CREATION OF A VIRTUAL REALITY EXPERIENCE FOR THE VIRTUAL CONSERVATION OF THE FLAMMAN THEATER USING UNREAL ENGINE 4

Explore techniques of video game design and immersive VR technology in Unreal Engine to preserve the Flamman cinema with game elements

Master's thesis in Computer Science and Engineering for a degree in Game Design and Technologies, MSc. Starting on 18th of January, 2022.

FAUSTO IVAN ZAMORA ARIAS
guszamfa@student.gu.se
faucar93@gmail.com

Thommy Eriksson
Academic Supervisor
thommy@chalmers.se

Department of Computer Science and Engineering
CHALMERS UNIVERSITY OF TECHNOLOGY
UNIVERSITY OF GOTHENBURG
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MASTER'S THESIS 2022

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Supervisor: Thommy Eriksson, Department of Interaction Design, Department of Computer and Information Technology
Examiner: Staffan Björk, Department of Interaction Design, Department of Computer and Information Technology

Master's Thesis 2022
Department of Computer Science and Engineering
Chalmers University of Technology and University of Gothenburg
SE-412 96 Gothenburg
Telephone +46 31 772 10

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ABSTRACT

The Flamman Theater identity was successfully digitally preserved for the cultural heritage of Gothenburg by creating a video game, while tested with pandemic restrictions. On the technical side, this project combines virtual reality, artificial intelligence and game mechanics to create an immersive atmosphere, inviting people to watch movies inside as the original theater was intended. Virtual reality makes a memorable experience for the player by allowing an interaction with the digital environment with grabbable objects. With the aid of artificial intelligence, the player is surrounded by Non-Player Characters (NPCs) walking around. In addition to that, the game mechanics allow the player to live the theater experience with textures where the movie is projected and spatial sound that changes the intensity of the sound depending on the distance from the speakers to the player. All the mentioned above were developed using Unreal Engine 4 (UE4) because it has capabilities to develop and play in real time virtual reality environments, artificial intelligence, interaction with human interface devices such as Oculus Quest 2, furthermore UE4 provides tools to prototype the already mentioned features without programming them from scratch therefore saving development time. On the other hand, the testing of the mentioned above required the creation of a new methodology based on the think aloud technique and the restrictions of the COVID 19 pandemic.

Keywords: virtual reality, Oculus Quest 2, preserving cultural heritage, Unreal Engine 4, game design and development.

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Fausto Ivan Zamora Arias

1. INTRODUCTION

Nowadays the Flamman Theater is no longer a place where people can see movies, eat popcorn and spend leisure time with family and friends because over time its original identity has been undermined by changing the purpose of the building and its interior several times, putting the original identity at risk. It is of great importance to the city's patrimony to maintain its architectural figure alive and restore it as close to its past glory as possible. But how can a movie theater be preserved with the current technology? The answer to that was to create a video game containing the Flamman theater as the main attraction that invites people to watch movies inside, as the original theater was made for.

This process is the result of the application of cultural heritage preservation techniques in digital media fashion. In this manner, people can immersively experience the Flaman Theater's genuine identity in a modern digital context, recreating the theater in a virtual reality to see movies as it was formerly intended in 1935, but adding elements like game mechanics and non-Player characters (NPCs) in order to make the experience more delightful. Nevertheless, a formal approach to the construction of the virtual world is looking at it as a game development project where game design theory could be used as a framework for the creation of a main design. Therefore, in this section and the following ones of the document, I will refer to the project as the game.

The game development followed four consecutive points and looped over its two last points until the game looked and felt good to play. The first one is the core game design definitions (game mechanics, aesthetics and dynamics), the development of a virtual world (level design), the collection of user information (testing) and the interpretation of the feedback to enhance the game (improvement). In this regard, the testing is important to understand if the development is complying with the core game design and/or understand if the core design is not working for the players (not fun to play or boring), the refinement process had to address potential issues in the design or development then return to the testing phase once they are done.

2. PROJECT AIM

To achieve the digital preservation of the Flamman Theater, this project ought to recreate the digital identity through the concepts of video game design, virtual reality and artificial intelligence, trying to mainly concern its architecture and use, and at the same time try to replicate the same aesthetics that a physical cinema offers. Furthermore, to create the virtual reality experience, various video game design theories had been used to test its feasibility to describe the experience of going to a movie theater in detail for development as a video game.

The problem is that (many) closed down cinema theaters cannot be experienced anymore.

However, with the VR technology, the possibility is given to recreate the cinema room and partially recreate the experience of going to see a movie in that particular cinema theater. Nevertheless, the currently available virtual reality cinema applications are focused on the young target group as they are considered to have access to VR headsets [15]. Adjusted to their needs, the visualization and aesthetics of those cinema simulations are focused on providing the experience of being in modern, futuristic, and fictional environments.

However, different target groups may be seeking for the experience of traveling back into the past, and virtually explore the once existent and historic cinema theaters that are now no longer accessible to the public. Utilizing the photographic documentation, I proposed the virtual reconstruction of the Flamman cinema theatre building of Gothenburg along with a recreation of the atmosphere that is set in the decade of the 50's. Our secondary goal is to provide engagement to the users by enriching the simulation with highly plausible loyalty to the game world. Thereby, they would be able to fully explore the interior, see and have cultural conversation with each other, purchase tickets from the cashier and sit in the cinema auditorium. Other than that, I would experiment the possibility of in-building some level of gamification regarding character needs, thus the user's avatar would have basic needs such as hunger and thirstiness.

2.1. Objectives

The main goal is to create a proof-of-concept VR reconstruction of the Flamman cinema experience.

Sub-goal 1: Recreate the digital identity through the concepts of video game design

Sub-goal 2: Possibility to watch a movie on the big screen using a locally stored video file, and/or YouTube movies

Sub-goal 3: Create a game with a mixture of game design theorical elements

2.2. Research Questions

As mentioned above, the experience of the target building was marvelous at that period, that is why the two research questions have been focused on reviving this vintage experience. First, it was important to determine the parts of the cinema experience that were feasible to reconstruct, in addition to the type of technology to map the cinema environment in three dimensions. Second, it was required to adapt the think aloud technique when testing the game, to measure how similar the cinema experience of the project was compared to the real cinema built, taking into consideration the COVID-19 physical interaction restrictions.

RQ 1: What could be successful to have in a theater experience with VR?

RQ 2: How to use the think aloud testing technique during pandemic times with capacity restriction measures and isolation recommendations?

2.3. Expected Results

Create a functional replica, as a prototype, of the experience of exploring the Flamman theater with VR using Unreal Engine, with immersive elements (mechanics, dynamics or aesthetics) for the user. Immersive elements mentioned can be artificial intelligence or multiplayer capabilities. For AI capabilities I used the Unreal Engine AI framework that offers great tools to design and implement game AI logic. Meanwhile, to test the prototype with the think aloud technique, which would have to accommodate to the COVID 19 restrictions.

3. BACKGROUND AND THEORY

A hybrid model, based on four elements: game mechanics, game dynamics and aesthetics, the GNS model and gameplay design patterns, was chosen because I wanted to experiment with several points of view for the Flamman theater. For instance, game Mechanics helps the programmer to describe the mechanics as if they were methods. MDA framework for game dynamics and aesthetics are based on the game mechanics by Sicart. Dynamics is the connection between mechanics in order to feel the aesthetics, whereas the aesthetics helps to guide the player's feelings, a clear goal of the product. Moreover, GNS describes the player modes (by gameplay, narrative or simulation) to understand more the player's experience and feeling (more simulationism approach and gamism mode). The design aims to make the players feel like playing the game at an ideal point of experience (referred to as modes). Gameplay helps design patterns to express dynamics, feelings and express the design simpler when describing technical terminology. Finally, level design theory the base because of its use in 3D video games development.

To prepare the reader for the topics that the project has had to deal with for its development, the theoretical bases and related works are presented in this section. Such concepts are relevant to understand better the decisions seen in the development and result sections. These topics are divided into: the theory behind the design to be used in the project, the aesthetics that the project would need to aim, the virtual reality basic concepts, game AI concepts, digital preservation foundations and game engine technical notions.

3.1. Game Design Theory

This section describes all the definitions required of game design and science to develop the basic ideas of the project.

3.1.1. Game Mechanics

Game mechanics are one of the bases used to describe how a game works, but its concept varies according to authors as they can refer to game components, actions, goals or compounds of the aforementioned. Therefore, it is necessary to have a clear definition with which to speak of mechanisms for the development of this document. The definition to be used in this document is Sicart's which defines mechanisms as methods invoked by agents, and these methods are designed to interact with the state of the game, which also can be seen as verbs that would translate easier into computer methods (2008). In other words, the mechanics that will be used in this document refer to the actions that can be taken in a game as verbs or functions, which also as a personal opinion is easier to translate to code when development is initiated.

3.1.2. Game Dynamics and Aesthetics

While mechanics are a great way to describe what a game could look like there are more things to consider when designing a video game experience, therefore tools such the MDA framework (Hunicke et al, 2004) helps to clarify the target design to a granular understanding so it is easier to develop, game research and game analysis. Therefore, it is needed so the reader could understand some vocabulary and decisions presented on the development process on this project.

The MDA framework divides a game into mechanics, dynamics and aesthetics, nevertheless, I will be referring as mechanics to the concept presented on section 3.1.1 since it is easier to describe mechanics as verbs than algorithms. On the other hand, dynamics are needed to describe a relation between the mechanics, the player's input and aesthetics that "describe the emotional responses evoked in the player when he interacts with the game" (Hunicke et al, 2004).

On the other hand, aesthetics describes the emotional responses evoked in the player when he interacts with the game, such as the feelings that a player would experiment during a play session, in my opinion, aesthetics is key to the design of a game as they give a guide for the development of the mechanics since they can be refined so that they fit the desired aesthetics. Which could also help to set design goals for a particular mechanic on a video game, for example, setting a mechanic of shooting to make a player feel the intensity as closer as a real war experience.

3.1.3. Movie Theater Experience Aesthetics

The experience of watching a movie in a cinema needs to be understood so it can be replicated as game aesthetics in game environments with players. According to Aurier and Guitcheva, the emotions felt by people while watching a movie at the cinema follow the flow of the film's story. For example, several strong emotions can be seen in key moments of tension or suspense, and in the same way, if there are sad scenes, the viewer

can feel those emotions. However, according to Fröber and Thomaschke, these strong emotions can only be fully appreciated when viewed in the context of the cinema theater and not in the living room of a house, as the feeling of boredom is increased (2019).

These emotions are well documented in numerous studies (such as the one made by Aurier and Guitcheva, 2015, and Fröber & Thomaschke, 2019) but the ones that appear the most are joy and sadness, of course depending on the movie and scene.

Thus, in my opinion, a way that one could demonstrate that a player is actually engaged emotionally during a movie reproduction in a virtual environment would be by analyzing the player's emotions on key time points while watching a film in the virtual reality theater (Aurier & Guintcheva, 2015).

3.1.4. GNS model

Although aesthetics is a great way to understand how a player would feel while experiencing a game system, I am convinced think that it is not enough to start with the elaboration of the design of the experience to be proposed in this project. I believe that focusing on how the player should experience the game is necessary for the game to fulfill its design goal (how the game will be experienced with players). To achieve this, I had decided to extend the aesthetics with a role play game emphasis as well. In this sense the GNS model gives some definitions that help in the aesthetics descriptions.

Although the GNS model was created to describe how players would emphasize their goals during gameplay (Edwards, 2001), for this project the GNS enriches the aesthetic goal of the design by adding its modes (GNS's player goals descriptions) to each desired feeling during gameplay. Specifically, GNS divides players' goals in three modes: Gamism: players focus on competition and playing to achieve in-game goals, Simulationism: focuses on exploration and simulating a character following the game theme; and Narrativism: player focuses on getting as much of the story as possible (Edwards, 2001).

3.1.5. Gameplay Design Patterns

Game design is an area that requires theory and technique for the creation of games, this theory is covered with game science that expands with concepts such as mechanics, game dynamics, game aesthetics, game patterns and level design (specifically for video games). As this paper is focused on the development of a video game, the theoretical concepts of game design will be used to describe its development taking into account that the player will interact with an interface with a computer.

3.1.6. Level Design

In order to have a clear understanding on the development of the game world in which the Flamman theater is going to be placed, it is needed to understand how this can be achieved with level design theory.

Level design can be described as the action of implementing the gameplay, organizing the mechanics, rules and assets (3D models for example) into an interactive, readable and playable space defined as the level (Phazero, 2019). Nevertheless, level design can be divided into different steps which Phazero lists as: Level concepts and maps: a description of the level which can include story and intents with reference images whitebox prototype or just a described description; Blocks out level geometry: creation of the level using low level geometry; script and codes: programming, on a high level fashion, gameplay events of the level; runs play test and iterates: testing session and improvements by users' feedback; and creation of environment art: assemble the final art and models to the level.

3.2. Virtual Reality Theory

Lately, the concept of virtual reality (VR) is used to refer colloquially to all experiences that use virtual reality head-mounted displays. However, technically virtual reality is a way of experiencing a virtual environment in such a way that users can be immersed in the experience, which unlike human-computer digital experiences such as computer video games on PC. VR involves the user in such a way that the concentration falls entirely on a virtual world. To further explain the experience of virtual reality it is necessary to understand immersion and the sense of embodiment since VR experiences can be described with those definitions. According to Zhang, immersion is a complex phenomenon that demands neuro-physiological involvement such as perception, attention and emotion. Nevertheless Nillsson et al. define it as a property of the system (game or virtual environment) which performs as a response to challenges demanding the spectator's intellect or sensorial motor skills. Likewise, the sense of embodiment is something that happens during VR experiences since it can be seen as a consequence of immersion (sensory-type), which lets the experiencer's imagination to stay on stand-by and let the sense of embodiment take over the consciousness into the flow, the game or story that is happening (Anne-Gwenn Bosser, et al, 2020).

On the other hand, regarding the experience, virtual reality is an alternative to experiencing an environment in a digital way with the assistance of a simulator or a game. It makes it possible to live a quite vivid adventure due to the sensors that provide feedback to the program (game/simulator) and other elements like joysticks or gloves, these, in turn, bring immersion to the user by changing the view angle, speed or even allowing for interactions with objects being grabbed in the digital world (Rajesh Desai, Nikhil Desai, Deepak Ajmera and Mehta, 2014).

3.2.1. Oculus Rift

The Oculus Rift is a virtual reality headset that allows users to experience virtual reality using a computer's GPU, and adding inputs such as two controllers for registering each player's hand, a chip for registering six degrees of freedom to capture player's movement and camera sensors. Therefore, the experience of the user in a virtual environment could be really rich in terms of game development. However, this device needs to be connected to a computer in order to be used by players, which also means that there is a requirement on the computers in order to run applications on this device.

On the other hand, there are some requirements for developers that plan to make a video game or application with this device as well, such as 3D audio support, compatibility (such as C++ and Unreal Engine compatible versions), standard input functionalities (such as always use the oculus home button to return to the main area in the oculus software) and performance (such as the app should always allow input detection within 4 seconds of launch), among other features (Developers.oculus.com, 2021).

3.2.2. Oculus Quest

The Oculus Quest is a device similar to the Oculus Rift but with its own Android-based graphics processor, memory and CPU. Unlike the Rift model, the programs can be run directly on the hardware (Developers.oculus.com, 2021). However, the graphics processing of this model is not as capable as that of a personal computer graphics card, which is why the games developed for the Quest model have quality reductions compared to those of the Rift model. On the other hand, the Quest model has a special feature which is called Oculus Link, which allows the user to connect the device to the computer and use it like the Quest model, and in this way the device can use the GPU of a connected personal computer and have high quality graphics.

3.3. Game AI Theory

Usually video games, regardless of genre, have artificial intelligence to give an extra feeling to the player whether it is competitive or to fill the void in a virtual world. For example, when a player plays chess against a computer or when one plays Mario Odyssey the NPCs bring a touch of reality to the levels and the enemies generate a feeling of competition or even desire to play the game (Nintendo, 2017). However, in computer science artificial, intelligence is a very extensive field that contains a large collection of algorithms that range from very simple tasks to very complicated tasks with a large amount of data. Thus, artificial intelligence can be seen in video games as a subcategory that tries to engage agents with the player in a way not as complicated as a deep learning algorithm (Malte, 2020).

According to Milington, artificial intelligence is about making computers able to perform the thinking tasks that humans and animals are capable of. Nevertheless, the game development focus on AI is different from academia since most algorithms in games are made for playing experience and make it so they feel mostly natural to the player. Furthermore, artificial intelligence in games is generally based on The Model of Game AI, which takes as an input world stimuli and outputs animations or physics. In addition, the Game AI model divides the strategies for development in two groups of algorithms: Group AI (Strategy) and Character AI (Decision making and movement). Since the application of AI in this project is focused on characters, I will follow this section with the basic algorithms for Character AI (Millington & Funge, 2015).

3.3.1. Kinematic Movement Algorithms

There are Character AI based algorithms that use static data like position and orientation but no velocities, and they output a desired velocity. The output is often simply an on or off and a target direction, moving at full speed or being stationary. Kinematic algorithms do not use acceleration, although the abrupt changes in velocity might be smoothed over several frames. In terms of mathematics, this is done by using the formula of velocity over time in different scenarios such as angular movement or spatial movement. For example, a simple movement from a point A to a point B could reflect an animation with smooth movement with a vector of movement plus multiplied a velocity vector, divided by a time interval which defines a kinematic algorithm.

- *Wandering:* It is a kinematic behavior that always moves in the direction of the character's current orientation with a maximum speed. This behavior can be improved by adding a steering behavior that modifies the character's orientation which allows the character to meander as it moves forward. In other words, this algorithm enables random walks by changing a character's orientation on time intervals.

3.3.2. Decision Making

Decision making in games can be described as the action that the character processes a set of information that it uses to generate an action that it wants to carry out. The input to the decision-making system is the knowledge that a character processes and the output is an action request. External knowledge is the information that a character knows about the game environment around it, and the internal knowledge is information about the character's internal state or processes.

- *State Machines:* For the development of the project, AI behaviors needed to be implemented, but how could a set of behaviors/actions could be executed in a way that they could merge the characters into the virtual world is by using State Machines. Usually, when creating AI characters in game, I want them to act in one of a limited set of ways depending on a situation. As Millington says, we would like them (the characters) to carry on doing the same thing until some event or influence makes them change (2015). As an example, he presented a covenant warrior in Halo, will stand at its post until it notices the player, then it will switch into attack mode, taking cover ad firing. State machines are the technique most often used for this kind of decision making and make up the vast majority of decision-making systems used in current games. Furthermore, he adds, state machines take account of both the world around them and their internal makeup (state).

- *Behavior Trees:* As state machines, behavior trees could combine different behaviors and execute them. However, they can combine the convenience of state machines with a cleaner execution due to its tree structure which also helps in the

design of AI while developing a game. In particular, behavior trees are a synthesis of a number of techniques that are used in AI, and their strength comes from their ability to interleave AI concerns in a way that is easy to understand, and easy for non-programmers to create. They are divided into tasks, selectors and sequences. Tasks are algorithms that a character will execute, usually AI algorithms. Selectors are boolean expressions that enable or prevent a sequence or a task to be executed. A sequence has a set of leaves that are meant to be executed in an order (right to left).

3.4. Digital Preservation

According to Deegan, digital preservation is an effort to maintain and disseminate the culture in a new format (2006). In this way, the population that consumes electronic content can explore places of outstanding value like national theaters or museums (Deegan and Tanner, 2006). In addition, a digital approach is important now, during the ongoing pandemic to safeguard people's life, by making available virtual visits to such historical places.

Today, digital photometric techniques and its evolution make it possible to map 3D objects and buildings to create a reliable database along with civil engineering blueprints of heritage sites (Giaretta, 2011). In this case, the Flamman theater was reconstructed using its blueprint and enriched with textures to give it a more natural appeal. In the case of this project, it is essential to reproduce physical interaction as naturally as possible into the digital game so that the heritage site can be appreciated as it was originally conceived for the movie experience in the game.

On the other hand, the standardization process requires data providers to define a format of the 3D building and curators that manage the materials generated to later make it available for the consumers (Giaretta, 2011). This process is not cheap, the size of the budget for preservation is usually fixed, while the amount of data safeguarded increases over time. Thus, making this situation unsustainable in the long term and limiting preservation programs only available for high income countries because of financial issues other than political ones (Deegan and Tanner, 2006).

In addition, it is very difficult to create an abstraction for representing all the information of a heritage site. For example, to better appreciate the value of the building, it is important to preserve the context in which it was created and how it changed with time such as the textures, colors or surroundings. Moreover, to retain the information it is also important to keep a similar format for all the heritage sites which are considered. Otherwise, the resulting database would need nearly a different program to process each digital heritage site.

Furthermore, Tanner adds that education and prestige gains are quite high with this type of delivery but with low economical return in comparison to physical institutions, again, presenting a challenge to sustain the project (2006). By making this game available to the

world, more people will be likely to virtually visit the game and get to know the Flamman Theater, similar to what some museums around the world did to overcome the limitations of the pandemic.

3.5. Testing Techniques for interaction design

In order to test the user experience and ensure that the resulting interaction does what the design intended to with the users, there are techniques that help designers to polish and ensure that the development is going towards a design goal. In this case, two elements will be considered: the think aloud technique and remote testing.

The first one enables designers to recollect more information about the user's perception while playing the game by taking note of what the user is feeling while performing the tests. This, in turn, helps us improve what is more enjoyable in the game and correct what brings little to no joy to the users. The advantages of it are the direct, easier and faster feedback for both, the client and the content creator.

Moreover, due to the global pandemic, I had to take extraordinary measures to safeguard the health of our test subjects (users), such as taking user tests remotely. This means that the data collected must be done online, in addition the presentation of the game must be by some means of remote communication. Therefore, tools that allow online chat with video and sound (such as Zoom or Discord) would be necessary for the presentation of the game and Google Forms as a data collection tool such as remote surveys.

3.6. Video game assets

In order for the reader to understand the terminology of the digital elements used in a video game, it is necessary to explain what I am referring to with game assets during the following sections on this paper. Assets in video games are normally referred as digital elements that are used when constructing a level or to enrich the experience of the game. These can be textures; 3D meshes or sounds and other visual elements. Here I describe: how to reproduce music and textures in the game for the digital theater, as other elements are widely known and described in literature in the game design field.

The first element of interest is defined as any sound that enriches the environment of a video game or simulator. The element enhances the experience in a game and makes it a key component in modern games, it is defined as, for example, sound effects and music that may be played during a narrative or a heated fight so that the player may get deeper into a role in a story by means of provoking emotions to the person (Zhang J. & Xiaoqing F., 2015). Thus, this definition helps the project in the creation and management of sound for the cinema while playing a movie.

Similarly, the second element is employed to understand how to show an image in a game environment, a familiarization of the basics of showing an image on computer graphics must be done, specifically for 3D graphics, because this concept is used to put textured

images inside the virtual cinema to show video and textures. The main way to present an image on a three-dimensional model is by texturing. According to Assarsson: “texturing is the action made in computer graphics to glue n-dimensional images onto geometrical objects, so more realism is achieved in a cheap computational way” (2019). Technically speaking, texturing works by mapping coordinates from the image (UV coordinates) and then placing them into a certain three-dimensional model.

3.7. Game Engines

Game engines are tools that help video game development as they are built as a framework to expose methods, properties and processes ready for game developers to use for their games (Gregory, 2018). Moreover, the features that a game engine has ease real time computer graphics methods for its interaction with players. For example, a 3D Mesh created by an artist could be imported to a game engine to be part of a level as a platform or character. On the other hand, it is necessary to take into account its existence for the rest of the development of this paper, since the production of a video game becomes easier if the concepts of game programming are applied in an engine that already has the necessary computational concepts implemented in its structure.

3.7.1. Unreal Engine

Since the concept of digital heritage results in a collection of digital models, the game developed in this paper would have to show these collections in real time. Since the digital models would be architectural models, they have to be shown as meshes in three dimensions. Therefore, a game engine capable of displaying these collections would be needed, but also be compatible with virtual reality artifacts, for example, Oculus Quest inputs. For these reasons, it has been decided to use Unreal Engine as it is a video game engine that is known for having efficient real-time rendering algorithms, artificial intelligence handling, input handling from various peripherals, and being compatible with virtual reality gadgets, such as the Oculus models mentioned above, without having to develop input behavior from scratch and being able to map in real time the position of the VR device.

On the other hand, readers familiar with the video game industry may be wondering why I have chosen Unreal Engine instead of Unity, and the answer is merely personal exploration to gain experience using a game engine that several companies are using for game development of AAA games and for my resume to be competitive with the use of that game engine.

4. RESEARCH METHODOLOGY

The methodology to be used for the videogame focused on game theory for its design. I decided to use the theory of mechanics defined by Sicard for the definition of game mechanics. As for the definition of aesthetics and Dynamics, I took the definitions of the

MDA model. For the design of levels, the definition of Phazero was used and as a test resource, the theory of think aloud has been used.

4.1. Research Setting

This project was developed by a student from the Department of Computer Science and Engineering within the Game Design and Technology MSc program of Gothenburg University, in order to recreate the original identity of the Flamman theatre. Moreover, this project has potential stakeholders such as young and future generations of Göteborgs residents, people that want to know about Sweden history and entities such as UNESCO, who handles heritage including its digital form.

4.2. Development Methodology

Because the project is focused on delivering a game that contains a theater experience, I decided to use the level design methodology, in which a prototype is made first from a grey box environment. Then, it adds more elements to the design until there is a testing phase to polish the game experience, which in this project will be to test out the theater feeling (aesthetics). However, to have a better understanding of how to proceed with the research, here are four points that were considered for the development of the project.

- Preliminary game design and requirements gathering: here a design was created under the theories of mechanics and MDA so that the game is based on the original identity of the theater and that it adjusts to VR technology with Oculus Rift. It is worth mentioning that the decisions of this phase will be the basis for the rest of the project and may be modified according to its progress.
- Development of a virtual world: here a video game was created according to level design theories to result in a gray box (base game level without details) to test a concept, which in other words would be a low-level prototype that would consolidate the theater experience. It is worth mentioning that since the nature of game development continues to improve the experience, this phase had continuous feedback through tests that will ultimately result in a vertical slice of the video game of this project.
- Qualitative Data Gathering: with the prototypes, testing techniques such as think aloud were used to know if the game is meeting the objectives of its design and what could be improved. Answers were collected from questionnaires and interviews.
- Results and Analysis: with the data collected, it is possible to know if the result of the prototypes fit with the design and in this way draw a conclusion that shows whether the vertical slice (the best prototype candidate selected) was an experience that served as digital heritage.

The development of the project was divided into three stages, the development of a virtual environment, the collection of user information in test sessions, and the interpretation of the collected data.

4.2.1. Game Design

In this section, I presented the basic properties with which the design has to be conserved as the conjugation between various game theories; and the division into mechanics, aesthetics and dynamics.

4.2.1.1. Core Design theories

To have a basic idea of the product to be conceived, I decided to use different game theories to draw a horizon for the development of the result. I have combined these theories in the MDA structure, as it is easier to visualize the design steps. For the mechanics, I will use the Sicard theory, while for the aesthetics and the dynamics I will use the MDA model pure concepts. However, I will extend the aesthetics concept from MDA with the GNS model, specifically simulationism and gamism since the result tries to simulate a real-life theater, but at the same time giving a new way of experiencing it as a game.

4.2.1.2. Aesthetics

As said before, in MDA aesthetics are the emotional description of the player. However, in my opinion, these should focus on a more global experience. For example, if a player experiences "thematic consistency" this would be very broad. If it does, conjugated with a mode (of the GNS), the designer could focus on the "thematic consistency" while the player plays or experiences the narrative. In other words, combining the aesthetics with the GNS model allows to focus the design in a more specific point of view than to consider the aesthetics individually.

Furthermore, I have decided to divide the aesthetics of this project into two types, the first are those that have been designed from the beginning for the conception of the project, which I will call as designed aesthetics, and the second which are the aesthetics that have to be obtain by user test that I will call them aesthetics obtained.

I defined the designed aesthetics for this project as **exploration**, **casual gameplay**, and **thematic consistency**. The exploration aesthetics, for this case, focused on simulationism, specifically on the player's ability to see the parts of the theater and observe the details made in the three-dimensional model. Likewise, casual gameplay aesthetics concentrated on evoking a gamism mode in the player, as I feel that the experience of going to the cinema should have been relaxed, and that it did not force players to stay in the game world for too long. On the other hand, the thematic consistency aesthetic was based on the fact that the players should believe that they are in a movie theater and that effectively all the content was related to the experience of going to the cinema, evoking a simulationism mode.

In the case of the aesthetics obtained, these were obtained according to a comparison between what has been verified (section 3.1.2) that people feel while they are watching a

movie in a movie theater and the feelings that users have to report during test sessions.

4.2.1.3. Mechanics

As stated above, the mechanics will be based on Sicard's definition. The reason is that by defining the mechanics as verbs, I, as a programmer, can extrapolate them into methods more easily and, in this way, organize the game code efficiently.

For the design of mechanics, I have divided them into two types: actions in which a person experiences the cinema and the fun actions with which they would like to give a new identity to the cinema when experiencing of the game. For the sake of convenience, I'll call them cinema mechanics and VR mechanics.

For the cinema mechanics, I decided to create them based on my own experience when going to the cinema physically. In general, the experience that I had going to the cinema can be summarized in the following steps: to enter the cinema, to buy the ticket to the cinema, to walk to the room, to enter the room, to watch and listen to the movie. These steps can be extrapolated to mechanics such as the following: enter, buy, walk, look and listen. However, I felt that the buying experience mechanic was not necessary to reproduce the full experience of going to the cinema, so I did take it into account for the construction design. In addition to the aforementioned mechanics, there are other actions that a person would expect from a video game such as using their hands, and grabbing objects, that I felt were necessary for the game. Therefore, the composition of the cinema mechanics is the following: **to enter the cinema**, **walk through the cinema**, **watch**, **listen** to a movie in the cinema, **grabbing** and **moving hands**.

The VR mechanics were molded by the users as these play the game and when necessary. Then, they were be added with the aim of adjusting the experience in a way that is more enjoyable for the players.

4.2.1.4. Dynamics

Given that the dynamics are the interaction that the player has with the mechanics and consequently experiences the aesthetics, this section describes the relationship between the aesthetics, discussed in section 3.1.3., with the mechanics, exposed in section 4.2.1.4. It is worth mentioning that the definitions of obtained aesthetics and new mechanics are not discussed in this section because, as already stated, these are defined by the results of tests with users and their consequent dynamics are discussed in the results section. Therefore, the dynamics were be based on the relationship between the designed aesthetics and the cinema mechanics, the following interactions are taken into account:

1) Upon entering the cinema, the player may experience a feeling of exploration as he has never experienced the model of the theater before.

2) When walking through the cinema, the player may experience a feeling of exploration.

3) When walking through the cinema, the player may experience thematic consistency since the elements of the stage belong to a cinema.

4) When taking things from the cinema with their hands, the player may experience thematic consistency since they are interacting with things typical of the place.

5) When watching and listening to the film in the cinema, the player may experience casual gameplay (characterized for its easy gaming experience) and thematic consistency, since the film is reproduced only once (just as in a real cinema experience) to enjoy it and a film is typical of a cinema.

4.2.2. Development of a virtual environment

To complete the experience described in the project objective, the definition of objects that make up a virtual environment was necessary to execute the objectives set out in the game design of section 2.1. Therefore, a process of level design was done by using the previously designed mechanics, dynamics and aesthetics into the level creation. Nevertheless, this section focuses entirely on the level concept, the level geometry and creation of environment art (concepts previously discussed in section 3.1.6).

4.2.2.1. Level concept

The concept was based on the architectural model of the Flamman theater in a way that is perceptible for the user and has the willingness to explore it, and at the same time making the player feel that he was in a cinema when he entered the door. and could explore it, and, thus, comply with the aesthetics of section 3.1.3.

4.2.2.2. Level geometry and creation of environment art

The level must have basic geometries for the mechanics to take place and therefore everything objective in section 3.1 can be achieved. These geometries were divided into non-movable 3D objects, the video player 3D object and the player character model.

4.2.2.2.1. Non-movable 3D objects

The non-movable models are those that the player were not be able to move and help the thematic consistency by communicating the elements of the Flamman theater to the player. This is why I considered that the non-movable models of the level are: the replica in three dimensions of the Flamman theater (mainly), the chairs, stands, doors, columns

and objects typical of a movie theater, and also elements of the outside environment of the theater such as the sky, light, trees or other buildings.

4.2.2.2.2. Video player 3D object

This object intended to help the mechanics of watch and listen so they could be executed and also to maintain thematic consistency. Specifically, this object would be a plane in a space of three dimensions facing the player, which would show an animated sequence in its texture while sound is produced. In this way, this object would act as a movie screen and speakers at the same time, which retains the thematic consistency.

4.2.2.2.3. Player character model

For the design of the player character model, I decided to base it on the use of hands that identify their position by the method of aiming and teleportation, because the player would have more control on the view so its attention could focus on the movie. However, a downside of this design is that it may affect the thematic consistency since teletransportation is not a common way to move on game worlds.

4.3. Data Collection Plan

Here, I defined the data collection procedures to refine the virtual reality game. The participants in this study were informed about the purpose of the research project and agreed to share their opinions on the game. Participants' data is protected and only numbers are used to differentiate between participants in surveys' results in Appendices B and D. In general, they followed the guidelines recommended by the World Health Organization (WHO) which commands social distancing and the use of additional personal protection equipment to face COVID-19 pandemic. There were three methods used to collect such data, classic, remote and guided testing; all include the think aloud technique. At the end of each session, the players gave feedback to the game by filling out a questionnaire.

The first thing done to comply with the health recommendations was to divide the user tests into three types: classic tests, individual remote tests, and guided tests between the participant and me. The second modification was to increase a questionnaire at the end of each test, to try to get more detail of what people can experience without seeing them directly when they were testing the game remotely.

The collection of the data obtained from surveys and consultations with users, were be measured in a qualitative and quantitative way. The qualitative test reported if the game made the players feel the aesthetics (made in the design), in other words, if the player feels the experience of going to the cinema while playing the game. Specifically, the qualitative data was obtained through user experiences by using the think aloud technique, which provides almost immediate feedback to understand if the game experience is fun. On the other hand, the quantitative one will help to understand what

type of experience they had and if the mechanics made in the design worked. For example, if a mechanic was designed for the player to have fun in the movies, then a questionnaire may help to understand if indeed the player used it for that case. In addition, the questionnaires could help to understand what devices the users to interview use, for example, if the game at the beginning is developed for Oculus but (hypothetically) most users do not have that device, perhaps the change of device for the project would be a consideration.

4.3.1. Collection of user information

The collection of information was necessary for the development of the project as it provided information on how users felt the aesthetics of the game. In this particular case, I decided to use the testing technique called think aloud (discussed in section 3.5) which is typically done with the participant and the test manager in the same place (testing room), classical tests. Nonetheless, the development of this project was during the COVID 19 pandemic and the WHO recommendations advised that there be few people in the same room and try to carry out activities remotely, which meant using only questionnaire, since the think aloud technique may not be as meaningful in remote tests.

To comply with the health recommendations was to divide the user tests into three types: classic tests, individual remote tests, and guided tests between the participant and me. A questionnaire was given at the end of each test, to try to get more detail of what people could experience without seeing them directly when they were testing the game remotely.

4.3.1.1. Testing types

In this section a description of user testing cases made specific for this project is presented. It is worth mentioning that testing had to be divided in types since the ongoing global pandemic did not really allow me to conduct tests on a physical basis, therefore this type of testing will address recommendations from WHO and prevent contagions.

4.3.1.1.1. Classic tests

This test used Think Aloud technique in a physical and face-to-face way (see Figure 1). In other words, me as a monitor of the face-to-face test to a user while he plays, observing on a screen what he is doing in the virtual world, and taking note of what the user reported they thought and felt. This testing type is based on the most common way of testing previous the recommendations of the WHO in 2020, since people should gather in one place to playtest a game with an observer that guides the session in order to recollect data. In this particular case, this type of test consisted of users using an Oculus Quest 2 connected to a computer through the Oculus link feature (Basically a USB-C cable connected to the Oculus Quest and a PC). In this way I, as an observer of the test, could see what they were doing on the computer monitor while they were playing on the Oculus.

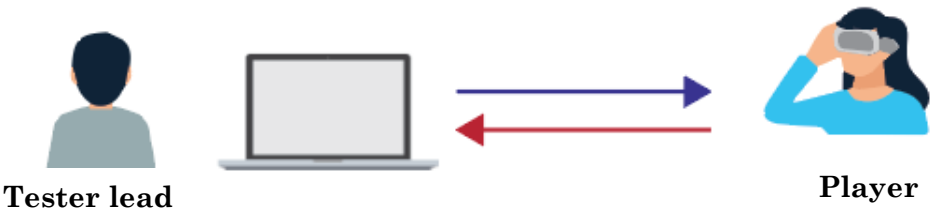


Figure 1: On-site testing: Helper and player with Oculus device.

4.3.1.1.2. Individual remote tests

These tests consisted of a remote user installing the program that contained the game in their virtual reality system (see Figure 2), then, when playing it, I could see it through streaming (Zoom or Discord call), and at that moment listened to what the user is saying. Because of the recommendations from the WHO and several countries to maintain social distance and avoid crowded areas in 2020, this testing type was the opposite of the 4.3.1.1.1. since it addressed those recommendations and promoted social distance as everyone could test from their homes. For these tests, users downloaded the executable game and installed it on their Oculus Quest 2, and shared a screen through Discord. Once connected, the user explained everything he was feeling while playing and what he found in the level. In this way, I taked note of what the users were doing and also see it in real time.

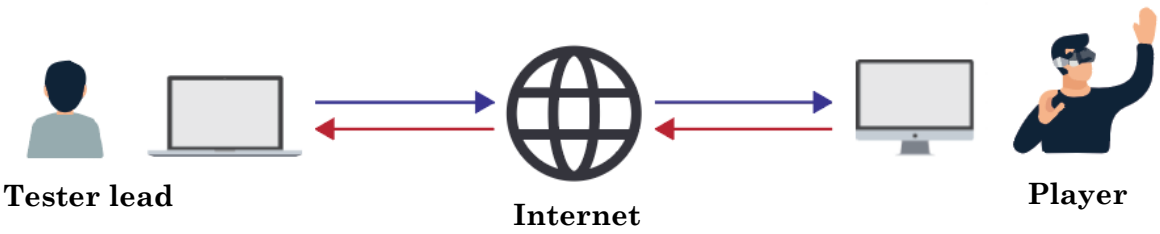


Figure 2: Remote testing: Helper and player with Oculus device through an internet connection.

4.3.1.1.3. Guided tests

In guided test of Figure 3, the user was shown the game that someone else is playing and, in this way, users could express their opinions, despite that, I have extended this idea by giving the user the opportunity to control the character by telling me where and how he wants to move. In this way, the user would be more interested and experience in a better way even if he is in another place. It is worth mentioning that I have created this technique for users who wish to participate remotely but do not have access to virtual

reality equipment.

This set of tests were made in order to engage the players into the game in such a way that they don't necessarily need a physical with a VR headset, so maintaining hygiene and social distance, and also opened the opportunity to show the prototype to people that were not able to use a VR headset but were eager to test the experience.

The setting of these tests was the following: first I started the game on an Oculus Quest 2 screen, which was connected by Oculus link, then I shared screen and real time gameplay on Discord and Zoom (depending on the user because some people were more comfortable using Zoom than Discord).

At the end, this testing option was more popular as most of the people in the sample did not have access to VR devices. Because testing sessions were made in the American time zones, all the users were from countries in the American continent (North America and South America) and most of them were from Latin American countries, in which apparently VR technologies are not as popular as they are in Sweden, so most of the users had not experienced virtual reality before or were not aware of that technology at all.

On the other hand, it is worth mentioning that this experience was very different from the previous ones because it was a kind of an exhibition while I received orders of where to move and where to explore.

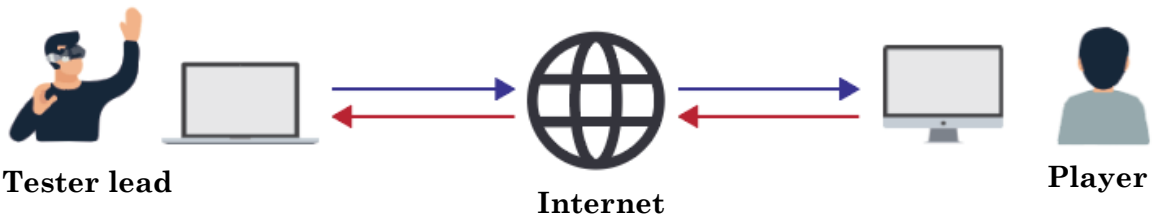


Figure 3: Guided testing: Helper and player with no VR- device through an internet connection giving instructions.

4.3.1.2. Questionnaires

Here the questionnaires were an important part to understand what the players thought about aesthetics (feelings when playing the game according to the MDA model), mechanics and dynamics in a more direct way, because in the tests what can be collected are thoughts that were present at the moment of playing but not thoughtful opinions. The questions from the questionnaires (Appendix A and C) should make the user compare the experience they felt while walking in the virtual theater with that of a movie theater experience in real life. In other words, the questionnaires of this project would compare

the feelings that a person has in a movie theater in real life (section 3.1.2) with those exposed in the game design (section 3.1.3).

As mentioned in the planning section, I made a questionnaire (see Appendices A and B) to understand how players felt about the overall design. I used the questions from Appendix A, which on this test sought to know what was the experience that users felt when exploring the level and the movie theater, but also to understand what they thought of VR technology. In particular, these questions were if the entrance of the theater was easy to find, in order to check if the greybox of the theater level was inviting to players to enter the inside of the building, if the construction of the level was clear so the players could understand that the greybox is representing a place to watch movies, and also a question to understand if the players were interested enough to explore the place.

4.4. Interpretation and Improvement Plan

With the data obtained from the aforementioned test sessions, it was possible to compare what users felt with the aesthetics proposed in the design and also understand what they lacked to have an enjoyable gaming experience. By enjoyable, I mean the fact that the user wanted to keep exploring the level of the game or continue watching the virtual cinema movie.

Once the key points of the aesthetics and enjoyment of the users had been identified, improvements were made to the world environment, to the control, and to the objects of the world.

4.5. Ethical Concerns

The potential ethical problems of this project were two, the first one was health problems due to COVID-19 contagion, and the second one could be dizziness problems due to the use of virtual reality headsets. The contagion risks due to agglomerations were related to COVID-19 because the experiments were carried out during the year 2021, but these were addressed by taking into account the recommendations of WHO and applying measures such as remote tests of users. On the other hand, the problems of dizziness due to excessive use of a virtual reality headset could be a negative aspect for users who play the game for a long time, since movies take a long time to watch them, which could cause visual discomfort. However, for this work it did not present a theater with long films, the films shown were short because I tried to make the project as prototypes and not as a whole product.

5. PROCESS

For six months, a virtual reality game was developed, that highlights the Flamman Theater in an environment, making it the center of attention for the player to explore, this is based on the design discussed in section 3.1. The development has been divided into four stages to visualize the progress of the project easily and divided the development

into stages of level advancement and testing tasks. The stages of development were as follows: first prototype development, first testing session, final prototype development, and final testing session.

The development of the first prototype was based on the principle of creating the level with geometry blocks (section 3.1.6.) and experimented with some camera modes for the character player. The creation by geometry was intended to represent the foundations of the level design (see Section 4.2.2.), as well as to show a basic version of the Flamman theater model, with base colors (white, gray and black) and without textures. Likewise, in this period of work, two camera and control modes were tested for the player character, the first was teleportation of the character with virtual reality and the second with third-person cameras, nevertheless, it was later concluded that teleportation was more immersive than the third person.

For the first test session, the techniques mentioned in section 4.3 were applied with users who participated in the classic, individual remote and guided test. Even so, this work session obtained an interesting conclusion about the population of users that was doing the tests, which is that most people did not have access to devices with VR technology, so most preferred to do the guided test type.

Then, with all the feedback collected from the testing session, I continued to improve the mechanics, objects and the model of the game level. This time, the implementation involved more complex versions (with textures, colors, and light) of the elements mentioned in Section 4.2.2.

Finally, a final testing session was conducted that focused on obtaining information about what users felt between the virtual theater experience and that of one in real life (ection 3.1.2). Most of the sessions consisted of guided tests (Section 4.3.1.1.3) because at that time most people in the city, where the tests were done, were distrustful of going out due to possible outbreaks of COVID in the city.

5.1. First Prototype development

The objective of this work session was to construct the game level in a way that encompasses the basic principles set out in Section 4.2.2. This session was divided into the basic construction of the level, and the basic construction of game objects.

5.1.1. Basic construction of the level

For the basic construction of the level, I used a floor plan for the level, a model of the architecture of the Flamman Theater building and a basic movie theater (see Fig. 4). It is worth mentioning that for the development of a base guide, I decided to employ the VR template that Unreal Engine 4 provides, because the objects created here were helpful to create more complex objects later. It was necessary to place simple objects in the three-dimensional world model to feature the theater, making a contrast of detail between them,

in this way, the player would clearly identify our object of interest, the theater.

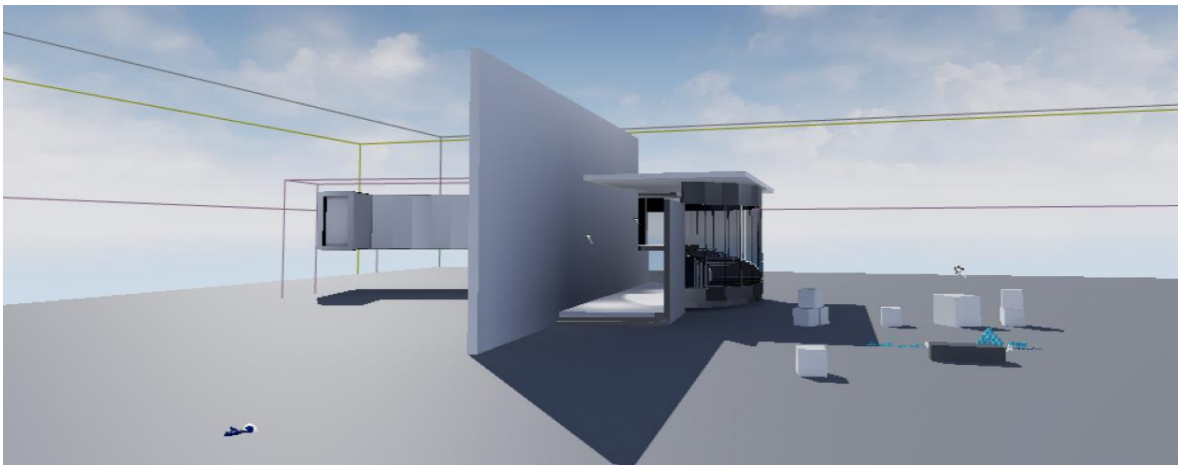


Figure 4: Flamman Theater building

In the case of the basic movie theater (Figure 5) developed in this session, I used a separate Unreal Engine level with the aim of experimenting with new features. Specifically, I divided it into a small space with chair geometries and a plane (screen plane) that acts as a screen to play a video through a dynamic texture. For the case of the screen plane, I executed a Media Player object to play a Media Source file (see Figure 6), that contains a reference of a MP4 file, that is referenced as texture on the screen plane's material, thus showing a video on the screen plane and playing the sound alongside in the world (see Figure 7).

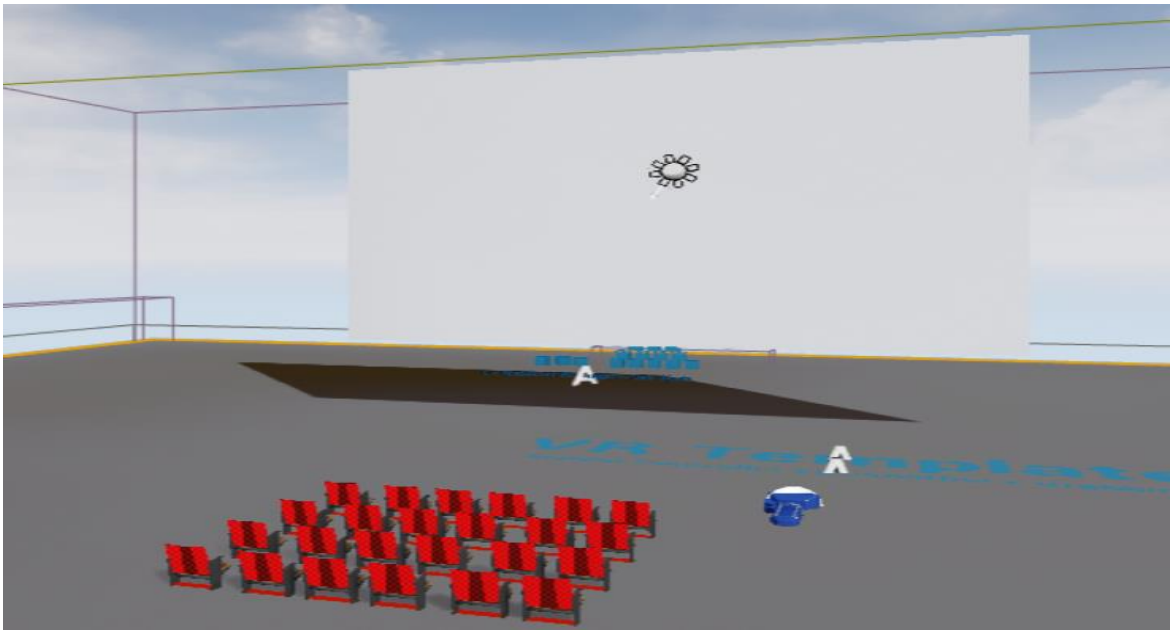


Figure 5: Example of a screen plane to test the movie being played.

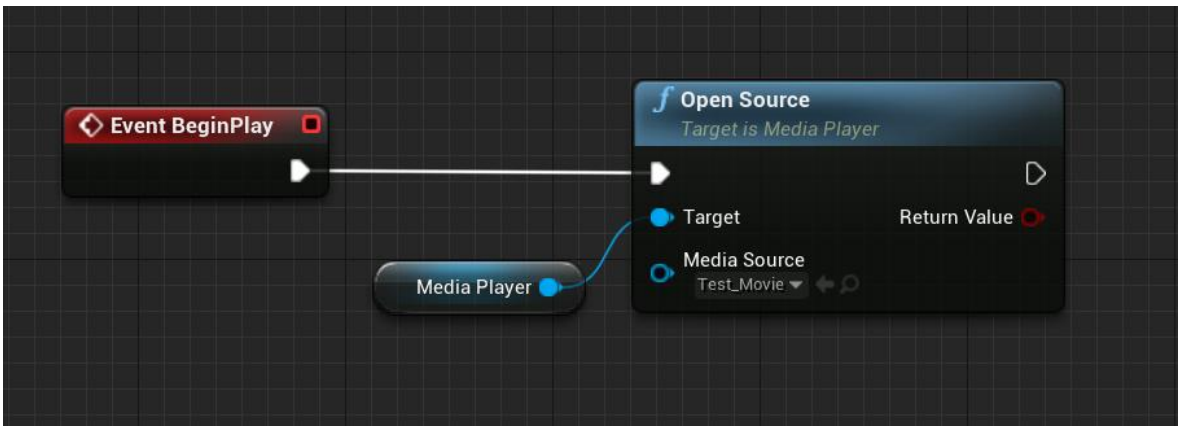


Figure 6: Blueprint node to play a movie with the screen of figure 2.

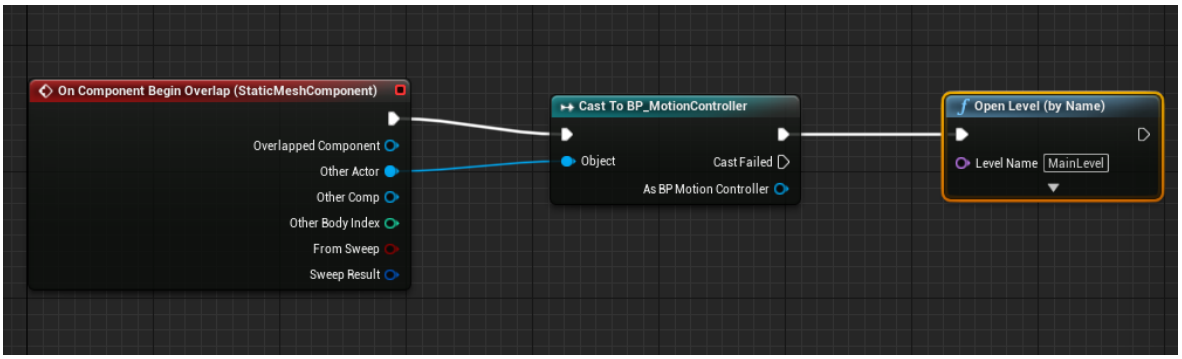


Figure 7: Blueprint nodes to open the theater level on geometry hit.

5.1.2. Basic construction of game objects

The game objects that were created in this section were the Flamman theater, a chair, and the player character. Although the basic model of the theater and its position in the level had already been discussed in the previous section, here the configurations that were necessary for it to act as an object within the game are explained. Similarly, for the player character, I experimented with three types of approaches to see which one would best fit the virtual experience.

5.1.2.1. Flamman Theater Object

The construction of this object took into consideration three things, the materials setup, lighting and collider. It is worth mentioning that the materials and the 3D mesh (Figure 8) were created by my supervisor with the original architecture blueprints of the theater which was a long and arduous process since modeling tools in three dimensions were involved. However, on my side, I had to set materials and meshes in the best possible way with the engine tools, therefore the theater model was converted into an Unreal Engine Blueprint class.

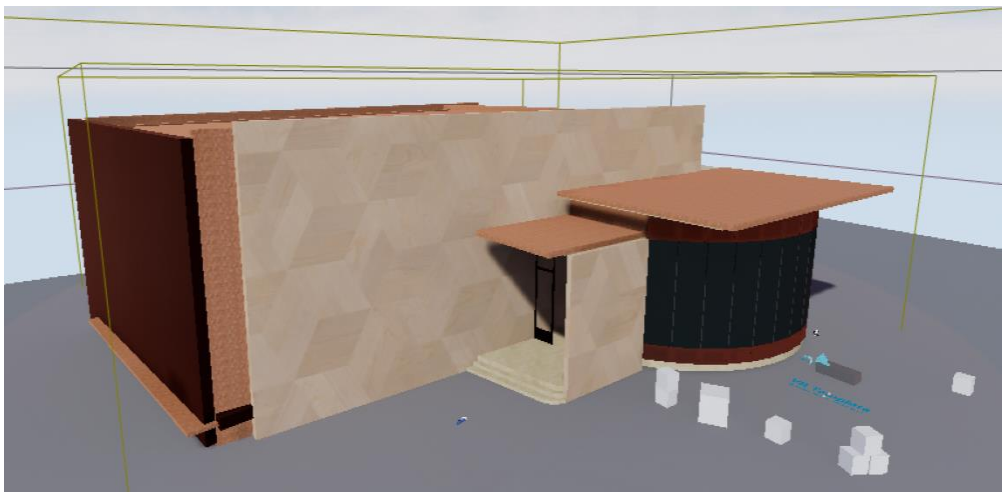


Figure 8: Materials on the digital Flamman Theater.

Furthermore, the original theater model did not have lights as it was purely architectonic three-dimensional model, this meant that a process of improving lighting had to be done in the model, so things such as spotlights (Figure 9) had to be added in the level so the players could see the interior to observe more of the details in the theater.

Figure 9: Inside the digital Flamman Theater with lightning and materials

On the other hand, the selection of the collider was a challenge because in Unreal Engine 4 all the elements have two types of collision geometry: a simple one and a complex one. The first, is basically the simple collider is a geometry generated with the least number of polygons possible, that is why in Figure 10 the geometry lacks details and resembles a cube, and all the original geometry of the mesh and prevents other objects from crossing that mesh in Figure 11. Taking into account the above, I decided to use the complex collider since this way the player could enter and explore the model freely.

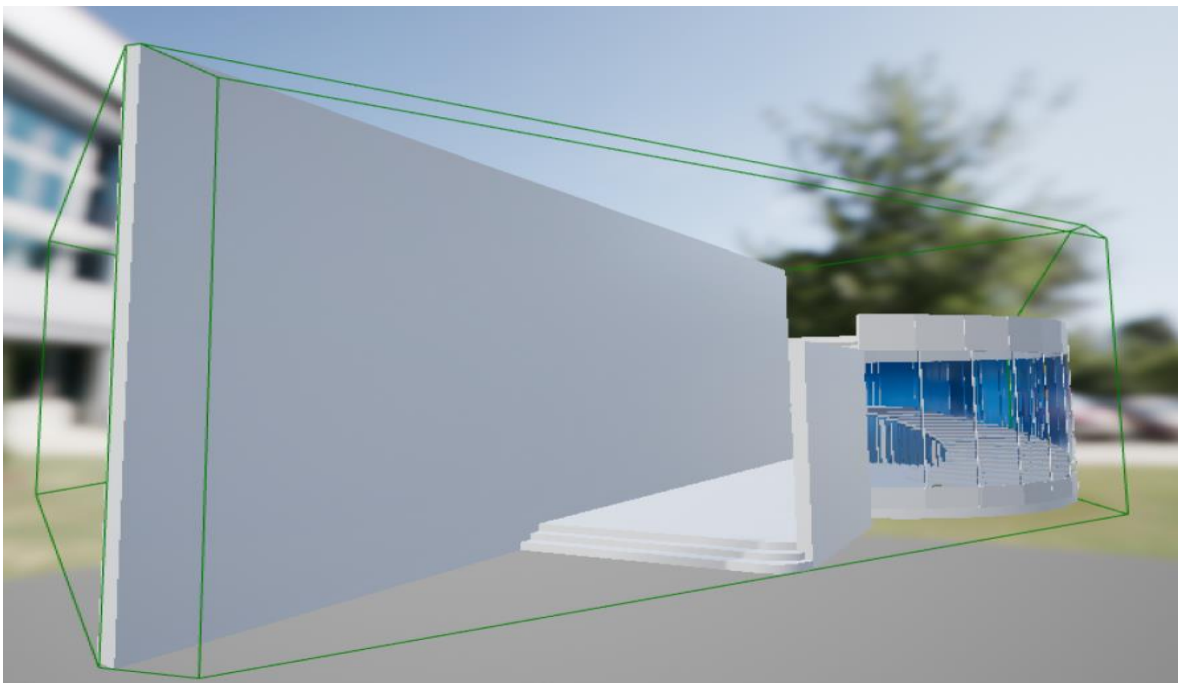


Figure 10: Simple Collision geometry.

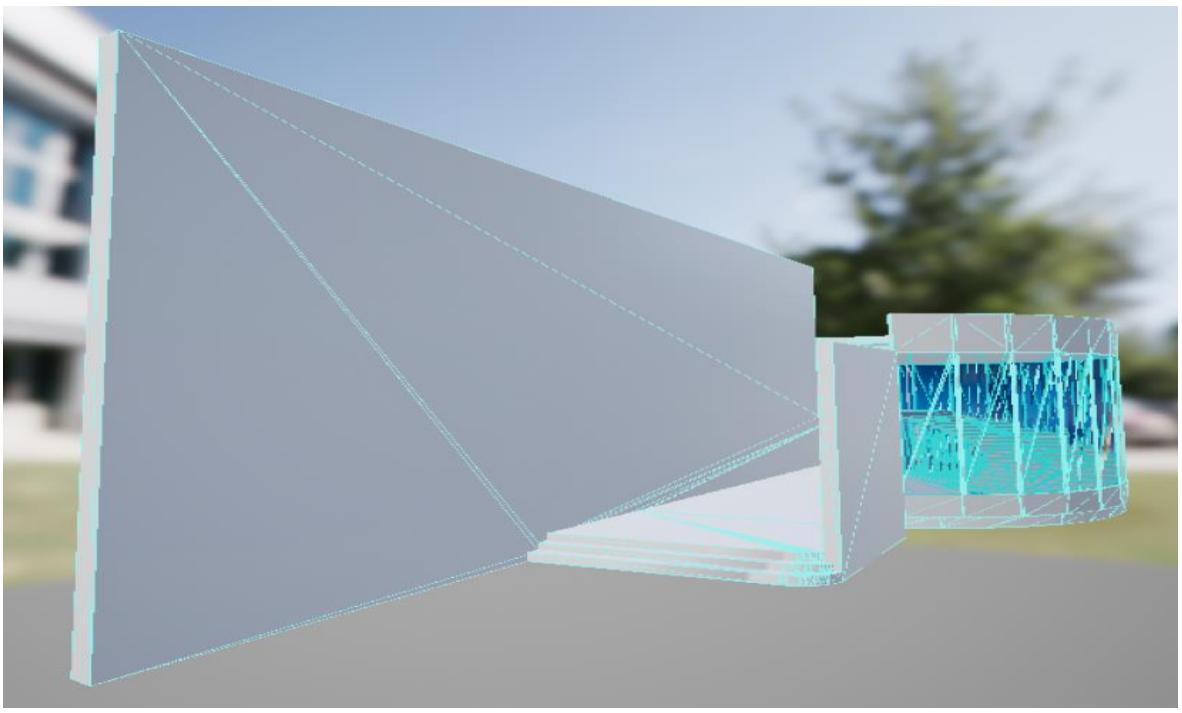


Figure 11: Complex Collision on the Flamman Theater.

5.1.2.2. The chair object

As with the theater model, the chair was also modeled by Thommy Eriksson, but the original materials were changed (see Figure 12) to combine with the style of the theater. The chair is an object that helps the theater feel full, which made it important to the experience and aesthetics of the design. However, for its implementation, the following considerations have been taken, first that the chair should be interactive, that is, the player could use it in some way, which would increase the complexity of said object. And for the second point, the object should be rigid so that it has a presence if the player approached it, so a complex collision should be set instead of a simple one.

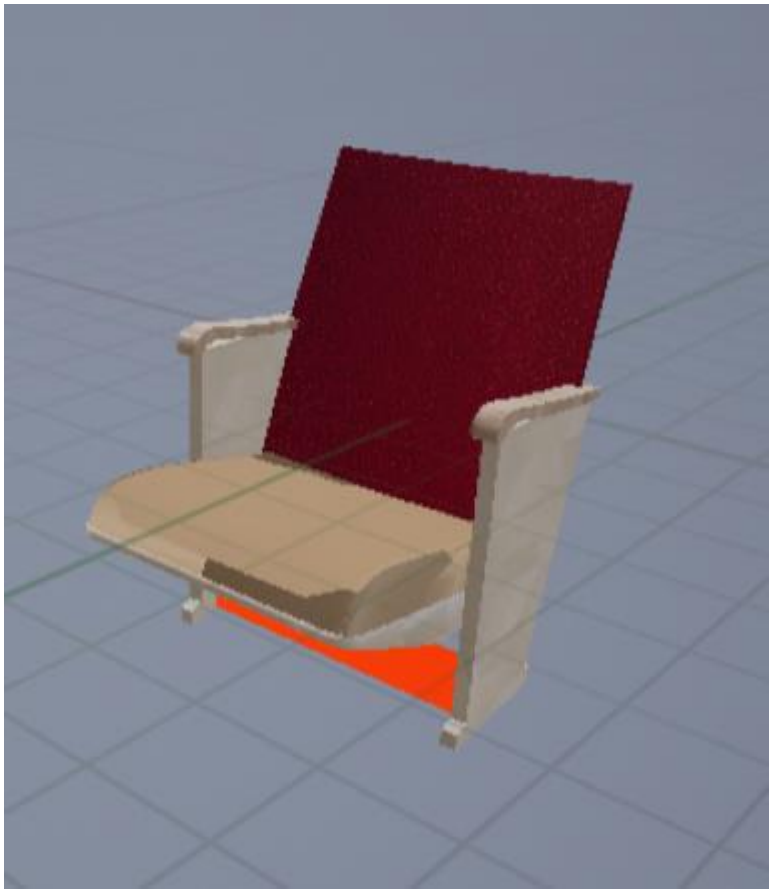


Figure 12: Chair object with complex collider on Unreal Engine editor

5.1.2.3. The player character

For the player character model, I tried three different types of approaches: First Person (FP), Third Person (TP) and First Person with Teletransportation (FPT), which brought different advantages.

The FP approach (Figure 13) seemed like a good option because when going through the level, it only needed a capsule to represent its volume and position, and the camera allowed the player to appreciate the objects in a more immersive way, since it would be like seeing from one's eyes. However, the FP approach required a movement with the left stick of the control which, in my point, of view caused dizziness.

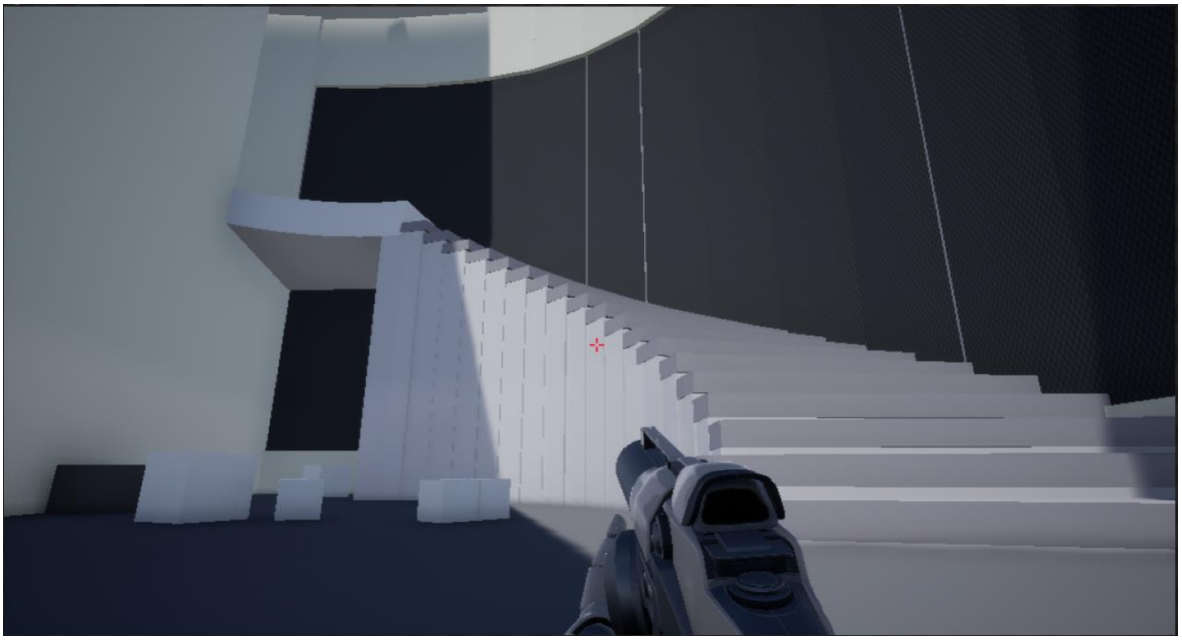


Figure 13: First Person Character on a test with simple collider

On the other hand, the TP approach (Figure 14) required a camera that would chase a character and would represent the player with the movement from the control stick inputs. Nevertheless, this took away the immersion and increased the complexity to interact with the objects since several animations were necessary to obtain an immersive feeling.

Figure 14: Third Person Character on the ground floor of the theater.

The FP approach with teleportation (Figure 15) had an advantage over the previous two

(FP and TP), which was that it was more immersive because the movement did not cause dizziness when changing position. Yet, the fact that one could use teleportation to move from one place to another produced a drive stop of the immersion. Thus, I decided to use this approach for the continuation of the project in view of the fact that FP with teleportation produced an immersive result without motion sickness.

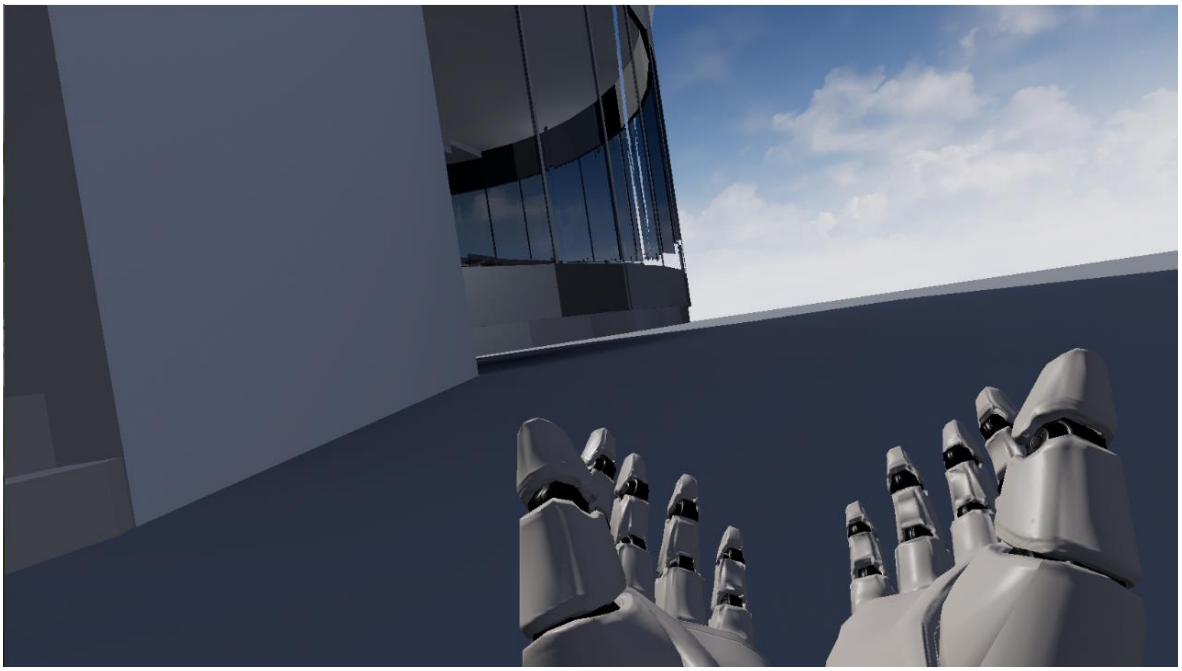


Figure 15: First Person with teletransportation movement.

5.2. First Testing session

The first test session collected information about how the game felt in its most recent stage (greybox). Nevertheless, the challenge of this section was not simply performing the test but adapting user test taking techniques taking into account the new reality of doing tasks remotely due to pandemic. Therefore, I used the three testing strategies (section 4.3.1.1) to ensure the most out of the limitations of social distancing. Further the tests were taken by thirteen persons, and at the end of each session I asked the users some questions to understand if the experience reached the design goal (section 4), so both talking to the players and data from questionnaires were considered for the game feedback.

The first thing done was to contact the people interested in testing the project such as fellow students, video game development enthusiasts, and people with familiarity in the industry. In this case, I contacted some testers from ADVEC (Association of Ecuadorian Video Game Developers). Once the interested parties accepted the invitation to be testers, I scheduled a date to test and a place (since some were willing to test it physically). If the person in question did not want to participate in person, we proceeded to have a call on Discord or Zoom. In addition, if the person did not have a VR headset, a "guided test" was

scheduled. In the end, I managed to schedule an individual test session with each of the 13 participants.

When running each test session, I divided them in three parts, so hat each session had an introduction and, then, the player had the opportunity to explore on their own while describing what they were doing (think aloud), and at the end a few moments to get feedback from the player on the game. prototype experience. By doing all of this for each session, the average session time was between 40 to 60 minutes for each of the tests.

5.2.1. Session Results

The results obtained from all testing types followed a consensus. The first one was that the place looked empty for players since the area was so big that unconsciously they were expecting to find more people playing with them. The second result was that players were actually eager to keep exploring the buildings and the surroundings, and that the level needed more colors and lighting which was expected because this first session was made with gray boxes mostly. On the other hand, some players were actually interested in interacting with objects, since some interactable cubes from the base project in Unreal Engine stayed in this version, they managed to find them at the beginning of the level and play with them, which added a new mechanic for player enjoyment.

The last potential improvement was noted while doing the first user testing session. I realized that many users are still very used to the First Person (FP) and Third Person (TP) control movements, so it took some time to adapt to the First Person with Teletransportation (FPT). However, one option to select the type of motion control would enhance the experience to make it achievable for everyone. For example, in the Star Wars: BattleFront series, one can switch from first person to third person point of view control.

On the other hand, none of the users that tested the prototypes described in this project were familiar with the Flamman theater nor the city of Gothenburg. Furthermore, testing sessions were in Ecuador with an American time zone schedule, this led to interesting results such as people not actually understand at first glance the value of this project because this was a new building for them. However, once people started to talk while playing, I let them know that this was an old building in a European city, which made them intrigued to explore and understand its value as a digital heritage.

5.3. Final Prototype development

In this part of the work, changes were made according to the results of section 5.2. Specifically, textures of the game objects were improved because the users felt that they were not realistic enough. The mechanics of some objects were also improved, because players felt that it lacked interaction with the virtual environment. Finally, increased lighting in the theater for players to explore as feedback received in the think aloud exercise showed that visibility needed to be improved.

To improve the visual realism, which players felt was missing, I increased textures inside and outside the 3D model of the theater. For example, grass texture on the outside of the building was added, and, then, edited the scale of the building to make it feel more natural to players walk inside.

Furthermore, object improvements focused on increasing billboards, trees, NPCs, and interactive objects like bags of popcorn, as this would improve interaction with players in the virtual world.

In the case of improving the lighting, I accommodated as much as possible the user experience that needed to explore the theater and see the details. Since the original 3D model did not have these lights, I also accommodated lights from the engine inside the model and inside some objects to make them feel as familiar to the real world as possible.

5.3.1. Improvements on the Flamman theater model

Next, I describe the enhancements in alignment with the two objectives. In order to show the materials on a clearer way to the player, I added three types of light inside the building, a Rect Light on the ceiling (Figure 16) and a directional light near the stairs (Figure 17) so that the player's first view inside the building would be as clear as possible. Also, I placed five Spotlights in the corridor (Figure 18) of the building because this place is in a position very far from the windows which made the light coming from the HDRI (High dynamic range image) not illuminate the corridor.

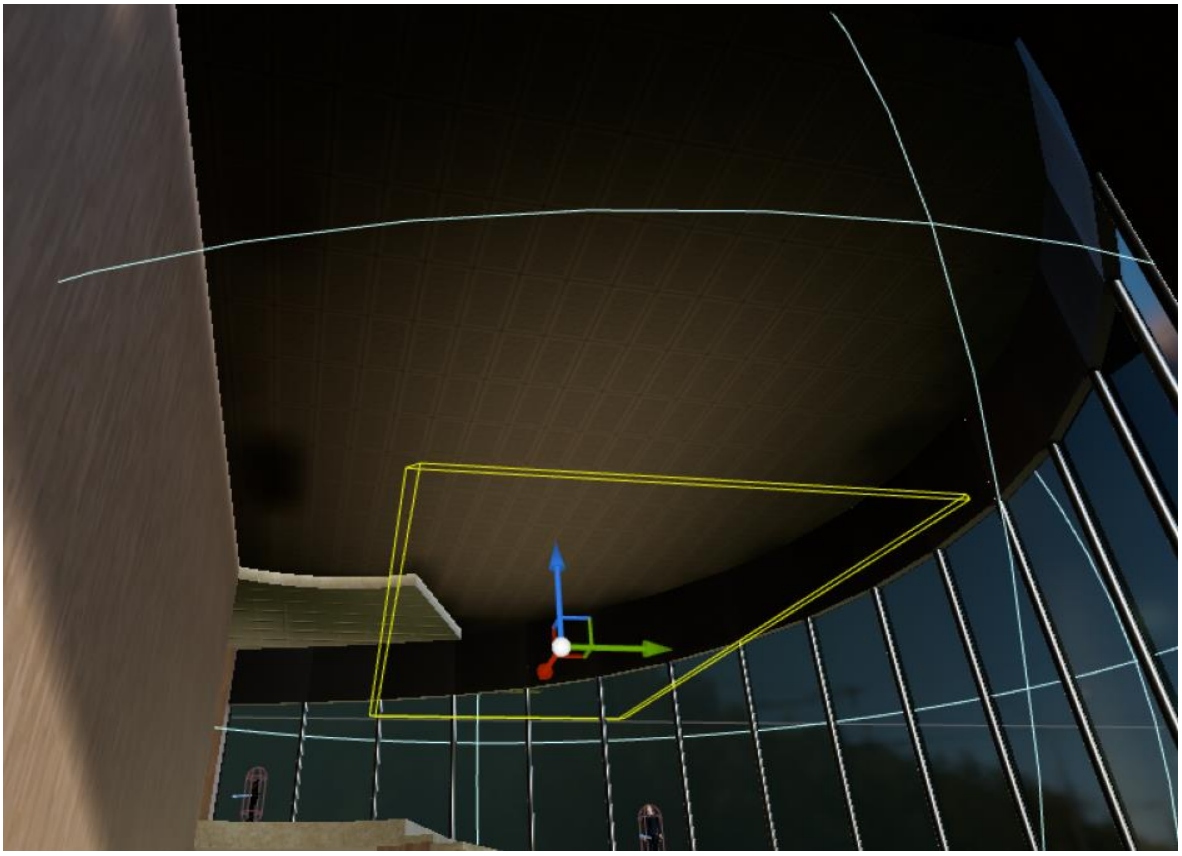


Figure 16: Rect Light pointing to the ceiling at the entrance of the theater.

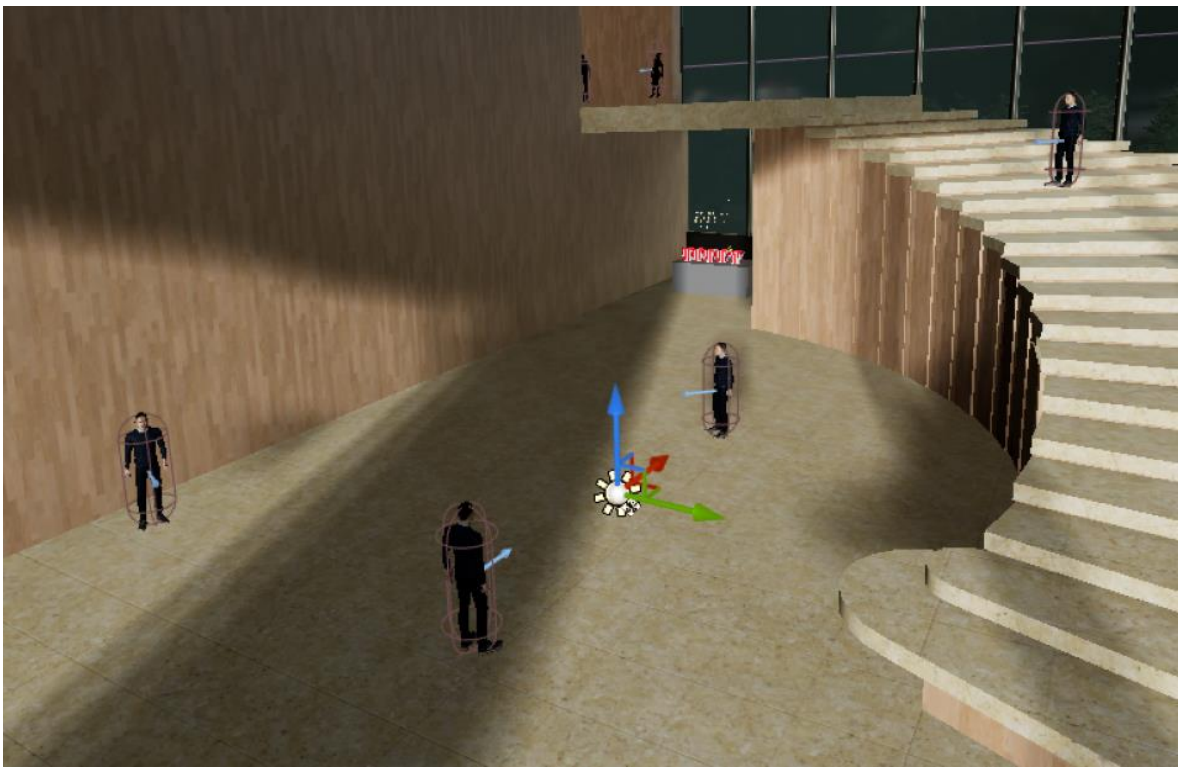


Figure 17: Directional light at the entrance of the theater.

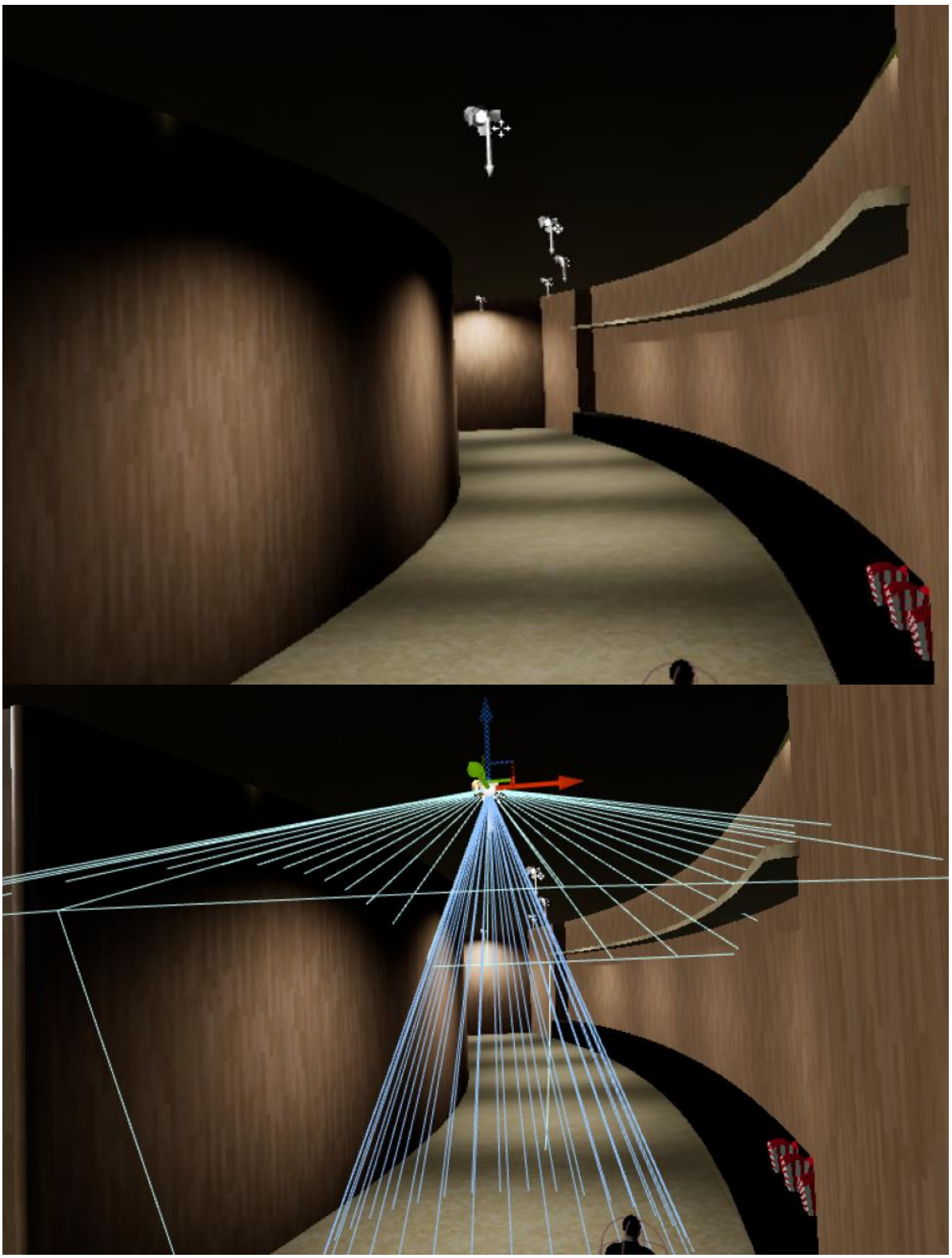


Figure 18: Spotlights illuminating the hall of the theater.

On the other hand, to present the theater in a more attractive way to the user, I included movie posters (Figure 19) around the outside of the theater. In this way the player felt that he is entering a building that shows the films that are exhibited in the posters.

Figure 19: Flamman theater model exterior with final materials on the game world.

5.3.1.1. The poster object

This object is made up of a plane and a Spotlight as seen in Figure 20. The shot has a material with a texture that shows the image of a movie poster. In addition, the Spotlight aims its light directly at the front face of the plane, in this way the image can be clearly seen at the game level and also simulates the effect in real life of a poster.

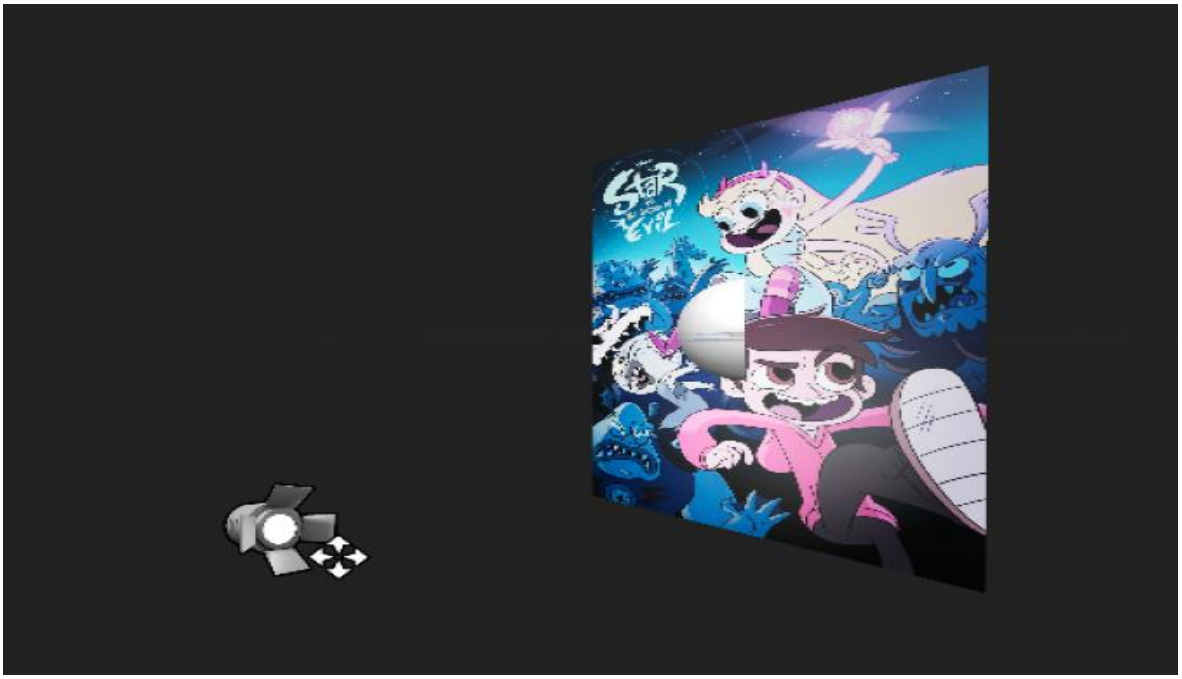


Figure 20: The poster object used on the digital Flamman theater.

5.3.2. Environment improvement

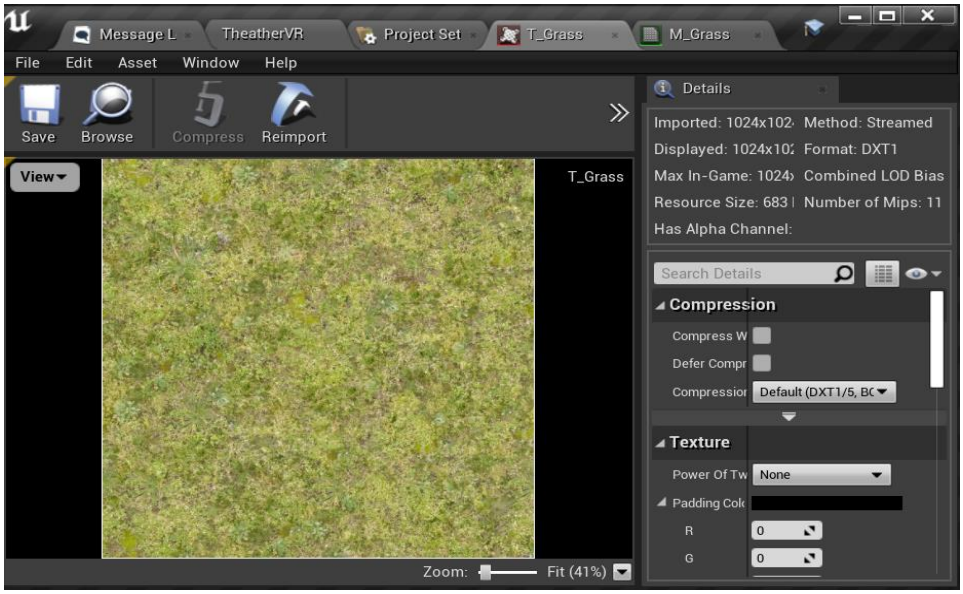
Most of the feedback received from the players of the first testing session concentrated on making the surrounding space around the theater. Thus, the level was enriched in a more natural way so people could feel that they are outside in summer. The environment was inspired from my experience visiting Slottsskogen park in summer, which has some paths through trees and warm light. The environment provides an open field area that the player can explore and enjoy the summer in Gottenburg.

5.3.2.1. Grass

As mentioned before, the goal for the environment improvements was to make the surroundings as a Gothenburg Park in summer. One of the key features to have during summer is a green place, which could be seen perfectly with grass covering the virtual landscape. In order to place grass in on the game level, I looked for an image or texture that resembled grass as much as possible. Second, I needed to create a material in UE, and, finally, added the created material into a primitive polygon that represented the floor, ensuring that the texture repeated itself all along one of its faces.

To find an image that could be used as texture for the grass in the virtual environment, I searched for a free image as seen in Figure 21.a. Then, this image had to be exported to the Unreal Engine project by a simple drag and drop to the content browser of the project, which creates a new file with a uasset (UE file) extension. This file represents a texture object in the engine, therefore there was no need to save the JPG original image.

a)


Message L
TheatherVR
Project Set
T_Grass
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File
Edit
Asset
Window
Help
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Browse
Compress
Reimport
Details
Imported: 1024x102
Method: Streamed
Displayed: 1024x10
Format: DXT1
Max In-Game: 1024
Combined LOD Bias
Resource Size: 683
Number of Mips: 11
Has Alpha Channel:
View
T_Grass
Search Details
Compression
Compress W
Defer Compr
Compressior
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Texture
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Padding Colc
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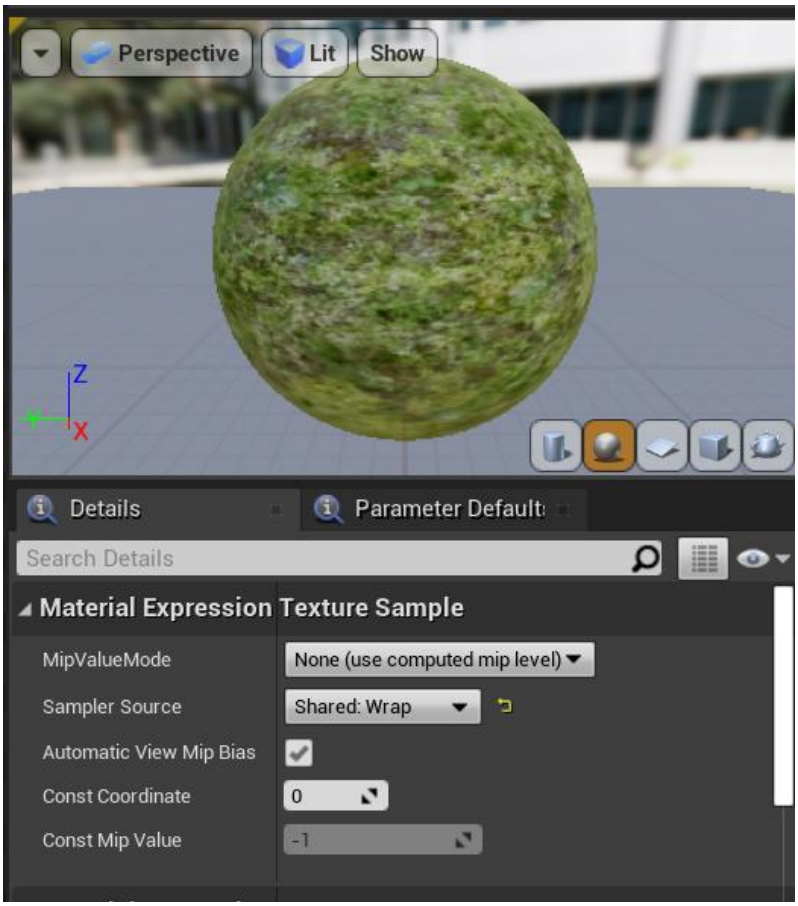
Zoom:
Fit (41%)

b)


Perspective
Lit
Show
Z
X
Details
Parameter Default
Search Details
Material Expression Texture Sample
MipValueMode
None (use computed mip level)
Sampler Source
Shared: Wrap
Automatic View Mip Bias
Const Coordinate
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-1

c)

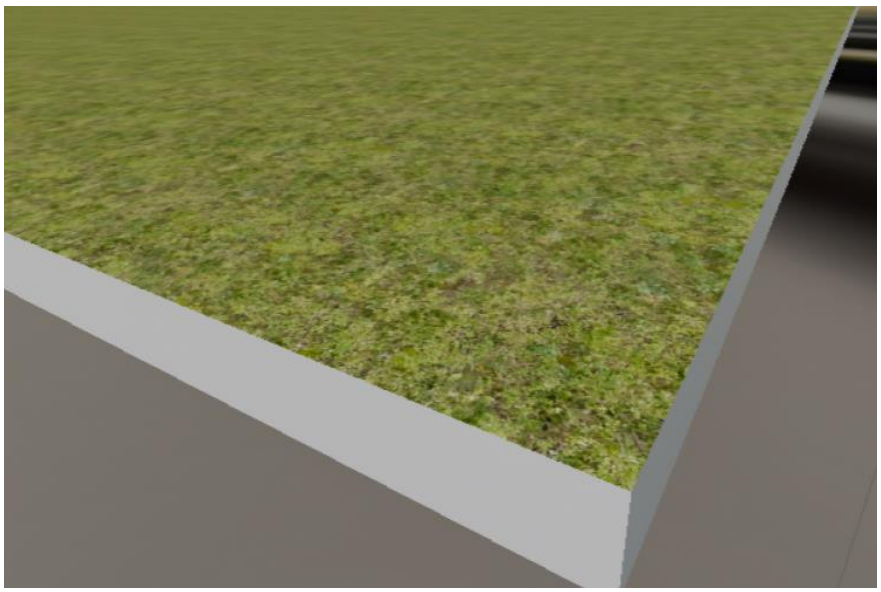

Figure 21: Implementation of grass texture on the virtual environment. a) Shows the image converted to texture in Unreal Engine. b) Shows the material made from the grass texture. c) Shows the Unreal Engine's Box Brush object with the resulting material as a component.

Then, with the texture as an engine's object, I created a material from the texture object. This material (Figure 21.b) was set to wrap as *texture addressing mode* because that way the texture is repeated over and over in every direction, therefore the grass texture could be visualized as a continued grass although it will show a repeated grass image.

Finally, I added the recently created material to the geometry for the floor of the level (which is called Box Brush and contains properties specifically made for representing ground on games) as part of the surface material component of the object. As a result, the entire environment took a more relaxing look with green colors surrounding the area.

5.3.2.2. Trees

To complement the feeling that the ground exhibits, I added trees around the ground level. Trees made an area look like a path with trees (Figure 22) around the theater in a Gothenburg summer.

a)

b)

Figure 22: a) 3D Tree object b) Path to the theater surrounded by trees.

5.3.2.3. Blocking areas

In the first testing session, it was found that the players teleported from the middle of the theater to the ground under the theater mesh, which was caused by a miscalculation of the teleportation line with a navigation mesh that continued below the model of the theater. To solve this problem, a nav. modifier volume was placed to block the area below the theater (see Figure 23), in this way the player character could not fall nor enter below the theater, especially because this area should be unreachable by the player since the focus of the game is to explore the interior.

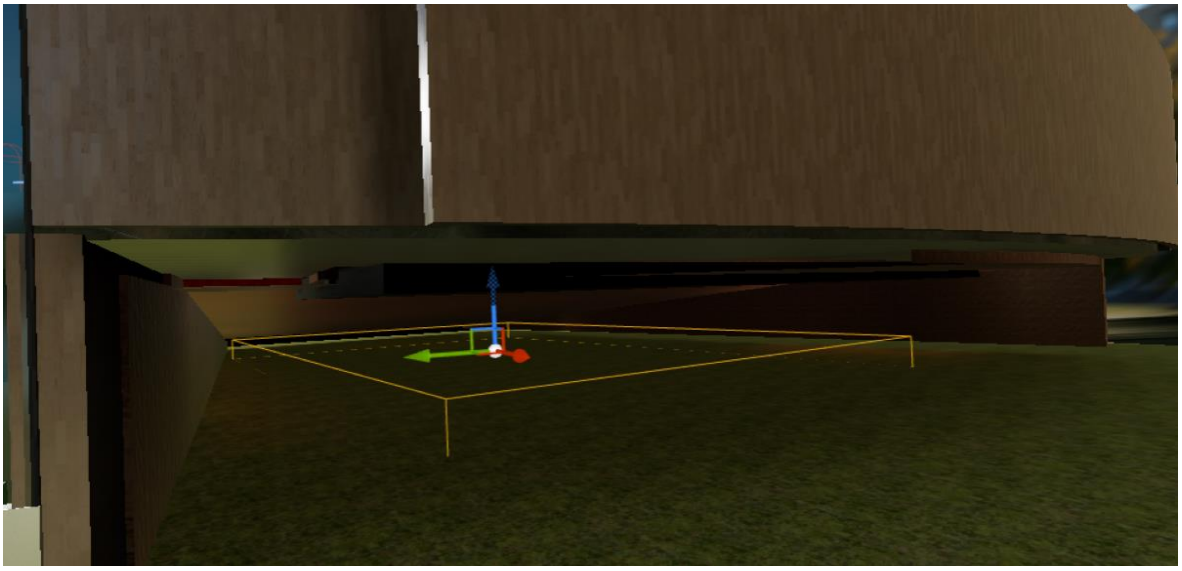

Figure 23: Blocking the space below the theater to forbid teleporting here.

5.3.3. Cinema video object

In the first prototype, the audio of the movie that was played surrounded the entire building, producing a cut-off feeling of being in a movie theater since the audio is normally only heard inside the room that has the screen and not at the entrance of the theater when buying a ticket. To amend this, I decided to create a game object that has three things: a plane to show video playback; an object that controls the direction and intensity of the audio; and a media player that plays a movie file. In Unreal Engine, the object just described (Figure 24) above would be created by means of a Blueprint class that contains the mesh component of a shot, a media sound component, a media player object and a reference to the media source.

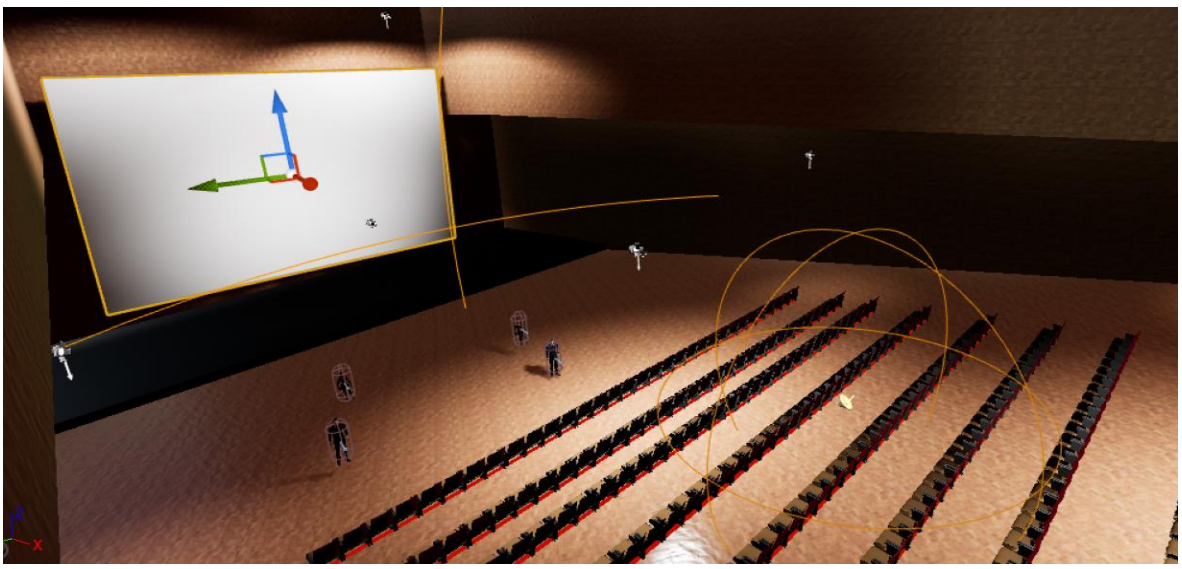

Figure 24: Cinema Screen Object with its sound volumes in the theater model.

The mesh of a plane was used together with a material that has a texture with reference to a video. These types of textures are called "media textures" in Unreal Engine. On the other hand, the media sound component has a property of being able to reproduce a media source within a geometry to attenuate the sound. This geometry consists of two spheres, one small within another. The small sphere is able to reproduce the original sound within its radius. However, the sphere that contains it attenuates it so that it decreases until it leaves its radius.

5.3.4. Non-player characters

To make the level feel more entertaining for players, I added smart characters that move around the level. These intelligent characters are instances of an Unreal Engine class called "character". The Character class has a collision component, a mesh with skeleton for animation movements and a movement component (Character Movement Component). However, in Unreal Engine the character needs an AI controller class for the character to act with artificial intelligence, so a reference to a controller class is necessary.

Thus, the class I made to represent an intelligent character is called RandomCharacter, which inherits from the character class, and has a reference to an AI controller class. I also made an AI controller class called BP_AIController that executed a Behavior tree in which it is described the way the character should move through the level.

5.3.4.1. Character model and animation

In order for the character to move in a natural way for the players, several animations had to take place in the Unreal Engine animation system. To do this I made an Animation Blueprint, which is a class that uses states and variables to display certain animation in real time. In the Animation Blueprint, I created a variable that stored the speed with which the character is moving, and depending on its magnitude the animation changes from one in which the character is standing/idle (Figure 25) to one in which it is walking (Figure 26) and then to one in which it is running (Figure 27).

Figure 25: Standing/Idle animation of a male and female characters.

Figure 26: Walking animation position of a male and female characters.

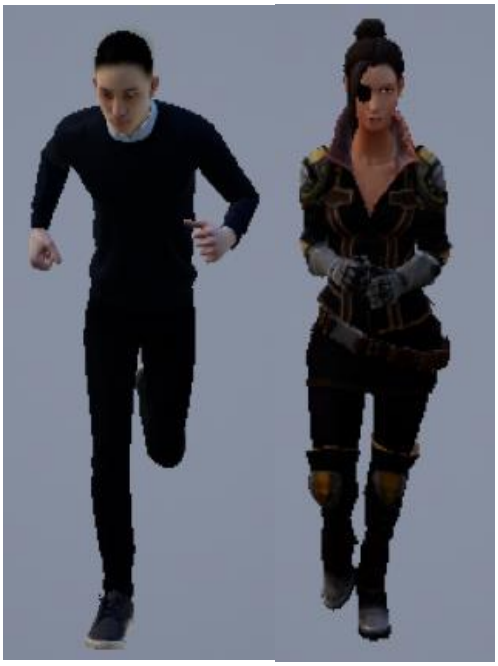

Figure 27: Running animation position of a male and female characters.

5.3.4.2. Character behavior tree

The behavior tree was designed to represent a more complex and time-controlled wandering algorithm (see Figure 28). Specifically, the tree consisted of a sequence and leaves included tasks that were executed in order from left to right. The first task tries to find a random position in space, the second task moves the character to the position obtained in the previous task, and the third task waits a while to repeat the sequence.

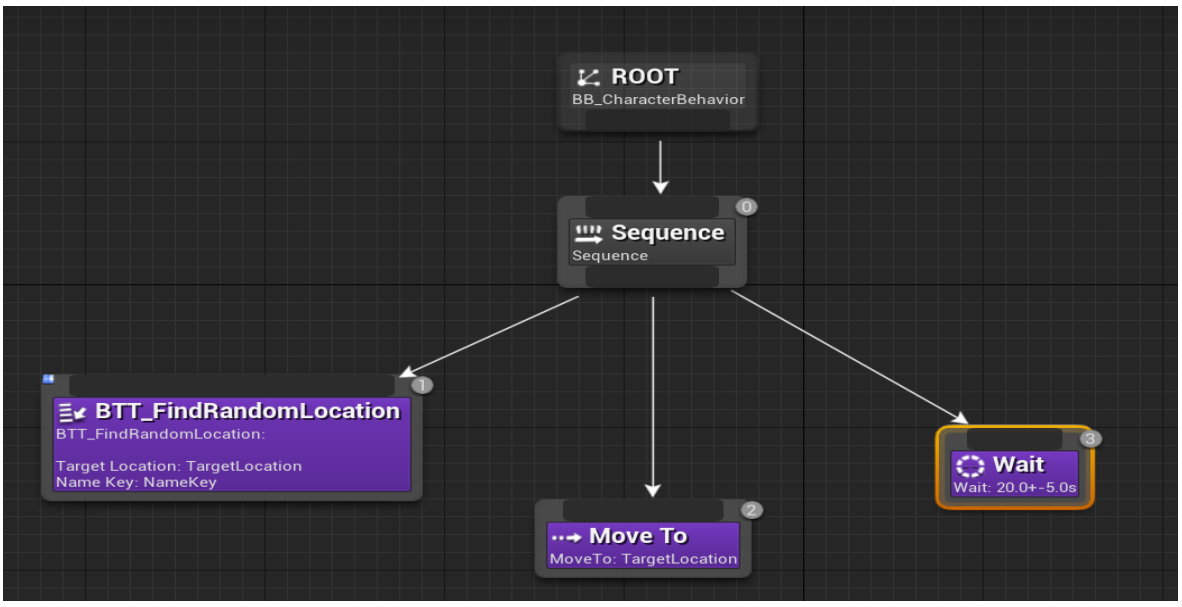

Figure 28: Character's behavior tree.

5.3.5. Interactive grabbable objects

Because people liked to interact with grabbable cubes in the first testing session, I used the original blueprint class to create child classes with different 3D meshes. One child class for popcorn, another class for popcorn container, other for nachos and another for nachos bowl (Figure 29). In the case of the popcorn container and the bowl, I enabled the complex collider in order to put other objects inside them.

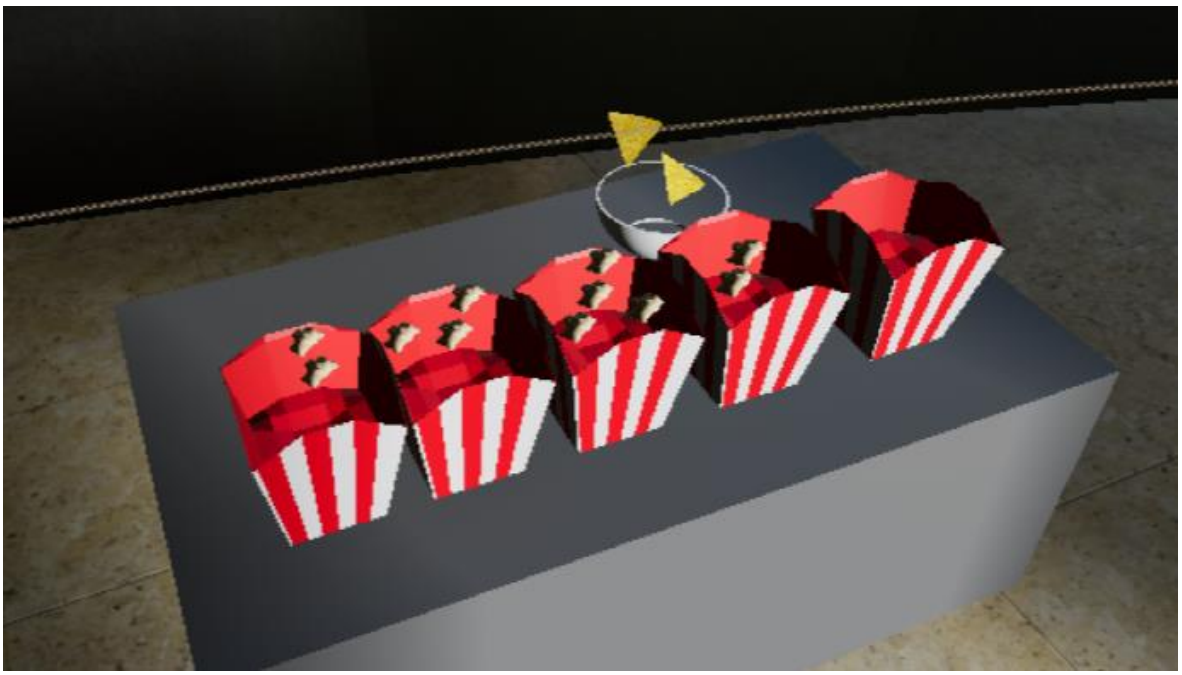

Figure 29: Grabbable objects on the level, nachos, a bowl, popcorn and its container.

5.4. Final Testing Session

In this testing session, users only tested the game with guided tests (see Section 4.3.1.1), as it was more comfortable for most of the players who participated in the project. In addition, a questionnaire was made at the end for each participant and what the people felt while they tried it. These answers were noted to record the improvements of the previous testing session.

In this testing session, the level of the game has more refined mechanics, sound and exploration to test the engagement when the player is watching the movies. Other factor that was evaluated is the presence of NPCs wandering around the theater.

5.4.1. Movie experience as game aesthetics

The emotions that the users showed in this session regarding the feeling of watching a movie in the theater were conclusive to ensure that a similar experience that the movie

showed also resembles what the users felt.

The movie shown was a cartoon episode that increased feelings of joy as the story progressed. The results showed 75% of the participants responded the felt joy while watching it. However, the rest of the people spent time exploring the story theater to see how far they could go inside the theater.

5.4.2. NPCs

On the other hand, the use of NPCs showed that users felt more comfortable with people around them interacting as players. On the contrary, 25% of users did not feel that it added anything to the experience.

5.4.3. Game aesthetics

In the case of the feeling of the game in general, users felt that it was a much more complete experience due to the use of the pickables, the exploration and the new objects around. Specifically, 100% of the users liked to play with the popcorn and nachos pickables. In comments, most indicated that it is fascinating to explore theaters from other parts of the world.

6. RESULTS

The result of this project was the conservation of the Flamman theater's original identity as it is now digitally preserved as an Unreal Engine 4 project in a google drive folder. The file is in google drive for the conservation of files and the ease to download to any other platform. Technically, this was made with the aid of a videogame that shows a virtual environment, which can be experienced with virtual reality. VR increases the interactivity between the players and the theater itself, in addition to NPCS. In this way, the environment feels more natural for the players.

As such, the theater is a three-dimensional model (3D model) that has a room. In this room, movies and sound are reproduced by a "cinema video object". In turn, the cinema video object is responsible for showing the video by means of a plane that changes its texture according to the reproduction of the video. The video object also contains a spatial sound structure so that the reproduced sound depends on the distance in which the player is found.

On the other hand, the mechanics that this game has, gives a more jovial identity to the experience of going to the cinema because this game contains grabbable objects with which users can play while watching the movie that is shown in the movie room of the model in three dimensions (3D model).

Finally, the artificial intelligence developed for this game makes it feel comfortable for players as it leads NPCS walking around the place in the virtual world in a more natural way, so players not only see more characters but they feel them real while going in and out the cinema.

a)

b)

c)

d)

Figure 30: Images taken from the final result of the theater with game elements, NPCs and environment, inside Unreal Engine. a) Theater lobby of the Flamman theater with NPCs. b) Outside of the Flamman theater with game elements for grabbing and trees. c) NPCs stationary in game editor mode with arrows pointing to their front direction. d) Inside of the theater with NPCs, chairs and screen.

7. DISCUSSION

The goal of the project was achieved, still, there are some enhancements that could be done to improve the video game experience. In addition, some interesting behaviors on the players that test the game had been found, like the need of some players to explore the environment surroundings of the Flamman theater or looking for interactions with objects. There are three aspects that would improve the experience for the players, the first is to enable multiplayer mode, the second is to experiment with a refined test methodology and the third is to give the player further control over the character. Furthermore, the behaviors of the testing players, although out of the scope of this project, were interesting in the way that all of the samples were from people that did not know about the theater. These group of people never went to Gothenburg before, which let them experience the theater in a unique way, not as they were part of a city but part of the world heritage.

The first improvement could be the option to make the game multiplayer would greatly augment the game by having players interact socially with other people, instead of seeing only artificial intelligence characters, this would also make the theater known in various parts of the world. In addition, the improvement as a multiplayer game is a very viable option since the game engine in which the video game was developed has capabilities to create and implement a multiplayer logic.

The second proposed improvement is focused on the method created to perform user tests. In this project, as a consequence of the COVID-19 pandemic, most people felt comfortable testing it remotely. The remote test highly influenced the experiences of the players, making it optimal. Otherwise, people would have been gathered in a room to test it. In addition, user testing protocols can be improved to make it a better experience and collect more data to understand better the user experience with the game.

The previous observation means that the actual stakeholders of this project were people outside the original scope, which were young people from the city of Gothenburg.

The third improvement is focused on the control of the player with the character. The ability to customize the skins and the shape of a player could add more interactions with the player to make it more appealing when visiting the Flamman theater.

Therefore, this change of demographic and stakeholders could impact a lot on a game design that relies on vintage nostalgia as a primary aesthetic. However, since the project aim was set to recover an identity and the new stakeholders did recognize the architecture as a place to see movies then the objective was reached.

8. CONCLUSION

After completing the Project two research questions were addressed, the first is *What could be successful to have in a theater experience with VR?* and the last one is *How to use the think aloud testing technique during pandemic times with capacity restriction measures and isolation recommendations?*

The answer for the first question "*what could be successful to have in a theater experience with VR?"* is that the elements that make a VR cinema experience successful are: the mechanics of entering a cinema and watching a movie; game objects, such as, grabbable objects (popcorn and nachos) and AI NPCs. Because the mechanics of entering the cinema and watching a movie in the projecting room revived the feelings of engagement in the players when listening and being attentive to what happened on the screen. Furthermore, game design and development with game objects, both grabbable objects and AI NPCs, allowed the player to enjoy the project as a videogame (gaming experience) and not just the cinema simulation. Grabbable objects allowed the player to interact with the world and not just explore it by teleporting around, whereas AI NPCs created an alive environment simulating a multiplayer experience, similar to what a person could find in a cinema, more people (feedback from testers reported a mindset of being playing a video game with VR rather than a pure theater simulation).

On the other hand, the answer to the second question "*how to use the think aloud testing technique during pandemic times with capacity restriction measures and isolation recommendations?"* is that the think aloud technique could be used with individual remote tests and guided tests types when physical interactions are restricted. Although, the think aloud technique was used with all three test types (classical tests, individial remote tests and guided tests), the technique required a different communication method (e.g., Zoom or Discord communication programs) due to the COVID 19 pandemic health recommendations (e.g., social distancing). Recall that, in the think aloud technique, the tester lead asked questions to inquire clearly about the feelings, thoughts and emotions of the player at each stage of the game. In the case of individual remote tests, players used their own VR headset to explore the project, while players in guided tests experienced the virtual world by means of the tester lead that followed the directions given. Both, individual remote tests and guided test were better received by most of the participants than classical tests (individuals were present in the room, while the tester lead was two meters away from the player), since the factor of fear of contagion was eliminated. Individual remote tests and guided tests may have encouraged more people to participate during the testing stage. As a personal opinion, I feel that the guided tests improved the diffusion of VR technology to people not so steeped in video games, showing the capabilities of the technology.

In addition, the attempt to preserve the architecture of the Flamman theater was successful by creating a video game with mechanics and dynamics. In this way the player can partially recreate the experience of going to the cinema with the help of virtual reality. To create an appealing game, the designed was based on a hybrid model. For that purpose,

the hybrid model was based on game mechanics, game dynamics and aesthetics, the GNS model and gameplay design patterns.

Moreover, talking about the development, I used game mechanics to help describe the aspects of game designs as methods that could be implemented such as entering the cinema by exploration and/or grabbing objects to exhort casual gameplay. On the other hand, the MDA framework for dynamics and aesthetics e strengthened the link between the mechanics in the game. For instance, when the player is watching and listening to the film in the cinema's screen, then he/she experiences thematic consistency and casual gameplay. Furthermore, aesthetics focused on appealing to the emotions of the player. In addition, the GNS model defined the player mode as simulation in combination with gamism. Level design theory helped in the development of the environment of the 3D environment of the theater.

And final comment on the technical side of the project is that the development of the videogame in Unreal Engine 4 made easy to recreate a projection room inside the Flamman theater. Unreal Engine 4 allowed projecting YouTube videos or imported files from the local directory. Moreover, UE 4 allowed to implement textures, interactive objects, and sound limits for the theater to isolate the projection room by importing objects. For this, a design was defined based on game design elements such as trees on a grass surface, Non-player characters (NPCs), posters, grabbable nachos and popcorn and extra light sources inside the cinema, test sessions were organized to verify that the objectives were met and mechanics programmed were consistent with the objectives.

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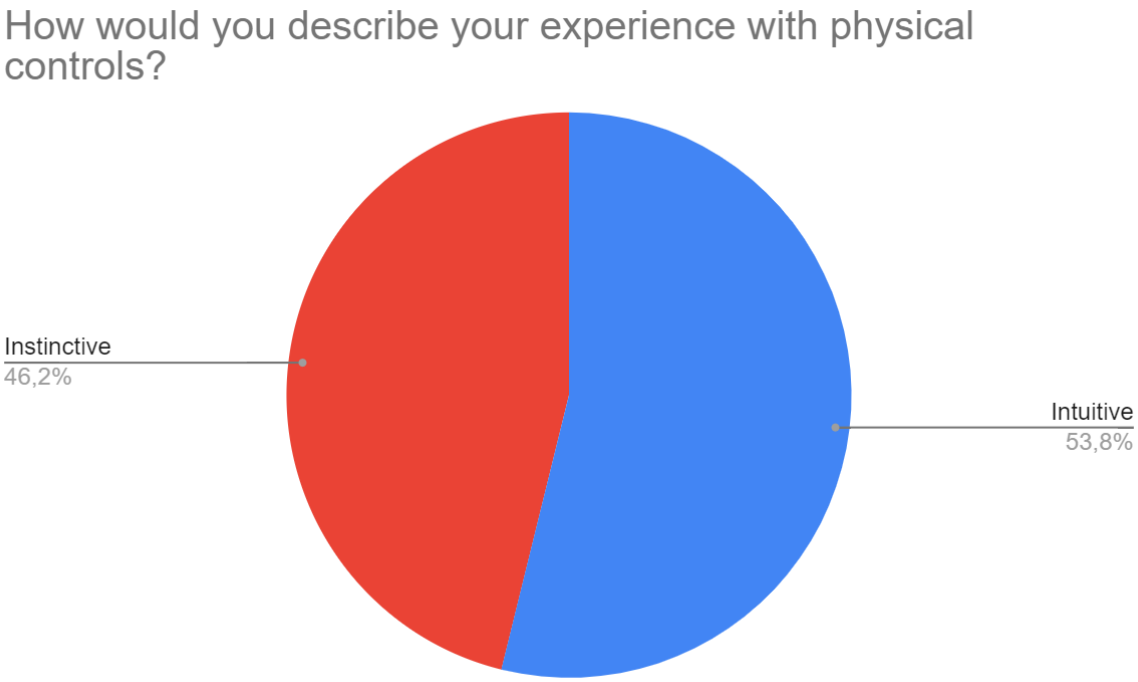
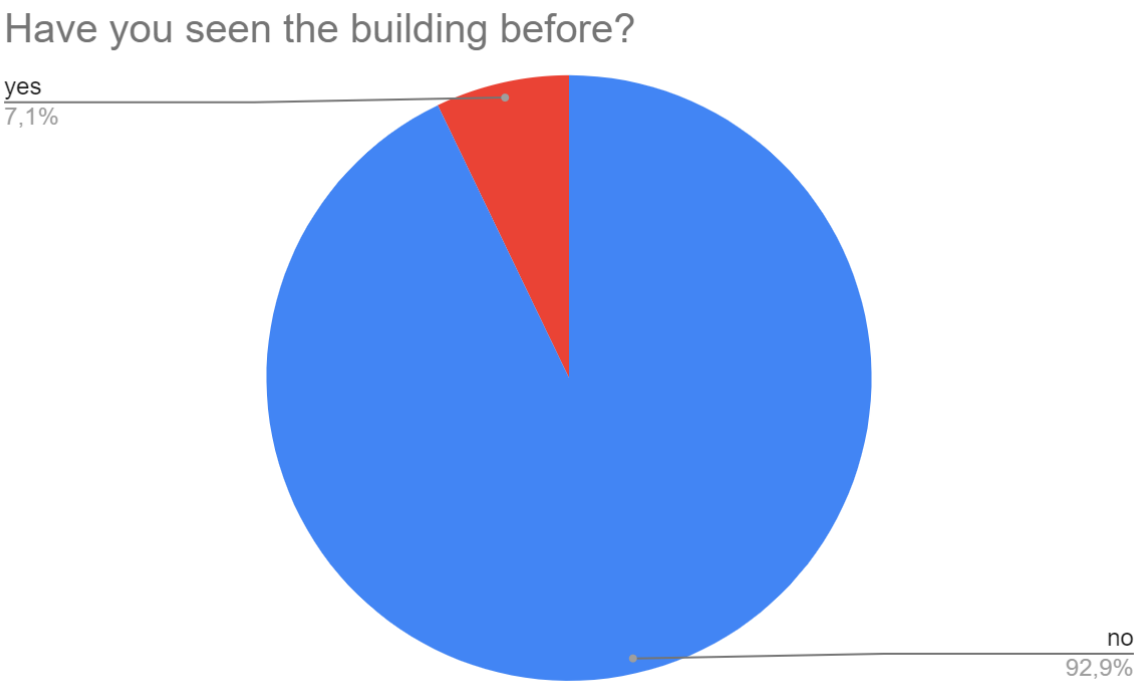
APPENDICES

Appendix A: Interview questionnaire for the first prototype

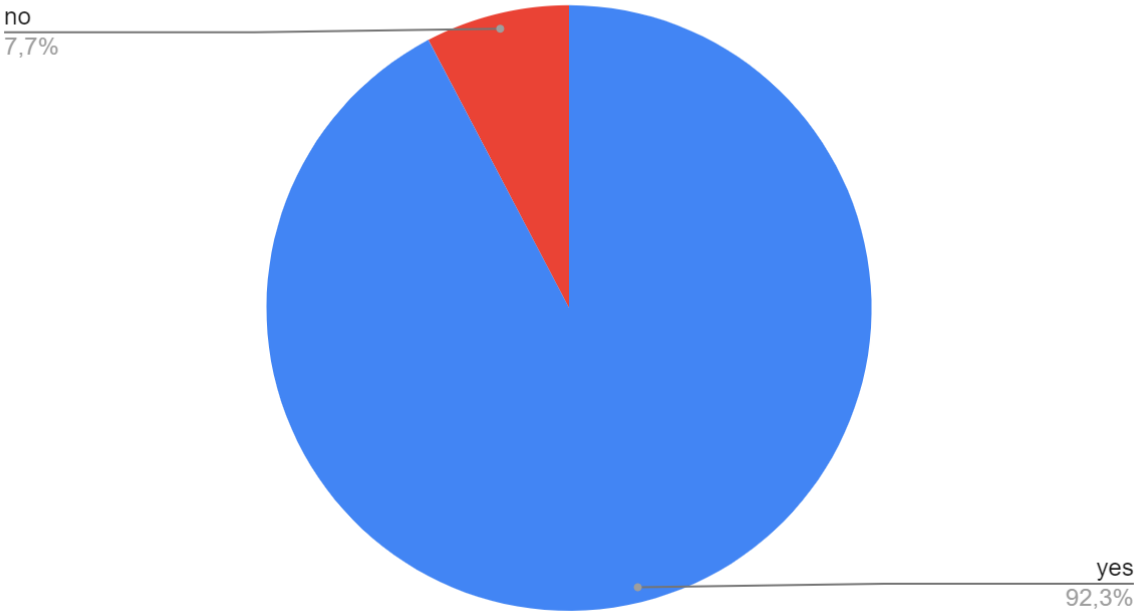
1) How would you describe your experience with physical controls?
   Alternatives:
   a) Instinctive
   b) Intuitive
2) Have you seen the building before?
   Alternatives:
   a) yes
   b) no
3) Was the entrance easy to find?
   Alternatives:
   a) yes
   b) no
4) If no, what was the main reason?
5) According to you, what does the building look like?
6) From 1 to 5, how easy was it for you to find the dark room?
7) From 1 to 5, how natural was it to play alone?
8) Would you rather stay in this cinema with Artificial Intelligence characters or real people playing with you?
9) From 1 to 5, how did you find the concept?
10) Do you have a VR device
11) If you don't have a virtual reality device, from 1 to 5, how likely is it that you will buy a virtual reality device in the near future?
12) What was the virtual reality viewer you used for the test?
13) Comments you want to add? any comment is good

Appendix B: Answers from the interview questionarie for the first prototype

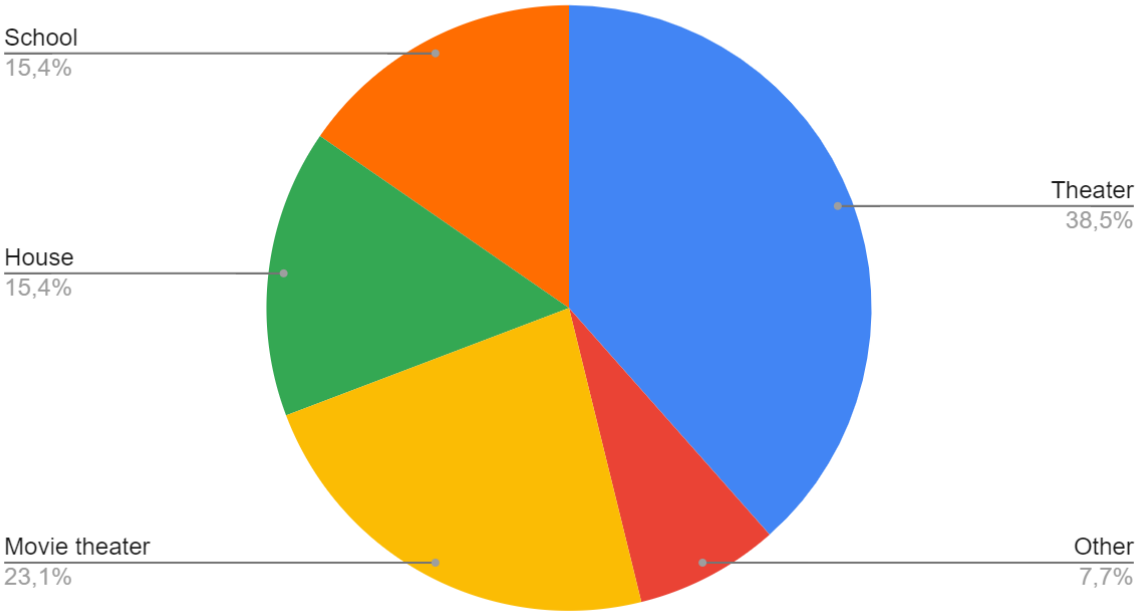


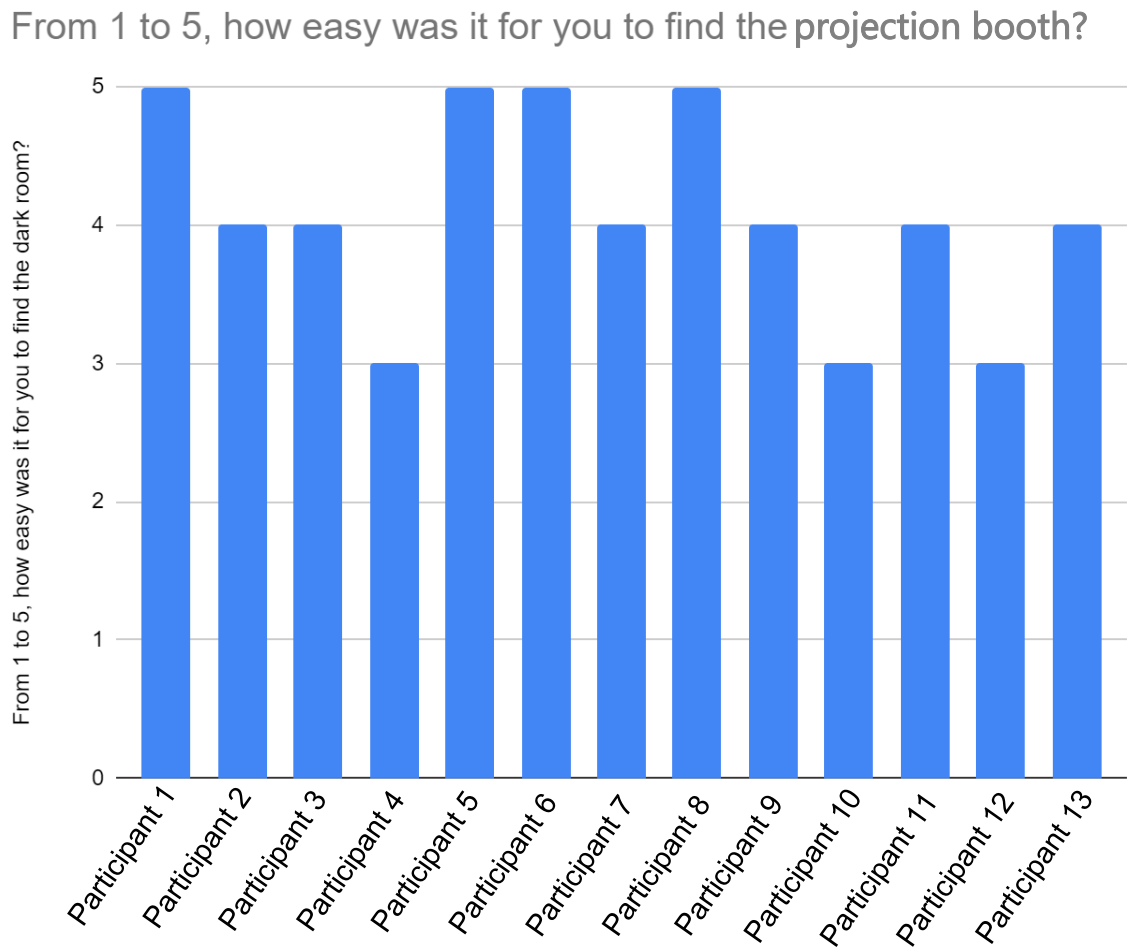


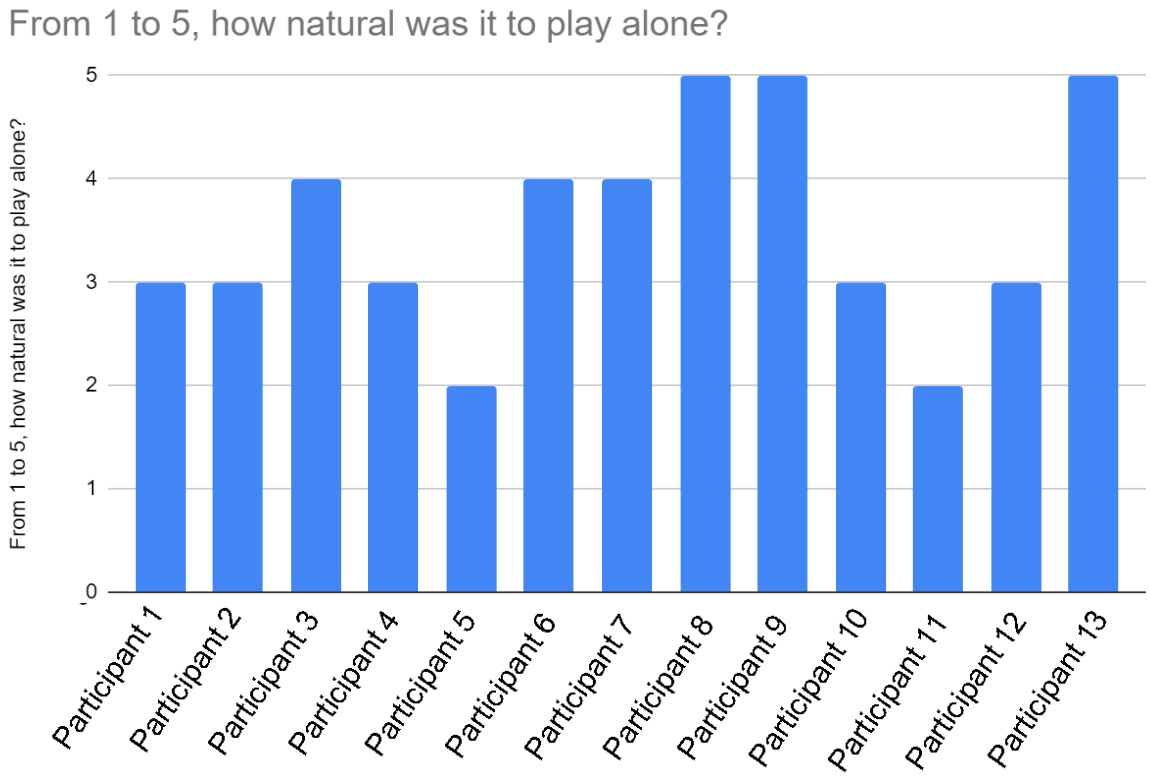
Was the entrance easy to find?

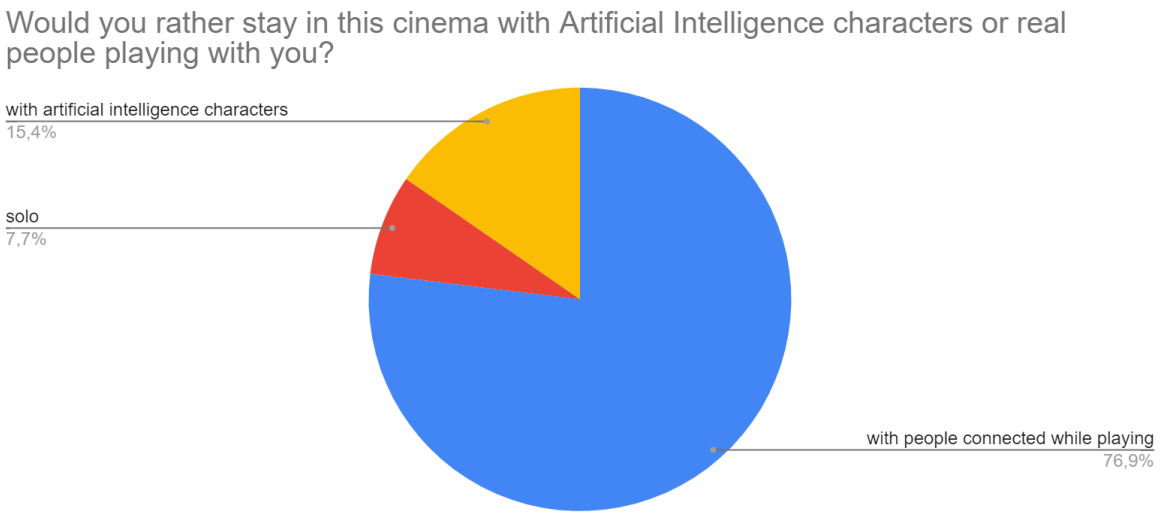


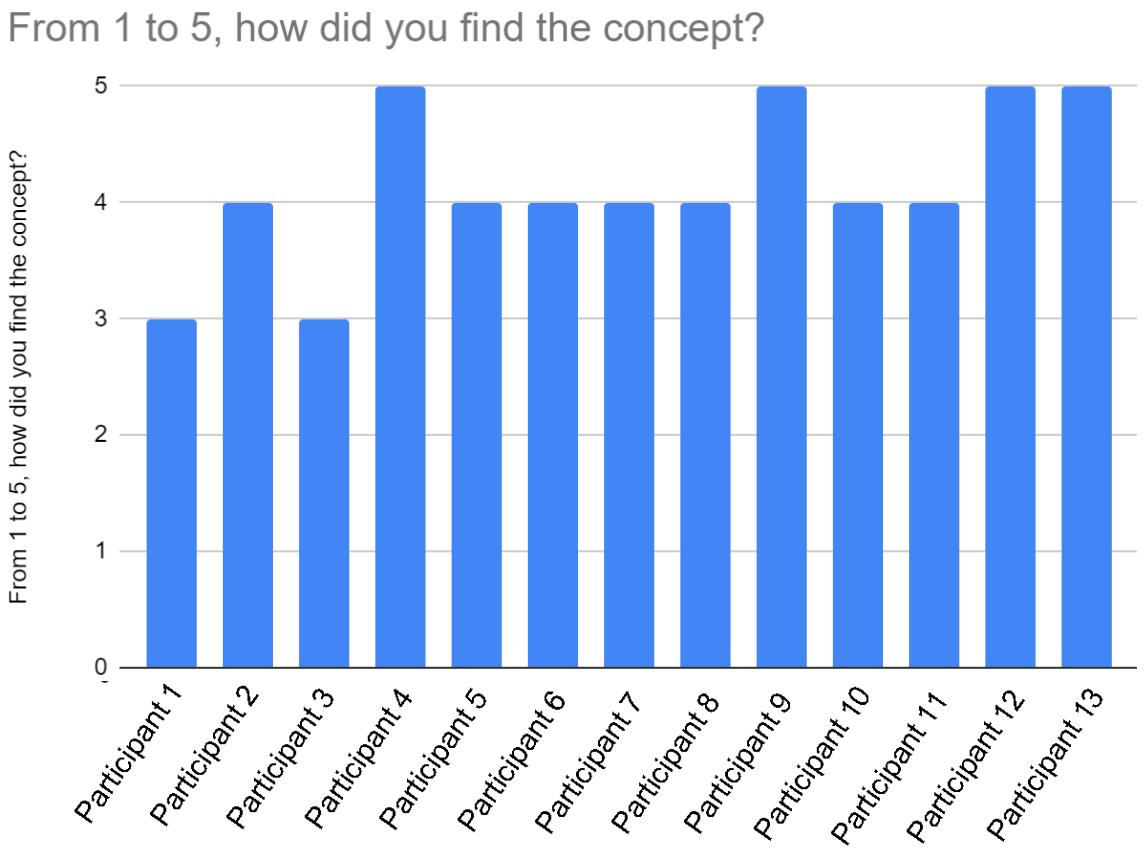
According to you, what does the building look like?



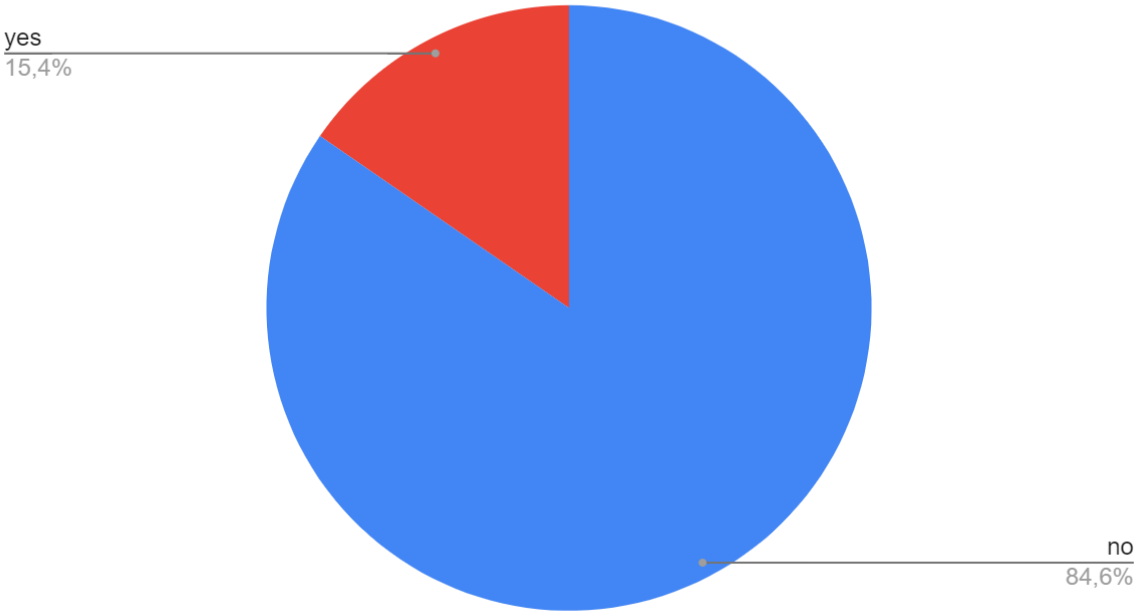

From 1 to 5, how easy was it for you to find the projection booth?
From 1 to 5, how easy was it for you to find the dark room?
5
4
3
2
1
0
Participant 1
Participant 2
Participant 3
Participant 4
Participant 5
Participant 6
Participant 7
Participant 8
Participant 9
Participant 10
Participant 11
Participant 12
Participant 13


From 1 to 5, how natural was it to play alone?
From 1 to 5, how natural was it to play alone?
5
4
3
2
1
0
Participant 1
Participant 2
Participant 3
Participant 4
Participant 5
Participant 6
Participant 7
Participant 8
Participant 9
Participant 10
Participant 11
Participant 12
Participant 13

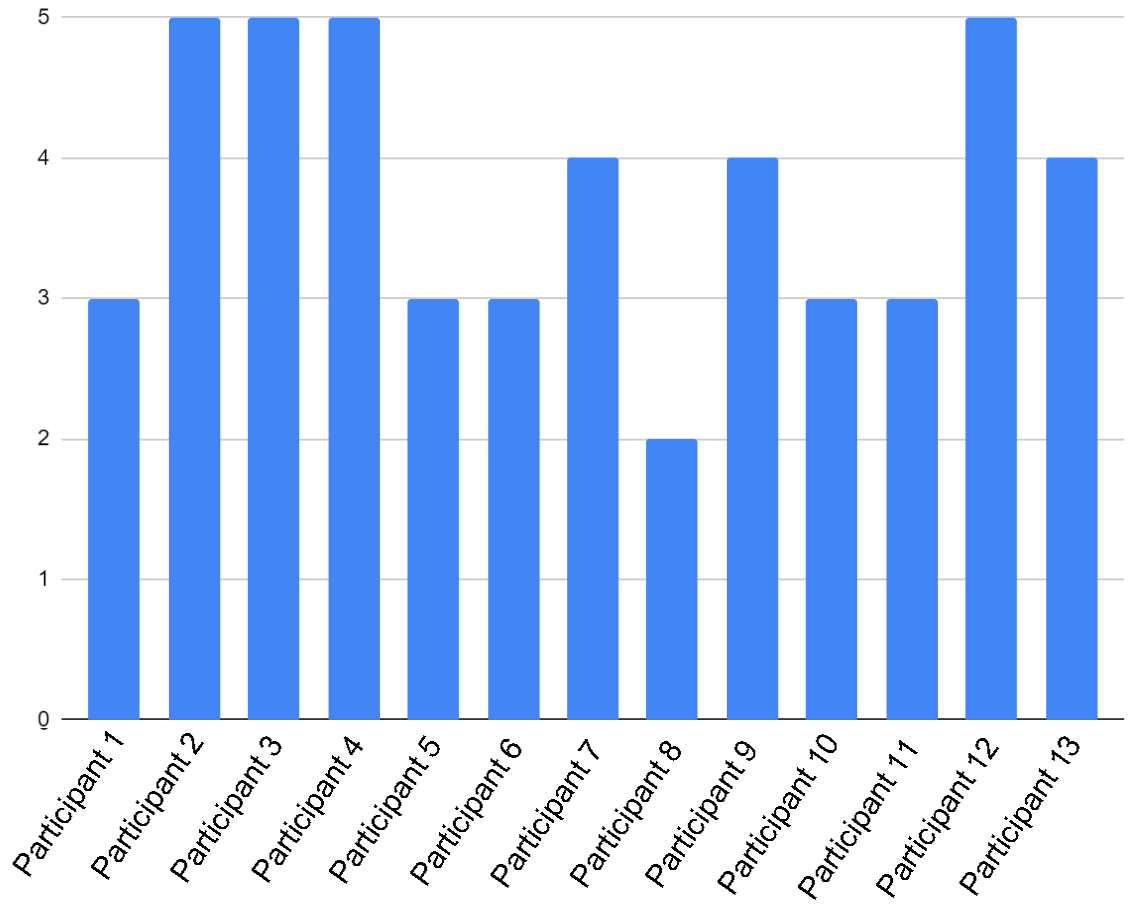

Would you rather stay in this cinema with Artificial Intelligence characters or real people playing with you?
with artificial intelligence characters
15,4%
solo
7,7%
with people connected while playing
76,9%

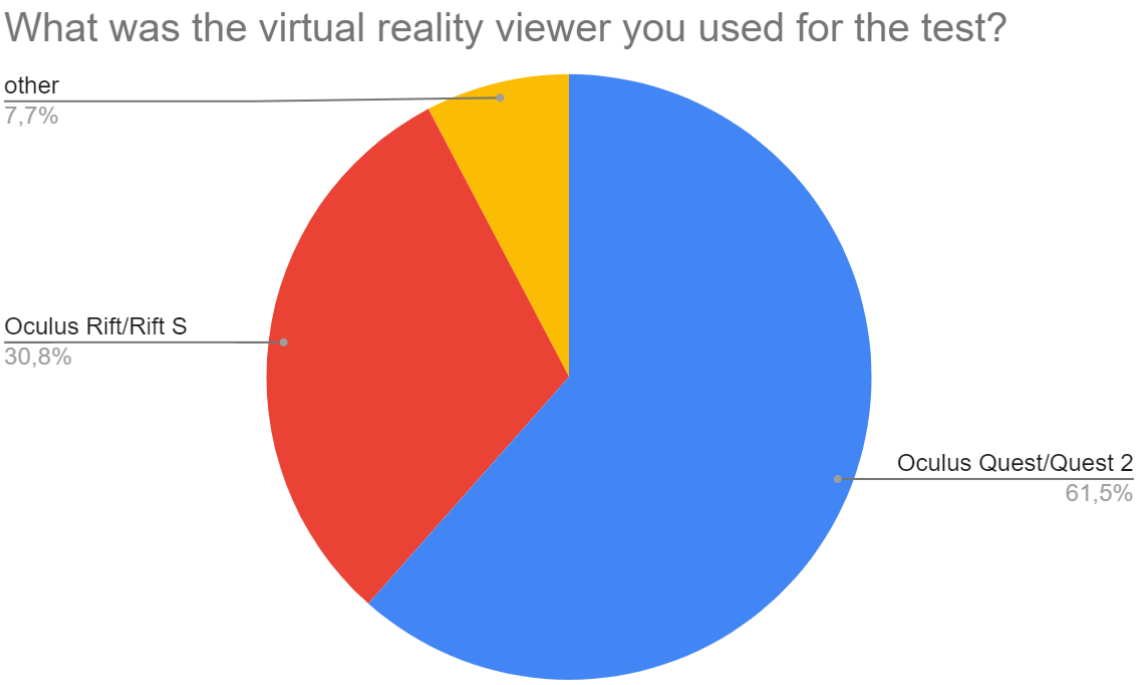

From 1 to 5, how did you find the concept?
From 1 to 5, how did you find the concept?
5
4
3
2
1
0
Participant 1
Participant 2
Participant 3
Participant 4
Participant 5
Participant 6
Participant 7
Participant 8
Participant 9
Participant 10
Participant 11
Participant 12
Participant 13

Do you have a VR device?



If you don't have a virtual reality device, from 1 to 5, how likely is it that you will buy a virtual reality device in the near future?





Comments you want to add? any comment is good
Implement an initial menu of the application Implement a site map Place textures of grass or buildings outside the construction site Allow the user to return to the starting point. Implement a tutorial or guides so that the user knows what actions can be performed in the application. Correct the lighting of the corridor, it seems that the light does not come from the source. Implement a light switch in the theater room to turn the lights on or off. Provide information to the user about the place where he/she is and a bit of history
I would like to see more things to interact with like the blue cubes. Maybe balls, lamps to turn off/on, buttons to turn on the ceiling lights. Maybe even an option to sit down, change the video on the screen. One thing that would make me feel more immersive is the feeling of walking. Maybe bots to interact with or another virtual character driven by someone who is also playing the game. The feeling of immersion diminishes a bit when you are outside the house/cinema because you notice that there is nothing on the horizon and it feels unnatural. Maybe if there were more houses or trees or mountains around it would be much better. Or even if the clouds were moving.
I would like to be able to choose the movies / videos shown, or have a previous selection, at least. If multiplayer is provided, it would also be interesting to have a screening room and snack bar. I find it counter-intuitive not to be able to sit in the seats. The cinema look is fine, but it could have a bit more detail, such as carpets, speakers, lighting level, and background. Finally, it's always interesting when a game or virtual experience makes use of all the spaces. The

cinema has an empty space at the back, and decorative ramps on the sides, which could be used for easter eggs or side quests, when players want to explore the outside.
With the purpose of the experience being more realistic/immersive it would be adequate to have access to things like popcorn and the like, also the wall looked kind of cold, some art/movie marketing would be a good addition, and there is the opportunity to add hand gestures to interact with other people, should there be anybody else.
In my opinion, it is better to make the building on the ground floor instead of a second floor for easier access and bring the stairs on the chairs section so the user may be able to choose a relatively upper view of the screen or lower view in addition to the left/right views.
Very good game, I would play it again
change the movie or video that is being presented
The mobilization should be more natural because it confuses a bit. The view out the window should have details to make it more realistic. A lot of movement in the game made me feel dizzy. The design and experience were super cool.
The best experience
Very good game, I would play it again

Appendix C: Interview questionnaire for the second prototype

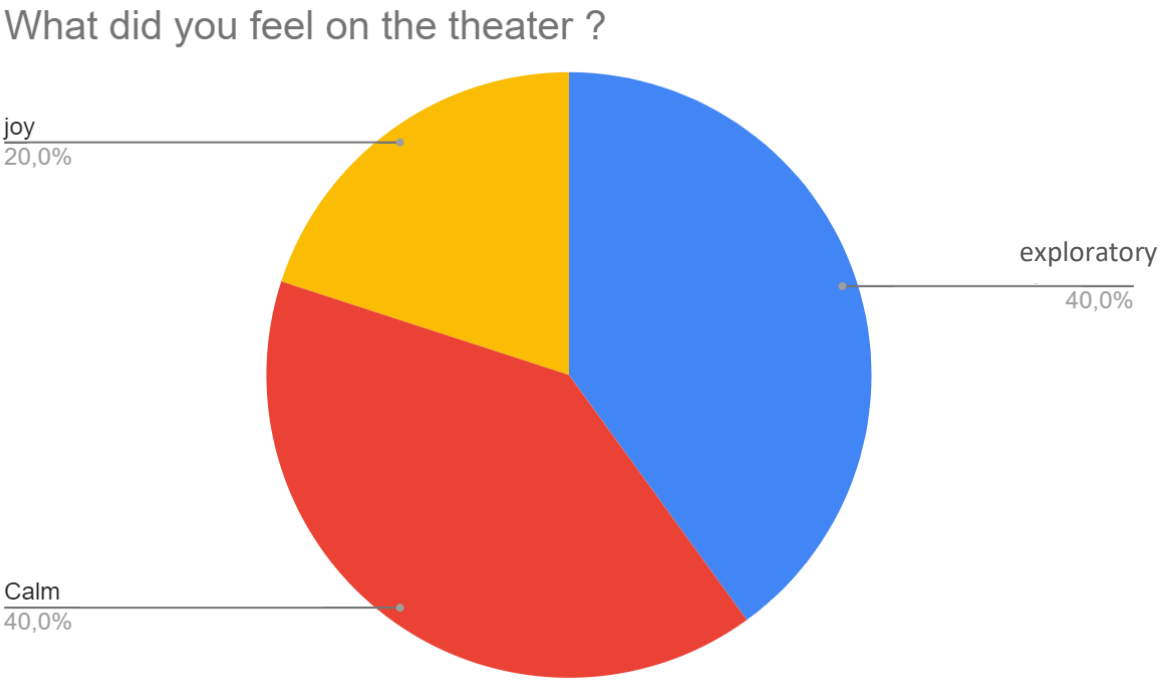
1) What did you feel on the theater?
   Alternatives:

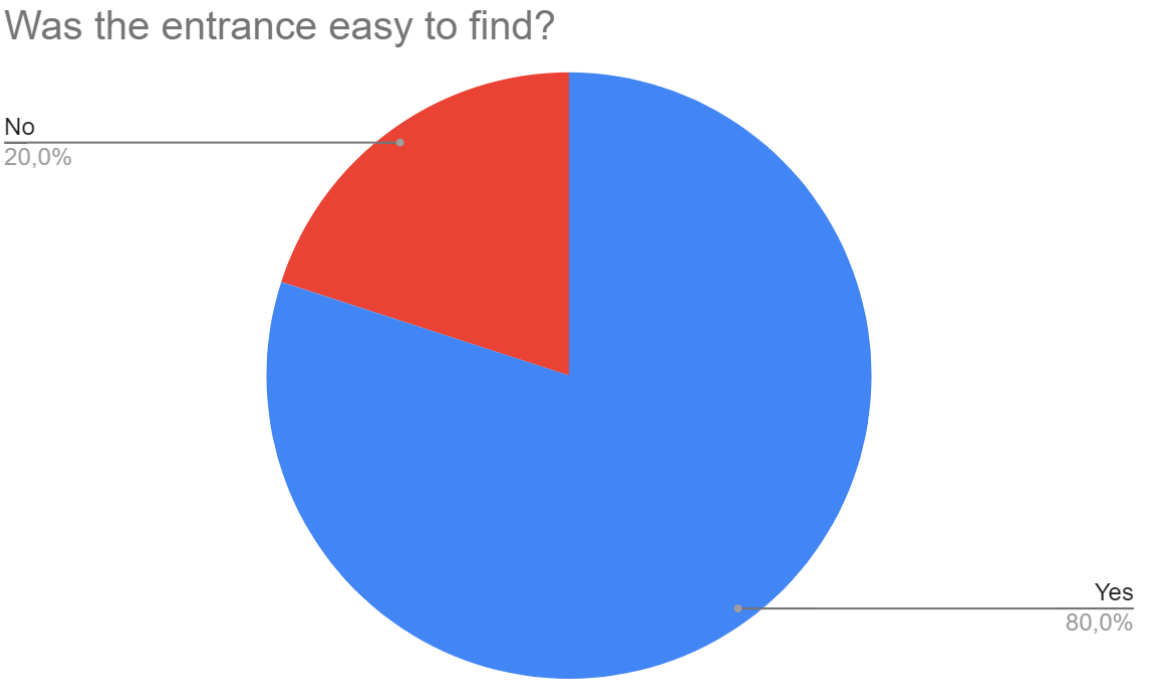
a) Joy
b) Calm
c) Sadness
d) exploratory

2) Was the entrance easy to find?
   Alternatives:
   a) yes
   b) no
3) Did you feel the experience more alive with more characters on the scene?
   Alternatives:
   a) yes
   b) no
4) Did you feel the theater experience more natural with characters wandering around?
   Alternatives:
   a) yes
   b) no
5) Did you feel enjoying the experience with the pickable items (popcorn and nachos) around the scene?
   Alternatives:
   a) yes
   b) no
6) How do you feel this experience compared with watching a movie from the tv on your living room?
   Selection from 1 to 5, one being “too boring” and five being “super exiting”
7) Do you feel that you would explore it again when the game changes the movie?
   Selection from 1 to 5, one being “never again” and five being “yes I would love to”

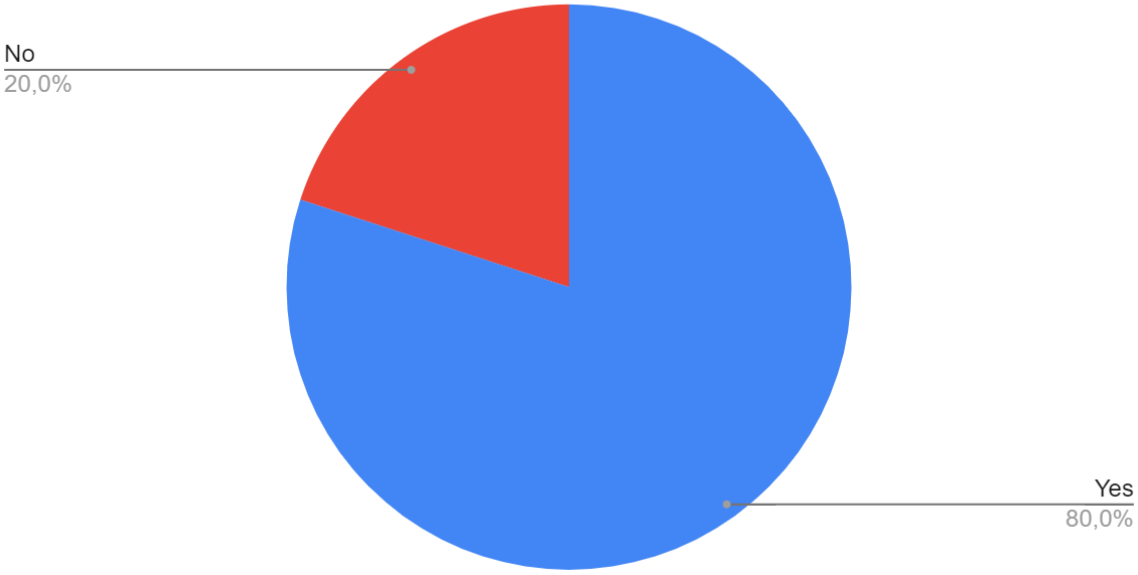
8) What did you feel while watching the movie?
   The answer could be any feeling that the testers would like to chare
9) What do you think about exploring the architecture of an old cinema from another part of the world?
   The answer could be anything that the testers would like to share

Appendix D: Answers from the interview questionnaire for the second prototype

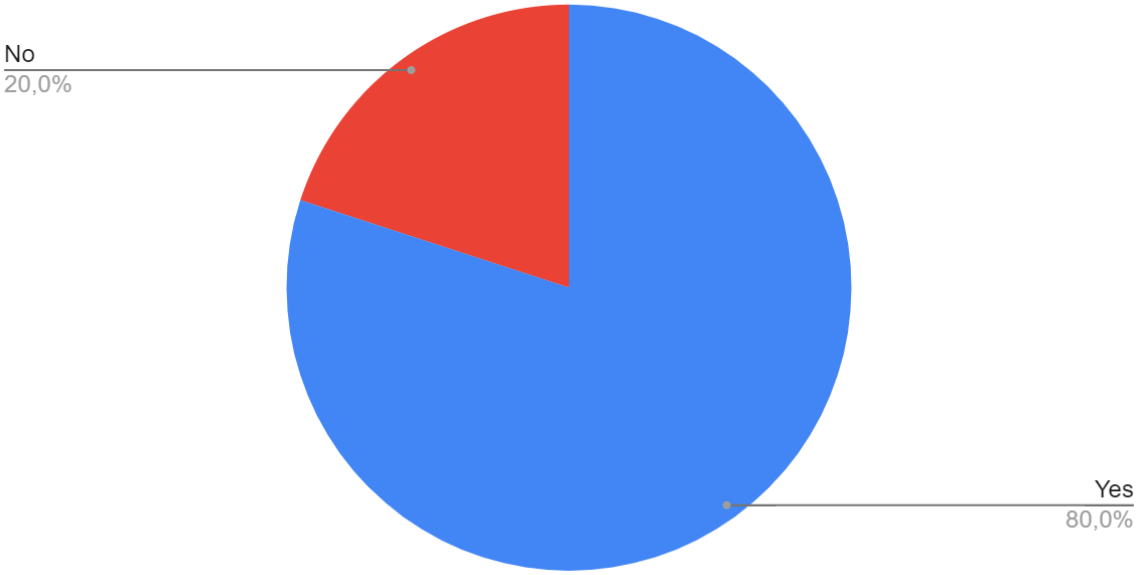




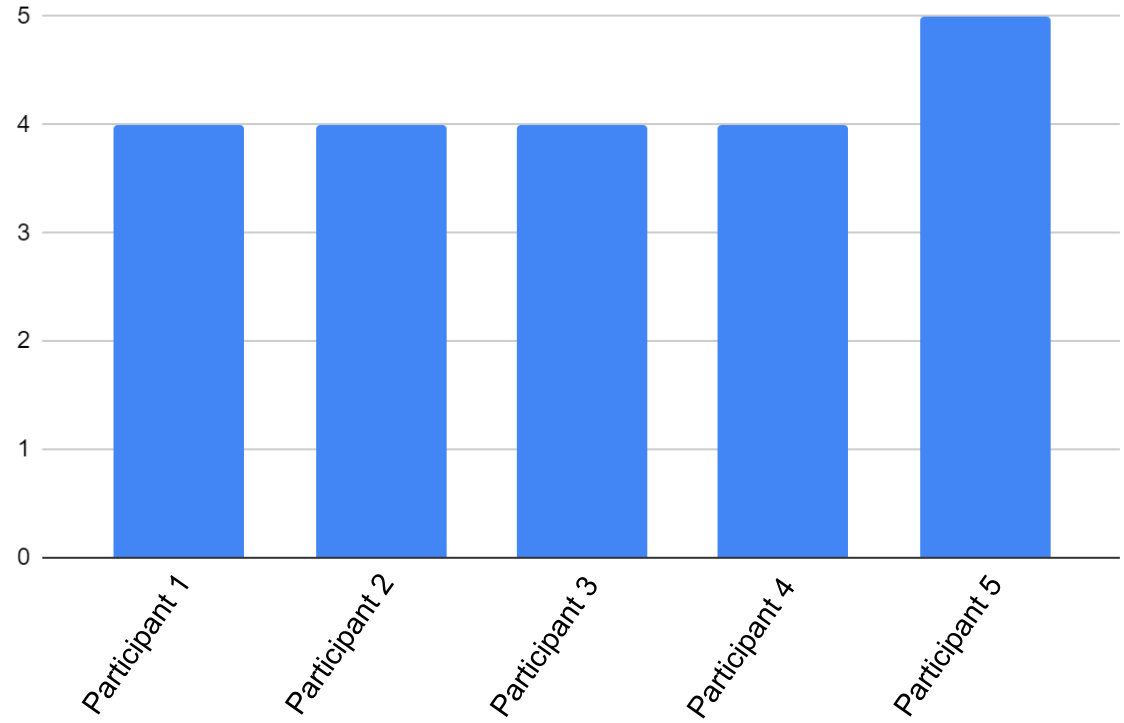
Did you feel the experience more alive with more characters on the scene ?



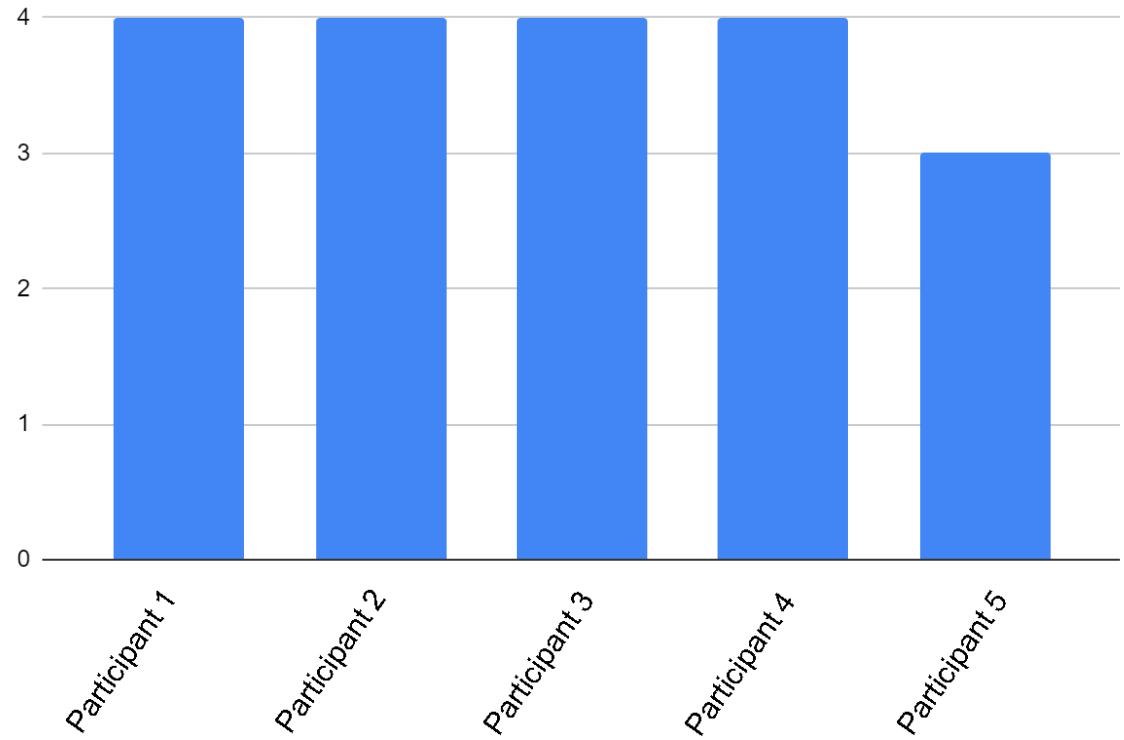
Did you feel the theater experience more natural with characters wandering around ?

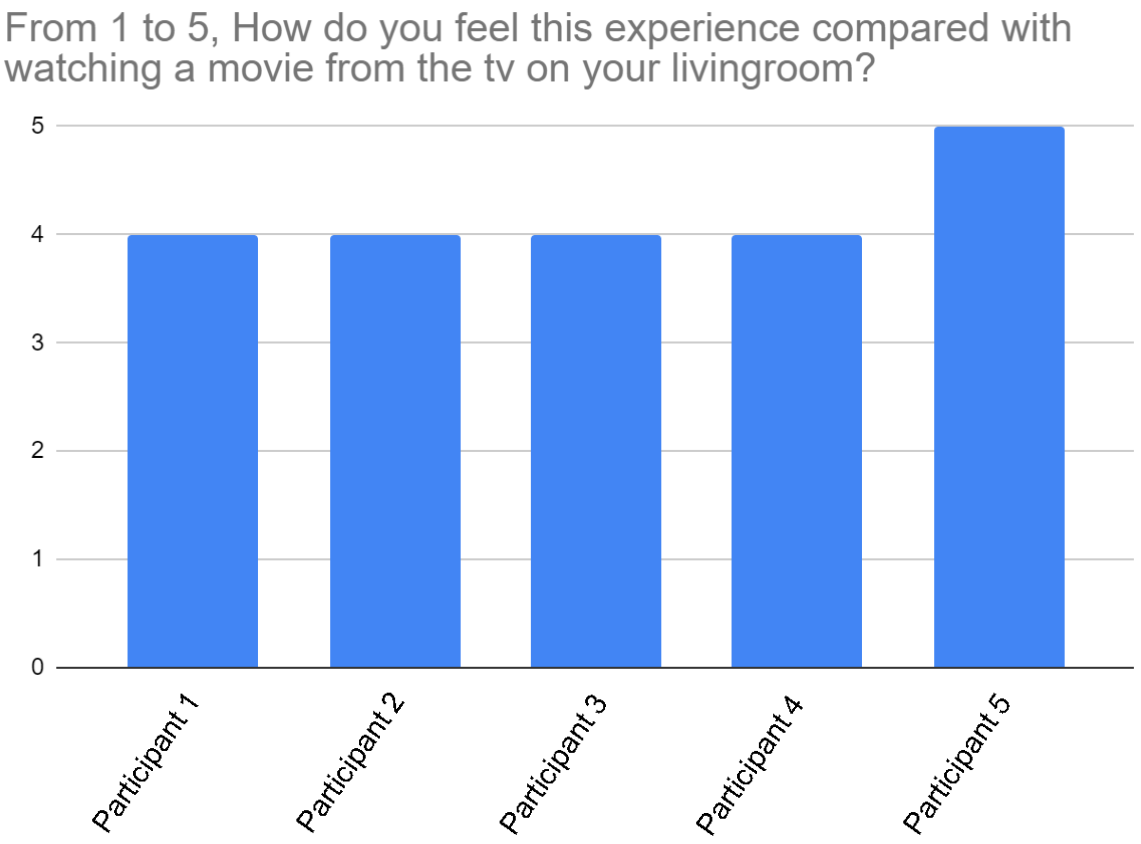


From 1 to 5, How do you feel this experience compared with watching a movie from the tv on your livingroom?



From 1 to 5, Do you feel that you would explore it again when the game changes the movie?





What did you feel while watching the movie?
I felt like on a cinema with friends
The whole experience was interesting, watching a movie in a different environment is a nice change and offer a good perspective
Feels interesting, would like it to be more configurable in terms on the videos
Calm
I feel like I could watch a movie with people without the need to talk with them
What do you think about exploring the architecture of an old cinema from another part of the world?
It is wonderful to experience other places such as theaters from around the world.
It was realistic which in itself makes it interesting and immersive
That would be awesome!
Interesting