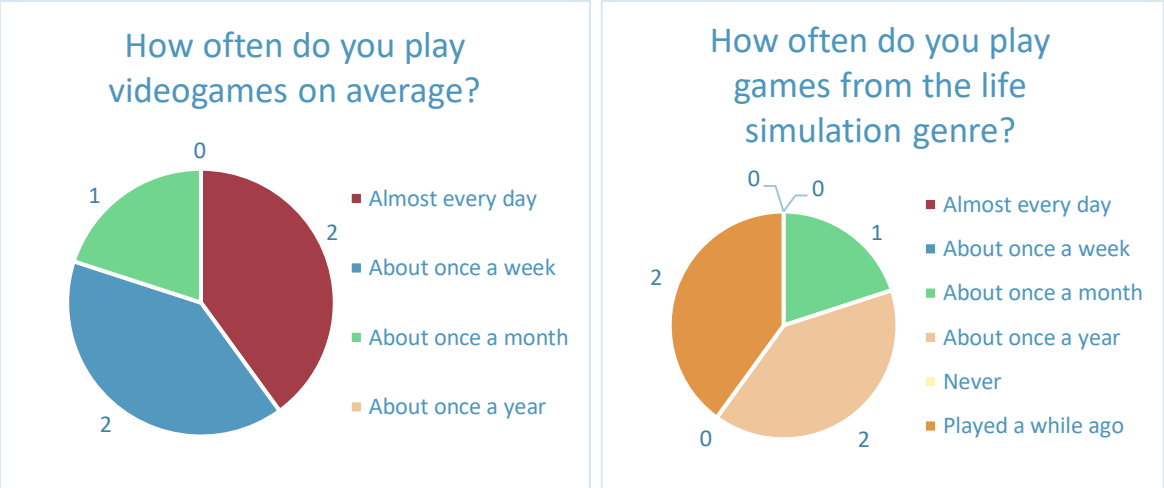

Figure 22. Frequency of playing videogames

There were 2 questions about testers' knowledge of houseplants and their effect on stress. Most testers answered that they have very little knowledge of houseplants but some stated that they are somewhat knowledgeable. 4 of the testers answered, that houseplants decrease stress and one thought they have no effect on people's well-being (see Figure 21).

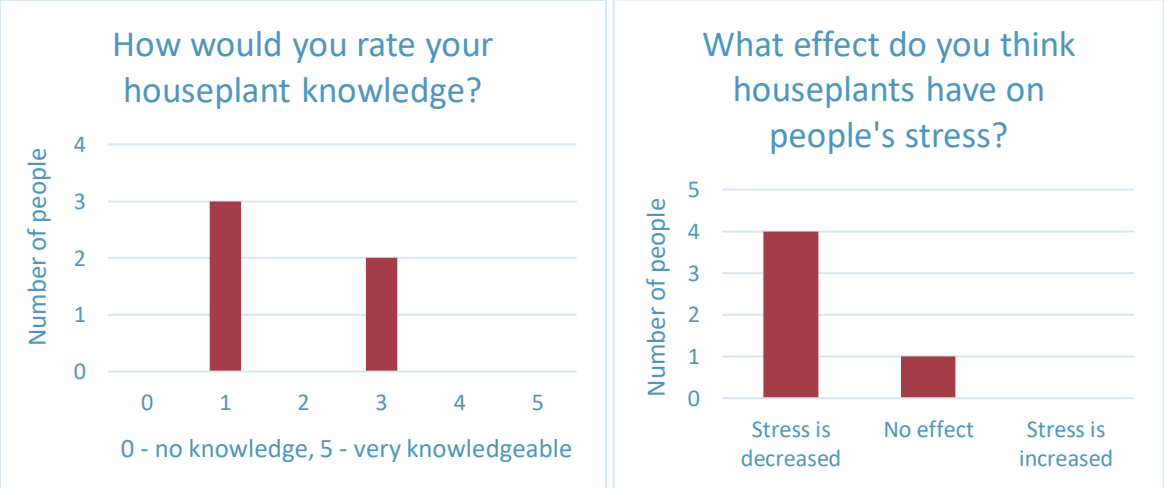

Figure 21. Houseplant knowledge and stress awareness pre-testing

The testing participants do not play life simulation videogames often, which could have affected the testing, especially if the tutorial were not comprehensive enough. Most testers thought that houseplant have positive effect on stress, which is also a message that the game

is trying to convey. On average testers have rather low knowledge of houseplants, which could improve after playing *Houseplant Care Simulator* if the game succeeds in its goals.

5.2.2 Feedback

To figure out whether the game managed to achieve the set goals and find parts that could be improved, second part of the questionnaire had 19 questions. 8 of them were questions about main components of the game and educational value of the game. Other questions were open answer to get more insight on what is done well and what should be improved.

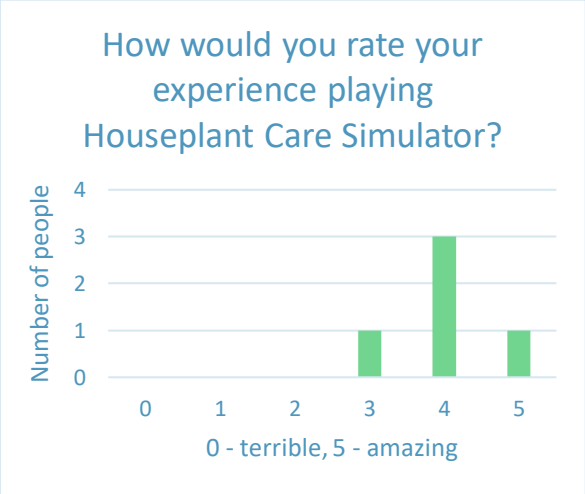

Figure 23. Experience with *Houseplant Care Simulator*

The general experience playing *Houseplant Care Simulator* was rated positively (see Figure 23). Most testers pointed out graphics and selection of music as the things they enjoyed. Individual testers also pointed out that the concept of the game was fun, and it was their first experience playing such game. Learning about houseplants and managing them were also brought out amongst the things testers enjoyed. The participants also left plentiful suggestions on what could be added to the game to enhance the experience (brought out in subchapter 5.3 Improvements).

According to the testers' answers, the game was rather easy, only 1 participant found the game a little challenging (see Figure 24). Main reasons that were pointed out are too little actions the player can do and the mechanics that are present are quickly mastered. One participant answered that understanding how to take care of plants was challenging because the numerical values on the plant statistics panel were not connected with the

Figure 24. Game difficulty

moisture or light level in a clear way. Overall, since there was no strict time constraint and all the needed information was available, during testing sessions participants managed to figure out how to care for plants by day 4 and reaching the 8th day was not a challenge. All the testers have gotten the best ending, meaning that they finished with less than 33.3% stress.

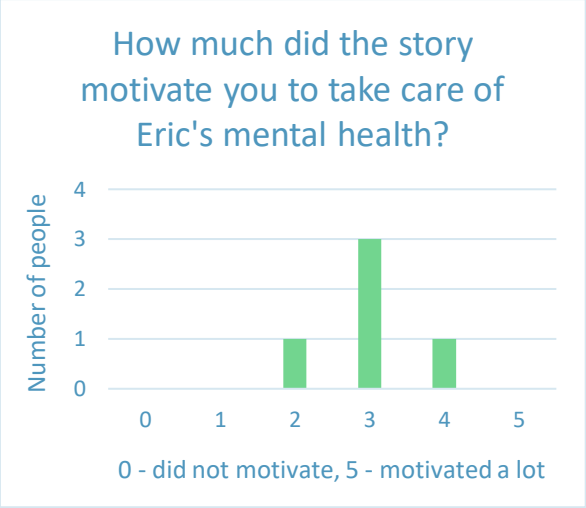

Figure 25. Motivation from game's story

Participants found that the story in *Houseplant Care Simulator* somewhat motivated them to take care of the character's mental health. The responses to an open follow-up question were rather divided – some answered that a goal set by the story motivated them to play, others said, that they were not thinking of the story during the game. One participant answered that they are not interested in story-driven games, thus the story did not motivate them. The story in the game did give some additional motivation but some improvements could be made during future development to motivate players more.

The opinion on whether the change in stress was clear or not is rather divided (see Figure 26). 3 testers answered that the change was clear – summary at the end of the in-game day was helpful. However, the change in music was not linked with the change in stress in an apparent way. Also, one participant pointed out that it was clear that stress was changing but overall stress was rather difficult to understand. Overall, the elements present in the game did help to see change in stress level, but it could be highlighted more.

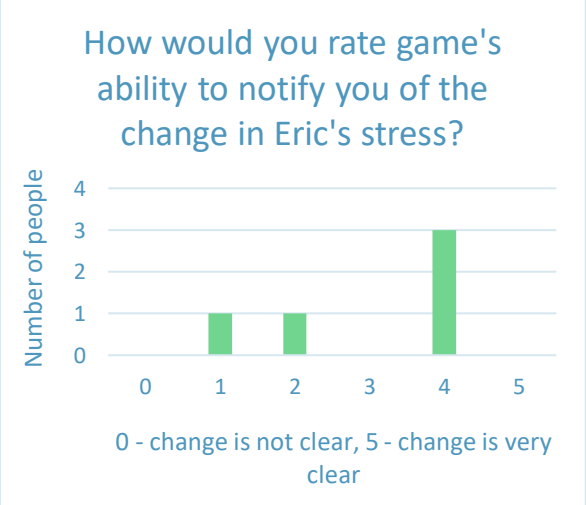

Figure 26. Game's ability to notify the player of stress change

The tutorial in *Houseplant Care Simulator* received positive feedback as most participants found that it helped them a lot

(see Figure 27). One participant mentioned that the transition from the tutorial to the game was not clear enough. Through testing, multiple participants were not sure whether the game was started after the last tutorial step and were helped by pointing out that the time is now going. Another issue that was pointed out and became apparent during the test sessions was the lack of a tutorial step for the delivery panel. It was not easy to find the panel and multiple participants were not clear on when their plants will arrive because of it. The issue was fixed after testing.

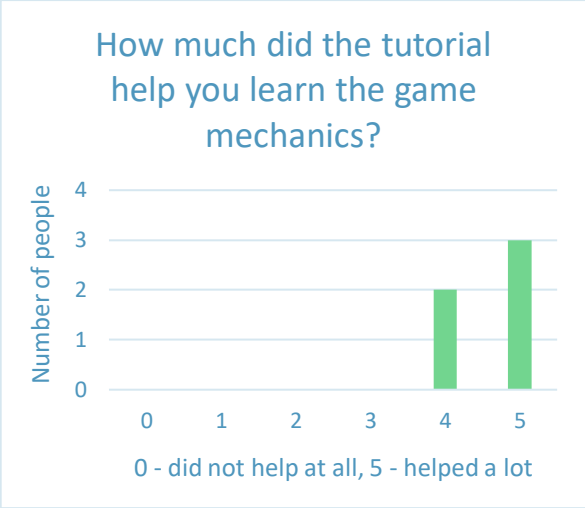

Figure 27. Tutorial feedback

Also, in their feedback about the tutorial one of the testers mentioned that it was unclear when a plant's moisture level changes (*e.g.*, from *Moist* to *Dry*). This can be improved by adding visual indicators instead of numerical values for the soil moisture level and the light level (brought out as a future improvement idea in 5.3 Improvements).

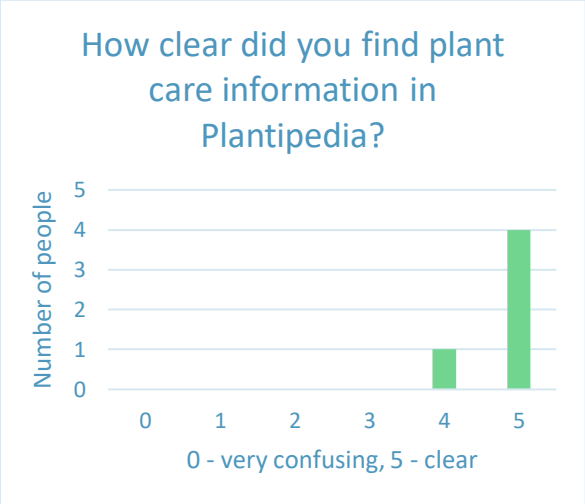

Figure 28. Plantipedia feedback

The same issue was pointed out in feedback about Plantipedia. Overall, it also received a positive response (see Figure 28). The information provided in Plantipedia seemed clear to the testers, apart from one instance when the description was misunderstood and should be improved. One of the testers wrote, that perhaps the labels make the game less challenging as they never looked at the descriptions and managed to figure out the care by just looking at the labels. This could have significantly brought down the educational value of the game.

The amount of new houseplant knowledge gained from the playing experience was rather low (see Figure 29). It was explained by the testers not focusing on the care need

descriptions. The testers who read into descriptions, marked the educational value of the game higher than those who did not.

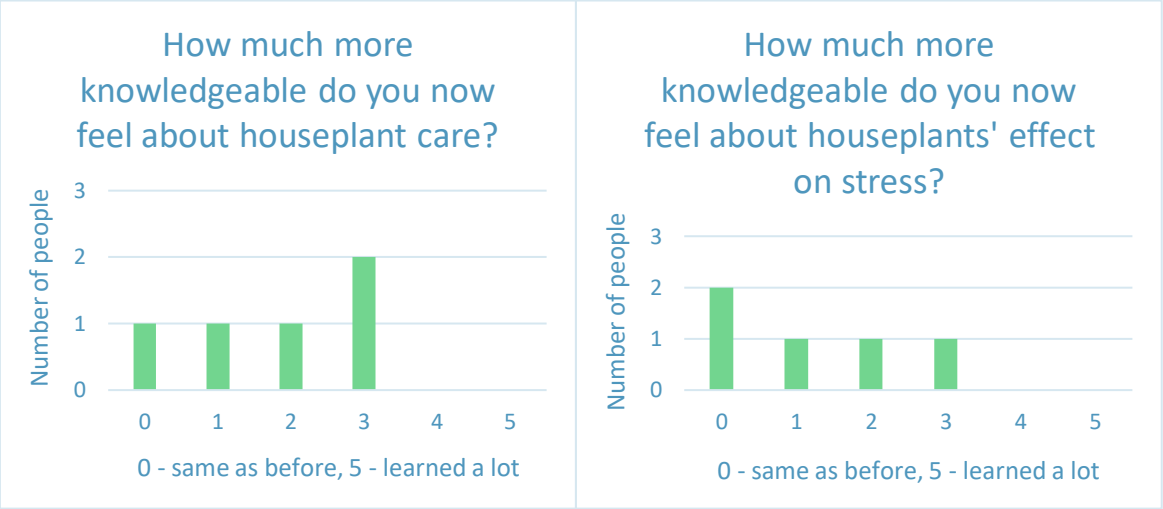

Figure 29. New knowledge about houseplants (left) and their effect on stress (right)

Testers felt that they got even less education information about houseplants' effect on stress as the game did not highlight it enough. One of the participants proposed that the game could have provided the player with information on how much each plant can affect character's stress. Another tester wrote that in their opinion the plants are more likely to increase stress levels in real life.

The questionnaire also had a question about games that *Houseplant Care Simulator* reminded them of. One of the testers brought out *Penguin Diner*[17], which is also a simulation game that requires the player to tend to guests of the diner and make as much money as possible. The main similarity is resource management through game mechanics – the amount of money the player gets in *Penguin Diner* depends on their actions, just like in *Houseplant Care Simulator* the amount of stress depends on how well the player managed to take care of plants.

Overall, the participants gave positive feedback about *Houseplant Care Simulator*. The main problem found through testing was the game not managing to reach its goal of providing educational value. This and other issues brought out by testers are something that should be taken into consideration for improving *Houseplant Care Simulator*.

[17] http://www.penguindiner3.org/

5.3 Improvements

Multiple issues and things to improve on were found through the testing sessions and via the questionnaire answers. Some of the feedback was used to improve the demo version of the game, that was developed in this thesis. Changes implemented after testing are as follows:

- improved precision of picking up plants;
- watering is now accelerated over time;
- the game character now ignores the first click outside the plant statistics panel to prevent the character from moving when not expected to;
- during the tutorial, the plant statistics panel is now inactive until a corresponding tutorial step that teaches the player how to use the panel;
- the tutorial plant now requires to be watered all the way to its water requirement at the watering tutorial step;
- added a tutorial step to show the player the delivery panel;
- work time does not start automatically anymore, the player has to make sure the character is on time for work (Eric will get less funds if late);
- when a plant dies, the plant statistics panel will now automatically close, and the plant death panel will open;
- changed the font to make descriptions easier to read.

To improve the ability of *Houseplant Care Simulator* to teach its players about plant care, a possible solution is to add multiple difficulty levels. On easy difficulty the game would show players the already existing labels (*e.g. Moist, Sunny*) in Plantipedia. On a higher difficulty the player would have to rely on the descriptions alone. Adding more ways to care for a plant (*e.g.*, repotting and pruning) and more factors that could affect their health (*e.g.*, temperature) could also provide more educational value and make the game more challenging. In addition, some in-game events (*e.g.*, power outage that shuts the in-game computer down) could be added as means of adding some challenge and testing players' plant care knowledge.

Most of the improvements suggested by the testers were not implemented during the work on this thesis. There were many suggestions aimed to improve the visuals, balance the game,

and make it more engaging. The list of features that could be added during later development:

- sound effects;
- more furniture and ability to put plants on the window seals to increase the amount of space for plants;
- bigger variety of plants;
- visual indicators of how much light and water the plant is getting;
- places where plants can be put are marked with plates;
- better graphics for the sleep and work panels, *e.g.*, add a GIF of the character at work to the working screen;
- support of higher resolutions;
- visual representation of plant growth, leaf colour change based on plant's well-being;
- light could be made more dynamic, *e.g.*, change the amount of light the plant is getting based on the time of day;
- add LED lamps that could also affect how much light a plant is getting;
- improve the immersion by replacing some of the buttons with objects in the room, *e.g.*, bed to go to sleep, door to go to work;
- add soil-changing and temperature-effect mechanics that would also affect plant's well-being;
- add more rooms in the house;
- add a pet that could harm the plants.

6 Conclusion

Through the work on this thesis, a demo version of life simulation video game called *Houseplant Care Simulator* was created. Its main goals were to provide educational value about houseplants and bring attention to their effect on people' stress. Games with similar goals and gameplay components were analysed to see how the newly created game could provide additional value to the potential player base.

In the process of designing the game, a background story of *Houseplant Care Simulator* was written to provide additional motivation to the players. Also, the core gameplay loop was designed, defining game's winning and losing conditions. Those conditions were also supported by the pieces of story added at the end screens of the game, where the ending depends on the final stress level of Eric, the main character of *Houseplant Care Simulator*.

The game mechanics like watering and in-game computer were designed and implemented to achieve goals set for the game. At the base of *Houseplant Care Simulator* is an event-driven architecture that is implemented using the event functionality of C#. Another important implementation commitment was the development of a tutorial, aiming to introduce main game mechanics of the game and improve users' experience. It was implemented using the state pattern.

To establish whether the game has achieved the set goals, usability testing was conducted. The total of 5 testing sessions took place online. The overall feedback for the game was positive, but multiple issues were found. Some of them were fixed during the creation of the thesis and some are left as ideas for the future development. The most important outcome of the testing was the general opinion that *Houseplant Care Simulator* did not achieve the goal of providing educational value as well as the author was hoping for. However, it is also something that can be improved on in the future versions of the game.

Deep gratitude goes to the supervisor Raimond-Hendrik Tunnel, who provided valuable feedback. It helped to profoundly improve both the gameplay and the contents of this thesis. Special thanks go to the usability testing participants who also provided extensive feedback and many suggestions that can be used to enhance *Houseplant Care Simulator*.

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Appendix

I. Glossary

Microtransaction	A small payment a user can make to purchase virtual goods. Microtransactions are often used as sources of income for developers of free-to-play games.[18]
Gameplay	A pattern that is determined by the game rules and is the way a player interacts with the game.[19]
Core gameplay loop	The essence of a game represented by key activities. It cannot be removed without completely changing the experience the game gives to its players. [7]
Game mechanic	Game element that gives players a set of methods to interact with the game.[20]
Observer pattern	A game programming pattern that lets an object (publicher) notify other objects (subscribers) of various events [8].
State pattern	A programming pattern using which a fixed amount of object states can be implemented. The object can be in one state at a time and it can move between states via transitions. [8]
UI	A combination of commands and menus that let the user interact with a program[21].
Tooltip	A graphical user interface element that shows the user additional information upon hovering over an object.[22]

[18] https://en.wikipedia.org/wiki/Microtransaction

[19] https://en.wikipedia.org/wiki/Gameplay

[20] https://www.gamedesigning.org/learn/basic-game-mechanics/

[21] http://vallaste.ee/

[22] https://en.wikipedia.org/wiki/Tooltip

UX	User experience describes the experience user has with software and its UI.[23]
Usability testing	A methodology aimed to research the user experience [9].

[23] https://www.nngroup.com/articles/definition-user-experience/

II. Project Repository

The project can be found at https://github.com/KrisKevel/Houseplant-Care-Simulator.

Build of the project it available at https://kriskevel.itch.io/houseplant-care-simulator.

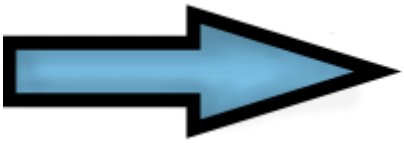
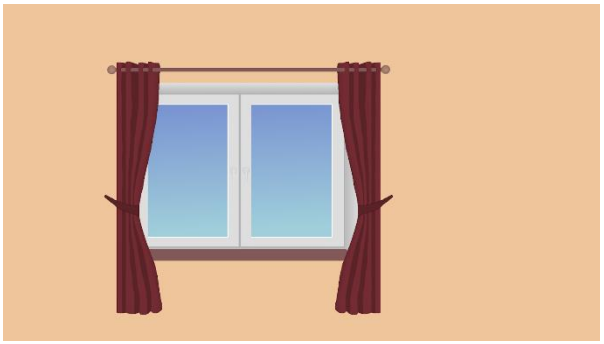
III. Assets

Table 2. Assets found from the Internet

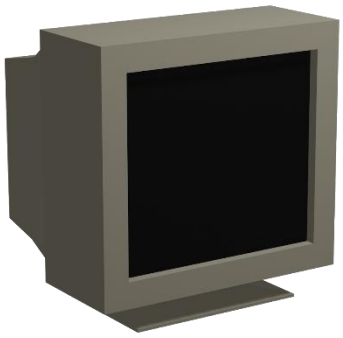
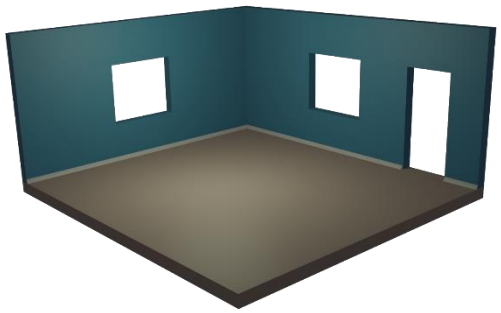
Asset	Author	Source	Image
Eric's model	Supercyan	https://assetstore.unity.com/packages/3d/characters/humanoids/character-pack-free-sample-79870	
Background music, "Potato"	Brave Warrior (Rizwan Ashraf)	https://assetstore.unity.com/packages/audio/music/free-music-tracks-for-games-156413	-
Background music, "BGM_04"	B.G.M	https://assetstore.unity.com/packages/audio/music/casual-game-bgm-5-135943	-
Background music, "Among The Townsfolk"	Bakuda Music	https://assetstore.unity.com/packages/audio/music/rpg-adventure-pack-185148	-
Background music, "Misty Shore"	Bakuda Music	https://assetstore.unity.com/packages/audio/music/rpg-adventure-pack-185148	-

Table 3. Assets made during the development of *Houseplant Care Simulator*

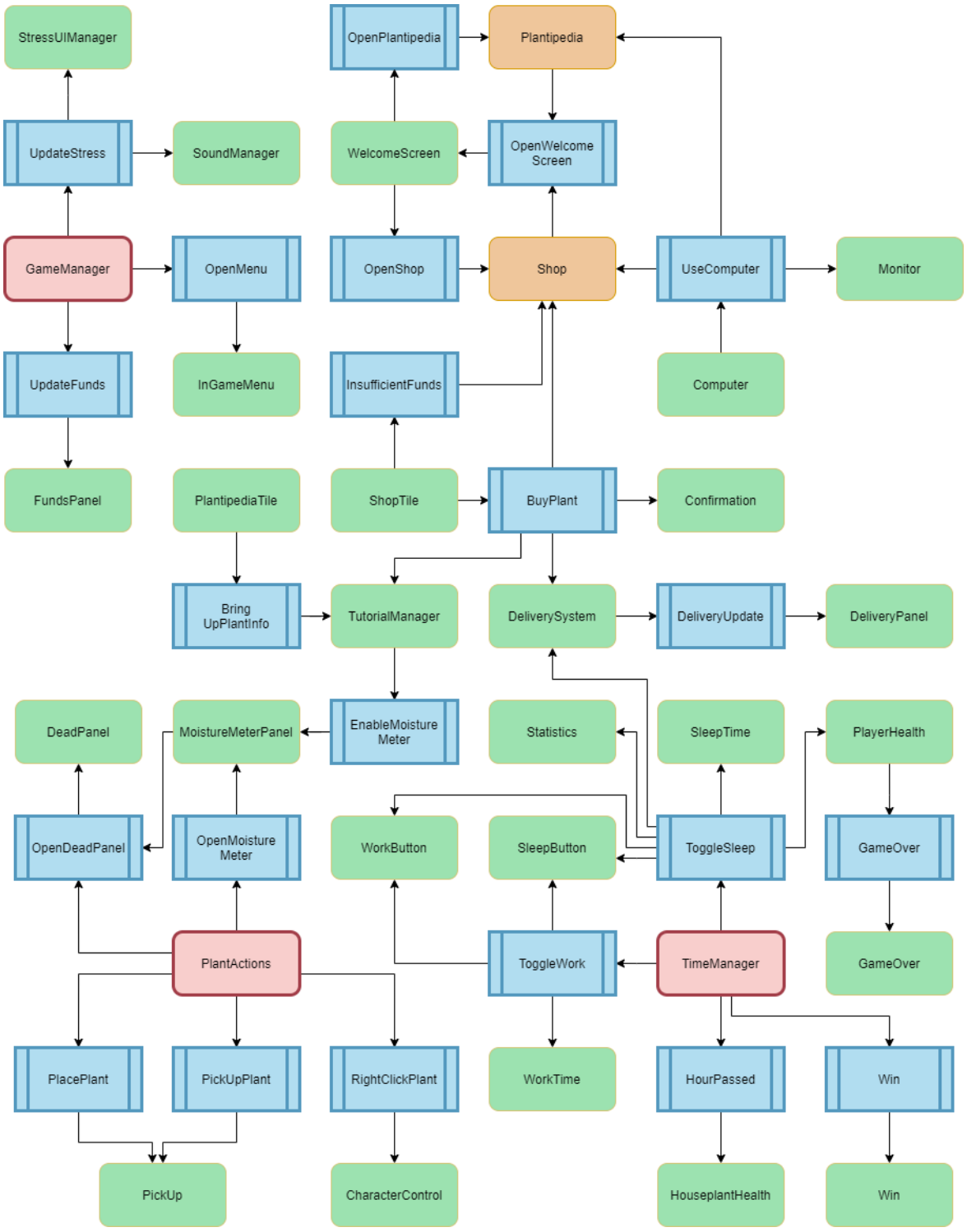
Asset	Image
Yellow button	
Blue button	

Tutorial arrow	
Delivery icon	
Funds’ icon	
Stress bar	
Main menu background	
Monstera Adansonii model	
Sansevieria Cylindrica model	

Fittonia Albivenis model	
Opuntia model	
Shelf	
Table	

Monitor	
Room	

IV. The Event-driven Architecture Overview



V. Test Sessions

Session 1	https://youtu.be/TO8McwTPSPk
Session 2	https://youtu.be/opjSG-TTAtc
Session 3	https://youtu.be/8kkpPQizDRI
Session 4	https://youtu.be/GvYJ_-kB-kA
Session 5	https://youtu.be/TvZaI75knUA

VI. Accompanying Files

- /Build – the folder containing the build version of the game with other files needed to run *Houseplant Care Simulator*.
- /Source – the folder with Unity project files.
- /Testing – the folder containing questionnaire and testers' responses.

VII. License

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07/05/2021