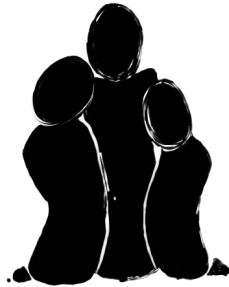


# Video game development in Unity to represent the addiction phases through the use of non-Euclidean spaces



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# Abstract

***Over the quiet storm*** symbolizes a voyage through the different phases that an addicted person could present: from the first contact, through experimentation, and finally to an uncertain end that can be decided by the player. For its correct representation, the game makes use of non-Euclidean spaces, with the intention of creating confusion and disorientation.

This game represents not only a journey, but complicated thoughts and emotions, using the fewest possible words. Playing it is a different experience for each person, leaving in each individual a complex mixture of feelings. Even though this game has been created to focus on a particular subject, the true meaning of itself can be only decided by each player.

**Key words:** *Addictions, Non-euclidean, Portals, Team work, Video Game development, Puzzles.*

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# 1. Introduction

## 1.1 Presentation

Throughout the project, the objective has been to discuss a topic that is infrequently debated in the field of video games: the addictions. The purpose has been to generate a story that is not only narratively compelling, but also visually and playable open to player interpretation. Simultaneously, the intention has been to transmit clearly, across different levels, the distinct phases that constitute an addiction.

Creating a video game with an uncertain and seemingly impersonal theme is a risky move, as it is much easier for players to develop an attachment to a character or a story. However, the aim has been to create narratively powerful yet confusing spaces that make players feel uneasy but interested in the plot, so it can capture their attention.

This can be considered an educational video game that seeks to invoke in the player a personal questioning about both their own experiences or those of others. Although many of these experiences may seem distant, the reality is that they are common to all human beings, coexisting in our society much more frequently than one might imagine.

It is important to highlight that this video game has been developed jointly by two students from the Video Game Design and Development degree: Alba Ramos Montañés and Héctor Rubio Rico.

## 1.2 Objectives

The different objectives set throughout the development can be classified into the following points:

- Program non-Euclidean spaces in three dimensions that provide mechanics for solving puzzles.
- Create a visual environment that reflects the psychology of the character in each phase of an addiction.
- Create an original game, with original models, scenarios, puzzles and animations, that tells the story in a metaphorical way.
- Show to the player that they have the decision of which way to go, even though it may sometimes seem difficult or impossible to get there; as long as they remain firm in their choice.

## 1.3 Methodology

As this has been a group project, it was necessary to develop a methodology to properly organize the project and its tasks.

Firstly, the common parts of the development have been decided, these are:

- The theme and concept of the game.
- The design of mechanics and gameplay.
- The creation of a storyboard.
- The design of portals.
- The testing phase.
- The correction of errors.

It has been decided that these parts must be common, as they are taken into account throughout the rest of the game development. If they are established together from the beginning, the individual members of the group can work separately while maintaining the cohesion of the work.

Regarding organization, it was decided to use the simplified Scrum methodology. This methodology, as explained on its website [1], consists of dividing the work into short and defined cycles. In this case, a one-week sprint was chosen. The work to be done by each member of the group is established in a meeting before starting the cycle, and it must be completed before starting the next one. Additionally, a small meeting is held every day to share the general status of the tasks.

To organize the sprints and carry out proper monitoring of the tasks, the Trello tool was used [2], which is explained in more detail in section 5.3.

To keep the project files updated for both group members, the GitHub tool was used [3].

Finally, it has been decided that the game will be developed by levels. It is preferable to completely finish one level before having basic gameplay in several levels. For this reason, we have worked by levels, and, for example, the development of level 2 has not been started until level 1 was practically completed.

## 2. Planning

### 2.1 Work distribution

It has been necessary to divide the work equally in order to distribute the work properly between the two members of the group, so that all aspects can be treated by the students. At the same time it has been crucial taking advantage of the knowledge of each one to minimize the necessary time to finish the project.

Three key aspects were considered as principal pillars when making this video game: design, art (visual and sound aspects) and programming.

It has been important to solve the first point mostly as a team, in order to reach an agreement that would ensure good cohesion throughout the rest of the project and establish a shared foundation. For this reason, the design of the mechanics, the gameplay and the artistic style has been designed collaboratively and with equal input from all parties involved.

From the initial stage of the project, the idea intended to convey has been very clear, something that facilitated the design part so can be developed more quickly.

Héctor carried out the majority of the puzzle design. This part took the longest to develop in this stage because of the complexity involved in designing the challenges that players will face. It has been sought to make the puzzles interesting and solvable without much difficulty, while taking into account that one of the main mechanics of the game must be used: non-Euclidean spaces.

A large part of the art made consists of three-dimensional models. It is possible to differentiate between scenarios and objects: scenarios are the structures that make up the overall scene (bridges, towers, walls, stairs, etc.) and objects are the independent elements that help to create the atmosphere, that are interactive or that indicate to the player how to orient themselves in the scenario (doors, statues, candles, buttons, etc.)

Distributing this work has not been easy. The students had to determine the amount of time needed to model each object in order to distribute them equitably. The first phases of development were useful to measure the approximate time needed for the modeling of the objects and scenarios. In later phases of development, the team was able to significantly increase their productivity by optimizing the distribution of tasks based on previous results. For example, while one student programmed, the other would model objects simultaneously. Once the first student had finished the programming part, the tasks were reversed.

Another section to consider within the art of the project has been the visual effects (such as particle effects, fog, post-processing effects, etc.) and the research and editing of sounds and music to add atmosphere to the project. These parts, as well as their upcoming implementation, have been mostly carried out by Alba.

Programming was the most extensive part of this project, and consequently the one that required the most working hours from both students.

The parts that have required the most time within this section are the creation and proper functionality of the main mechanic, the portals. Additionally, the programming of all other playable sections that involve interaction with the environment, such as the general gameplay, has also taken a significant amount of time.

Héctor has been primarily responsible for all aspects of creating portals, including subsequent adjustments, beyond the initial programming. This has been a crucial task as the portal system is one of the key mechanics in the game and any errors could affect the gameplay experience.

The gameplay includes aspects such as ensuring that the game responds to the player's actions, preventing the player from trespassing beyond the level boundaries, managing transitions between these levels, providing a smooth transition between them and positioning all modeled objects within the scenes. This section has undoubtedly been the most extensive of the entire project, requiring many hours of work from both Alba and Héctor.

To achieve a complete and professional-looking final project the programming has also involved other secondary but equally important sections.

The tasks have been divided, once more, equally among the team members. These have consisted of: animation creation and implementation, edition and implementation of music and sounds, UI creation (main menu, level selector and pause menu) and optimization of all scenarios that cause significant FPS drops and make the game difficult to play, specially on less powerful computers.

During the development of the video game, the playtesting was carried out by the students themselves and by various people outside the group, after the first version was completed. Once this period ended, a time was set aside to address all reported errors.

## 2.2 Time planning

**Initial time chart** [Chart 2.1] (Work planning before starting the project).

	Task	Alba individual work (hours)	Héctor individual work (hours)
<b>D e s i g n</b>	Mechanics design	10	10
	Scene design	14	13
	Script and gameplay	13	14
	Puzzle and level design	17	22
	Artistic style definition	1	1
	UI design	4	0
<b>A r t</b>	Structures modeling	25	20
	Object modeling	20	25
	Visual effects and postprocessing	15	15
	Search for music and sounds	10	0
<b>P r o g r a m m i n g</b>	Character movement	1	0
	Gameplay	40	40
	Portals	40	40
	Animations	5	15
	UI implementation	10	0
	Implementation of music and sounds	10	10
	Transition between scenes	0	10
	Playtesting	15	15
	Project memory	40	40
	Presentation preparation	10	10
	<b>Total hours</b>	<b>300</b>	<b>300</b>

*Chart [2.1], work planning before starting the project*



**Final time chart** [Chart 2.2] (Work planning at the end of the project). The difference in hours from the original plan is indicated in parentheses.

	Task	Alba individual work (hours)	Héctor individual work (hours)
<b>D e s i g n</b>	Mechanics design	10	10
	Gameplay design	15 (+1)	15 (+2)
	Puzzles design	5 (-12)	30 (+8)
	Artistic style definition	1	1
	UI design	2 (-2)	1 (+1)
<b>A r t</b>	Structures modeling	25	25 (+5)
	Object modeling	20	20 (-5)
	Visual effects and postprocessing	10 (-5)	2 (-13)
	Search for music and sounds	15 (+5)	0
<b>P r o g r a m m i n g</b>	Character movement	1	0
	Gameplay	80 (+40)	65 (+25)
	Portals	5 (-35)	25 (-15)
	Optimization	15 (+15)	15 (+15)
	Animations	1 (-4)	25 (+10)
	UI implementation	10	0
	Music and sounds implementation	20 (+10)	1 (-9)
	Bug fixing	10 (+10)	10 (+10)
	Playtesting	5 (-10)	5 (-10)
	Project memory	40	40
	Presentation preparation	10	10
	<b>Total hours</b>	<b>300</b>	<b>300</b>

*Chart [2.2] Work planning at the end of the project*

## 2.3 Tasks along the project

As previously mentioned, to ensure a proper project organization, the students have decided to organize themselves using sprints. The game was completed in 8 sprints, with an additional week dedicated to finishing small details that were left pending.

<b>Sprint 1: Initial sprint</b>	06/02 - 12/02
During this first sprint, the team defined the main mechanics of the game and implemented a first approach. A basic movement system was also implemented in order to be able to experiment.	

<b>Sprint 2: GDD and storyboard</b>	13/02 - 20/02
In this sprint, all other issues related to the design were defined in order to be able to perform a complete GDD. A storyboard of the entire game has been also made, to simplify the development of each level in subsequent sprints.	

<b>Sprint 3: Level 1</b>	21/02 - 27/02
<p>This has been the first sprint dedicated to programming the gameplay. Following the methodology, the goal is to complete the first level entirely throughout this week.</p> <p>During this sprint, the objects used in the first level of the game (<i>Knowledge bridge</i>) were modeled, as well as their programming, sound effects, music, visual effects, and post-processing effects.</p> <p>Most of the created assets, such as models, sounds, and post-processing effects, have been reused in later levels.</p>	

<b>Sprint 4: Level 2</b>	28/02 - 06/03
<p>This sprint has been dedicated to the development of the level 2 (Experimentation tower). 3D models of the structures and objects that are part of the level have been created, the interactions with the buttons that activate the revolving stairs have been programmed, sound effects and background music have been added, and element animations have been designed and integrated.</p> <p>Level 2 is not finished yet at this stage, as the transition to level 3 and some portal optimizations to improve game performance are pending.</p>	

<b>Sprint 5: Level 3 and level 2 optimization</b>	08/03 - 15/03
<p>During the first part of this sprint the students have focused their attention on the completion and optimization of level 2.</p> <p>The following aspects, among other, have been implemented: loading and unloading of non-visible elements on the screen (by code), appearance and disappearance of unused cameras, better lighting management, ambient occlusion, improvements in the colliders of interactable objects, and finally, a smooth transition to the next level.</p> <p>On the other hand, the students have started the development of the third level of the game (Bridge of doubt). The first steps have been, as in previous sprints, the creation of the 3D models of the stage, positioning and implementation of the portals, textures, visual effects and general operation of the level. Once again, at the end of the sprint some aspects remain pending.</p>	

<b>Sprint 6: Level 4, end of level 3</b>	16/03 - 22/03
<p>To ensure good performance, the third level required similar optimization to the second level. This is due to the size of the scenario and the use of multiple cameras and visual effects.</p> <p>At this point in the project, reusing previously mentioned elements has been crucial for its rapid progress. For instance, parts of the code have been repurposed to improve performance or to quickly implement the sounds of the scene. Additionally, work on the fourth level (<i>Moment of choice</i>) has begun, including the creation of its models, textures, and effects.</p>	

<b>Sprint 7: End of level 4</b>	23/03 - 29/03
<p>To implement the fourth level (<i>Moment of choice</i>), no new programming elements need to be created. For this reason, one of the main priorities of this sprint has been to reuse previously created scripts, adapting them to work in a more general setting.</p> <p>On the other hand, since the rest of the elements have needed to be created from scratch, extra time has been required for their complete creation and implementation. These elements include finishing the modeling and texturing, searching and editing sounds, creating the animations and their correct functioning (as they are part of the main puzzle of this level), and ensuring a smooth transition to the last two levels.</p> <p>To address the transitions, a meeting has been necessary as the previous approach had not been clear enough and could lead to misinterpretations by the player.</p>	

**Sprint 8: Levels 5.1 y 5.2**

30/03 - 07/04

At this point, all that remains is the implementation of the last two levels (Last ascend and Last descend), which share mechanics (although in an analogous way) and a similar scenario.

As before, all the necessary effects (both visual and sound) have been modelled, implemented, textured and added in both scenes. Most of the 3D objects that appear in this level as well as their textures have been able to be reused, but this has not been the case with the animations, music and effects, so several hours of work have still been necessary.

A credits scene has also been added in both levels with their respective music and effects (which varies depending on the scene), as well as the transition to the final scene and its subsequent transition to the menu.

A logo for the team has also been created.

This finished version of the project has been sent to different testers to collect undetected bugs, as well as unconsidered suggestions.

**Extra sprint: Last settings**

08/04 - 13/04

This last week has been dedicated to analyzing the data obtained in the previous test and incorporating the proposals into the game, in order to improve the gaming experience for users.

Titles and a short introduction to each level have been implemented, they help to clarify the theme of the game.

Some users have presented problems with the sensitivity of the mouse (camera movement speed), so a bar has been implemented so that the user can adjust it manually.

Optimization has continued to be an issue, so it has finally been fully improved.

With the correction of these, and some other small bugs, the creation of the game project was finished.



## 3. Theoretical framework

### 3.1 Motivations and topic to be addressed

From the beginning, it was decided that the video game would deal with a profound theme in a rather abstract way, and that it would be possible for the user to give it multiple interpretations.

Psychological themes have been addressed in video games of various genres on multiple occasions, one example could be *Gris*, a video game created by the studio Nomada in 2018 [4]. This video game deals with loss, depression, and acceptance without the use of words. For the gameplay, it combines narrative, exploration, and platforming to form a story that places the player in an intense but at the same time sensitive context of what is being explained.

At this point, it was clear that this would be the approach to follow throughout the project, the only thing left was to find a topic to address. When talking about educational video games, people tend to think of childish, repetitive, and simple games that use few resources to present mainly academic topics. The team had decided that a change in this mindset would be crucial for the development of this game, as it would be possible to educate and raise awareness in the player about a topic that is not often addressed in the world of video games.

After several meetings and much deliberation, a topic that has almost always been ignored in contemporary video games, addictions, was agreed. Making a video game where the dangers of addiction were continuously repeated to the player was not enough; it would only be imposing an idea and may not have a positive impact on the minds of younger players. Therefore, the approach to this theme would be to put the player in the role of an addicted person, someone who has to experience firsthand all the sensations and difficulties. It was preferable to leave the user with an unpleasant feeling of confusion; associating the feeling of discomfort with the concept of addiction was a much more powerful message than any speech could convey.

The next step has been to learn as much as possible about addictions, and find a way to relate them in the video game. One little-known aspect of them are the stages of addictions. Various websites [5][6] make different approaches to what are the stages that an addicted person goes through, although they all share a structural similarity. Based on this, it only remained to simplify and enumerate them:

1. Knowledge phase: This is the phase in which a person becomes aware of an addiction but has not yet experienced it. Their knowledge is based on various sources of information.
2. Phase of experimentation: The person in question begins to explore the world of addiction. In this phase the ignorance predominates and therefore, as its name suggests, the experimentation by the individual is necessary.

3. Consolidation phase: In this phase, doubt predominates as the person has not yet decided whether their past actions will become an addiction or not. Throughout this process, it is up to the person to make a decision.
4. Maintenance or abandonment phase: Finally, the person decides whether to continue consuming what keeps them addicted or to abandon it.
5. Relapse: At this point in the process, someone with the determination to overcome their addiction experiences a relapse, that means that they are not able yet to overcome it.

Since the structure of these stages shares great similarities with the levels in a video game, it has been established that each level would correspond to one of them in order to create the playable narrative mentioned before. It has been also agreed that the player would have the power to decide the fate of the person they were representing, increasing the realism.

## 3.2 Portals and non-Euclidean spaces

With the theme already chosen and the levels structured, the game narrative was practically complete, it only remained to find a way to combine it with some playable mechanics that would complement the game's idea.

The chosen theme was abstract enough to leave room for imagination. Using attractive and fun mechanics such as platforms can be very satisfying for the player who manages to overcome them, and as has been previously indicated, this type of sensation was completely opposite to what was thought from the beginning.

For that reason, just like in the game theme, it was sought to be innovative enough and choose a type of mechanics that are rarely explored in video game development, portals and non-Euclidean spaces.

The portals, as the name suggests, consist of a structure that allows a player to move from one portal to another and vice versa. Both structures are connected to each other with an invisible connecting space, which gives the player the sensation of teleportation. When exiting the second portal, the player maintains the position, rotation, and acceleration with which they entered the first portal. The only thing that changes is the direction, which becomes the same as the exit portal.

Using portals in video games is not such an innovative activity, but using them in such a way that they are imperceptible to the player is a much more interesting way to present this mechanic. Furthermore, it creates more entertaining and disconcerting situations, which is in line with the chosen theme.

Taking advantage of this mechanic, as has been already indicated, it was decided to use non-Euclidean spaces [7]. To understand this type of geometry, it is necessary to first understand Euclidean geometry, the one that satisfies the principles of Euclidean geometry [8].

The real world is based and operates according to these principles, which establish a series of mathematical rules that are always fulfilled. Some of the most basic ones are the following:

- Given two points, a line can be drawn to connect them [9].
- The distance between a point and itself will always be 0.
- A line segment can be extended infinitely in any direction.
- The shortest distance between two points will always be a straight line.
- The Pythagorean theorem must be satisfied in all right triangles: the sum of the squares of the legs will be equal to the square of the hypotenuse [10].
- The angle formed by two intersecting lines is defined as acute.
- If a line intersects two parallel lines, it will create two equal angles.

In a non-Euclidean world, as it can be deduced, these rules do not apply, and therefore, for an inhabitant of the Euclidean world, completely impossible and disconcerting situations can be created. This was precisely the mechanical reference that has been sought for this video game.

Some of those that can be used, based on the principles mentioned above, are the following:

- The shortest distance between two points may be different from the distance of the segment that connects them. This is the basic foundation of portals, directly connecting two points that are far away in space. This principle can also be used to create impossible situations, such as crossing a very long bridge by walking a short distance or approaching a point that has been initially moving away.
- The Pythagorean theorem may not hold. In some situations, the square of the hypotenuse may be smaller than the sum of the squares of the legs. This is a direct consequence of the previous point.

### 3.3 Artistic/mechanical references

#### **Programming-mechanical references:**

Portal 1 and 2 [11]: Popular video games, the main mechanics are based on the creation of portals.

Antichamber [12]: The most popular video game that deeply explores non-Euclidean spaces and uses them as playable mechanics.

Superliminal [13]: Video game that makes use of perspective as a mechanic.

Gris [14]: This video game uses the playable space to address a psychological topic such as depression without the use of words.

Journey [15]: Similar to Gris, it depicts the stages of a journey without using words, only through its mechanics.

#### **Artistic references:**

M. C. Escher (1898 - 1972) [16]: Artist, known for his paintings depicting impossible spaces. His drawings have served as inspiration.

Untitled Goose Game [17]: This video game uses a visual style similar to the one that is wanted to be achieved.

Mind Path To Thalamus [18]: This video game uses the environment as a narrative medium.





## 4. Over the quiet storm

The game aims to show, in a slightly abstract way, the different stages a person can go through during an addiction, leading up to either a "good" ending where they overcome it, or a "bad" one where they succumb to it without any hope of recovery.

From the beginning, *Over the Quiet Storm* has been a complex project that conveys complicated feelings using very few words. As a result, it employs different mechanics and spaces that make the player feel the confusion, disorientation, and even fears of those who are experiencing, or have already experienced, this process.

The initial design of the game's ambience and the one that has been kept in mind at all times when designing each of its levels has been two inverted towers joined by their respective bridges [Figure 4.1], surrounded by a strong storm and dense fog.



This setting is perfect to visually exemplify confusion, as there is no way to distinguish whether one is going up or down, and it fits perfectly with the chosen theme. Each level aims to explore one of the phases, corresponding to one of the parts of the tower: the initial bridge, the first tower, the connector bridge, the entrance to the second tower, and finally either an ascent or a descent depending on the path the player chooses to take.

Figure [4.1] Sketch of the original game scene design

In this section, a description is provided for the design of each level, along with a clearer explanation of its relationship with the scenario. The new mechanics within each phase and their relation to the main theme (addiction phases) are also indicated. Additionally, images of each level are included.

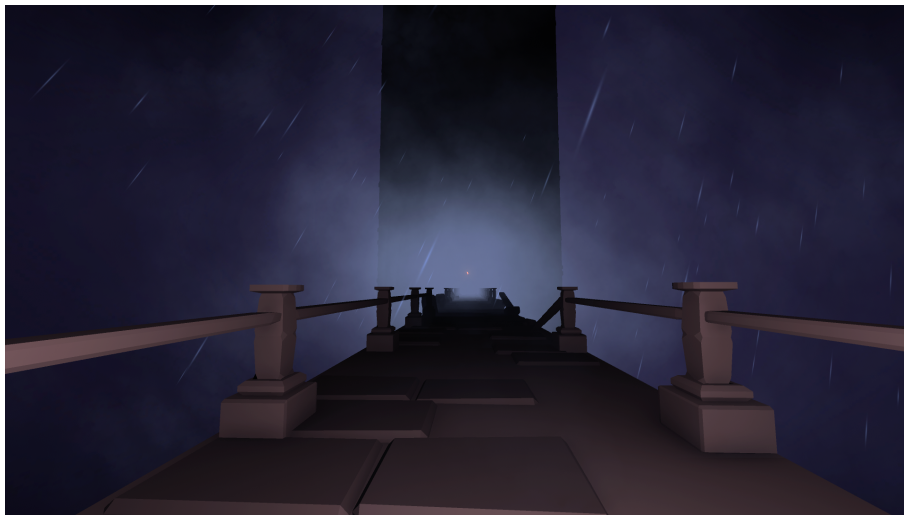
## 4.1 Level 1 - Knowledge bridge

*“Under the ominous storm, the terrifying tower looks tempting”*

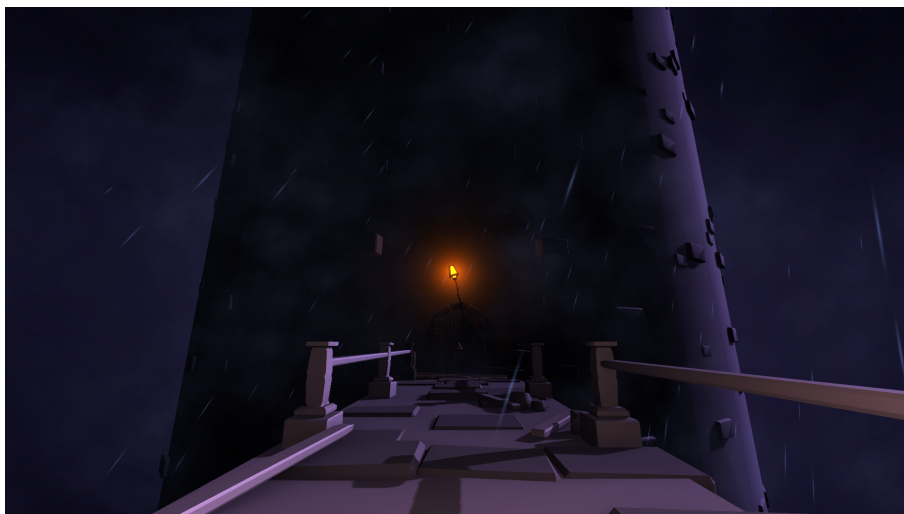
**Gameplay:** The game starts on a dark screen and the text above. In the background it's possible to hear lightning and rain. When the screen lights up it is possible to see a light in the distance [Figure 4.2].

The player can't see himself due to the game being in first person view. The distant silhouette of a towering structure looms over the horizon, with a ruined bridge stretching out towards it.

The user can move away from the tower (the game will reset) or move closer to access the next level. When close enough, a lantern indicating the path to follow will be clearly distinguishable [Figure 4.3]. This mechanic is preserved in the following levels, always marking the exit. At this point, the door opens, giving way to the next area [Figure 4.4].



*Figure [4.2] First view of the level*



*Figure [4.3] Lantern indicating the path*



*Figure [4.4] Closeup of the lantern and the open door*

**New mechanics:** Movement, jump, light marks the way.

**Progression:** This short introduction helps the player familiarize himself with the video game environment and learn the basic controls. Also to relate the doors lit by a lantern to the exits of the level.

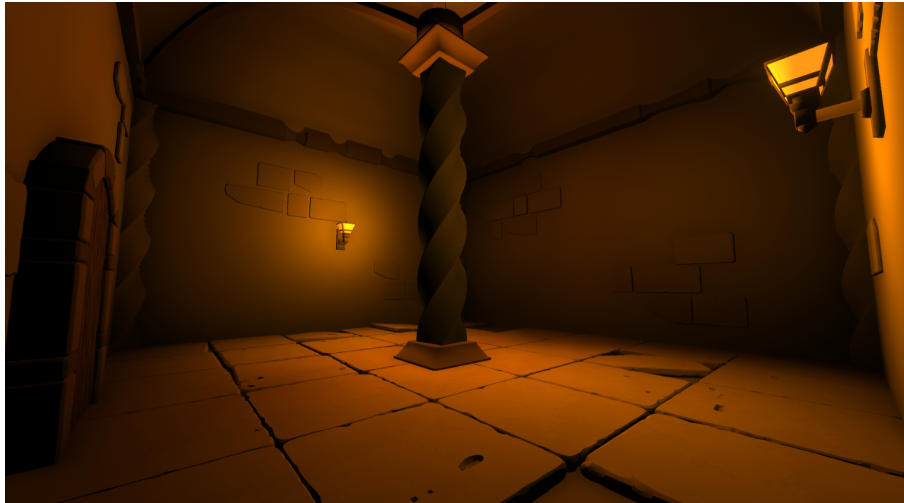
**Addiction phase:** The character has knowledge about addiction but has never experienced it. Their situation is complicated, represented by the fog and the storm. The tower is the only way out they can see, tempting in the distance.

Entering through its door represents that first contact with addiction.

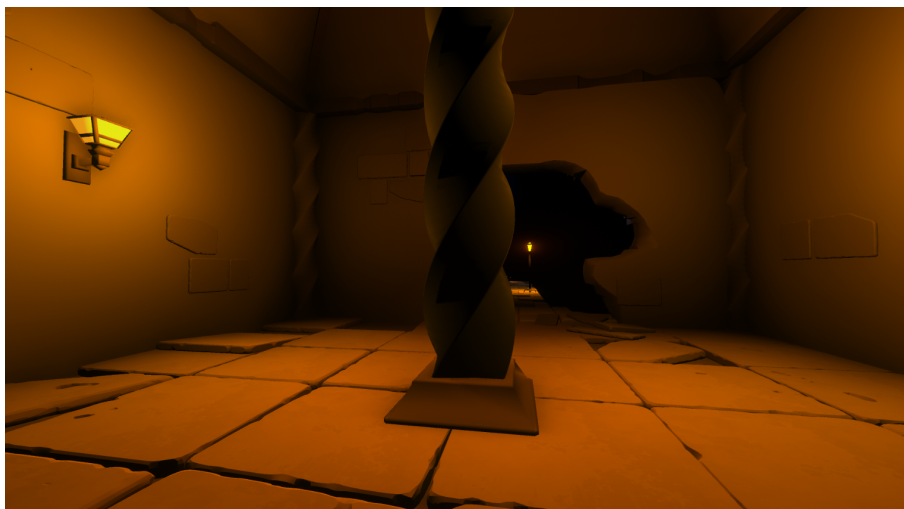
## 4.2 Level 2 - Experimentation tower

*“This place is wonderful yet dark at the same time. How far could I go?”*

**Gameplay:** Once inside the tower, an empty room with a single pillar in the center and two lamps can be seen [Figure 4.5]. When the player crosses the pillar from behind, the door where they entered changes. This process must be repeated three times before reaching the same place, but with an opening to the next scene [Figure 4.6].

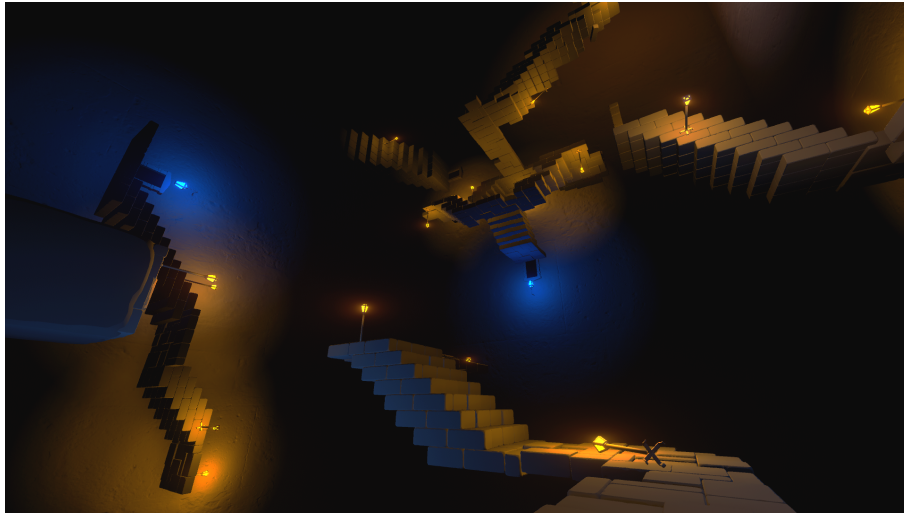


*Figure [4.5] Level 2 initial room*



*Figure [4.6] Level 2 initial room. When the pillar is crossed from behind, a hole appears at the wall*

The second room consists of several structures made of stairs and bridges, the atmosphere shares a great similarity with Escher's paintings. To progress, the player must go straight until reaching a first button, which rotates the main structure of the room (it will be referred to as Structure A.), allowing them to reach the first portal [Figure 4.7][Figure 4.8]. This portal, along with its twin, is indicated by a blue light.

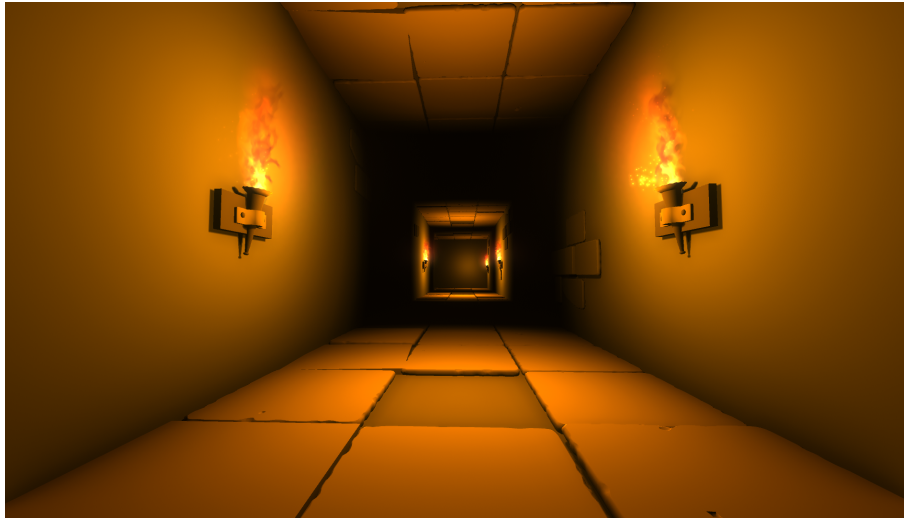


*Figure [4.7] Structure A at the initial state*



*Figure [4.8] Structure A rotated 180 degrees after pressing the button*

From this new position, the only thing left is to reach the final door, marked once again with a lamp. Behind it, a hallway with stretches of lights on and off is visible [Figure 4.9]. When the player crosses the section of lights that are off, they fall through a hole that was not visible in the darkness, thus accessing the next level.



*Figure [4.9] Level 2 final corridor*

**New mechanics:** Use of space and gravity portals, activate mechanisms.

**Progression:** The player begins to move through non-Euclidean spaces. At this point they can learn that when crossing a portal, they can exit in another direction following non-Euclidean logic. In addition to that, when exiting through certain portals, the gravity can change. The user also learns that there are mechanisms that can be activated by stepping on a trigger button.

**Addiction phase:** This phase represents when the person begins to learn about an addiction at the same time they delve into it.

The space is confusing, it's hard to tell if you're going up, down, moving closer or further away from a point. This is a playable exemplification of a person's experience in the early stages of addiction, and ultimately, how they inevitably but unexpectedly fall into this dependence.

## 4.3 Level 3 - Doubt bridge

*“Is there any way to go back? Do I even want to?”*

**Gameplay:** The player falls from the area before to a room. Once they leave that room, they find themselves on the connector bridge between the two towers [Figure 4.15]. Two exits marked by a light can be seen in the background, behind a huge statue that blocks the way [Figure 4.10].



*Figure [4.10] First view of the level 3*

The player can't keep advancing through this path, so they must turn back; only then they discover that the same door they previously entered to the bridge has now become a portal.

This is a temporal portal, slightly different from the ones presented before, as it not only changes the player's position but also alters the time. By crossing it, the user gains access to the nighttime area of the same level, where they can find the same statue, but destroyed.

And as the player approaches, a mysterious blue light illuminates the ruins [Figure 4.11], completing the figure, and familiar voices can be heard in the distance.

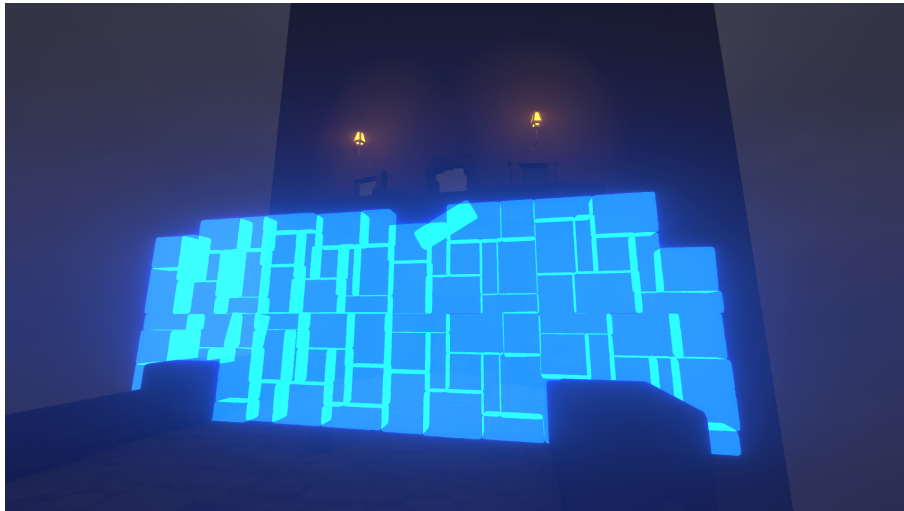


*Figure [4.11] Ruined statue completed with the light*



When the player returns to the original area during the day, the central statue falls, forming a bridge that they can cross. However, the path is once again cut off as the bridge further ahead is in ruins. Through a portal located near the edge, the other side can be seen. Crossing it leads to the other side, but back to the nighttime area, the exit of which is blocked by a blue wall of light [Figure 4.12].

The player must backtrack and find a hidden portal that links to the portal closest to the exit of the nighttime zone, allowing them to reach the end of the level [Figure 4.13].



*Figure [4.12] Wall of light blocking the path in the nighttime zone*



*Figure [4.13] View of the final area of level 3*

In this final door, there are some stairs going down [Figure 4.14]. However, when the player passes through them, they appear on the platform above, another example of how in this game going down can mean going up.

In the upper doors, there are stairs going up and stairs going down. This is the first decision that the player must face, to decide which one to follow to continue their story. These stairs are just a distraction, as both lead to the same destination. However, eventually the player will have to make a real decision, so these stairs serve as preparation for when that moment arrives.

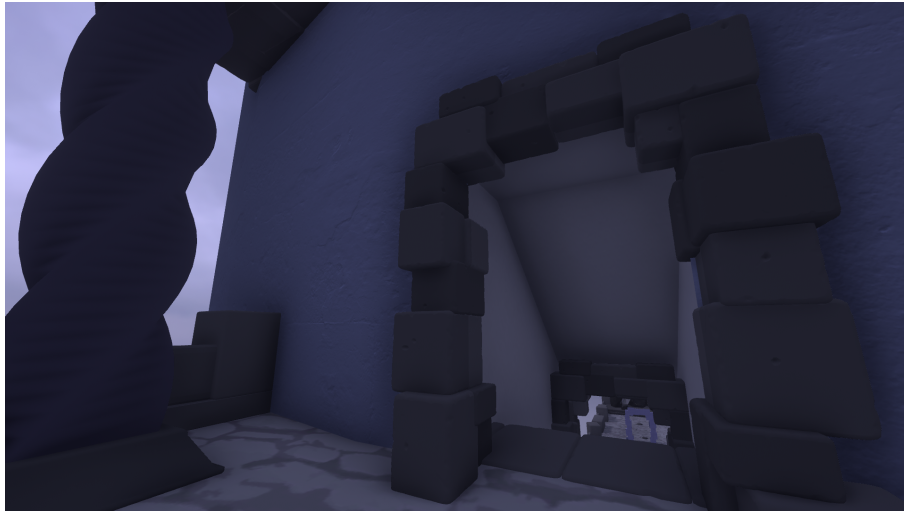


Figure [4.14] Stairs that descend, teleporting the player to the top part

**New mechanics:** Use of temporary portals, night and day.

**Progression:** The player discovers a new mechanic, night and day. When crossing through a time portal to its twin, not only space (the final position where the player appears), but time is also altered. During the night, new structures are revealed so that the player can continue advancing.

**Addiction phase:** This phase is related to the decision of a person who is already addicted. The bridge in its entirety embodies the stark duality that the player confronts: whether to succumb to addiction or to overcome it. As the player journeys through the level, this pressing question echoes incessantly. This dualistic theme is most vividly represented by the two exits that can be glimpsed from the start, as well as through the contrasting day and night elements.

Meanwhile, the statues signify the external factors that influence the addicted person's life (from friends and family to their surrounding environment) all of which crumbles as the addict descends further into the abyss. Initially, the statues appear destroyed, mirroring the addict's detachment from the world around them. At times, external factors may offer the player a helping hand, or conversely, block their path to prevent them from sliding deeper into self-destruction.

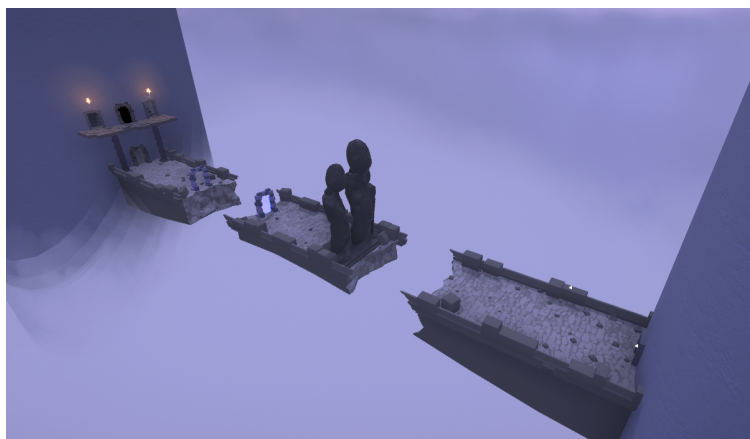


Figure [4.15] Overview of the bridge between the two towers (no in game)

## 4.4 Level 4 - Moment of choice

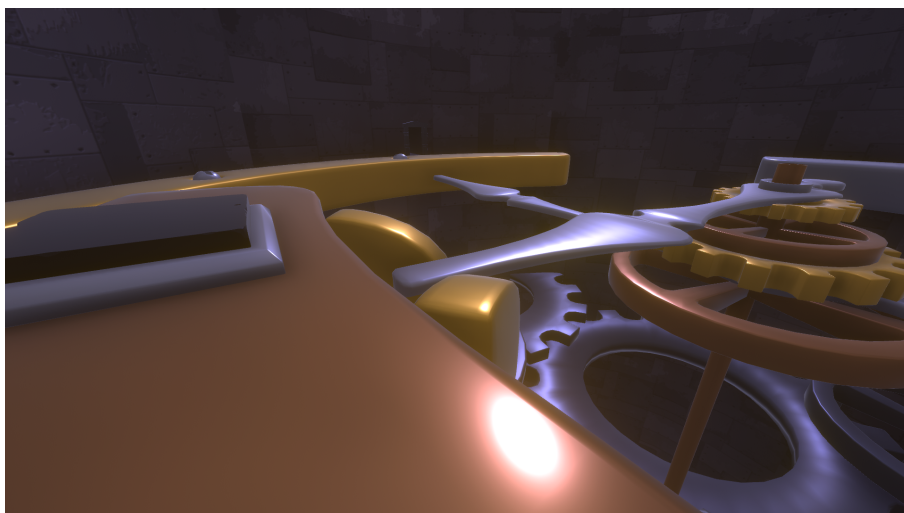
*“The clock is ticking and I need to decide”*

**Gameplay:** The player enters the large tower and reaches a circular room with a clock that occupies the entire base of the room [Figure 4.16][Figure 4.19]. The exit to this level can be seen further up, Once again, it is indicated by two lamps showing the two exit doors. This time the lights are two different colors, one red and one green [Figure 4.20].

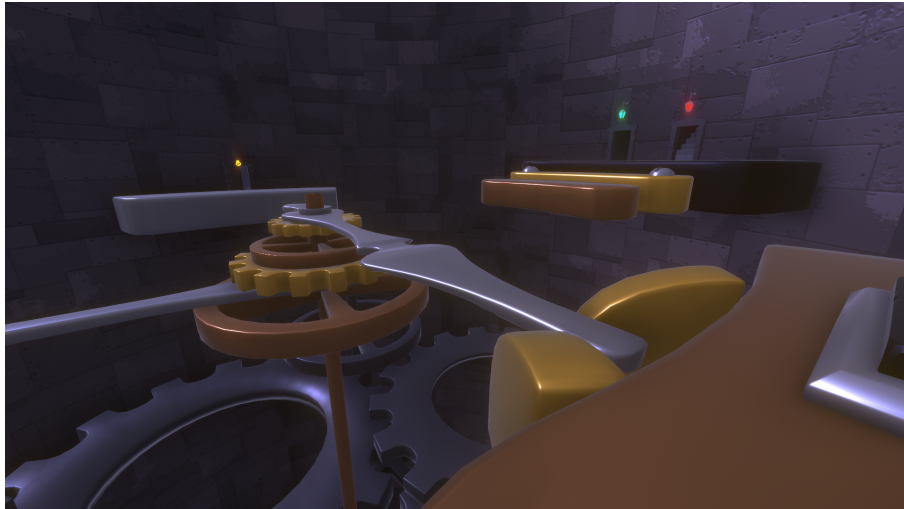


*Figure [4.16] First view of the level 4*

When the player enters the room, they can access the central platform and a smaller one on the right, where there is a button. This activates a mechanism that blocks the small needle, as shown in the image [Figure 4.17][Figure 4.18]. It is also possible to access the door on the right, crossing through it leads to the portal on the left (its twin), and the needles rotate in the direction indicated in the portal itself. If a needle is blocked, it does not rotate



*Figure [4.17] Needle lock mechanism*



*Figure [4.18] Needle lock mechanism*

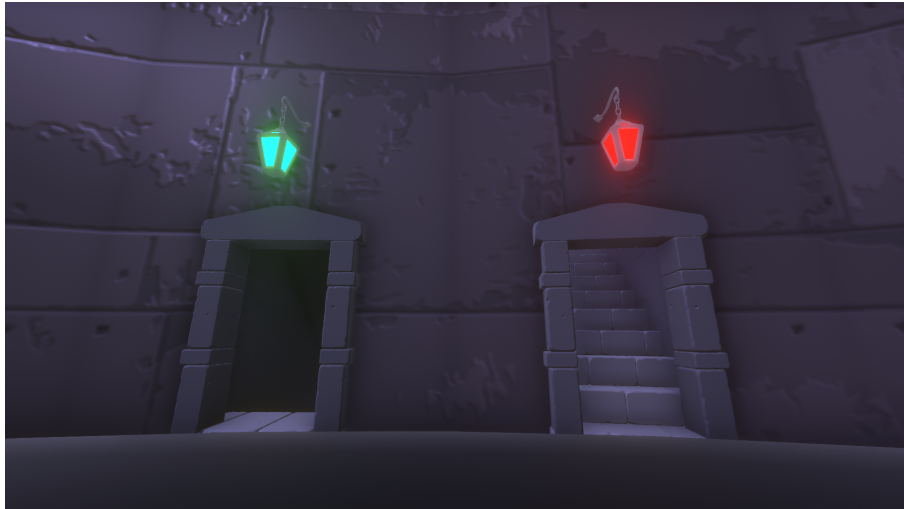
The player must lock and unlock the needle, as well as rotate them enough times so that they align to form a straight path to the exit.



*Figure [4.19] Aerial view of the clock structure (no in game)*

As mentioned in the previous level, this time the player's decision will matter, as a different ending will be unlocked depending on the door they choose. To give a hint about the meaning of each one of them, a sentence appears when the player approaches each one. These are the following:

- For the red door: "I'm never going back to that awful storm"
- For the green door: "I miss that quiet storm"



*Figure [4.20] The two doors to choose*

**New mechanics:** Temporary portals can move structures affected by time, like the clock of the room. Choice that determines which is the next level that is played.

**Progression:** The player manages to reach the end of the level, he must reaffirm or correct the decision he has previously made, choosing again between two doors, one that leads to level 5.1 and another that leads to level 5.2.

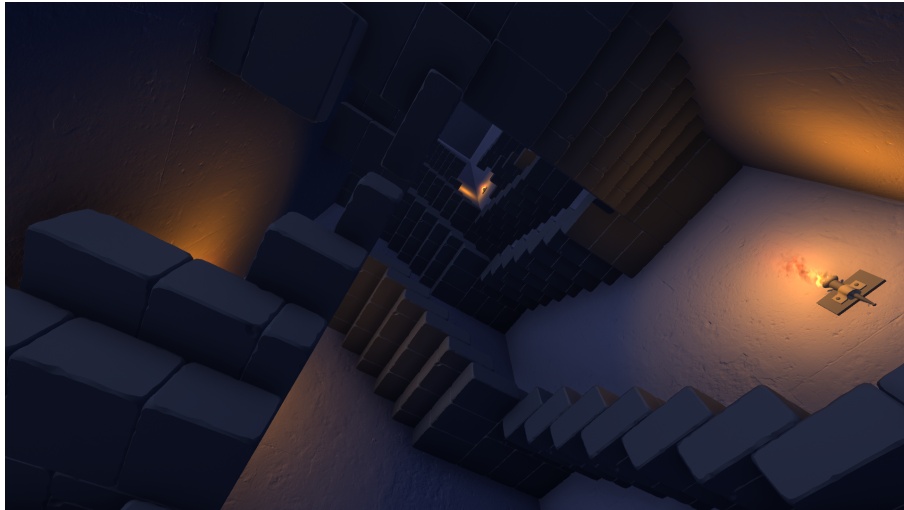
**Addiction phase:** This phase represents the decision of what should be done after the maintenance or doubt phase, whether to maintain the previous decision or not. To display it in the most obvious visual way possible, the entire level is themed as a clock.

Time is running out for the dependent person, they must finally make a decision and stand firm not to go back once this happens. Choosing the ending for the one who is experiencing all these sensations is in the hands of the player.

## 4.5 Level 5.1 - Last descend

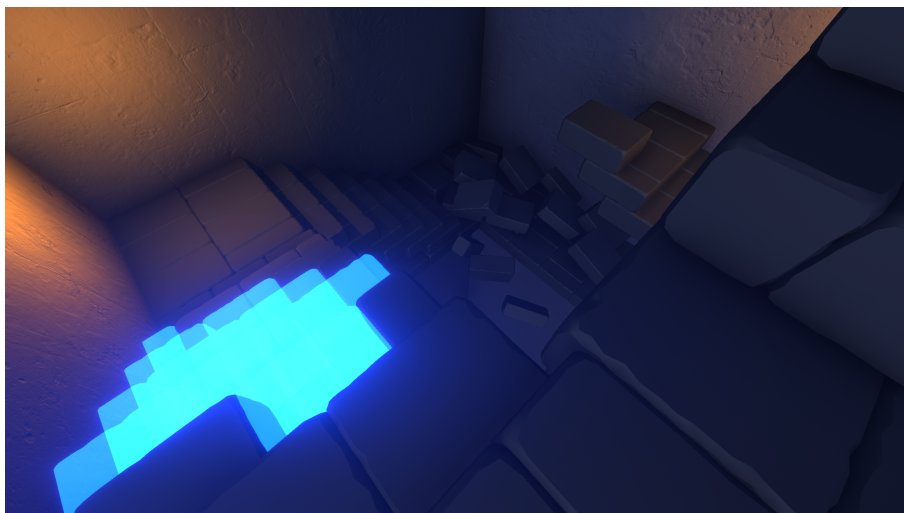
*“Nothing protects me now. If I get too close to the edge, I’ll fall. I won’t fall. I won’t fall. I won’t fall.”*

**Gameplay:** The player arrives at a slightly narrow and incredibly high room filled with stairs [Figure 4.21]. As indicated in the text at the beginning of the level, for the first time, the player is not shielded from harm. If they get too close to the edge, they will fall into the void.

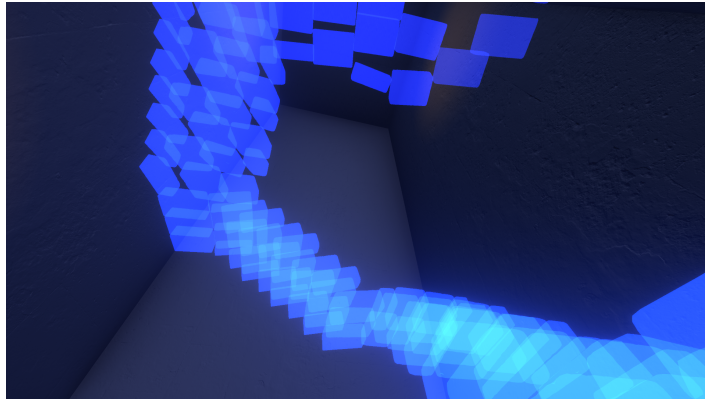


*Figure [4.21] First view of the final level 5.1*

As the player ascends the stairs, some may crumble underfoot due to the difficult climb. However, much like before, external factors symbolized by the blue light aim to aid in achieving the goal of reaching the top of the tower [Figure 4.22].

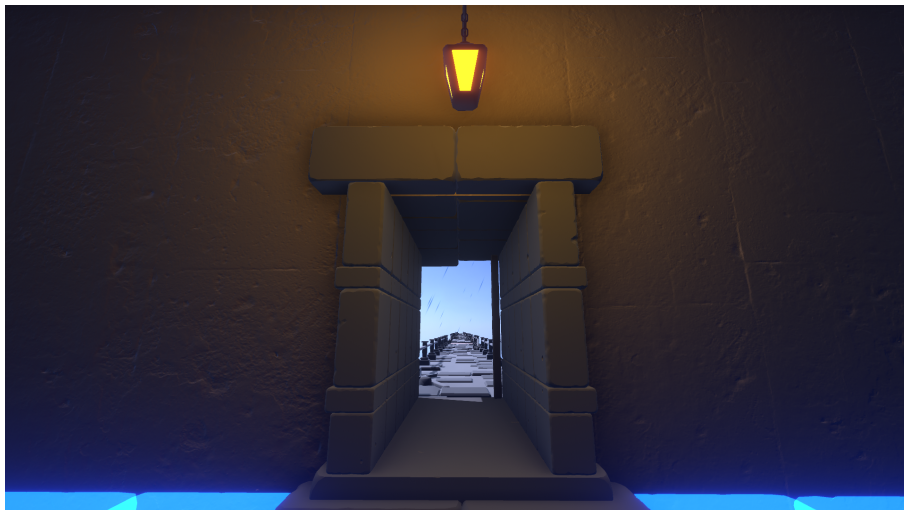


*Figure [4.22] Reconstructed light stairs and destroyed stone stairs*

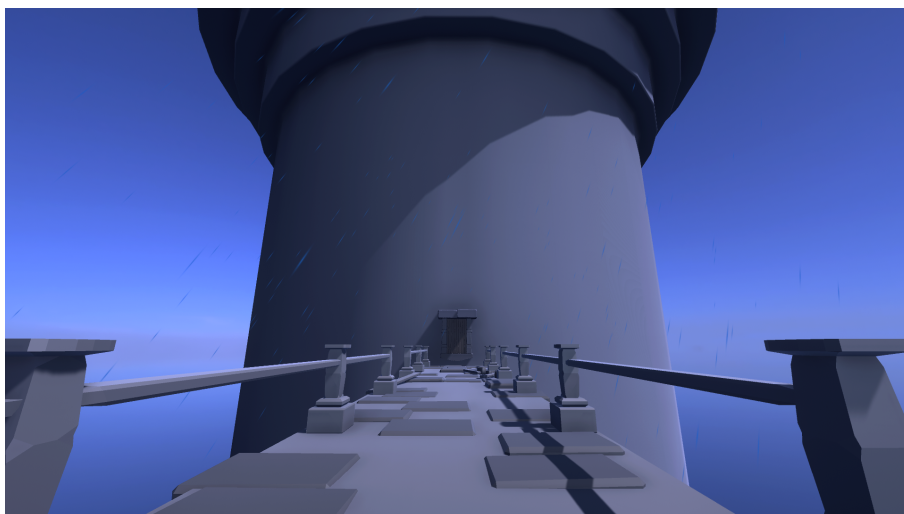


*Figure [4.23] Staircase of the final climb being rebuilt*

Various structures will be constructed as the player progresses [Figure 4.23] until they finally reach the highest point where the last door awaits, marked as always by a lantern [Figure 4.24]. Upon crossing the threshold, the door will close behind the player, signifying their final escape from the towers. For the first time in the game, the player will clearly see that the tower is actually inverted [Figure 4.25].



*Figure [4.24] Exit to the outside of the tower*



*Figure [4.25] Exterior of the inverted tower*

Beyond the bridge lies only a clear sky, with a gentle rain awaiting the player. After such a grueling journey, the addiction has finally been overcome [Figure 4.26].

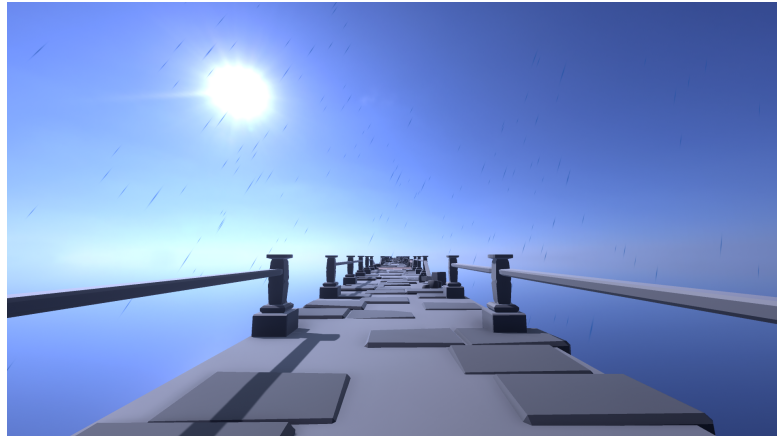


Figure [4.26] Exterior bridge

**New mechanics:** It is possible to fall through unprotected areas, and structures may crumble under the player's weight. New structures can be generated to aid in their journey.

**Progression:** The player must exercise caution in navigating a treacherous landscape that threatens to topple them at every turn, striving to reach the pinnacle of the tower without succumbing to its many dangers. If they do fall into the central abyss, they will be transported back down to level 3 (*Doubt bridge*).

**Addiction phase:** This phase is equivalent to a last effort that a person must make to overcome an addiction. They must make an effort to climb a high staircase, representing something that requires true willpower to achieve. The path is difficult, with obstacles that may cause them to fall, but they can also receive help from others to propel themselves towards the outside, where the situation that once seemed dark and stormy has been reduced to a gentle rain. Ahead of the player, only a clear day and a long road can be seen.

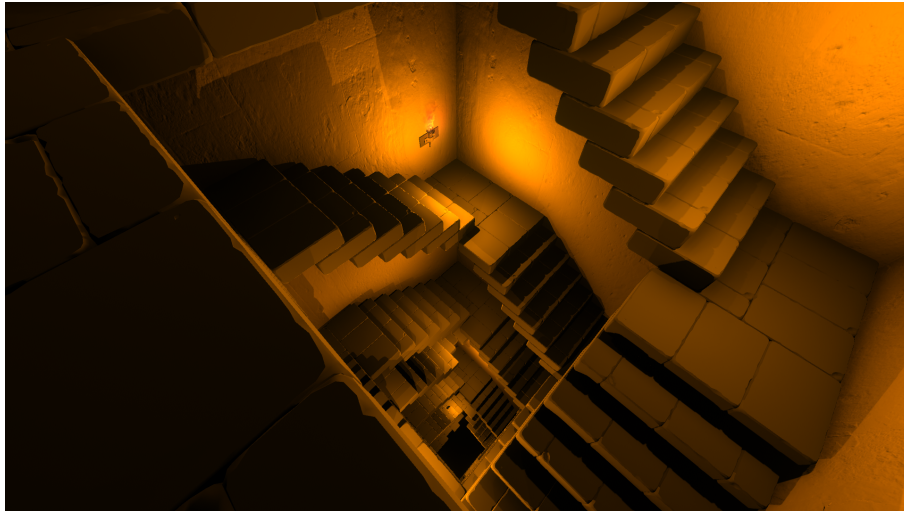
However, if the scenario manages to bring the player down and make them fall, they go back to level 3, as previously indicated. This is the most obvious representation of a relapse into addiction, as when they were very close to overcoming it, they started to doubt again. So, the player continues from the *Doubt Bridge* once again.



## 4.6 Level 5.2 - Last ascend

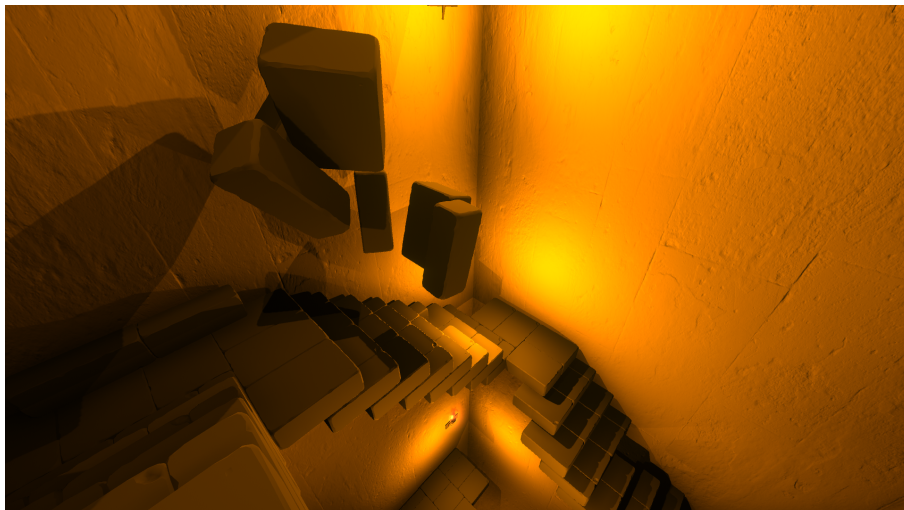
*“Nothing protects me now. If I get too close to the edge, I’ll fall”*

**Gameplay:** The player enters a room analogous to the previous one [Figure 4.27]. This time, the stairs go down and the lighting is much dimmer.



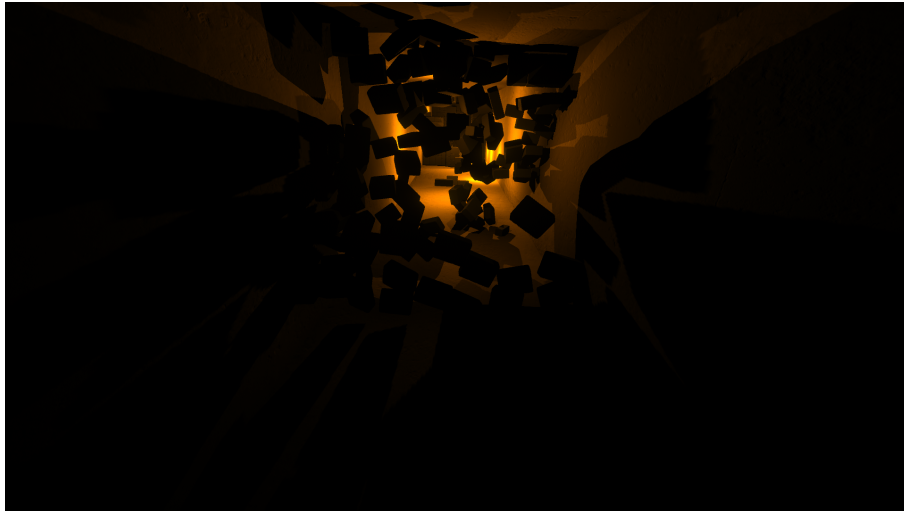
*Figure [4.27] Exterior bridge*

As the player descends, the stairs break and are left suspended in the air [Figure 4.28]. The player must be careful not to fall into the abyss that is presented to them while continuing to descend.



*Figure [4.28] Stair bricks suspended in the air after falling*

At a certain point, the stairs break completely, pushing the player into the void. If the user manages to stay on them, in the end they have no choice but to jump into the darkness, ending the game [Figure 4.29].



*Figure [4.29] Final fall into the abyss*

**New mechanics:** As with its complementary level, it is possible to fall through unprotected areas, and some structures are destroyed as the player progresses.

**Progression:** The player must move cautiously in a scenario that wants to bring them down. Falling means the end of the game. There is no way to reach the "good" ending or any other point in the game from this part.

**Addiction phase:** This phase is equivalent to the final descent of a person into an addiction that has overcome them. The user has voluntarily surrendered to their dependency, and now there is no way back.

The structures are broken in this path, there is no outside help that can get the character out of the tower, they can only keep going until they finally fall (or jump into the void of his own free will).

Similar to before, where climbing required effort, here only a descent is contemplated where everything happens very quickly. The protagonist no longer contemplates the option of not falling, which is why the phrase "I won't fall" has been removed at the beginning, as they do not have this predisposition.

Finally, to increase the drama and make the consequences of choosing this ending more evident, distant cries can be heard during the credits.



## 5. Game development

In the following chapter, an enumeration of the different rules followed during the development of Over The Quiet Storm is presented. It has been important to keep these rules in mind at all times, as they form the foundation for developing the project and ensuring its coherence throughout.

### 5.1 Functional, non functional requirements and use cases

For the proper development of this project, a set of functional requirements (the gameplay features provided to the player) and non-functional requirements (technical aspects of the project) have been established. The following section includes a list of the aforementioned requirements and a section with the different use cases that can occur, along with a diagram depicting them.

#### **Functional Requirements:**

- R1 - The player can start the game.
- R2 - The player can choose the level to start.
- R3 - The player can exit the game.
- R4 - The player can navigate through different 3D environments.
- R5 - The player can control a first-person character.
- R6 - The player can interact with buttons.
- R7 - The player can jump.
- R8 - The player can open the pause menu at any time.
- R9 - The player can adjust mouse sensitivity.
- R10 - The game should indicate the current level to the player.
- R11 - The game should prevent the player from falling off the scenario.

#### **Non-Functional Requirements:**

- R12- The game can be played on a PC.
- R13 - The game can be played on screens with a resolution of 1920x1080 px.
- R14 - The game begins upon selecting "Start" from the main menu.
- R15 - The game is modeled in 3D.
- R16 - The game elements are based on reality.
- R17 - The game experiences are fantastical and not based on reality.
- R18 - The mechanics are learned throughout the gameplay.
- R19 - A new mechanic is introduced in each level.
- R20 - The game automatically activates the credits upon completing the final level.

## Use cases

<b>Requirements</b>	R1, R2
<b>Actor</b>	Player
<b>Description</b>	The player can start the game by pressing the “Play” button located in the main menu.
<b>Preconditions</b>	1 - The player must be in the main menu.
<b>Steps normal sequence</b>	1 - Player presses the "Start" button. 2 - The game loads the scene of the first level.
<b>Alternative sequence</b>	1.1 - The player presses the "Level" button. 1.2 - The player chooses the level they want to play 2.1 - The game loads the scene of the desired level.

*Chart [5.1] Case of use CU01 - Play*

<b>Requirements</b>	R3
<b>Actor</b>	Player
<b>Description</b>	The player can exit the game by pressing the “Exit” button.
<b>Preconditions</b>	1 - The player must be in the main menu.
<b>Steps normal sequence</b>	1 - The player presses the “Exit” button. 2 - The game shuts down.
<b>Alternative sequence</b>	None

*Chart [5.2] Case of use CU02 - Exit game*

<b>Requirements</b>	R4, R5
<b>Actor</b>	Player
<b>Description</b>	The player can move through different scenarios using a first-person view.
<b>Preconditions</b>	1 - The player must be in one of the levels. [Chart 5.1]
<b>Steps normal sequence</b>	1 - The player presses the movement buttons. 2 - The player moves the mouse. 3 - The player moves depending on the button pressed and rotates the camera according to the position of the cursor.
<b>Alternative sequence</b>	3.1 - The player does not move if they hits an obstacle or wall 3.2 - The player does not move if there is text on the screen

*Chart [5.3] Case of use CU03 - Move*

<b>Requirements</b>	R6
<b>Actor</b>	Player
<b>Description</b>	The player can press buttons by standing on top of them.
<b>Preconditions</b>	1 - The player must be in one of the levels. [Chart 5.1] 2 - There needs to be a button in the level. 3 - The button needs to be deactivated.
<b>Steps normal sequence</b>	1 - The player stands on the top of a button. 2 - The button gets activated. 3 - Some structures move or rotate. 4 - The button deactivates and can be stepped on again.
<b>Alternative sequence</b>	None

*Chart [5.4] Case of use CU04 - Press buttons*

<b>Requirements</b>	R7
<b>Actor</b>	Player
<b>Description</b>	The player can jump in the direction they are facing.
<b>Preconditions</b>	1 - The player must be in one of the levels. [Chart 5.1]
<b>Steps normal sequence</b>	1 - The player presses the jump button. 2 - The player jumps according to the direction they are facing.
<b>Alternative sequence</b>	2.1 - If the player is standing still, they can jump without moving from their position.

*Chart [5.5] Case of use CU05 - Jump*

<b>Requirements</b>	R8
<b>Actor</b>	Player
<b>Description</b>	The player can open the pause menu by pressing "Esc".
<b>Preconditions</b>	1 - The player must be in one of the levels. [Chart 5.1]
<b>Steps normal sequence</b>	1 - The player presses the "Esc" button. 2 - The game opens the pause menu and pauses the game.
<b>Alternative sequence</b>	None

*Chart [5.6] Case of use CU06 - Pause game*

<b>Requirements</b>	R9
<b>Actor</b>	Player
<b>Description</b>	The player can adjust the mouse sensitivity from the pause menu.
<b>Preconditions</b>	1 - The player must be in one of the levels. [Chart 5.1] 2 - The player must be in the pause menu. [Chart 5.6]
<b>Steps normal sequence</b>	1 - The player moves the bar indicated as "mouse sensitivity". 2 - The sensitivity is adjusted to the value chosen by the player.
<b>Alternative sequence</b>	None.

Chart [5.7] Case of use CU07 - Adjust sensitivity

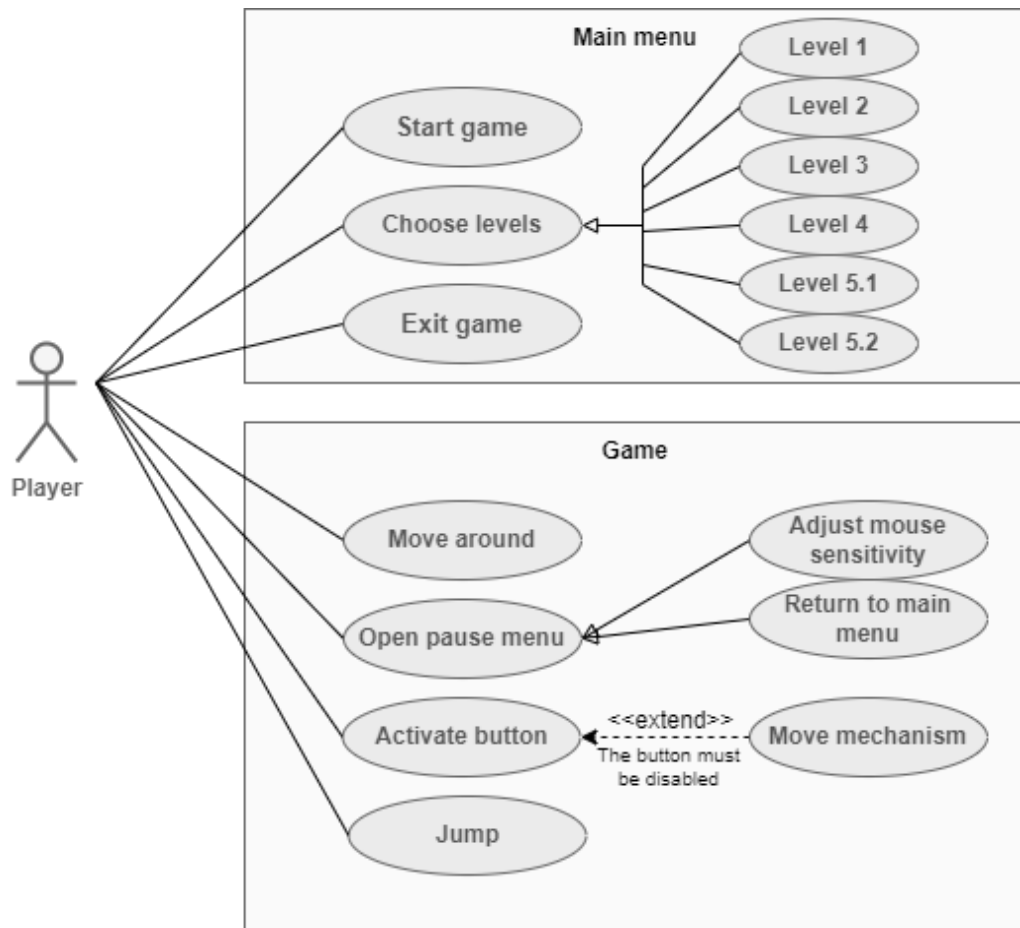


Figure [5.1] Use case diagram, made with <https://www.drawio.com/>

## 5.2 Mechanics and rules

### Written rules

- Character movement: WASD / arrows.
- Camera control (character view): Mouse.
- Jump: Space.
- Escape: Open the pause menu.

### Operational rules

- Throughout the game there are portals (not always perceptible to the player).
- The portals can only be crossed in one direction.
- Each portal connects to only one other.
- When crossing a portal the player orients and positions himself like the twin portal.
- The gravity of the player can change if the portal is orientated in another axis.
- During the night, different structures can appear.
- There is no falling damage and no health bar.
- The player cannot die.

### Foundational rules

- The exit door from a level is always at sight.
- There may be more than one exit door.
- The exit door or doors are always indicated with a lantern.
- The color of the lantern can vary, indicating that it is a portal or a decision door.
- There may be hidden holes that the player can fall through.
- Once the game ends, automatically returns to the menu.

### Limits

- The playable space is delimited by the room where the player is located.
- It is impossible to jump out of the rooms.
- The player can only fall in the last levels. When this happens, the player will be clearly informed that there are no longer any barriers protecting the edge of the map.

### Mechanics

- Go through portals: allows the player to move through space.
- Cross day/night portals: change the space and also the time.
- Step on a button: activate/deactivate a mechanism.
- Change gravity: reach areas previously impossible.
- Move structures: create new paths to keep moving forward.
- Make decisions: the player can choose how to progress during the gameplay.



## 5.3 Components and costs

This chapter will discuss the various implementation costs of the project. These costs include the physical components (hardware) and the different software programs. Additionally, an estimation of the total project cost will be provided, considering hypothetical funding from an entity and execution by a professional team.

### 5.3.1 Hardware

This game has been developed by two students, so it has been necessary to use two functional computers to work together. The cost of the computer mice and the graphic tablet, (necessary for creating the sketches and storyboards prior to project development), has also been taken into account.

(Laptop) **MSI GF63 Thin 11UC-447XES**: 769,00 €

- Intel Core i5-11400H
- 512 GB SSD
- 16 GB RAM
- RTX 3050

(Laptop) **MSI GF63 Thin 10SCXR -042XES**: 1.319,00€

- Intel Core i7-10750H
- 1 TB SSD
- 16 GB RAM
- NVIDIA GeForce GTX 1650

(Mouse) **MX Master 2S** 82,14 €

(Mouse) **Steelseries Rival 3**: 40,37€

(Graphic tablet) **Wacom One 13.3"**: 299,90€

- 1920 x 1080 Full HD

### 5.3.2 Software

Throughout the project, various tools have been used for the development of this video game, as all the elements of it, except for the sounds and music, have been developed by the students.

- **Unity 3D, Unity 2021.2.0f1 - Development** [19]: Engine chosen for the game development. It was an arbitrary choice, as it has been used throughout the degree in subjects such as VJ1231 - Artificial Intelligence, VJ1227 - Game Engines or VJ1238 - Foundations for Educational Video Game Design, and both students know how to handle it fluently. It has been used in the free version.
- **Blender, Blender 3.4 - 3D modeling** [20]: Used for the creation of all 3D elements in the game. Competencies with this program have been acquired in VJ1212 - Graphics Communication. Free tool.

- **Photoshop, Adobe Photoshop CC 14.0 - Texture creation** [21]: Used for the creation and editing of textures for the different models in the game. The tool costs 24.19 € per month, with a free trial version available for 30 days.
- **Paint Tool Sai, Paint Tool SAI Ver.2, 2020.04.10 - Design**[22]: A drawing program widely used in the early stages of the project for creating the storyboard. It costs 45.95€ and requires a one-time purchase.
- **Audacity, Audacity 3.2.4.0 - Music and sound** [23]: Used for the editing of all sounds and music in the game. It is a free tool.
- **Github, GitHub Desktop 3.2.1 - Sharing the project, Coworking** [3]: Used to efficiently and quickly share the project among group members. The free version was used, but there are paid versions available starting at €3.60 per month.
- **Minecraft, Minecraft java edition 1.19.2 - 3D Level design** [24] : Popular construction video game. Used as a complement to create three-dimensional scenarios, as it allows for the quick creation and visualization of complex structures. One-time payment of 27.70€.
- **Trello, Atlassian Trello - Organization** [2]: Website used for project management, crucial for task distribution and sprint organization. The free version was used, but there are paid versions starting at 9.05€ per month.

For all resources obtained directly from the internet, the following websites have been used:

- **Poly Haven** [25]: Website from which most of the textures and HDRI maps were obtained. Downloading these resources is free with an option to donate to the author.
- **Textures** [26]: Website where some textures for 3D models have been obtained. The download is free but it offers paid options starting from 11€/month.
- **Manytextures** [27]: Website where the texture for the bridge floor used in Level 3 was obtained. Free.
- **Freesound** [28]: Used to obtain all the sound effects and music for the game. The download is free, but each piece has its copyright indicated. These have been taken into account in the project and are correctly displayed in the credits. Free.
- **Fire FVX** [29], Sirhaian Youtube: The fire particle system used to enhance some of the game's environments was obtained from here. It is free of charge.
- **One click damage, free version - Plug In** [30]: Blender extension that allows adding a damaged and worn-out appearance to models. Used in its free version.

### 5.3.3 Team management

For the development of this project, it was necessary to comply with the roles of various professionals in the sector, including:

- **3D Artist: 2200 €/month - 12€/hour**  
According to *Jooble* (job search portal) [31] the average salary of a professional modeler varies between 2,100 - 2,300 € per month.
- **Game designer: 2500 €/month - 13 €/hour**  
It has been found on websites such as *dondeestudiar.eu* (a page that compiles information about job offers and their career prospects) [32] and *glassdoor.es* (a job search portal) [33] that the salary for a game designer in Spain is set at around 30,000 € per year.
- **VFX artist: 2300 €/month - 12,5 €/hour**  
According to the *Payscale* website [34] (a website that provides information about salaries and compensations), the average salary of a VFX artist is around 26,000 € per year and between 10 and 15 € per hour.
- **UI Designer: 2300 €/month - 12 €/hour**  
As indicated on the *Uifrommars* website (a page specialized in interface design) [35] the salary of a UI designer ranges from 18,000 € to 40,000 € per year, with an average of 28,000 €.
- **Programador: 2600 €/month - 14 €/hour**  
Based on the information gathered from *jooble* [36], *jobted* [37], and *payscale* [38], it can be concluded that a video game programmer earns around 30,000 € per year in Spain.
- **Game tester: 2000 €/month - 10 €/hour**  
Based on the information from *Jooble* [39] and *Infojobs* [40], it can be determined that a Game Tester earns between €18,000-€25,000 per year in Spain.

### 5.3.4 Total

This budget is an estimate of what it would cost an external entity to finance this project, taking into account the programs used [Chart 5.8], the hours worked by each professional [Chart 5.10], and the necessary hardware [Chart 5.9].

Software		
	License Price	Project cost
Adobe Photoshop	290,17 €/year	72,54 € (3 months)
Paint Tool Sai	45,95 €	45,95 €
Unity	369 €/year	92,25 € (3 months)
Minecraft	27,70 €	27,70 €
Github	3,35 € user/month	80,4 € (3 months, 8 users)
		<b>318,84 €</b>

Chart [5.8] Software cost

Hardware		
	Price	
PC 1	769,00 €	
PC 2	1,319,00€	
Mouse 1	82,14	
Mouse 2	40,37€	
Drawing tablet	299,90 €	
		<b>2510,41 €</b>

Chart [5.9] Hardware cost

Working hours			
	Hours	Price per hour	Total price
Game designer	90	13 €/h	1170 €
3D artist	100	12€/h	1200 €
UI designer	10	12 €/h	120 €
VFX artist	30	12,5 €/h	375 €
Game programmer	300	14 €/h	4200 €
Game tester	30	10 €/h	300 €
			<b>7365 €</b>

Chart [5.10] Working hours

Based on the previously calculated prices, an estimate of the total cost of financing the project can be made:  $7365 + 2510,41 + 318,84 = 10.194,25 \text{ €}$

It is important to keep in mind that this is an estimation of the final game cost if it were a professionally funded project. In reality, the funding for this project would be much lower, since only the students have worked on the project using the free version of all programs.

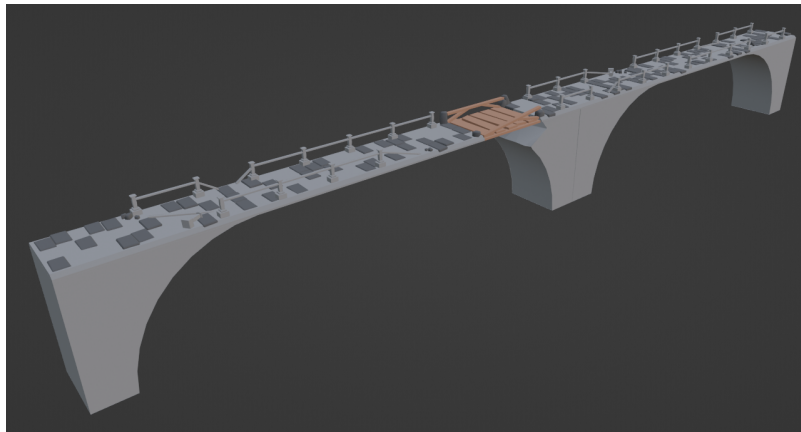
## 5.4 Level development

In this section, each student will focus on their own part when creating the video game, since both have worked on programming and art throughout all levels.

### 5.4.1 Level 1

In this first level, Alba has been in charge of the character movement system. The chosen system consists of a first-person view, controlled with the arrow keys or "wasd," and the option to jump with the spacebar. This is a very popular controller in many video games and relatively easy to program in Unity. In this case, the character checks to be on a solid object to be able to walk and jump.

Regarding the models, Alba has created the initial bridge model [Figure 5.2]. This model was the first to be implemented in the project. Its review and adjustments were crucial as all the rest of the 3D modeling had to be visually consistent in terms of structure with this one.



*Figure [5.2] Final version of the bridge*

In the art section, she has also been in charge of the visual effects. Among them, there is the creation of the Skybox material, that is, the visible "sky" in the level. To increase realism, different visual effects have also been created, such as rain and fog. These have been implemented using Unity's particle systems.

Using multiple particle systems can drastically reduce the game's performance, so the students opted to reduce the size of the rain and make it follow the player on the screen. With this fix, the realism of the storm has been maintained and increased the game's fluidity.

In the following image [Figure 5.3], the implementation of the aforementioned can be observed: the character is located in the center of the screen (represented by a small cylinder, since a 3D model is not necessary in a first-person game), and a small cube formed by rain particles surrounds it.

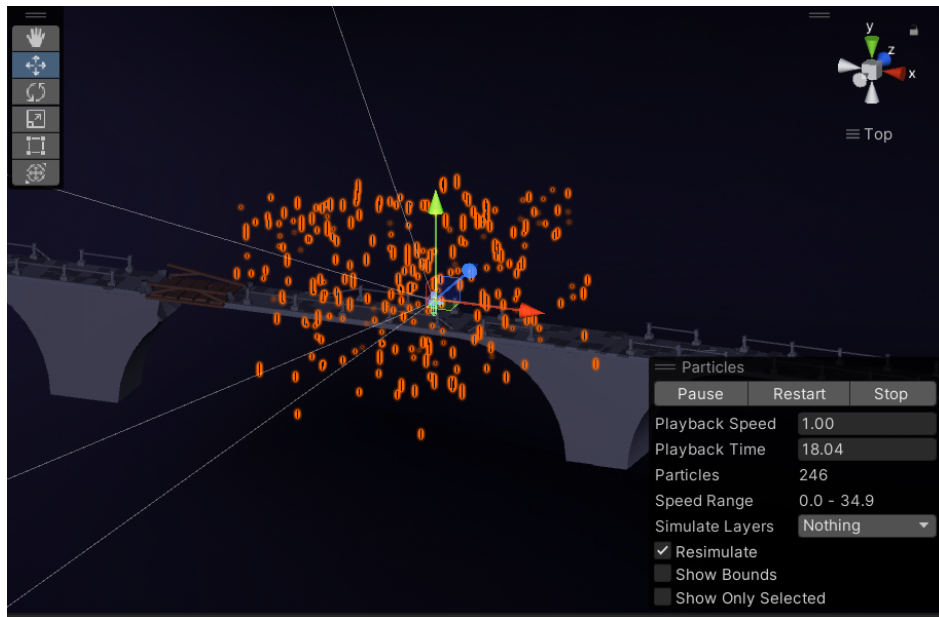


Figure [5.3] Screenshot of the Unity editor showing the rain particle system

Random lightning bolts were added to the scene [Figure 5.4]. To achieve this, several different animations were recorded to illuminate the scene from different areas, creating the effect of a lightning strike. Various thunder sounds were also selected. A script was programmed to activate one of the animations and a corresponding thunder sound after a random interval of time (chosen between two variables) to simulate the appearance of lightning.

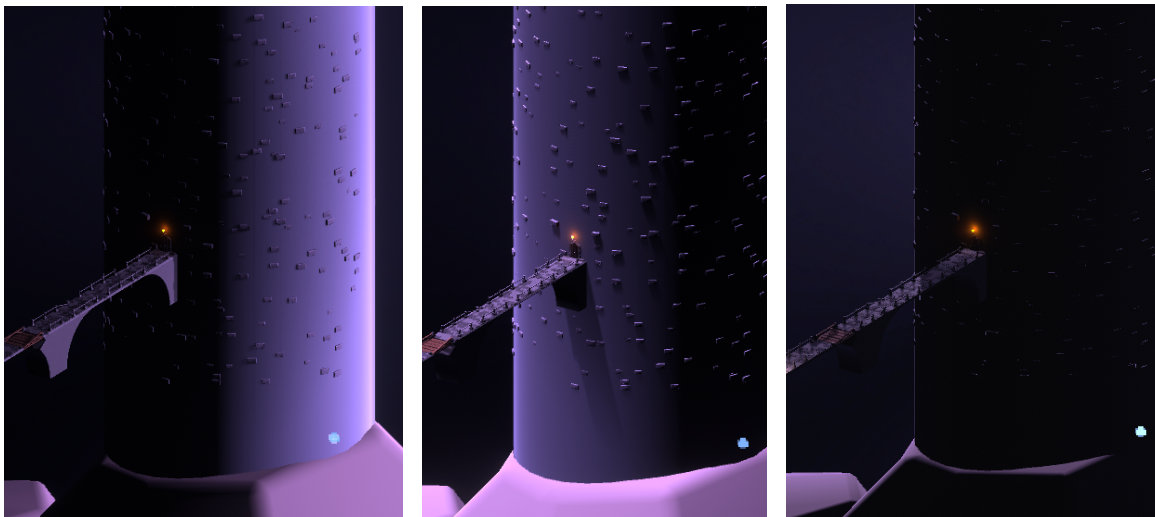
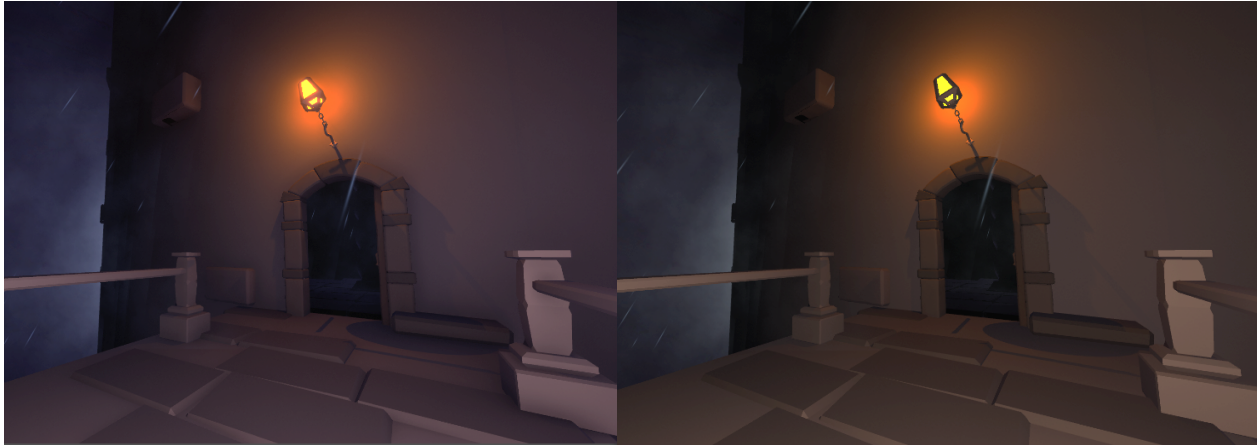


Figure [5.4] Examples of tower lighting by different lightning strikes

In the original design of the scene, it was planned to add some fireworks (also created with particle systems) at the bottom of the bridge, but they were finally discarded because, due to the camera position, the bridge itself made it too difficult to see them properly.

A post-processing profile was also created [Figure 5.5]. This was particularly useful as it could be reused in the rest of the game's scenes. As specified in Unity's official documentation [41], it consists of a set of visual adjustments that are applied in real-time to improve the final view of the scene.



*Figure [5.5] Capture of the same scene with (left) and without (right) post-processing effects*

As it can be seen, the final color of the scene has a much more pronounced blue tone and the lighting and reflections are more evident.

The programming part of this scene was relatively simple, as the gameplay only consists of walking to the door. A system was programmed to restart the scene if the player decides to walk in the opposite direction. For this, only a collider was needed to trigger a small animation where the screen darkens and calls this scene again. To make it more enjoyable to play, it was also implemented that if the player approaches the tower again while the screen is still darkening, it will return to its normal state.

A collider has been also placed near the door, which opens it when the player is close enough to see it, and another one that closes it once inside. These can only be activated once, preventing the animation from being repeated more than once if the player passes through the same point again.

Finally, the script mentioned before that darkens the screen has been reused to smoothly transition to the next level.

The student also manages the sounds and music of this level. The music has been downloaded from a free music website, and later the clip was reversed with Audacity for added atmosphere. A loopable clip was created for the character's footsteps, and it was programmed to only play when the character is walking on an object and to stop, for example, if they jump. Finally, some additional sound adjustments were added, such as the sound of the storm, thunder, and the door opening.

### 5.4.2 Level 2

As previously mentioned, this has been by far the most expensive level of the game. Several elements have been used for the first time, such as portals or triggers (buttons) to move structures, so doing it correctly would be crucial for future levels (since the code could be reused).

On the artistic side, the student modeled the small rooms of this level, both the initial and the final one, as well as the elements found in them.

In the right image can be observed the final modeling of the room used at the beginning of level 2 [Figure 5.6], with the extra elements already placed (columns, tiles on the floor/walls, and the door).

In the initial plan, this room would be illuminated by two torches in the position where the lamps can be seen. However, for optimization reasons (which will be discussed in more detail in section 5.6), it was necessary to discard the entire model, replacing it with a lamp.



Figure [5.6] Design of the first room

Also, a final room has been modeled where there is a secret hole for the player to fall through. This was a visual challenge, as it involved illuminating only certain areas of the scene, while keeping the rest dark enough to hide the hole [Figure 5.7].

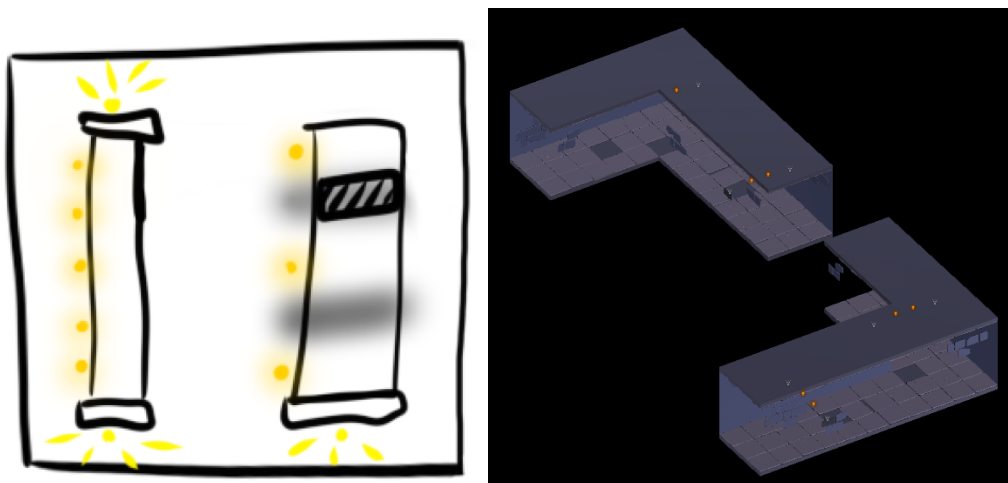
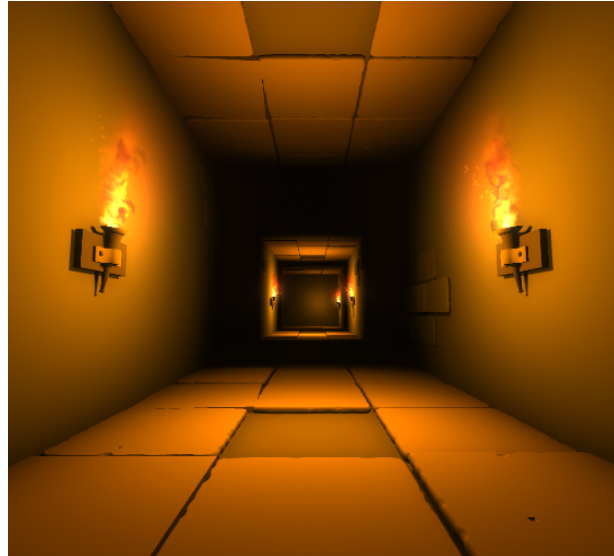


Figure [5.7] Original and final design of the last room



The initial design for this room consisted of two separate corridors connected by a portal. Once again, this was removed from the final version during optimization to improve performance. The idea of showing a first room with all the lights on and then a second one with some darkened was to make the player believe that there was no reason to not trust the hidden parts.

To continue generating this effect, in the upper right image, the first part of the corridor can be seen with some lights on and others off, and how the hidden hole is located once the first turn is made



*Figure [5.8] Final design of the last room, in game view*

In the image on the right [Figure 5.8], it is possible to see the final version of this hallway with the corresponding lighting. In this area, the previously discarded torch models could be used along with the particle system that emulates fire.

The placement of colliders, invisible barriers that prevent the player from falling off the edges of platforms, have been also a time-consuming task in this level. A system has been also programmed to activate and deactivate colliders in areas where the player can pass according to the circumstances. An example would be the first button, where there is initially no bridge, so there must be a collider to prevent falling into the void, but once the structure is rotated, the player can pass through, and this collider must be deactivated.

This system was not initially planned, as the original agreement was that the player could fall off any platform and appear at the beginning of the level. However, this made the creation of vertical puzzles much more complicated, as shortcuts could be created by jumping. For these reasons, this proposal has been ultimately discarded, and colliders have been decided to be used.

Alba focused especially on the optimization part of this scene. She also worked on the transition between levels and, like in the previous one, on the implementation of the level's music. Again, the main piece of this level is inverted, and to add drama it was programmed in such a way that it only starts playing once the player reaches the large room with stairs.

Other sounds that have been added include: the player's footsteps (this time with a different sound, as the material being stepped on in this scene does not match the audio of the footsteps in the first level), pressing buttons and rotating structures.

### 5.4.3 Level 3

As in the first level, the student was in charge of modeling the bridge in this scene. Since the scene would be much more illuminated this time, creating a texture for the base of the bridge has been considered, as using only solid colors made it look too empty.

As the first bridge, this one had to be broken in various places and look slightly in ruins. As props, destroyed areas and fallen stones were added. The student also created the statue, a significant symbol that later became the game's logo.

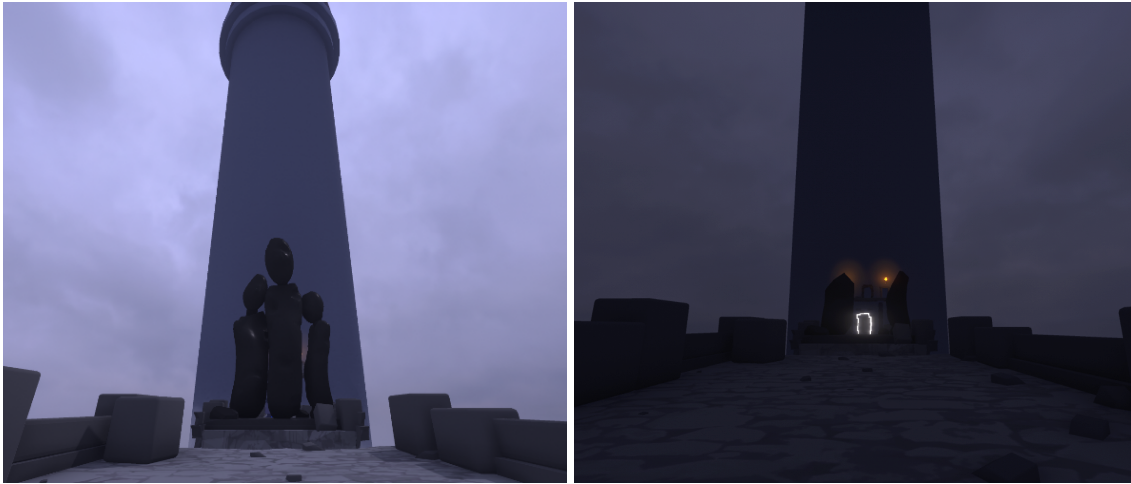
The inspiration for this was various abstract figures that represented groups of people. As can be seen in the following image [42][Figure 5.9], these sculptures created by the sculptor Olivier Messas were a direct reference when modeling.



Figure [5.9] Original statue by Olivier Messas (left), statue used in *Over The Quiet storm* (right)

Regarding the programming, different inputs must be managed in this scene. Initially, the player cannot access beyond the area before the statue since the bridge is broken, so colliders have been used again to limit their position. Later, the statue falls, creating a bridge. For this part, it was important to move this collider away from the edge; otherwise, it is possible that the player stands under the falling statue, which pushes them into the void. Once it has fallen, the new colliders need to be adjusted to prevent the player from falling.

A system has also been created that changes the scenery between day and night. To do this, an HDRI of the sky has been added to the scene. A cloudy sky has been chosen for the day zone, even though the sun is not visible, it is a quite bright image. When crossing through the portal, it gradually becomes night, reducing the brightness of the sky based on a variable until it is practically completely dark [Figure 5.10].



*Figure [5.10] Comparison of the bridge by day and night*

Another interesting change that was added during the night is the music. For this scene, as with the previous ones, it was decided that the audio track would play in reverse. However, in this scene, when entering the night zone, it will change in real time to play normally.

To achieve this effect, the music was loaded in reverse and configured as the background audio of the scene. Once the portal is crossed, the pitch of the music is accessed through code and reversed, so it plays in reverse from the second it was paused.

The rest of the tasks carried out by the student in this scene consist of positioning the different elements in their place, placing and managing colliders, adjusting the lighting, and creating and managing the UI, as well as optimization (which will be discussed in sections 5.4 and 5.5, respectively).

#### 5.4.4 Level 4

The student has been in charge of the complete modeling and texturing of all the elements in this scene. As this is a particularly symbolic scene, it has been necessary to theme it as clock elements.

A complete room inspired by the interior of a clock has been created, with the top part made of a transparent material. Several gears were also added to the bottom part as decoration. At this point in development, most of the scripts were already done and could be reused, so the time needed for programming was drastically reduced for both students, and this time could be dedicated to better modeling and texturing.

As can be seen in the image below [Figure 5.11], the results were very close to the initial level design, and no adjustments were necessary compared to the original plan.

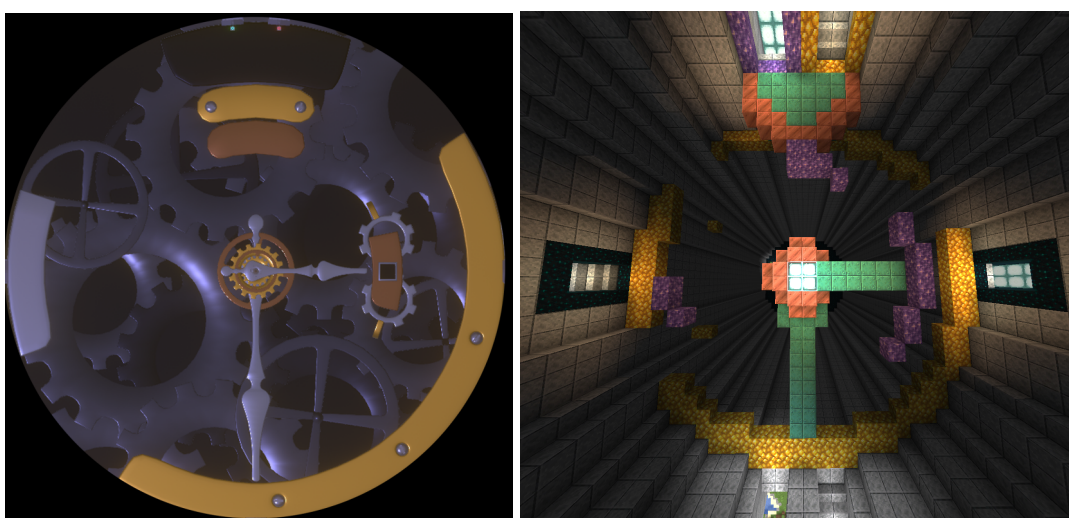


Figure [5.11] Final design of level 4 (left) and original design of it made with Minecraft (right)

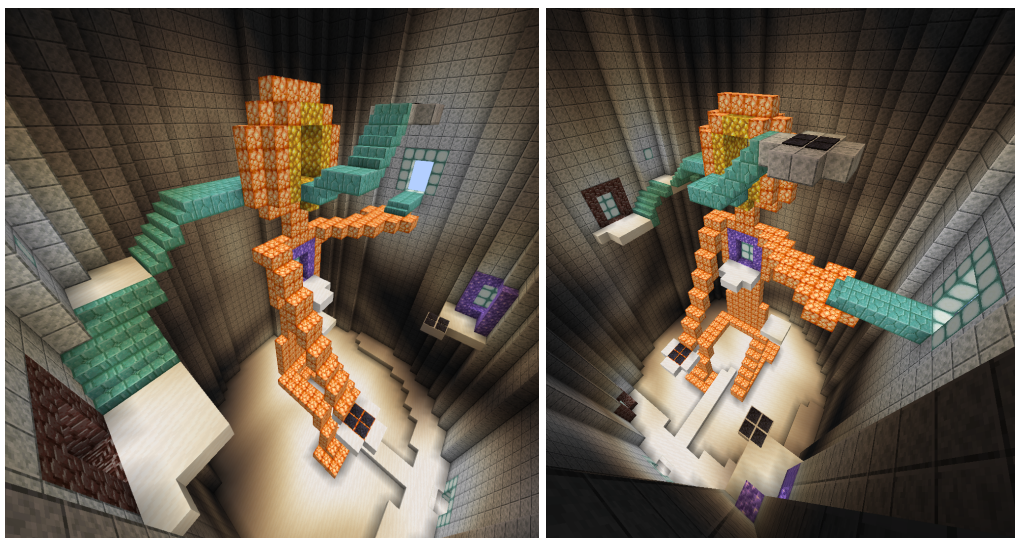
Since the puzzle felt a bit confusing due to the huge clock theme, it was necessary to create and implement a series of signs in the scene to guide the user in the right direction. Among others, a luminous clock sign indicating the direction in which the clock hands will rotate when crossing that portal was added.

Once this was completed, it was only necessary to create a smooth transition to the next level, as was done in the previous zones. In this case, a text appears on the screen before crossing the two doors that lead to different endings. This function is activated by proximity; if the player comes into contact with a collider located near the initial zone of each door, the transparency of the text will gradually increase. It will also work in reverse as the player moves away, fading with distance.

### 5.4.5 Level 5.1 & 5.2

In these last two levels, a complete revision of their design has been necessary, as during the development it became obvious that implementing a scenario with such a complex concept would not only require excessive time, but also extensive optimization to function properly.

The initial idea for these levels consisted of two analogous rooms, both containing a huge central statue (one of them would be inverted). The player had to climb up or down the statue, taking advantage of its shapes, and activating mechanisms. Once all were activated, the player would ascend to the highest part of the level while the ground collapsed, making the ascent more difficult. The analogous level would be similar, but descending.



*Figure [5.12] Original design of the last level made with Minecraft*

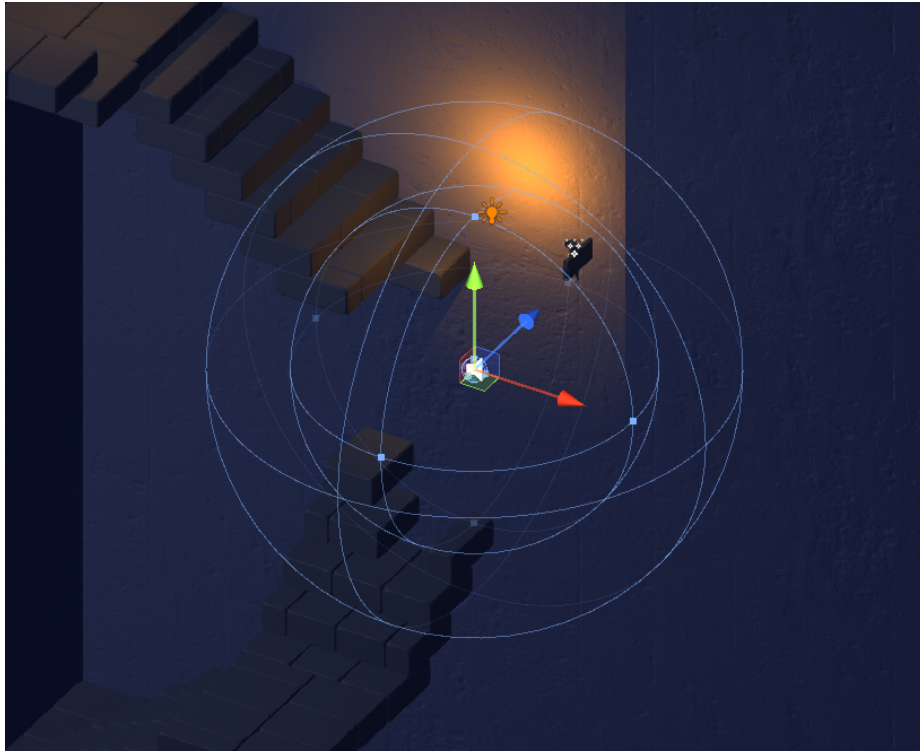
In the upper image, a conceptual version of that idea is shown, with a very basic design of the central statue, the activators to press, and the path to follow [Figure 5.12]. The location of the different portals that form the scene can also be seen.

Finally, the decision has been made to reduce this idea to the minimum, keeping only the part where the player climbs up or down an unstable terrain until escaping or falling into the abyss.

The models of these levels, as well as their textures and most of the code they use, were already done beforehand, so it was only a matter of reorganizing the different elements and modifying them minimally before finally assembling the scenes.

For the music, some dramatic effects were used.

First, the sound of the blue elements. All models that emit blue light (such as the self-forming stairs) emit a sound of distant voices when approaching, which increases the closer the player is to the center. This has been done using Unity's 3D audio system. This, as can be seen in the manual [43], uses an AudioSource component, managing its different parameters to play audio in a three-dimensional space [Figure 5.13].



*Figure [5.13] Sound range of 3D audio*

The students also wanted to create a release effect once the player manages to escape the tower. To achieve this, the background music was edited, creating two versions. In the first one, which is played while the player is inside the tower, the bass has been enhanced and the highs decreased from the synthesizer. The other version is the original song, which plays once the player manages to escape.

A technique has been used that consists of playing both versions from the beginning, so that both songs sound perfectly synchronized. This means that at the moment one song fades out and the other begins, it starts at the exact second where the original song left off.

To achieve this, the song that is not playing is played with the volume set to a minimum, and at the moment they need to switch, their volumes are swapped. This ensures 100% synchronization, but may impose a small performance load.

The rest of the music and sounds have followed a similar process to the previous levels. The music for the other ending is the same piece but reversed, and, like this, it sounds “worse” before falling into the void, generating a greater impact when the volume finally increases upon falling. Other sounds that appear are footsteps, rain, and bricks breaking and falling.

The rain particle system used in the first level has been reused in this scene, making some small adjustments to fit the new HDRI sky (this time, a sunny day). To make the rain appear only once the player has exited the tower, it has been placed just outside the tower door, so that it can be seen from inside. Once outside, it becomes a child of the character, following them along the bridge.

In both levels, a credits system has been implemented, which appears once the game is completed (escaping the tower in one ending and falling into the abyss in the other). These were created as independent objects in each scene, as it was necessary to be able to play the different music depending on the ending chosen.

Finally, a logo has been created to represent the team formed by Alba and Héctor. The chosen name was *Fractal* and is represented by the figure of the impossible triangle. The logo underwent various transformations throughout the project [Figure 5.14]. Although the name was decided from the beginning, the logo and typography were a challenge to design.



Figure [5.14] Several discarded designs for the team logo

Finally, it has been opted for the shape that most commonly represents impossible spaces, the Penrose triangle [44]. To give it a more simplified and suitable appearance for a logo, three of its edges were removed [Figure 5.15].

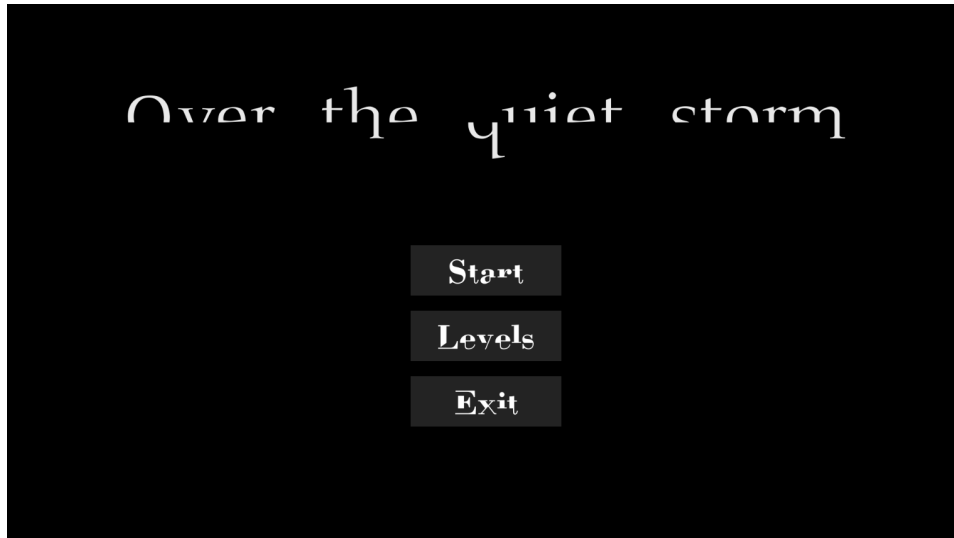
The chosen typography is *MingLiU* [45], a free font. This has been used entirely in lowercase to better balance the weight of the text below the logo image.



Figure [5.15] Final logo chosen, on black and white background

## 5.5 User Interface

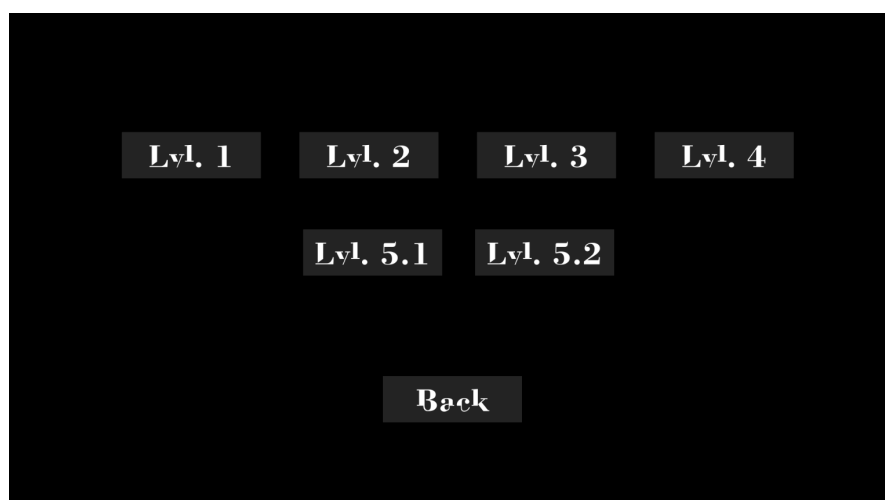
Alba has been in charge of designing and implementing the game menu in its entirety. This menu consists of several parts: an initial menu, a level selector, a pause menu used in each individual level, quotes at the beginning of each level, and a title. Finally, the end credits have also been implemented.



*Figure [5.16] Home menu of Over The Quiet Storm*

As can be seen, the initial menu consists of the game title, which has a small animation where a dividing line appears right where the text is split. Later, the screen flashes and the music starts playing. The title then blinks, emulating a light.

The three buttons that appear are Start, Levels, and Exit: the first button starts the game from the first level, the second allows the user to choose which level they want to start with, and the last one allows them to exit the game [Figure 5.16].



*Figure [5.17] Level selection screen*



On the level selection screen [Figure 5.17], the players can choose any of the 6 levels available in the game, starting directly from the chosen level. The "back" button returns to the main menu screen.

The font used for the title is *Fragmenta* [46] and, for the buttons, *Bodom* [47].



Figure [5.18] Text displayed at the beginning of each level

At the beginning of each level, a phrase appears to clarify the theme of the level [Figure 5.18]. This image slowly fades away after a few seconds to make way for the gameplay. While the image is visible, the player controller is deactivated so that the player cannot move freely and start in an incorrect position. Once it begins to fade, the player control activates back.



Figure [5.19] Pause menu

The pause menu [Figure 5.19] can be activated by pressing the escape key at any time during the gameplay, except while the initial text is on screen. When activated, the game is completely stopped, from animations to particle systems, everything is frozen. This has been possible because all animated objects use the `Time.deltaTime` value [48], which, as shown on the Unity website, calculates time precisely by counting the interval of time elapsed since the last rendered frame. Therefore, it was only necessary to program to progress, so that all objects in the game paused. It is possible to similarly tell it to pause music and sounds, but it was decided to leave them playing while the menu is open.

Another thing that changes when opening this menu is the state of the cursor. Since the game is in first-person, having the cursor constantly visible would be annoying for the player, so it has been decided to hide it, except in the menu, where it is necessary to click on the buttons. Something similar happens in the pause menu, so it is also automatically activated when opened.

The bar called Mouse Sensitivity serves to regulate the speed of the camera movement (the player's view). By default, it has a specific range that was deemed appropriate for playing, but it is an option that was considered necessary to add because many users prefer to adjust it manually. This will be discussed in more detail in point 6.2. The menu button allows access to the main menu.



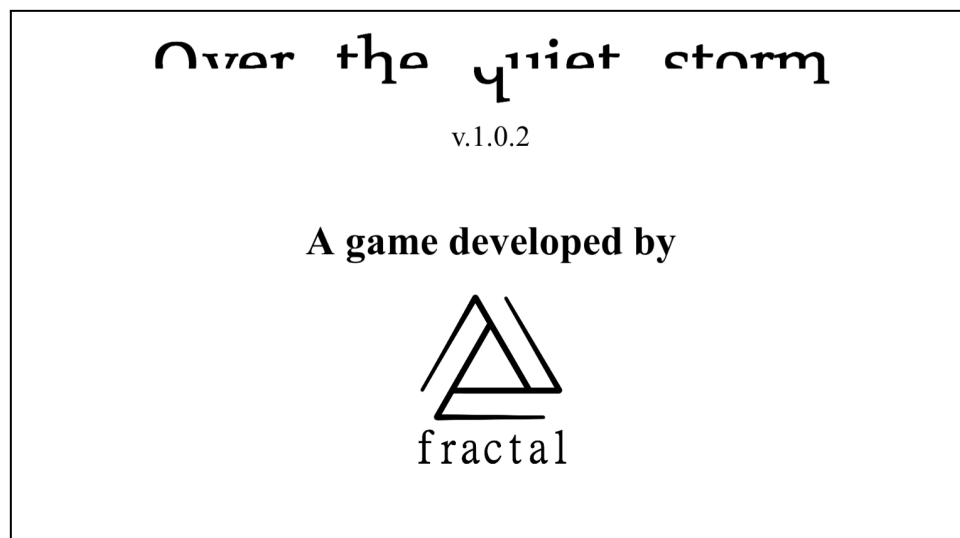
*Figure [5.20] Level 1 title on screen*

At a certain point in all levels, the title is displayed on the screen [Figure 5.20]. This point is arbitrary, chosen simply because it looks best aesthetically to present the playable area. While the title is on the screen, the player can continue to move and rotate the camera, and the title remains in place for a few seconds before fading away.

Finally, credits have been added to the game [Figure 5.20]. These have been really useful to include information about the project. Some of the information that appears in the credits includes:

- The version of the game: Necessary to keep organized the proposals for improvement and the bugs reported during testing.
- The team name and logo.
- The name of the students.
- The acknowledgments.
- Credits to all the musicians who created the tracks used throughout the game.
- Credits to the fonts used throughout the project.
- Credits to the University Jaume I.
- Credits to Unity.

Once the player reaches the final part of the last levels, the credits are triggered. The screen slowly fades to white and the credit letters move from the bottom to the top of the screen.



*Figure [5.20] End credits image*

## 5.6 Optimization

The process of optimizing this game has been quite lengthy and sufficiently complex, taking into account that initially [Chart 2.1] there was not even a consideration of the need to optimize the project.

The first time when the need to optimize the scene became evident was in level 2.

When programming the basic development of the portals, an empty scene was used, with minimal elements to test the proper functioning of the mechanics. However, when the same system was applied in a scene full of elements, the performance was clearly affected, causing the game to run below 30 frames per second, which greatly interrupts the gameplay experience.

One of the main issues had been the cameras required to achieve the sensation of a continuous space. Each portal requires a camera located in its twin, which moves synchronously with the player to maintain the same field of view. This camera must focus on the room on the other side, and its image is drawn in real time onto a texture located in the first portal to create the desired illusion. [49]

Once implemented, it was possible to deduce that placing more than two portals in a single scene required the operation of more than three cameras simultaneously, which was the maximum before performance was diminished. Since the level designs has been made prior to this finding, the puzzles had to be adapted to these new circumstances.

Observing other games of this style, such as Antichamber, demonstrated that to make use of a large number of portals it is necessary to reduce the size of the scene in polygons (with simpler models), textures (flat or without textures), lighting (without lighting or pre-calculated), and effects (without post-processing effects). Due to the style of the game, these are changes that cannot be optimized, so the decision was made to reduce particle systems (for example, changing torches with their respective system that emulates fire for lamps), the number of portals (connecting rooms with a maximum of 2 portals), and the shape of the colliders.

All colliders in the scene have been changed to box colliders, which do not fit the model shape as well as mesh colliders, but are much faster to load for the engine. A load and unload script for scene elements has been implemented; it works on contact, touching a collider activates or deactivates non-visible parts for the player, freeing up memory.

All those areas unnecessarily connected by a portal have been replaced by an exact replica of the real area that moves at the same time as the original. For example, in the staircase level, the portal that connects both blue doors is not actually a portal, but a door to a complete replica of the room.

Finally, occlusion culling has been applied, a technique that, as explained in the Unity manual [50], improves scene performance by unloading all elements that cannot be seen from the player's perspective.

## 5.7 Minimum requirements

Minimum requirements to play Over the Quiet Storm:

- Operating System: Windows 10 32/64 bit
- Processor: Intel Core i5 or equivalent.
- RAM Memory: 8 GB
- Graphics: Nvidia GTX 750TI or equivalent, integrated graphics not supported
- Net: Not necessary to play.
- On-disk memory: 500 Mb
- Screen: 1920 x 1080

Minimum requirements to play smoothly:

- Operating System: Windows 10 64 bit
- Processor: Intel Core i5 4000 series or equivalent
- RAM Memory: 8 GB
- Graphics: Nvidia GTX 970 or equivalent, integrated graphics not supported
- Net: Not necessary to play.
- On-disk memory: 1 Gb
- Screen: 1920 x 1080

## 6. Testing and evaluations for the future

Once the development of the project was completed, the testing phase remained, which is especially critical in the making of a video game. In this phase, the game is sent to different people, with a wide range of ages and varying levels of knowledge about video games.

The idea is to have as many people as possible play the game before releasing a final version of it. This is especially useful in order to improve possible errors that may have been imperceptible to the developers, or to implement interesting ideas that may come from the players.

### 6.1 Testing results

It has been requested to the different testers two specific things: to report possible bugs and to make a small summary with their interpretation of the plot.

Although the game functions correctly for the most part, some small errors have been discovered by the testers, including:

1. The menu cannot be accessed from one of the levels.
2. In some cases, level 2 does not transition to level 3.
3. In some cases, the portal in level 2 teleports the player outside of the map boundaries.
4. Both portals at the end of level 4 lead to the same ending.
5. In some cases, the camera rotates too quickly or too slowly.

The interpretation, on the other hand, serves to determine if the meaning of the game has been understood or if conclusions have been drawn that are far from the original theme. Some of them have been:

1. The game is about depression, where the character manages to overcome it or succumbs to it, ultimately committing suicide.
2. The death of a family member/close person, where the character must learn to accept this situation or succumb to grief and despair.
3. Overcoming or not overcoming a traumatic moment.
4. Making an important decision, deciding whether to accept help from others or face it alone.

### 6.2 Testing conclusions

Once the team had the necessary information, the work on the project continued to improve these aspects. Some reported errors, such as n<sup>o</sup>1 and n<sup>o</sup>4, were simply incorrect variables, parameters that had been written incorrectly, so their fix was instant.

For issue n<sup>o</sup>5, the camera rotation, it was decided to implement a manual sensitivity adjustment slider in the pause menu, so that each user can adjust it to their liking.

Finally, errors n<sup>o</sup> 2 and 3 were the most difficult to replicate and, therefore, to solve. Despite replaying that part of the game many times to recreate those errors, they simply never occurred, which led to hypotheses being raised about their occurrence.

As a conclusion, it has been deduced that this error only occurs on less powerful computers, and when passing through certain thinner colliders, it may not load the frame in which the player touches it, and therefore never activate its effect. Increasing the size of the colliders has been sufficient to solve error n°2, but it continues to cause problems with n°3. To solve it, it has been necessary to adjust the FPS limit according to the power of the computer in question: those PCs with better performance can play smoothly without noticing any difference, while those with lower performance can play with lower performance but without these derived errors.

It can be observed that all the conclusions provided are about complex psychological themes, despite not mentioning addiction. Since the game idea was already meant to leave the theme open to possible interpretations, the fact that they are all so related is an indication that it is possible to deduce the general idea of the game, and, perhaps, with a little more observation and analysis, arrive at the original theme.

### 6.3 To implement in the future

Once the game implementation was completed, there were some pending aspects that may be interesting to add to it in the future. Some of them are:

- Making the game adaptable to different screens: This game is exclusively designed for a screen resolution of 1920x1080 px, causing errors on larger or smaller monitors. If the project continues to be updated, this is the most important change, adjusting all texts and images to any possible screen size.
- More optimization: it is possible to further optimize the game's performance by including additional techniques, such as level of detail, which involves using models with fewer polygons for each object that will be displayed when it is seen from afar.
- Adding more options: complementing the pause menu with other options such as making the music and sound volume adjustable, activating a central pointer for dizziness, making the FOV adjustable, etc.
- Adding more languages: since the game text is minimal, it would be interesting to be able to play with different languages.
- Adding the initial idea of the final room: With dedication and time, it is possible to include it in the game between level 4 and the final levels.

## 7. Conclusions

After several months of work and once the project has been completed in its entirety, I can say that I am very proud of the outcome. Throughout the degree, I have worked on different 3D video game projects, but none had a similar scope or difficulty as this one.

I am very grateful for having had the opportunity to work on this project together, to experience what it's like to work collaboratively with another person, from conceptualization, creation, organization, and development of a project of this magnitude.

My personal appreciation of this project is that the initial objectives have been fully completed. Additionally, I consider that the reception of this work has been very positive, supported by a final outcome that meets sufficiently high quality standards.

I can say without a doubt that my knowledge and experience in game development have increased throughout the creation of *Over The Quiet Storm*, as there have been challenges to overcome and situations where it was necessary to make decisions.

In the future, I would like to continue working on this game to further polish it and add all the features that we couldn't include due to lack of time. If possible, by doing so, we would have a complete and perfect game to showcase as a portfolio piece.

I would also like to continue exploring the field of 3D video games in the future, especially the part of visual effects, such as shaders and post-processing. It is one of the parts that I have enjoyed the most during the development of this project, but it has also been one of the shortest.

In summary, the development of this video game has been an enriching experience for both my personal and professional growth. I have learned a lot throughout the process, both as an individual and as part of a team. I believe this project represents the beginning of a career in the world of video game development, and I am excited for future possibilities. I am grateful for everything I have learned and look forward to create innovative video games in the near future.



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# Appendices

Since over 30 different scripts have been used for the development of this project, it has been decided to include a link to a Drive folder that contains a file with all the game assets.

<<https://tinyurl.com/OverTheQuietStormProject>>