A video game to discover important women in Science, Technology, Engineering, and Mathematics.

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Final Degree Work

Bachelor's Degree in
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To every woman that fought even without being a female role model.

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To every woman that will fight **with** female role models.

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ACKNOWLEDGMENTS

ABSTRACT

This document represents the Final Degree Work report of Maria del Olmo Marco in Video Game Design and Development.

The objective of this application is to show, especially children, that there were, there are, and there will be a lot of important women in the STEM (Science, Technology, Engineering, and Mathematics) area, and, because of that, women can engage in these fields as men do. And demonstrate that the contribution of the women to the STEM area (and others) have been made invisible along the history.

In order to achieve this objective, a game has been devised that consists in a labyrinthine museum room where the main character can move and discover paintings and pictures, and read about these women. To make the experience playful, the player has to pass some mini-games or puzzles about these women.

Contents

1

INTRODUCTION

Contents

This chapter aims to provide an overview of the work, including its purpose, the motivations that it had in the beginning, the goals to achieve, what was the state from it was started, and how it was developed.

1.1   Work Motivation

I have been thinking and "baking" the idea of a feminist video game since the second year of the degree. My experience is that there are not a lot of women in any field of this industry [5], from the design and the development of a video game to the production of the video game itself. As a result, men mostly appear as main characters, or antagonists, or even as other important characters inside the video game [2]. If we read the white book of the video games of 2018 [21], according to the last statistics, we can see that only around 20 percent of the workers are women. Even in my classroom, we were 5 women and 50 men.

My first idea was to develop a platform game to show the discrimination suffered by women throughout their lives, like comments or attitudes. But then I realised about the scarcity of female role models in any field but specially in the STEM area.

There is a personal motivation for this work as well. My mom studied Computer Engineering, and, when I ask her who were her female role models, she, like many other

women, says the same, she had not female role models. And this evidence was the first step to prove that I should do something. I knew something, there was a problem, so, what can I do to show it? How can I make my contribution? As a result, I developed this idea.

1.2 Objectives

I had some general objectives, and technical objectives, separately.

Based on the motivation of the work, these were my priorities goals to achieve:

- Give young girls strong and empowering female role models in general, and in the STEM area in particular.

- Create an educational game about the important things that these women did in their lives.

- Promote and get closer the STEM area to girls.

- Dissemination about women in the STEM area.

And these were my technical goals to achieve:

- Implement some interactive puzzles.

- Build an intuitive but challenger stage.

1.3 Environment and Initial State

In this section the initial state is analyzed and, later, the work motivation is explored slightly.

Not having references, I started the concept of the game from scratch. Seeing and identifying deficiencies in this sector, I made a sketch of what the game would end up being.

Regarding personal motivation, as I mentioned before, I have been interested in this topic since I was a child, and then more, when I became a teenager but I have never studied it carefully. In this area I have my own testimony, but it was not enough. Therefore I asked about these "differences" between men and women I saw along my life, like judging us more than them, or the social expectations among us.

When I started the degree I saw these evidences more than never. 5 women surrounded by men, and I asked why is it like this? Is it something biological? I do not agree with this argument, I needed an explanation. At that time, when I was at second year of the degree I started studying it, analyzing and understanding what is this about. It was firstly using YouTube videos and later I read some books about this.

This is something historical. In this industry, as in every other area women have been made invisible along the history [3] [4] [19]. Specially, in the STEM area, When

we dedicate to science, we hear names like Marie Curie [23] [31] or Ada Lovelace [26], but they are not the only important figures that these areas had [1]. They suffered a repression and suppression, maybe you do not know about Mileva Maric, the scientist that probably helped Einstein to formulate the theory of relativity [1], or Grace Hopper, closer to us, who invented FLOW-MATIC [30], the first high-level programming language geared towards management and later helped the development of COBOL [1] [22]. Or Maryam Mirzakhani, an important mathematician who won the *Fields Medal*, a prize known as the Nobel Prize in Mathematics [1]. If you do not know about these important women, it is not because you are uncultivated, it is because of what I mentioned before, women have been made invisible along the history.

I read a lot of experiences of another women, who did not had other female role models [2]. So finally, I decided to bring these women (who have never been highlighted as men have) to the people and making it in an enjoyable way. I wanted to make a serious game about these women, focusing the attention on each one of them.

1.4   Study of Recreational and Educational Video Games about Women

The first one I remembered was *In the Nighty Jungle* [36], a game where there are two main characters. These characters are two girls at the disco at night. They have lost each other. But, in their way to find each other, they are attacked by some different enemies, that are presented as some mutants but, they are, actually, abusers and stalkers men. This shows a reality that every women, at least once in life, has to suffer (See Figure 1.1).

Then I realised that I did not know many games about feminism and how this area of the industry has addressed the issue. So I started looking at Internet, where I discovered some examples.

On the one hand there is a video game called *Chuka: Rompe el Silencio* (Chuka: Break the Silence) [32], a video game that helps children respond assertively to situations of violence. It is developed by the United Nations Office on Drugs and Crime (See Figure 1.2).

On the other hand there is *Tsiunas* [34], an educative tool oriented specially to young men. This game tries to educate young men to understand important facts to prevent the gender-based violence. This game was developed by *ONU Mujeres de Colombia* collaborative working with the Cauca University (See Figure 1.3).

In this game the players see the consequences of some phrases that support the violence against women. Later they see some characters who defend or reject these macho behaviors or thoughts. The events will depend on how the player acts against these behaviors.

I studied the video game called *Vona* [33] too. This video game is a video game made for the *Gendermuseum* of Ukraine. This is the only gender museum at East Europe and it is supported by Spanish funds. At the video game, the player takes the role of a compliant housewife, with so much housework. But the player can take another path and change the destiny of this housewife (See Figure 1.4).

Figure 1.1: Sample of the video game *In the Nighty Jungle*

There is another game, *Missing* [35], a video game about prostitution. At the game, the player takes the role of Champa, a prostitute, a kidnapping victim. The player must to have the largest number of clients per day.

The Madame of the place will demand more and more money. A man will come to your room night after night to ask you for money and when the money do not reach the stipulated amount he will beat you up. You can try to escape from that place, but if you get caught running away the consequences will be serious. This game tries to show the reality of thousand of girls and women in the world have been kidnapping and forced to prostitute (See Figure 1.5).

The last game I am going to talk about is *Mujeres en ciencia: el videojuego* (Women in Science: the Video Game) [39], a Farm Simulator where the player must grow her own farm. The special thing that this game has is that the main character will find some important women at the STEM area, like Marie Curie and Grace Hopper (See Figure 1.6).

There are not a lot of video games about this subject. This is another reason why I decided to make this video game, because, with it, we can raise awareness about the imposed machismo along the history. And with this communication channel, video games, reach many more people.

Figure 1.2: Sample of the video game *Chuka: Rompe el Silencio*

Figure 1.3: Sample of the video game *Tsiunas*

Figure 1.4: Sample of the video game *Vona*

Figure 1.5: Sample of the video game *Missing*

Figure 1.6: Sample of the video game *Mujeres en ciencia: el videojuego (Women in Science: the Video Game)*

Planning and resources evaluation

Contents

This chapter details the technical part of the work and the planning I followed while developing the game.

2.1 Planning

This section reflects the time planned for the work, including all its tasks and sub-tasks. Some of these tasks have changed from the first idea because I though it was going to take less time and, in the end, it took longer.

- **Task 1 (15 hours)**: Analysis of the state of the art in recreational and educational video games about women.

- **Task 2 (7 hours)**: Study about some other similar products.

- **Task 3 (15 hours)**: Study of recommendations about puzzle video games.

- **Task 4 (10 hours)**: Study of recommendations about non-sexist video games.

- **Task 5 (12 hours)**: Get closer to women in STEM and search some women to talk about them.

- **Task 6 (15 hours)**: Study about a number (10-15) of influential women in the STEM area.

These two tasks have been developed along the time, I was constantly learning and studying about women in STEM area.

- **Task 7 (7 hours)**: Interview women from the STEM area and develop the interview.

- **Task 8 (5 hours)**: Choose women I am going to talk about.

- **Task 9 (230 hours)**: Design and Development of the application.

- **Task 10 (30 hours)**: Write the diploma thesis manuscript.

Summary of this information in the form of a Gantt chart can be seen in Figure 2.1.

2.2   Resource Evaluation

The only material and human costs are my personal computer equipment and my working hours:

- **HUION WH1409**: Wireless graphic tablet that I used for the design of the work, starting from the sketches to some of the final graphics.

- **Desktop computer (and peripherals)**: Where I developed all the work.

- **Laptop computer (and peripherals)**: Where I did the firsts drawing sketches and the first Unity project.

On the other hand there are the software and hardware resources used to develop the work, this is the list:

- **Adobe Photoshop CS6 (portable) (basic licence)**: Used to draw the sketches and some of the final graphics.

- **Unity 3D and 2D 2019.2.6.f1 (Student license)**: The main software.

- **Blender 2.8 (Free software)**: Used to model the main scene, and the other 3d models.

- **Overleaf (Free pack)**: The web where the diploma thesis manuscript was written.

- **GitHub (Student license)**: Used for having a repository where the game was uploaded.

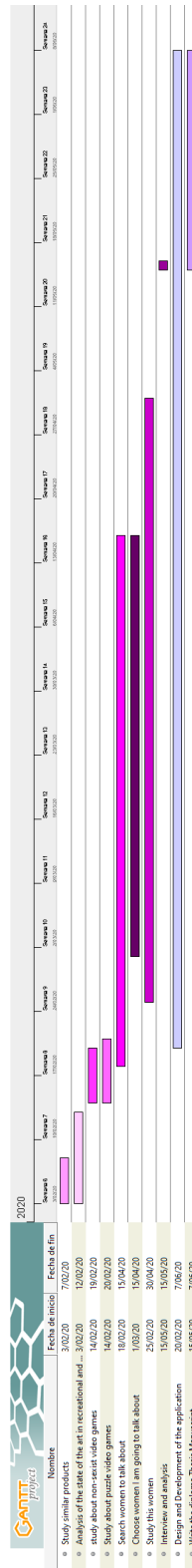- **Visual Studio 2019 (Student license)**: The main programming software (with C# as the programming language).

Figure 2.1: Gantt chart of the task planner (made with GanttProject)

CHAPTER **3**

SYSTEM ANALYSIS AND DESIGN

Contents

This chapter presents the requirements analysis, design and architecture of the proposed work, as well as, its interface design.

3.1 Requirement Analysis

To carry out a job, it is necessary to perform a preliminary analysis of its requirements. This section collects the functional and non-functional requirements of this work.

Our objective is to give visibility to women from the STEM area, and thus to give the opportunity to people, specially girls or young women, to meet these women and have them as female role models.

To achieve this objective, I have designed a video game called *A video game to discover important women in Science, Technology, Engineering, and Mathematics*, and, trying to make this approach the most simple and enjoyable, for young people and also for older people, I have made it like a labyrinthine museum room, intuitive but, at the same time, challenger for the player. In this museum the player interacts with paintings and pictures that introduce women from the STEM area.

When the game is executed, the first thing the player sees is the main menu screen, where it is shown the play button, the options button, the quit button and the credits

button. The quit button closes the game. The options button shows another menu where the player can down and up the music volume if it is too loud or the opposite. And the play button starts the game showing the main game scene. At any time in the game, the player can press pause (P key), to go to a similar menu screen with the quit button, the resume game button, and the volume options buttons.

This scene is a simple 3D museum room with pictures and paintings but they are distributed in such a way that the player must walk around all the stage to find all the paintings and pictures. There are some hidden 2D mini-games that are related to the professions of the women presented in them. Furthermore in each picture there is a small information that talks about the woman represented in it. The player has the option to extend the information about the women shown by pressing the space bar over the small image representing a paper placed next to each one of the paintings. The player can visit the paintings and the pictures in any sequence and solve the puzzles in the same way.

There are several actions that the player can do in this stage. The player can use the keyboard WASD keys or the arrow keys to move its character. She can use the mouse to move the camera point of view. Each time the player has the option to interact with a painting or picture of the game, a pop-up menu is displayed with some explanation and the keys to be used. For reading the information that every picture gives, the player must press space. With the shift key pressed while walking, the player runs. And in front of the pictures that have a puzzle, the player can choose to play the mini-game (if the player wants to play it, depending of the picture, the puzzle is activated with a key or another).

Regarding the implemented puzzles, the first one is a 2D jigsaw puzzle, where the player should assemble an image of a Black Hole (representing Katie Bouman, the first person to photograph a Black Hole [12] [13] [11]). It is a 9x9 puzzle that lacks a piece (see Figure 3.1). The player can only move one of the pieces next to the hole using the mouse, by clicking the piece to move and the gap. In order to be more challenger there is a counter for the movements (but the player can ignore it and this does not affect the game). When the puzzle is finished, the missing piece of the 9x9 puzzle is placed in the hole and, pressing space the player can return to the main scene.

In the second puzzle, the player sees a 2D labyrinth, where he has to move the picture of the inventor Ann Makosinski [3] [15] [14]. The objective is to find the three parts of the Hollow Flashlight (which works with human heat) this woman invented (see Figure 3.2). Once the player has the three parts, which appear at the center of the screen but they are repositioned (with an animation) at the upper left corner forming up the complete flashlight, the labyrinth is opened and the player finishes this puzzle. At this moment the player can return to the main stage pressing the space bar.

3.1.1 Functional Requirements

A functional requirement defines a function of the system that is going to be developed:

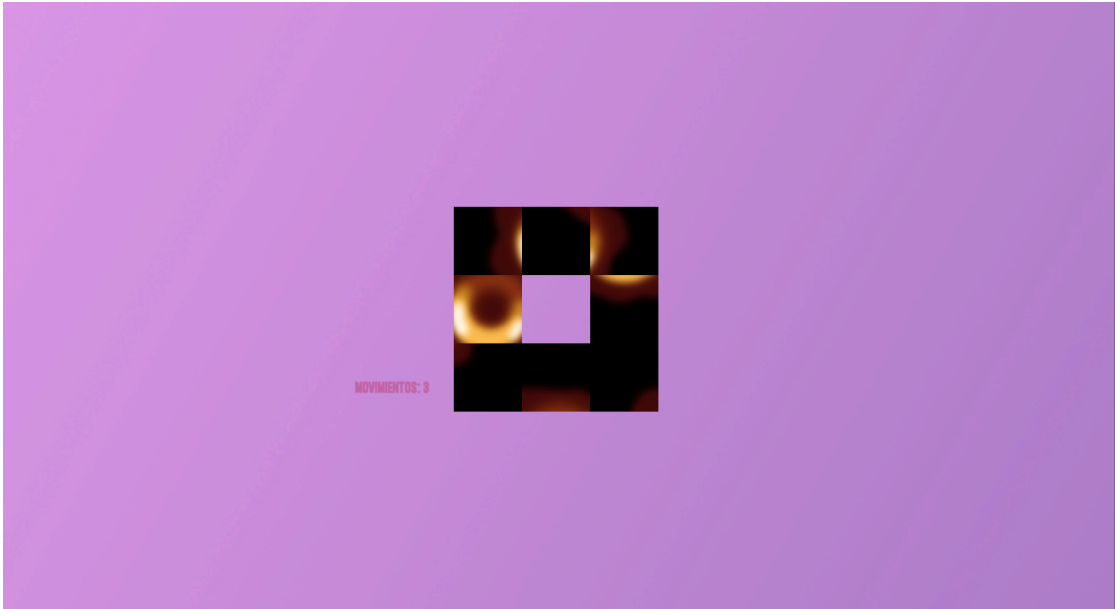1. The player can change the volume.

Figure 3.1: Sample of the jigsaw puzzle

Figure 3.2: Sample of the Hollow Flashlight completed

2. The player can start the game.

3. The player can quit the game.

4. The player can see the credits.

5. The player can move the character in the main stage.

6. The player can run in the main stage.

7. The player can move the camera in the main stage.

8. The player can read the information for each picture or painting.

9. The player can play any puzzle.

10. The player can pause the game.

11. The player can resume the game.

12. The player can return to the main stage when the mini-game is finished.

    Inside the first puzzle:

13. The player can move the pieces.

    Inside the second puzzle:

14. The player can move the character thought the labyrinth.

15. The player can collect the parts of the collectible.

Plan to implement the functional requirements will be detailed in the system design section (see Section 3.2).

3.1.2   Non-functional Requirements

Non-functional requirements impose conditions on the design or implementation.

1. The aesthetic will be like a museum.

2. The HUD will be simple.

3. The game is related about STEM area women.

4. The game will work in a fluid way.

5. The system will attend all the requests of the player.

6. In the 2D puzzles all the scene will be painted.

7. The puzzles should be solved in a simple way.

8. In the 3D stage the aesthetic will be low poly.

3.2   System Design

This section must present the design of the system to be carried out.

Name:	Modify volume
Requirement:	1
Actor:	Player
Description:	The player can change the volume.
Preconditions:	The player must be on the options screen.
Steps:	

    1. The player ups or downs the volume.

    2. The volume ups or downs.

Other sequence:	None

Table 3.1: Functional requirement «Use case 1. Modify volume»

Name:	Play the game
Requirement:	2
Actor:	Player
Description:	The player can start the game.
Preconditions:	The player must be on the main menu screen.
Steps:	

    1. The player press the Play button.

    2. The main scene is load.

Other sequence:	None

Table 3.2: Functional requirement «Use case 2. Play the game»

Name:	Quit the game
Requirement:	3
Actor:	Player
Description:	The player can quit the game.
Preconditions:	The player must be on the pause screen or main menu screen.
Steps:	

1. The player press the Quit button.

2. The game closes.

Other sequence:	None

Table 3.3: Functional requirement «Use case 3. Quit the game»

Name:	Show the credits screen
Requirement:	4
Actor:	Player
Description:	The player can see the credits.
Preconditions:	The player must be on the main menu screen.
Steps:	

1. The player press the credits button.

2. The game shows the credits screen.

Other sequence:	None

Table 3.4: Functional requirement «Use case 4. Show the credits screen»

Name:	Move the character (in the main stage)
Requirement:	5
Actor:	Player
Description:	The player can move the character in the main stage with the WASD keys or the arrow keys.
Preconditions:	The player must be on the main game screen.
Steps:	1. The player press the keys. 2. The character on the game moves according to the keys pressed.
Other sequence:	If there is an obstacle in the path, the character will not move.

Table 3.5: Functional requirement «Use case 5. Move the character (in the main stage).»

Name:	Run
Requirement:	6
Actor:	Player
Description:	The player can run by pressing the shift key.
Preconditions:	1. The player must be on the main game screen. 2. The player must be in movement.
Steps:	1. The player press the shift keys. 2. The character on the game moves faster.
Other sequence:	If there is an obstacle in the path, the character will not run.

Table 3.6: Functional requirement «Use case 6. Run.»

Name:	Move the camera
Requirement:	7
Actor:	Player
Description:	The player can move the camera in the main stage with the mouse.
Preconditions:	The player must be on the main game screen.
Steps:	

1. The player moves the mouse.

2. The camera moves according to the direction of the mouse.

Other sequence:	None

Table 3.7: Functional requirement «Use case 7. Move the camera.»

Name:	Read the information under the picture or the painting.
Requirement:	8
Actor:	Player
Description:	The player can read the information for each picture or painting pressing space bar.
Preconditions:	

1. The player must be on the main game screen.

2. The player must be in front of a painting or a picture.

Steps:	

1. The player press the space key.

2. The game shows the information about the woman in the painting or picture.

Other sequence:	If the player is not close enough to the painting or the picture, the information is not displayed

Table 3.8: Functional requirement «Use case 8. Read information.»

Name:	Play a puzzle.
Requirement:	9
Actor:	Player
Description:	The player can play the puzzle pressing the appropriate key.
Preconditions:	

1. The player must be on the main game screen.

2. The player must be in front of the painting of the specific woman with the jigsaw puzzle.

3. The player must have read the information about the woman before playing (Use case #7 completed)

Steps:	

1. The player press the appropriate key.

2. The game shows the puzzle screen.

Other sequence:	If the player is not close enough to the specific painting the puzzle will not shown.

Table 3.9: Functional requirement «Use case 9. Play a puzzle.»

Name:	Pause the game
Requirement:	10
Actor:	Player
Description:	The player can pause the game pressing P key.
Preconditions:	The player must be on the main game screen or in any of the puzzles.
Steps:	

1. The player press the P key.

2. The game shows the pause screen.

Other sequence:	None

Table 3.10: Functional requirement «Use case 10. Pause the game.»

Name:	Resume the game
Requirement:	11
Actor:	Player
Description:	The player can come back to the game
Preconditions:	The player must be on the pause screen.
Steps:	

1. The player press the back button.

2. The game turns back to the game.

Other sequence:	None

Table 3.11: Functional requirement «Use case 11. Resume the game.»

Name:	Turn back to the main game screen
Requirement:	12
Actor:	Player
Description:	The player can turn back to the main game screen once a puzzle is solved.
Preconditions:	

1. The player must be in a puzzle screen.

2. The puzzle must be solved.

Steps:	

1. The player press space.

2. The game shows the main game screen.

Other sequence:	None

Table 3.12: Functional requirement «Use case 12. Turn back to main game screen.»

Name:	Move the pieces in a puzzle
Requirement:	13
Actor:	Player
Description:	The player can move the pieces with the mouse.
Preconditions:	

1. The player must be in a jigsaw puzzle screen.

2. The puzzle is not solve.

Steps:	

1. The player clicks on piece of the puzzle with the mouse.

2. The player clicks on the gap in the puzzle.

3. The piece and the gap swap their positions in the puzzle

Other sequence:	If the player clicks on a piece that it is not next to the gap, it will not move.

Table 3.13: Functional requirement «Use case 13. Move the pieces in a puzzle.»

Name:	Move the character thought a labyrinth puzzle
Requirement:	14
Actor:	Player
Description:	The player can move the character thought the labyrinth.
Preconditions:	The player must be in a labyrinth puzzle screen.
Steps:	

1. The player press the keys.

2. The character on the labyrinth moves according to the keys pressed.

Other sequence:	None

Table 3.14: Functional requirement «Use case 14. Movement thought a labyrinth puzzle.»

Name:	Pick up parts of a collectible
Requirement:	15
Actor:	Player
Description:	The player can collect the parts of the collectible.
Preconditions:	The labyrinth puzzle must not be solved.

Steps:

        1. The player touches any part of the collectible.

        2. The game puts the part of the collectible in its place.

Other sequence:	None

Table 3.15: Functional requirement «Use case 15. Pick up the parts of a collectible.»

3.3 System Architecture

This section should describe the architecture of the projected system. The hardware and software requirements of the device where the game was develop and the requirements where the game can be executed.

The game has been developed in a PC with these specifications:

- OS: Windows 10 Pro, version: 18362.836.

- Processor: Intel (R) Core (TM) i7-6700 CPU @ 3.40GHz.

- RAM: 16.0 GiB

For running Unity 2019.2.6f1 there are necessary these requirements:

System Requirements for development:

- OS: Windows 7 SP1+, 8, 10, 64-bit versions only, macOS 10.12+.

- CPU: SSE2 instruction set support.

- GPU: Graphics card with DX10 (shader model 4.0) capabilities.
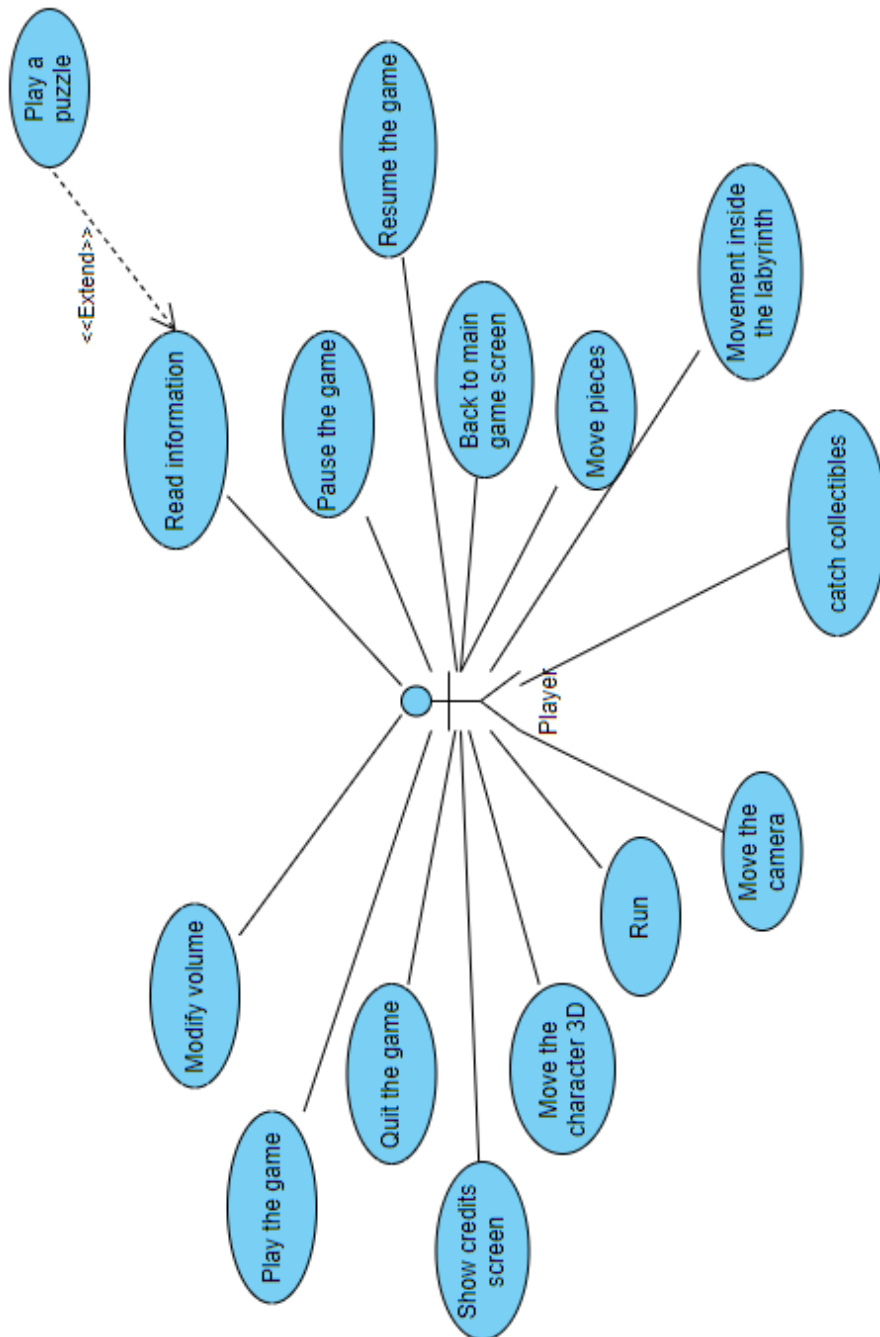
Figure 3.3: Case Use chart (made with online.visual-paradigm.com)

3.4   Interface Design

Some examples of the 3D interface are shown in Figures 3.4, 3.13 and 3.14. I have deliberately implemented a rather simple 3D interface, since I do not want to overshadow the main objective of the game, which is to empower women in STEM and show to anyone who plays the game about these women. If it is about showing some different women in a "educational" context but making the experience playful and enjoyable, what could be better than a museum scenario to reach the largest number of people. In the 3D scenario, the player may explore and read information about the lives and achievements of the selected women. As shown in Figure 3.11 and Figure 3.12, there are some decorations like plants or benches. The lights focus the attention on the pictures and paintings and also serve to guide the player through the labyrinth (see Figures 3.4, and 3.14).
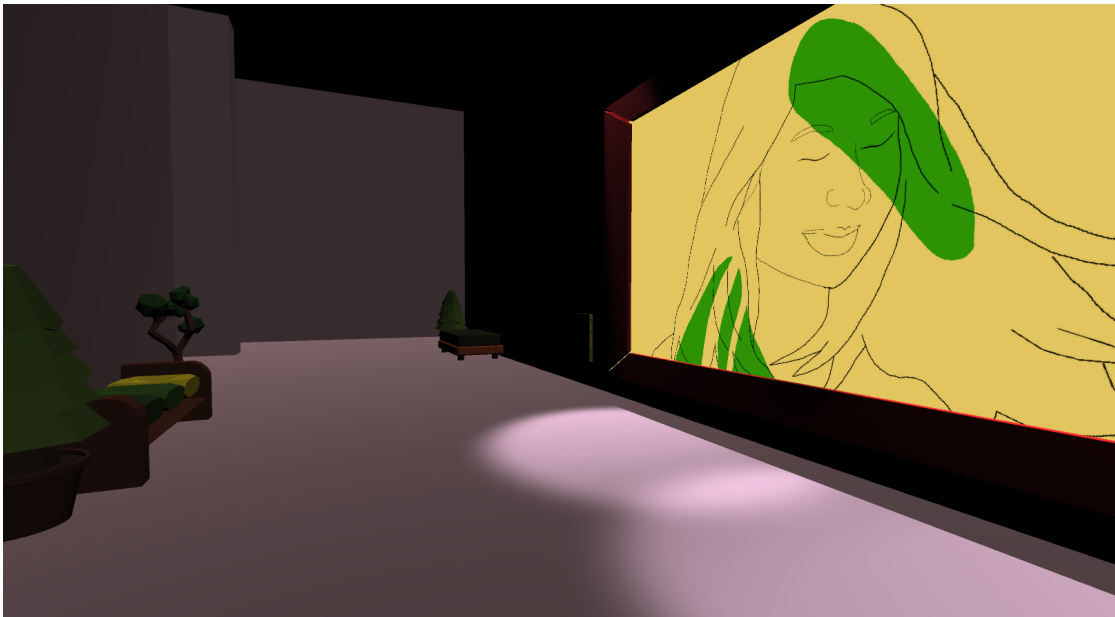

Figure 3.4: Image of a painting and the labyrinthine museum

In the 2D mini-games, the interface is in 2D, it is about some puzzles to incorporate the person that is playing the game, in the lives of these women, making a bit challenger but not so frustrating to give up. What we want is to get the player's attention to learn about the women in the paintings and pictures through the puzzles. So, the concept of each mini-game is focused on the important woman that it represents, about her inventions or discoveries along her life. And giving information to the player in every section of the resolution of the puzzle. Before, reading the information in the painting, while in the puzzle (collecting the pieces of an invent, assembling the parts of a puzzle), and later, completing the data of this knowledge.

The fist puzzle starts with a introduction screen where it is explained the mechanics
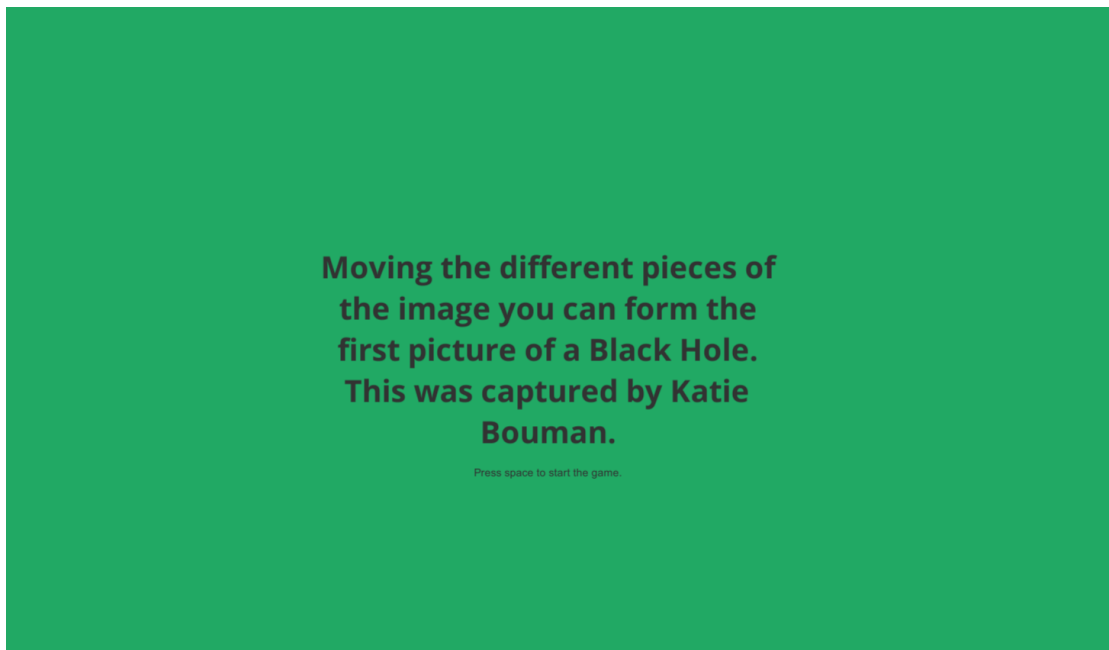
Figure 3.5: First image at the jigsaw puzzle, before pressing space and play the game

of the game (see Figure 3.5) and then, when space is pressed, the game takes the player to the jigsaw puzzle itself (see Figure 3.6), where the player must assemble the puzzle, and, when it is completed, the last piece of the puzzle is placed in its place. Then, the player returns to the main game screen. There is a counter of the movements that the player makes with any slide of the pieces (see Figure 3.7). When the jigsaw puzzle is assembled, the mini-game ends and there appears the last screen of the puzzle where the player can see the movements that he has made, and the instructions to turn to the main stage of the game. These instructions explain that the player must press the "exit" button to return to the museum level (See Figure 3.8).

The rules of the second puzzle are explained before entering the game. The interface of this game is a 2D labyrinth where the player must guide the protagonist of this puzzle (Ann Makosinski) looking for the pieces that recompose the Hollow Flashlight that Ann invented, a Flashlight that works with human heat (see Figure 3.9). Once the player has collected the three parts of the object (that are storing at the upper left corner, where is an empty silhouette of the item), the exit of the labyrinth is opened, and the player must find it (see Figure 3.10). Once the player goes out of the labyrinth the game is finished. Then the game redirects the player to the main game screen again.
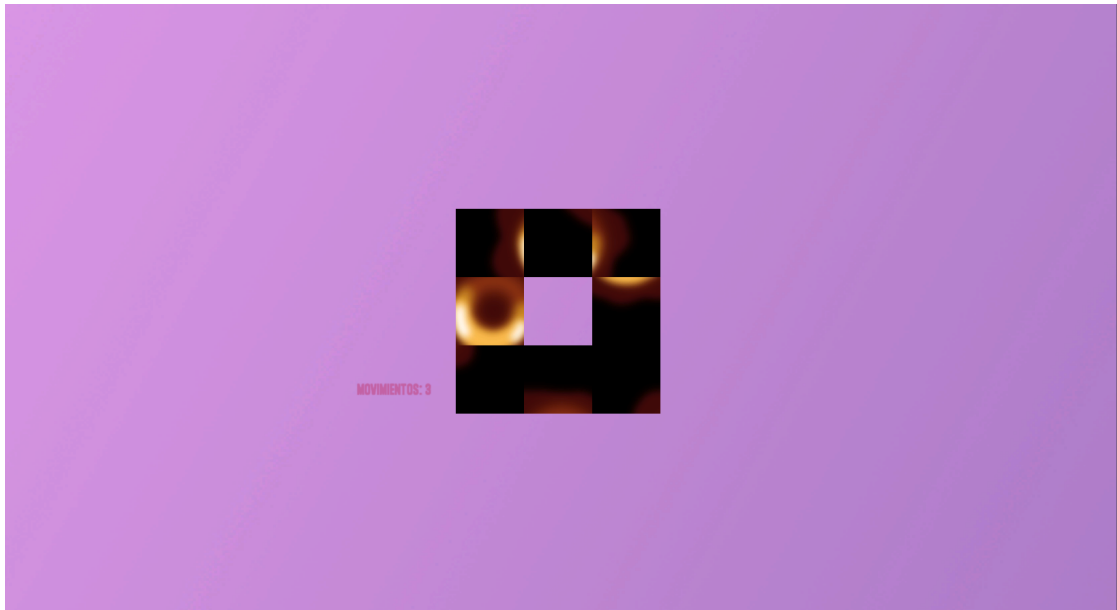
Figure 3.6: Image of the interface of the Jigsaw Puzzle

Figure 3.7: Sample of the counter of the movements
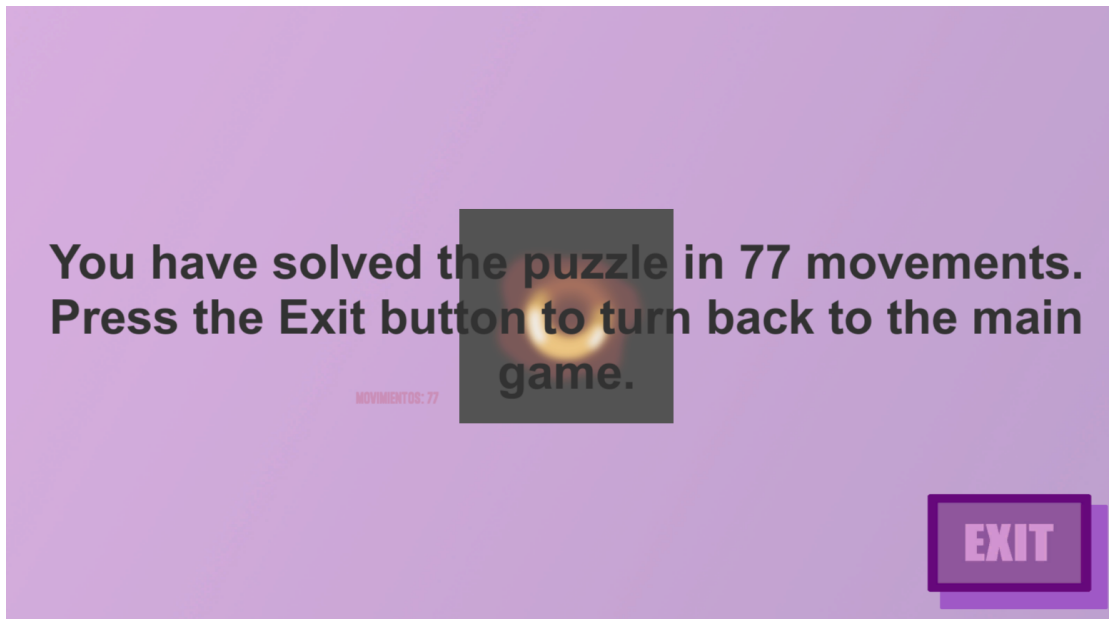
Figure 3.8: Sample of the finished jigsaw puzzle where the player see the counter of the movements and the instructions to exit the mini-game
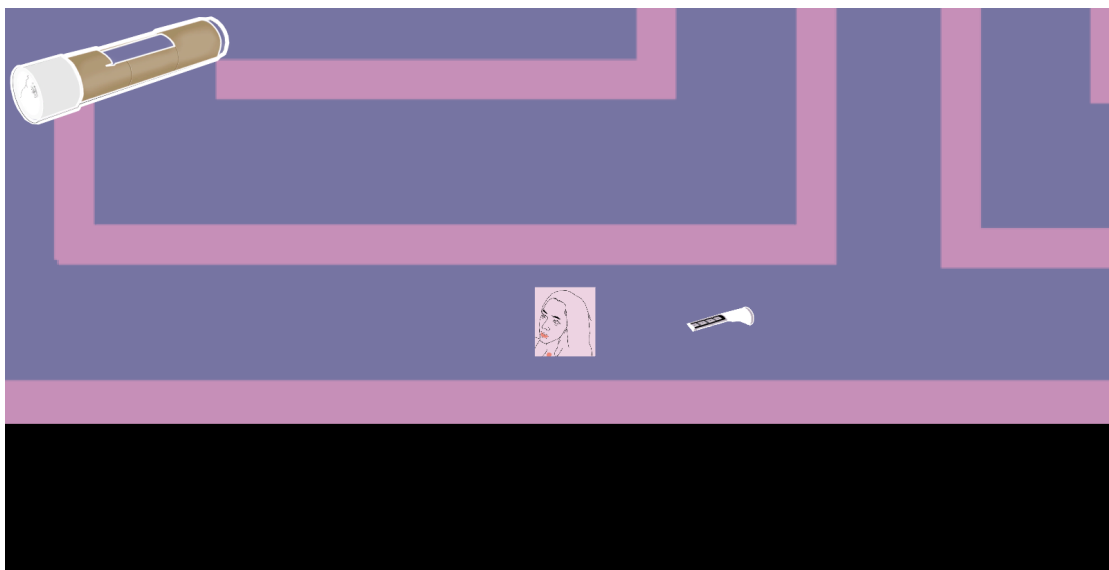
Figure 3.9: Image of the interface of the Labyrinth puzzle (before taking the last piece of the flashlight)
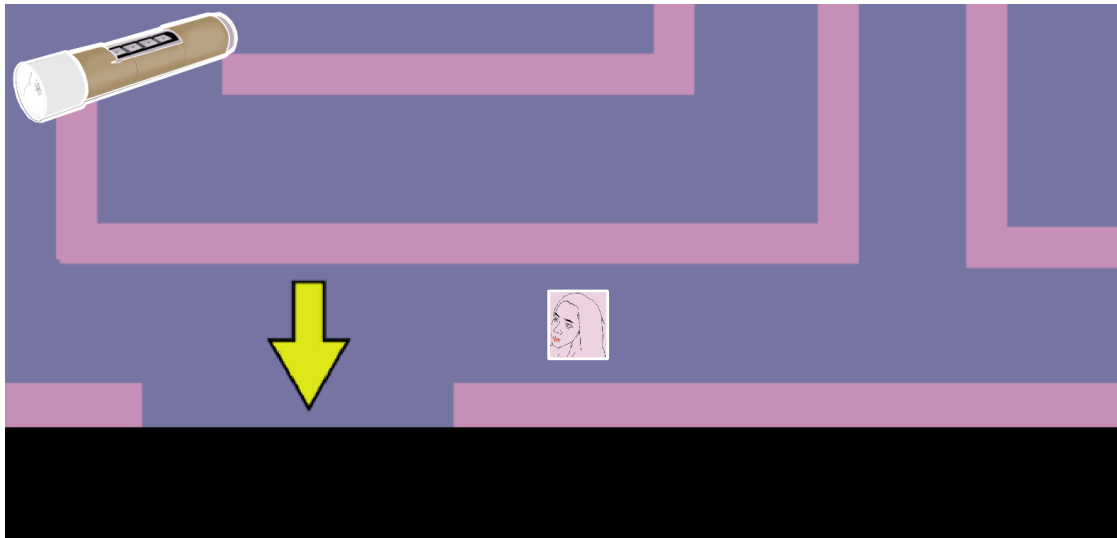
Figure 3.10: Image of the interface of the Labyrinth puzzle (after taking the last piece of the flashlight)
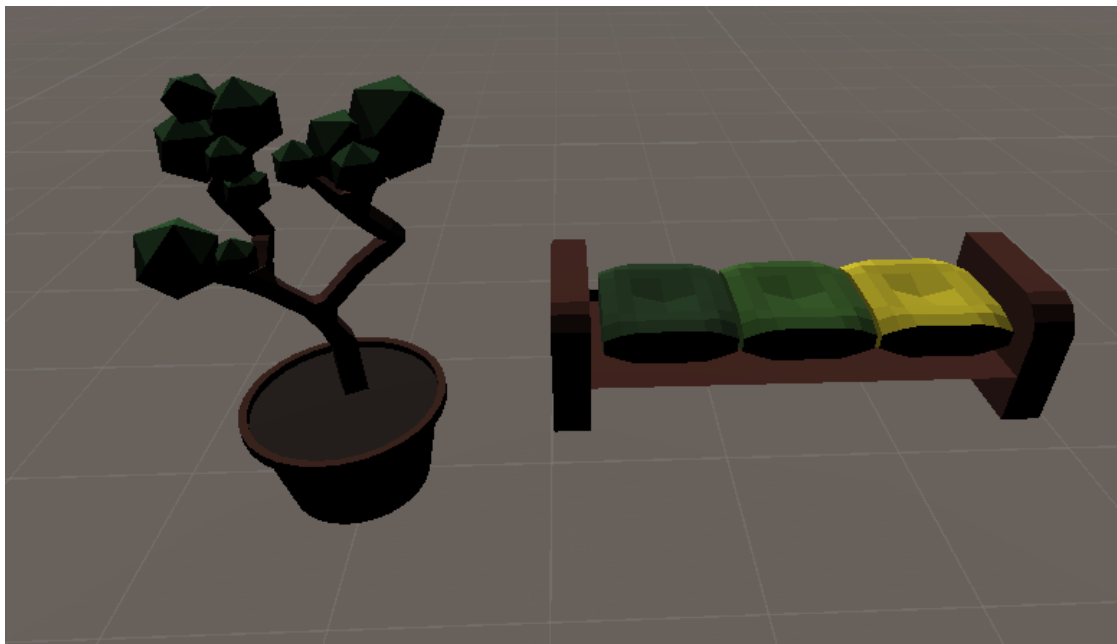
Figure 3.11: Image of the different decoration

Figure 3.12: Another image of the different decoration

Figure 3.13: Box dialog and option to play the puzzle

Figure 3.14: Sample of the three pictures of the WAC

WORK DEVELOPMENT AND RESULTS

Contents

4.1 Work Development

In this section I will talk about how I have developed the game, the variations from the initial planning and why these occurred.
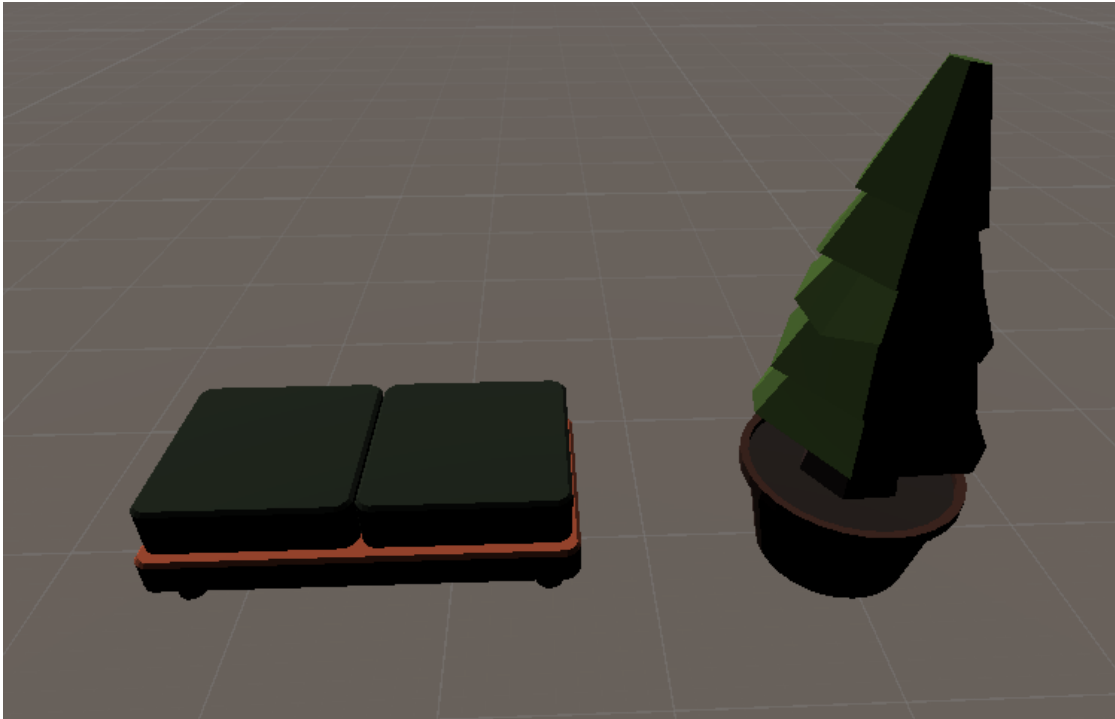
In the *Game concept* subsection I talk about the concept of the game, how the idea was developed and performed. In the *Study and selection of the female role models* subsection I present the women I have chosen and why. In the *The Art of the video game* subsection I talk about the art and how it was chosen and why and how I made it. Finally, in *The programming of the video game* subsection I talk about some important parts of the programming part of the project, as the programming of the mini-games and other relevant parts.

4.1.1 Game Concept

My first idea was a platform video game but with a feminist message, but I realised that in this way, the message would not have the importance that I was looking for and it could go unnoticed. Then I determined I had to make a simpler game to easily convey the message.

After deciding that the main stage should be intuitive and practical to learn, my principal idea was a museum with the pictures and the paintings. But the labyrinthine

stage was a later idea, and the decision was because this makes the experience more enjoyable for younger public [20], making it challenger and not boring

Furthermore this is an open game, that anyone who plays it, can leave it in any moment and let someone else play, because the players can play the puzzles as many times as they want. The knowledge of game can be acquired by anyone who plays it even if only for a while. This property of the game makes it very adaptable to some scenarios, like exposing it in a place and let the people play with it whenever they want. And they can even play again if they want or they think that something is not clear for them.

Actually, the player does not need to play the whole game, if she plays a part of it, he will be learning already. This is because it is developed making the experience of learning in the most easy way for them.

When the player starts the game, she has the liberty of choosing which way wants to follow. This makes their experience with the game unique.

I had many sources of puzzles of mini-games, like the Professor Layton series [25], a puzzle adventure video game series developed by Level-5. To the Moon [27], an interactive storytelling and an adventure game developed and published by Freebird Games, where there are some puzzles that the player must solve to advance. Florence [24], an interactive storytelling game about the sense of love, developed by Annapurna Interactive. The WarioWare games [28] have collections of short, simple "microgames" presented in quick succession. Some of these games and others inspired me and made me develop the puzzles I decided.

Finally, the different mini-games inside the game are chosen thinking about the protagonist woman in each one of them. I will talk about these women in the next subsection but, for the fist woman that took a picture of a Black Hole, I made a jigsaw puzzle where the player must assemble the picture (it is a painting made by me imitating the picture (see Figure 4.9)). For the inventor of the Hollow Flashlight, I made a labyrinth 2D puzzle where the player must walk around it finding the parts of this invention (see Figure 4.7).

4.1.2 Study and selection of the female role models

In this section I talk about the women that I chose to talk about, but I have left many women out. I would like to talk about Hypatia (c. 350/370 - 415) who was a mathematician, astronomer and important Hellenistic Neoplatonist philosopher, or Wang Zhenyi (1768 - 1797), a famous scientist from the Qing dynasty, she specialized in astronomy, mathematics and poetry. Another remarkable woman was Margherita Hack (1922 - 2013), a scientific and astrophysicist disseminator [3].

I have studied a lot of important women in the STEM area; the first woman I chose was Katie Bouman [11] [12] [13], she is an imaging scientist. She is responsible for the first image of a Black Hole that was taken in 2019. I have chosen her because she is contemporary, and the people that may play the game can consider that this is something from the present.

My second choice was Ann Makosinski [14] [15], from Canada. She is an inventor and an artist. I have chose her because she is young, she was born in 1997 and I think that if the children that play this game have some young female role models, they could have more weight for them to realise that there are and there were a lot of important women in the history of the STEM area.

My third choice were three black woman; Katherine Johnson [6], Dorothy Vaughan [9] and Mary Jackson [8]. The three of them, with other African American female mathematicians formed the West Area Computers [10], a section at the NACA (who will turn NASA [7]) that had a big presence in space travels [16] [17]. Katherine Johnson died at 2020.

There is a long list of women I want to put inside the game, but I couldn't (at least in this version of the game, maybe in the future).

I have interviewed a person in the STEM area, Sasha Sirozh (See complete interview in Appendix A Section). I met her from an interview I saw on Facebook [18] and I contacted her and she gave me an interview. She is doing her doctorate at the CNIO, a laboratory in Madrid, where two-thirds of the people that work there are women, as she emphasized. She devalues the claims that say that women are more prone to dedicate to the Letters areas [29].

I tried to contact other women but they never answered me.

4.1.3   The Art of the video game

After studying about the women I wanted to talk about, it was the moment of studying the way to design the puzzles. I have several sources from art design of puzzles like Professor Layton series (see Figure 4.1), Nintendo Clubhouse Games [41], Mario Party [40], to the Moon [27], etc.

Figure 4.1: Example of a puzzle in Professor Layton and the Pandora's Box

I have presented some women with paintings and other ones with picture (See Figure 4.2). The paintings are made with an Art lineal technical, in Adobe Photoshop,

and then the colour is applied focusing attention on the important parts and decorating others (See Figure 4.3 and Figure 4.4).

Figure 4.2: The three West Area Computer women who worked for the NACA (NASA)

Ann Makosinski was famous because she made a flashlight that worked with the body heat. Taking an eye on this invent, I have decided to make a puzzle about finding the parts of the flashlight. I have divided this invent in three parts, the head (see (a) Figure 4.5), the body (see (b) Figure 4.5), and the tail (see (c) Figure 4.5). There is an edge for the collectables where all the components come together(see (d) Figure 4.5 and See Figure 4.6).

The player moves the 2D character around the labyrinth finding the three parts of the Ann Makosinski invent, the Hollow Flashlight (See Figure 4.7). Once the player has collected all the parts, one of the walls is opened, and an arrow indicates the exit (See Figure 4.8).

The Jigsaw puzzle is formed by a painting of the first picture of the Black Hole that Katie Bouman photographed (See Figure 4.9).

There is a logo at the beginning of the game, it shows my dog, Suc. It is the logo of the game (See Figure 4.10). This logo is designed and drawn by Mario Tormo García.

Finally, the menus are the last part of the 2D art. There is the main menu (See Figure 4.11), where the player can go to the credits screen to see the credits (See Figure 4.12), and the Options Screen, where the player can change the volume, like in the Pause Screen (See Figure 4.13). The pause menu has the volume bar too, but it is in the game.
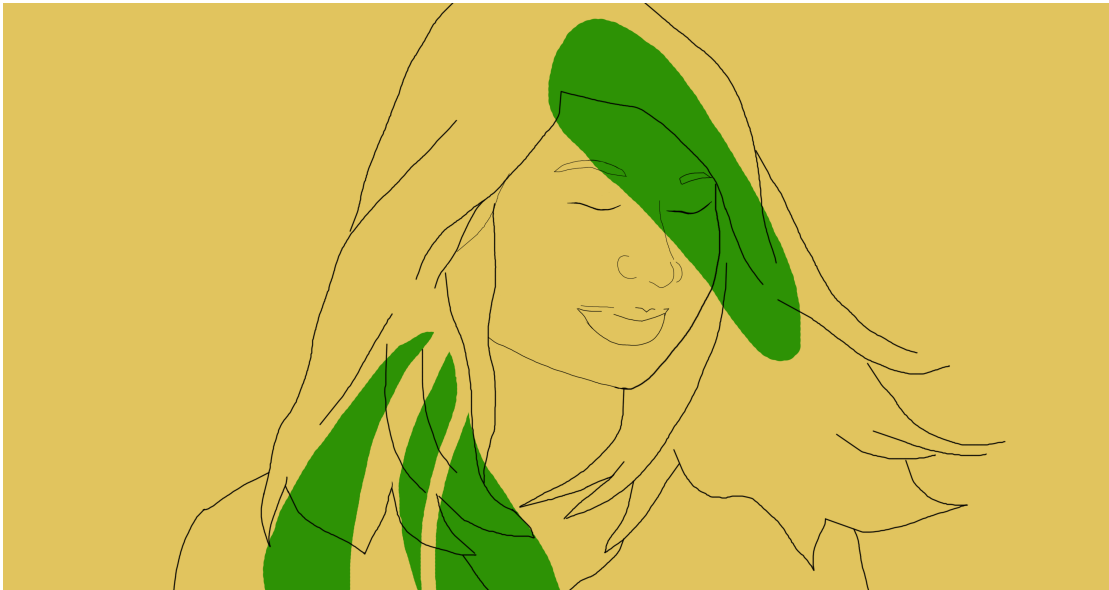
Figure 4.3: Painting presented in the game of Katie Bouman, the first person that took a picture of a Black Hole

4.1.4 The music and sounds of the video game

There are some sounds and music along the video game, I talk about them in this subsection.

On the first hand, there is the music that sounds along the game. There is a song for every scene at the game, the first one is at the Main Menu (this one is chosen to introduce the player to the game, is a quiet song, but, at the same time, this music transmits mystery like other puzzles video game), in the second place there is other for the Main Screen Game. What I tried with this one was to recreate a museum room, so the music the player listens to in this scene is a quiet song, like she was in a real museum. In the third place, for the credits screen and the Options screen, there is a soft song. For all the puzzles the sound that the player listens is the same. It is a playful song. This was made on purpose, because, like other puzzle games, there is a song that sounds in every puzzle and in this way, the player recognizes that he is in a mini-game. Like *The Professor Layton series* [25].

All these songs have been extracted from *patrickdearteaga.com* and modified by me.

On the other hand there are some sounds at the game. When the character walks at the 3D scene, there are two steps sounds in a loop, one behind the other. When the character runs, these to sounds are played faster. The last sound is the sound is found in the labyrinth puzzle, where the player must collect the parts of the flashlight. This sound is activated at this moment, when the player catches any collectable.
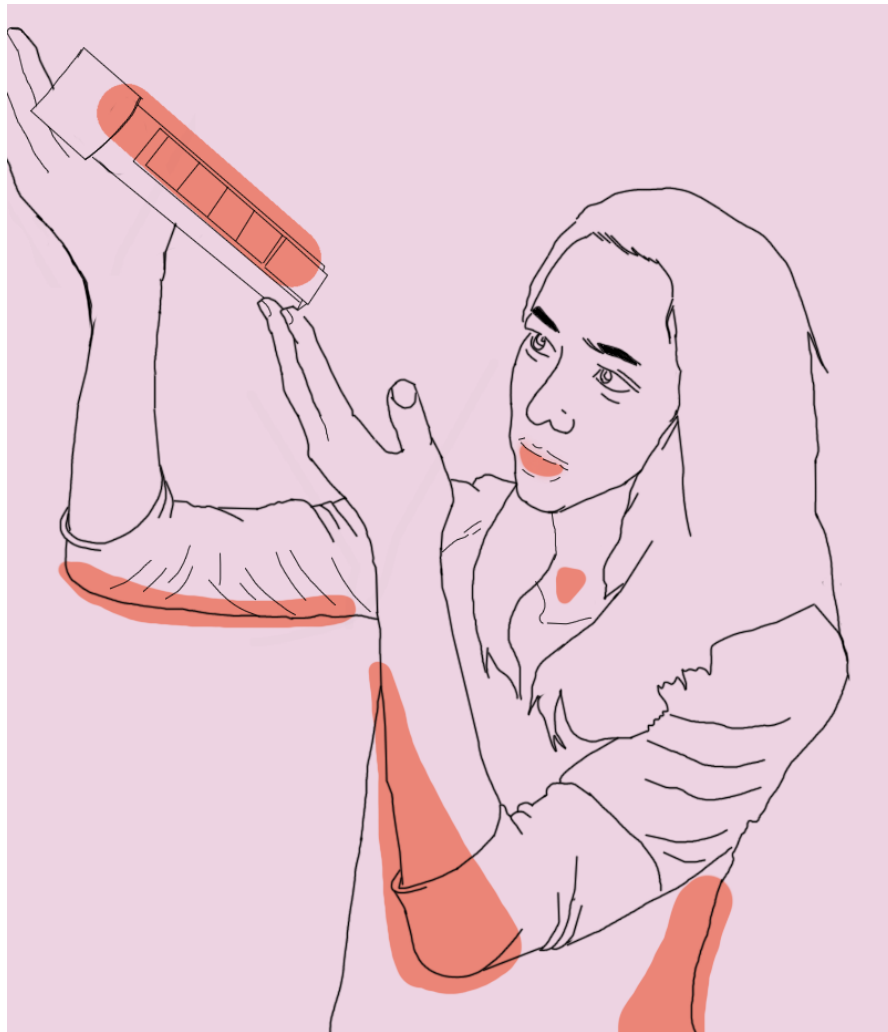
Figure 4.4: Painting presented in the game of Ann Makosinski with her invention, the Hollow Flashlight
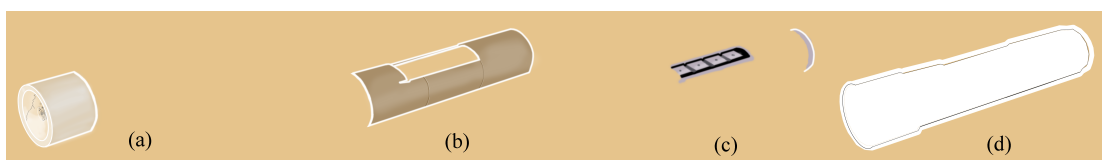
Figure 4.5: The 3 parts of the Flashlight and the edge which unites them
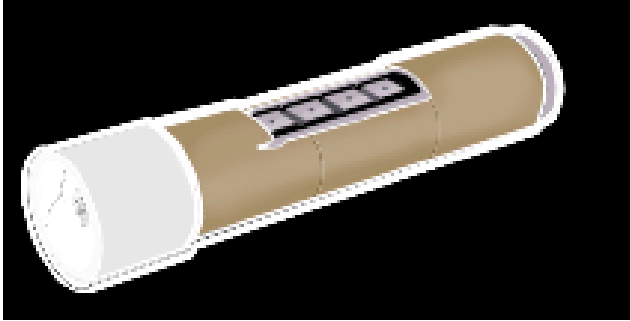
Figure 4.6: The 3 parts of the Flashlight and the edge which unites them, connected
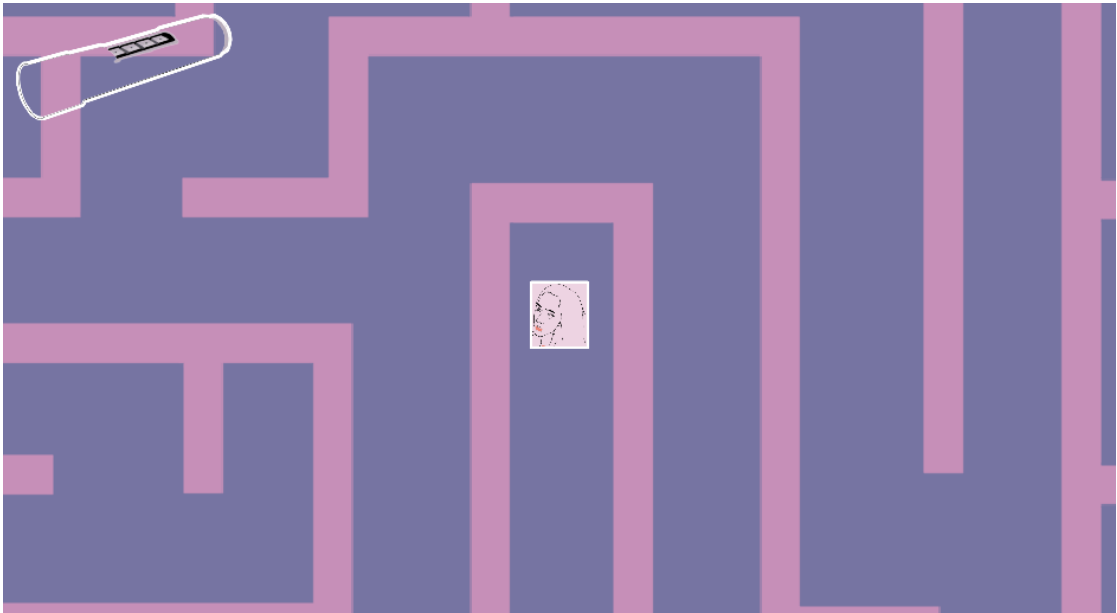
Figure 4.7: Example of the art in the 2D labyrinth
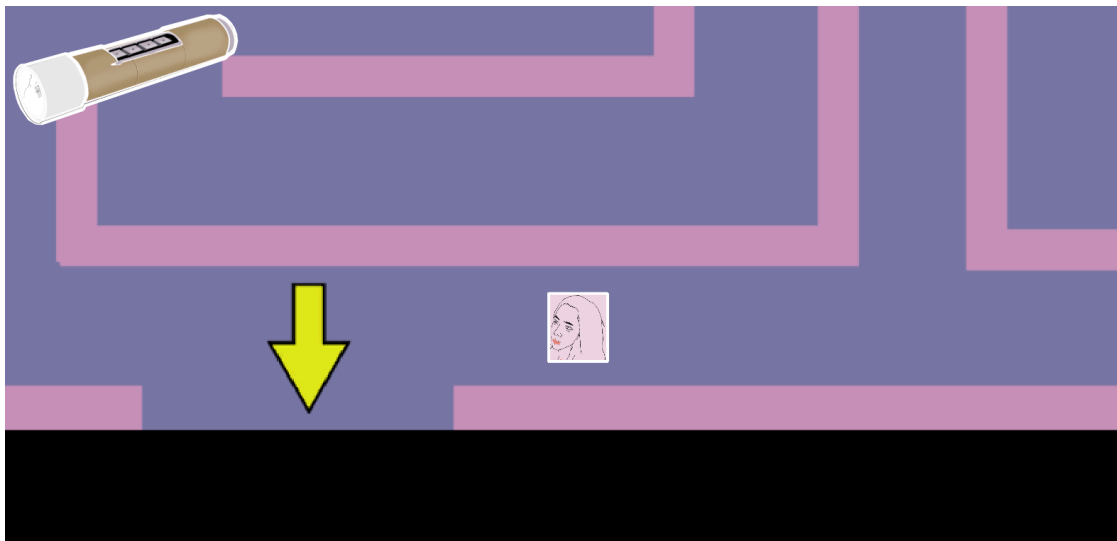
Figure 4.8: Example of the art in the 2D labyrinth, where the player has the three parts of the flashlight and the walls are opened

Figure 4.9: The black Hole that Katie Bouman captured with the Event Horizon Telescope.

Figure 4.10: The logo of the game made by Mario Tormo García.
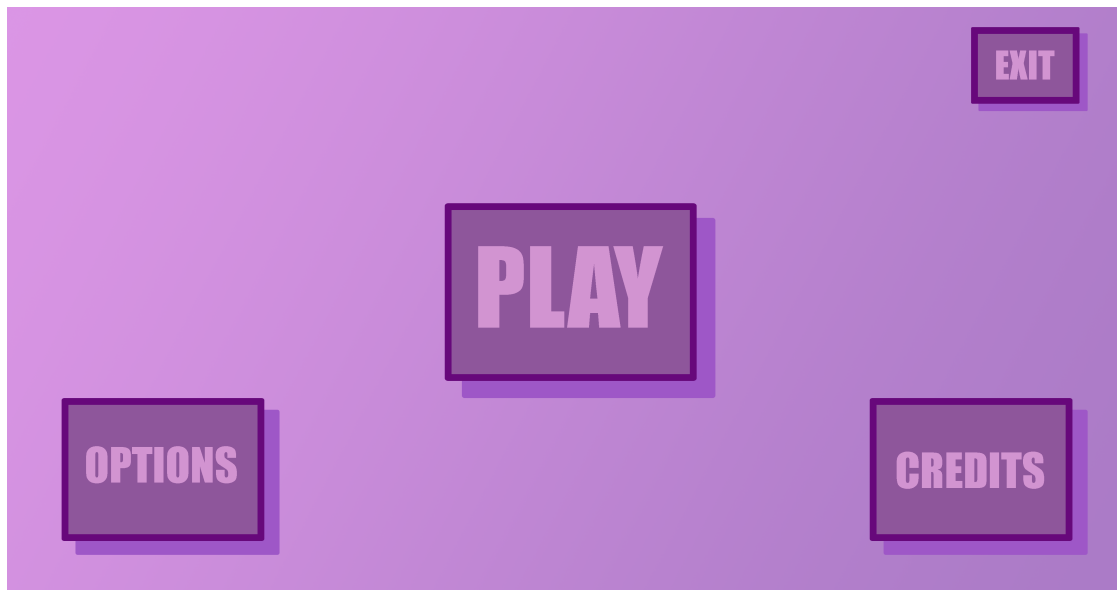
Figure 4.11: The Main Menu of the game
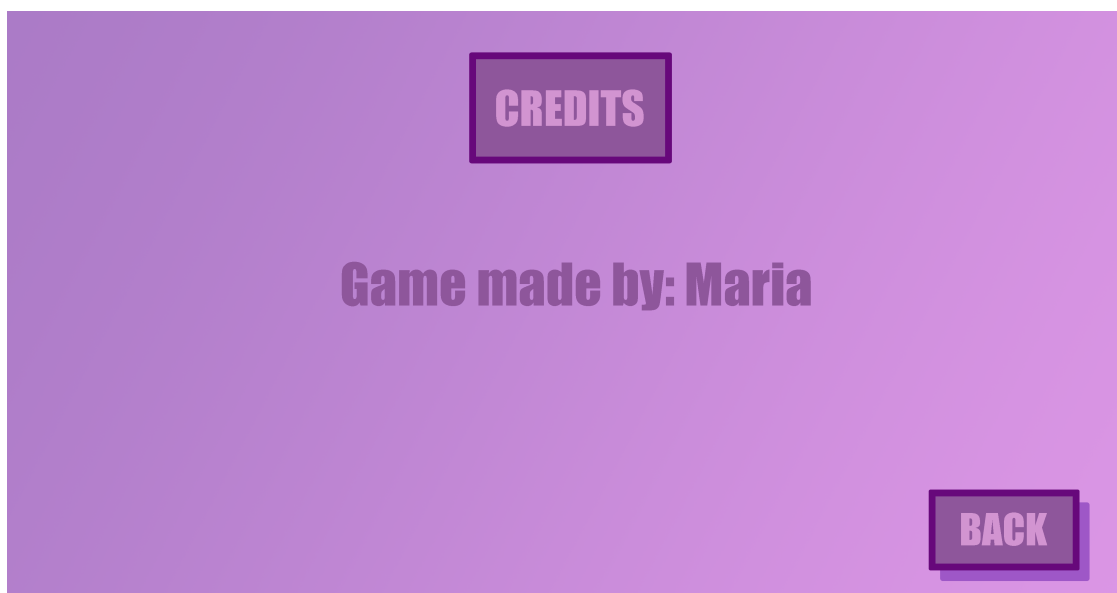
Figure 4.12: The Credits Screen
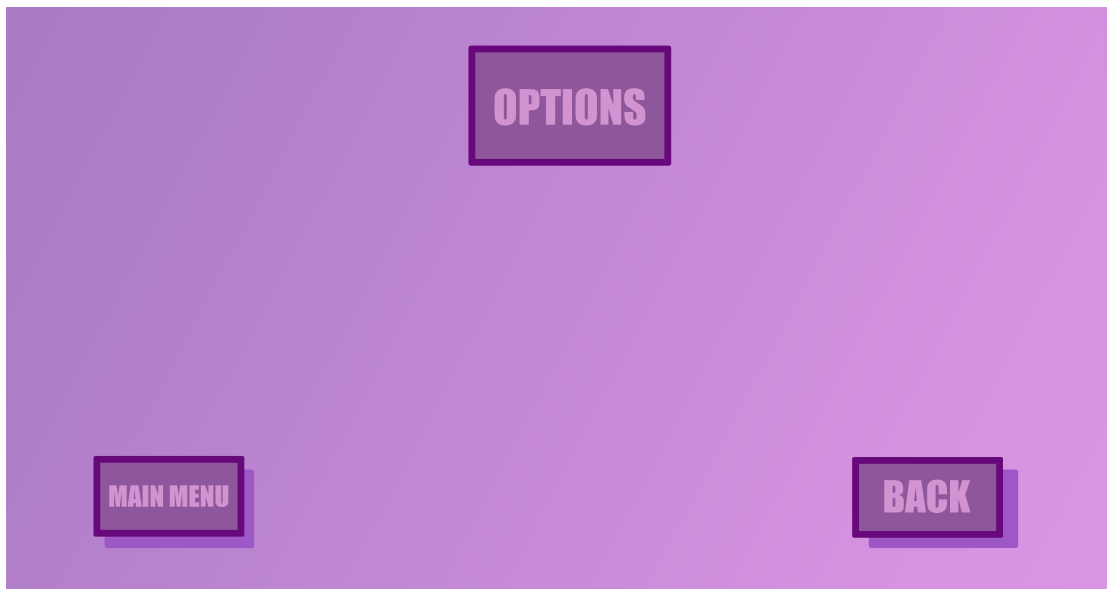
Figure 4.13: The Pause menu

4.1.5 The programming of the video game

I used two scripts for the camera, one of them for the 3D camera and the other for the 2D camera, and two for the controller of the player, the first for the movement of the player at the 3D scene and the other for the movement of the player at the 2D labyrinth, where he must find the collectables. One script for the Collectables themselves. Another script was used for the HUD of the 2D labyrinth. One script for the management of the buttons, and two of them for the pictures and the collisions with the character and the texts. Another script for the manager of the first text that the main game scene shows. The last one was for the volume manager. And a *GlobalData script* to declare the global variables and use them along the project.

In this section I talk about the important parts of the programming of the video game.

I would like to highlight the Programming part of the jigsaw puzzle when the pieces are relocated in a random way and the animations of the labyrinth puzzle.

The first one is made with some methods where the game checks that the player makes a movement of the pieces (See OnPieceClick method at Figure 4.1.5), and, if it is a valid movement, then the game carries it out and move the pieces (See movePieces method at Figure 4.1.5). After that is checked if the player has win the game (See ComprobarVictoria method at Figure 4.1.5), and, if it is not, the execution of the game keeps going (See comprobarMovimientoValido method at Figure 4.1.5). The *CambiarPiezas* method is a method where the game exchanges one piece for another (See CambiarPiezas method at Figure 4.1.5).

OnPieceClick Method

```
1     public void OnPieceClick(Image myImage)
2     {
3         if (myImage.color != hiddenColor)
4         {
5             pieceToMove = myImage;
6             posicionPiezaActual = POSICIONES_PIEZAS[piecesMatrix.IndexOf(myImage)];
7                                                             //Actual Position
8         }
9         else
10        {
11            if(pieceToMove != null)
12            {
13                MovePieces();
14            }
15        }
16    }
17 }
```

MovePieces Method

```
1     void MovePieces()
2     {
3         bool cambioPermitido = ComprobarMovimientoValido(posicionPiezaActual);
4
5         if (cambioPermitido)
6         {
7             contadorMovimientos++;
8             TextoMovimientos.text = "Movimientos:␣" + contadorMovimientos;
9
10            CambiarPiezas(pieceToMove, piecesMatrix[hiddenPieceIndex]);
11
12            pieceToMove = null;
13
14            ComprobarVictoria();
15
16        }
17    }
18 }
```

ComprobarMovimientoValido Method

```
1     bool ComprobarMovimientoValido(Vector2Int posicionPiezaActual)
2     {
3
4         bool cambioPermitido = true;
5
6         if (posicionPiezaActual.x == posicionHueco.x &&
7                         Mathf.Abs(posicionPiezaActual.y - posicionHueco.y) > 1)
```

```
 8            {
 9                cambioPermitido = false;
10            }
11            else if (posicionPiezaActual.y == posicionHueco.y &&
12                             Mathf.Abs(posicionPiezaActual.x - posicionHueco.x) > 1)
13            {
14                cambioPermitido = false;
15            }
16            else if (posicionPiezaActual.x != posicionHueco.x &&
17                             posicionPiezaActual.y != posicionHueco.y)
18            {
19                cambioPermitido = false;
20            }
21
22            return cambioPermitido;
23        }
24 }
```

ComprobarVictoria Method

```
 1     void ComprobarVictoria()
 2     {
 3         bool victoria = true;
 4
 5         for(int i = 0; i < piecesMatrix.Count; i++)
 6         {
 7             if("" + i != piecesMatrix[i].name)
 8             {
 9                 victoria = false;
10                 break;
11             }
12         }
13
14         if(victoria == true)
15         {
16
17             piecesMatrix[hiddenPieceIndex].color = Color.white;
18             //print("Has ganado");
19         }
20     }
21 }
```

CambiarPiezas Method

```
 1     void CambiarPiezas(Image a, Image b)
 2     {
 3         int IndexPieceA = piecesMatrix.IndexOf(a); //Sacamos su índice
 4         int IndexPieceB = piecesMatrix.IndexOf(b); //Sacamos su índice
 5
 6         Vector3 nuevaPosicionFichaA = piecesMatrix[IndexPieceB].transform.position;
```

```
7          Vector3 nuevaPosicionFichaB = piecesMatrix[IndexPieceA].transform.position;
8
9          piecesMatrix[IndexPieceA].transform.position = nuevaPosicionFichaA;
10         piecesMatrix[IndexPieceB].transform.position = nuevaPosicionFichaB;
11
12         Image aux = piecesMatrix[IndexPieceA];
13         piecesMatrix[IndexPieceA] = piecesMatrix[IndexPieceB];
14         piecesMatrix[IndexPieceB] = aux;
15
16         if(a.color == hiddenColor)
17         {
18             hiddenPieceIndex = piecesMatrix.IndexOf(a);
19             posicionHueco = POSICIONES_PIEZAS[hiddenPieceIndex];
20         }
21         else if (b.color == hiddenColor)
22         {
23             hiddenPieceIndex = piecesMatrix.IndexOf(b);
24             posicionHueco = POSICIONES_PIEZAS[hiddenPieceIndex];
25         }
26     }
27 }
```

The class keeps the initial positions of the pieces. Then, It is called the *Barajar* method (See Barajar method at Figure 4.1.5), who shuffles the pieces. And, for every movement made by the player, it is checked if the puzzle is solved(See ComprobarVictoria method at Figure 4.1.5).

Barajar Method

```
1      void Barajar()
2      {
3
4          int aleatorio;
5          int numeroDeMezclas = 1000;
6          int mezclasLlevadas = 0;
7
8
9          while(mezclasLlevadas < numeroDeMezclas) //Con esto aseguramos que hace 50 movimientos
10         //for (int i = 0; i < numeroDeMezclas; i++) //50 bucles, pero no necesariamente cambios
11         {
12             aleatorio = UnityEngine.Random.Range(0, piecesMatrix.Count);
13
14             if (ComprobarMovimientoValido(POSICIONES_PIEZAS[aleatorio]))
15             {
16                 CambiarPiezas(piecesMatrix[aleatorio], piecesMatrix[hiddenPieceIndex]);
17                 mezclasLlevadas++;
18             }
19         }
20     }
21 }
```

The second one is the class where the collectables are caught and stored (See Collectable Class at Figure 4.1.5). When the character collisions with a part of the Flashlight, an animation is started and it is assemble in its site.

Collectable Class

```csharp
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public enum CollectableEnum { FlashlightPart = 0}

public class Collectable : MonoBehaviour
{
    public CollectableEnum MyCollectable;
    public AudioClip CatchedSound;
    public int CollectableIndex;

    private bool catched = false;
    private AudioSource myAudioSource;


    // Start is called before the first frame update
    void Start()
    {
        myAudioSource = GetComponent<AudioSource>();
    }

    private void OnTriggerEnter2D(Collider2D collision)
    {
        if(collision.tag == "Player" && !catched)
        {
            catched = true;
            switch (MyCollectable)
            {
                case CollectableEnum.FlashlightPart:
                    HUDLabyrinth.Instance.ShowAnimationFlashlightPart((FlashlightParts)CollectableIndex);
                    break;
            }
            StartCoroutine(catchCollectable());
        }
    }

    IEnumerator catchCollectable()
    {
        Vector3 ANIMATION_SCALING_SPEED = new Vector3(1, 1, 0) * 1f;
        bool disappear = true;

        myAudioSource.PlayOneShot(CatchedSound);

        while(disappear)
        {
            transform.localScale -= ANIMATION_SCALING_SPEED * Time.fixedDeltaTime;
            if (transform.localScale.x < 0)
            {
                transform.localScale = Vector3.zero;
                disappear = false;
            }

```

```
54              yield return new WaitForFixedUpdate();
55          }
56          Destroy(gameObject);
57      }
58 }
59 }
```

4.2   Results

The result of the work is a functional game with an educational and informative message about some women from the STEM area.

The 3D scenario is the main game screen, where the player will move and search, discover and learn about these women in the STEM area. The player can tour the stage in a free way, there is not an specific order to know about them. While the player is touring the scene, she will see some pictures and paintings and some puzzles are hidden in some of the pictures or the paintings.

In every puzzle the player has to meet the goals that the puzzle itself proposes. The mechanics are oriented to a young public, but it can be played by an older public with the same objectives, to learn about these interesting and invisible women along the history.

The game can be expanded with more information about other women, so it could be an infinite game, only limited by the information collected along the history and the physical requirements of the device where the game is executed.

Only my closest circle have played the game. This fact caused a deficiency of feedback. In a future versions of the game, my intention is to give it to several more people (As I explain more widely in the "Future work" subsection), so they can play it, and acquire more feedback. The people who have tested it agree that the main goals are exceeded. The work is an intuitive and playful game.

Here is the link to the build of the game in Google Drive: `https://drive.google.com/drive/folders/1M82CcE48zFBw0Nsm-pahrTysatJ6-wCW?usp=sharing`

Here is the link to the repository of the game in GitHub: `https://github.com/al315233/TFG`

Conclusions and Future Work

Contents

This chapter details about the conclusion of the work, as well as its future extensions.

5.1 Conclusions

Developing the game I realized that I had the adequate skills acquired thanks to the degree because I have not noticed deficiencies and any shortcomings when developing the project. I also have added a lot of knowledge to what I already knew, like knowing much fluidly Unity 3D, or learn to use LaTex from scratch.

Maybe the only deficiency that I have noticed has been while developing the technical document. We have not had to develop many technical documents throughout the degree and, writing this one, I realized that it had limitations and made some mistakes.

Also I did not study the "Foundations for Educational Video Game Design" subject but now I think maybe it would have been a good idea, because I could apply that knowledge to the development of this project (because this is an educational video game).

I think, this project may be useful both for undergraduate students (Bachelor's Thesis students), and for people interested in not necessarily recreational video games.It is the proof that there is also space for Serious Video Games.

It may be useful to museums or schools, because it is an open game, it can be played by two or more players one after the other and there is no need to close the game. And there are some puzzles to motivate the younger players.

The design and development of this game have resulted an enriching experience. In the process of making the game I met many more women than I thought. There were some invents or knowledge I had, but there was not any *name*. And now, there are many more interesting, strong, independent, fighter women at my head than I could imagine, and this fact points to the need for the development of this application. One of my goals was this, to demonstrate that there have been (and there are) women in the STEM area since there have been men.

I would have liked to make the game larger: more puzzles, more women. I feel that there are many important and interesting women that have been left out, and I wish I have more time to expand the game.

The moment when this game has been developed was a sad moment for everyone, in the quarantine. It was a gray moment for me, seeing the social situation. Some days were difficult. But, in general, with the idea of the work and its development I could not have been more pleased and comfortable.

5.2   Future work

My objectives for the future of the game are, mostly, that the people who play it, learn about these women in STEM in a easy and friendly way, so I have to bring the game to much more people than my immediate circle. And then pass them a questionnaire to know what they think and apply their opinions to the develop of the game.

I want to extend the game and keep investigating about some other women, I know I did not have enough time to learn about all the women I wanted to, but there have been left so many women out of this work, that I would like to amplify this work and show and teach about how important women have been along the history.

When the game becomes larger I would like to contact with some schools and introduce the game in some of the classes or like an extracurricular activity, if it is interesting for any person that would like the idea and wants to try the application.

This work would be a good starting point for finding a job like a programmer or like a conceptual designer, that would be my ideal jobs in the future.

I hope that someday, someone will realize, with this project, as I have done developing it, the number of important women there have been in history.

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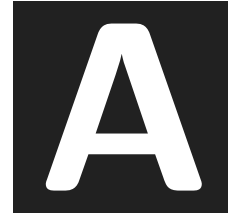
OTHER CONSIDERATIONS

In this appendix I reproduce the interview I made to Sasha Sirozh on the 5th of May of 2020

A.1 Interview to Sasha Sirozh

I made an interview to Sasha Sirozh, which I present here:

Date: Tuesday, May 05th, 2020

Maria del Olmo*: Could you introduce yourself?*

Sasha Sirozh: Hello, my name is Sasha Sirozh, I am 27 years old and at present I am doing the doctorate at the National Cancer Research Center (Centro Nacional de Investigaciones Oncológicas (CNIO)) at Madrid. I am working as investigator and at the same time I am working in my doctorate.

Maria del Olmo*: Where were you born?*

Sasha Sirozh: I was born at Ukraine but I have Spanish nationality. At the age of 9 I moved to Jávea, Valencia. To do my degree I moved to Valencia, where I did my Biotechnology degree at UPV (Polytechnic University of Valencia) and for my doctorate I moved to Madrid. I also did the Master in *Biomolecules and Brain Dynamics* in Madrid, at the Autonomous University.

Maria del Olmo: How did you start in science and why did you choose that branch?

Sasha Sirozh: At first I really liked Arts and wanted to go for the Fashion Design branch but, in ESO, the sciences got more serious and I was good at them. Since I was good at science but in a very broad sense, I was changing my career until I found one that I really liked.

Maria del Olmo:What is your job focus right now or the last one you have had?

Sasha Sirozh: The laboratory is dedicated to Neuroscience and I specialize with amyotrophic lateral sclerosis, in the most common mutation. I am developing a mouse model to study it and test the treatments.

Maria del Olmo: Have you ever noticed the glass ceiling when looking for a job? If so, how have you dealt with it?

Sasha Sirozh: In my personal experience, the answer is no. It is also because I work in a place where most of us are women and also I have just started in my professional career. But I have seen these thing in other women, such as the women directors and others who have been in the field the longest. For example, the director's husband is told about science, but not despite dedicating herself to the same. Or the distribution of household chores, motherhood, etc. Also keep in mind that I am in the field of health and biology. In technological sciences like Mathematics and Engineering you see these things more because there are many more men than women.

Maria del Olmo: Have you ever heard comments to you about being a woman in the scientific field?

Sasha Sirozh: Above all they (men) have been surprised that I am a scientist and there are even people who have not believed it.

Maria del Olmo: People who inspire you and who have been important references in your life to feel able to study what you wanted to study and do what you wanted to do.

Sasha Sirozh: I thought in that question because on the one hand I thank very much my mother because she is the one who has always encouraged me to be who I am and do whatever I want to do. She is a hairdresser. But on the other hand, regarding female scientific role models I have not had any, perhaps except, maybe, Marie Curie, and it was very little. But I am sure that we would be many more if there were more visibility than other female role models. You do not get that thought that you have with actresses of "when I grow up I want to be like her" especially in the scientific field, and this is where the Matilda Effect comes in, women are not well-known, they are more exalted contributions from fellow men, etc.

Maria del Olmo*: What hobbies or other fields that are not necessarily scientific do you interest, inspire or enjoy?*

Sasha Sirozh: I am a restless person, I do not have time to do everything I would like to. I love photography, drawing and painting. I read a lot, do martial arts, write for a music blog. I love it, I take a project and I give everything.

Maria del Olmo*: If you had not been a scientist, what else would you have liked to study?*

Sasha Sirozh: My frustrated career per se is Arts, I would have liked to study it and I do not rule out doing it.

Maria del Olmo*: Would you say that science has suffered?*

Sasha Sirozh: Overmuch, hahahaha, you have to like it because it is a lot of work, very little appreciated and, very poorly paid hahahahaha. In addition there are all those people who watch 4 videos and already think they are experts, they are against you in every way they can.

Maria del Olmo*: Thank you very much for participating and I wish the quarantine is as pleasant as possible.*

Sasha Sirozh: It was a pleasure.

A.2   Credits

Credits to Patrick de Arteaga (*patrickdearteaga.com*) for the music of this project.

Credits to Mario Tormo García (*https://www.instagram.com/mariotormo/*) for the logo for this project.

Source code

GlobalData Script

```
1
2  using System.Collections;
3  using System.Collections.Generic;
4  using System.Security.Policy;
5  using UnityEngine;
6
7  public class GlobalData : MonoBehaviour
8  {
9      public static float GameVolume = 1f;
10
11     public static List<string> LevelsWithCursor =
12                    new List<string> (new string[] { JIGSAWPUZZLE_SCENE_KEY });
13
14     public const string LABYRINTH_SCENE_KEY = "puzzle1";
15     public const string CREDITSSCREEN_SCENE_KEY = "CreditsScene";
16     public const string FIRSTMENU_SCENE_KEY = "FirstMenu";
17     public const string OPTIONSCREEN_SCENE_KEY = "OptionScreen";
18     public const string PAUSESCREEN_SCENE_KEY = "PauseScreen";
19     public const string JIGSAWPUZZLE_SCENE_KEY = "puzzle2.3";
20     public const string MUSEUM_SCENE_KEY = "scene1";
21
22     public static bool GamePaused;
23 }
```

The GlobalData Script (See Figure B) is used for cleaning the code of all the project, with it, the global variables are declared in one script. This variables are ready to be used in the rest of the document. At the ButtonsController Script there are some examples, to every scene variable used, the name is replaced for a call to the GlobalData Script

(See Figure B).

ButtonsController Script

```
1
2  using System.Collections;
3  using System.Collections.Generic;
4  using UnityEngine;
5  using UnityEngine.SceneManagement;
6
7  public class ButtonsController : MonoBehaviour
8  {
9      public void PlayGame()
10     {
11         //Debug.Log("has play");
12         SceneManager.LoadScene(GlobalData.MUSEUM_SCENE_KEY);
13     }
14
15     public void ShowCredits()
16     {
17         //Debug.Log("Credits");
18         SceneManager.LoadScene(GlobalData.CREDITSSCREEN_SCENE_KEY);
19     }
20
21     public void ShowOptions()
22     {
23         //Debug.Log("Options");
24         SceneManager.LoadScene(GlobalData.OPTIONSCREEN_SCENE_KEY);
25     }
26
27     public void QuitGame()
28     {
29         //Debug.Log("has quit the game");
30         Application.Quit();
31     }
32
33     public void BackButton() //Volver a la pantalla de título desde créditos
34     {
35         //Debug.Log("Back Button pressed");
36         SceneManager.LoadScene(GlobalData.FIRSTMENU_SCENE_KEY);
37     }
38 }
39 }
```