Echoes in Kellie's Castle: A Virtual Escape Room

By
NG XUE EN

A REPORT
SUBMITTED TO
Universiti Tunku Abdul Rahman
in partial fulfillment of the requirements
for the degree of
BACHELOR OF COMPUTER SCIENCE (HONOURS)
Faculty of Information and Communication Technology
(Kampar Campus)

OCTOBER 2025

COPYRIGHT STATEMENT

This Final Year Project proposal is submitted in partial fulfilment of the requirements for the Bachelor of Computer Science (Honours) degree at Universiti Tunku Abdul Rahman (UTAR). This Final Year Project proposal represents the author's work, except where due acknowledgement has been made in the text. No part of this Final Year Project proposal may be reproduced, stored, or transmitted in any form or by any means, whether electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the author or UTAR, in accordance with UTAR's Intellectual Property Policy.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my supervisor, **Dr. Sayed Ahmad Zikri Bin Sayed Aluwee**, for granting me the opportunity to embark on this 3D VR gaming project. His unwavering support, invaluable guidance, and insightful feedback have been instrumental throughout this journey. Without his mentorship, overcoming the challenges faced during the project would have been significantly more difficult, and completing it on time would not have been possible.

I am also sincerely thankful to my family and friends for their continuous encouragement, patience, and assistance. Their support played a vital role in motivating me and helping me stay focused.

I acknowledge that the success of this endeavour is not mine alone, it is a collective achievement made possible by everyone who contributed, directly or indirectly, to its realization. Thank you all for being part of this journey.

ABSTRACT

This project seeks to innovate a 3D virtual educational escape room that leverages VR technologies and the history of Kellie's Castle to promote tourism in heritage sites while educating users about the site's historical and cultural significance. Virtual educational escape rooms are digital adaptations of traditional escape rooms where users solve puzzles to "escape" a confined space while learning through interactive storytelling. Current approaches to promoting heritage tourism lack gamification elements like virtual escape rooms, leaving untapped potential in the virtual tourism industry. In addition, there also exists a gap in the integration of historical and cultural narratives within virtual educational escape rooms, as existing studies primarily focus on the effectiveness of virtual escape rooms as an educational tool and their impact on learners' engagement. Therefore, this project aims to address these gaps by creating a virtual educational escape room based on the real-world setting of Kellie's Castle, offering an immersive experience that enhances users' understanding of the site's history and culture while promoting tourism through interactive learning.

Area of study: Virtual Reality in Tourism, 3D Games-Based Learning

Keywords: Virtual Reality (VR), Educational Escape Room, Kellie's Castle, Virtual Tourism, Gamification

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

VR	Virtual Reality
3D	Three-dimensional

CHAPTER 1
Introduction

The following sections of this chapter present the research background and motivation, as well as this project's contributions to the field.

1.1 Background Information

Escape rooms are immersive games in which players must solve a series of designed clues, tasks, and logical puzzles intertwined with a storyline to escape from the confined room within a limited time. These games often feature elements that either serve as accessories or play a crucial role in advancing the game, such as keys to open doors or chairs to reach high places. The popularity of social media platforms such as RedNote and Instagram has significantly boosted the popularity of escape rooms worldwide. According to [1], the $7.9 billion valued escape room market in 2022 is predicted to achieve $31 billion by 2032. The emerging nature of this sector has proven its popularity as a collaborative and recreational activity, particularly for young people. Due to the growing market of escape rooms, businesses are exploring alternative opportunities beyond their initial locations, such as through online platforms.

With the rise of esports and the shift towards online platforms during the COVID-19 pandemic, the escape room industry has begun to explore virtual alternatives. The intersection of gaming, sports, and digital technology has fuelled the development of online escape rooms, incorporating virtual reality (VR), artificial intelligence (AI), and virtual simulators to enhance user experiences. [2].

Virtual Escape Rooms and Cultural Tourism

In recent years, ordinary attractions like industrial buildings, and street markets have seen a decline in appeal among tourists who seek more engaging and meaningful experiences. They often desire opportunities to participate actively in their adventures, enhancing their personal development and skills while exploring heritage sites. This

shift has paved the way for creative tourism, where visitors can develop their skills and knowledge while exploring heritage sites [3]. Escape Rooms, which combine creativity, gamification, and hyper-reality—the state of being "more than real"—convincing the tourist that it is real even though the surroundings are known to be simulated, have emerged as a popular form of creative cultural tourism, making escape rooms to become attractive tourist sites [4].

Virtual tourism, which enables people to explore destinations or experience tourist attractions without physical travel, has significantly increased in popularity, especially during the pandemic. Leveraging technologies such as virtual reality (VR), tourists can enjoy fully immersive, near-realistic tours of various destinations from the comfort of their homes [5]. This approach not only serves as an alternative to traditional travel but also effectively promotes actual tourist destinations by offering compelling experiences during the early stages of trip planning.

Educational Impact of Virtual Escape Rooms

Virtual escape rooms have expanded their influence in education to serve as educational and training tools. Escape rooms usually include simulation elements, providing a suitable environment for simulation training programs to leverage this training method. For example, simulation escape rooms for healthcare providers follow a similar structure to typical escape rooms by using patient cases as the narrative. The healthcare providers need to work together to locate the clues, allowing more realistic hands-on practice and improving their clinical and teamwork skills [6]. Virtual escape rooms, as a digital adaptation of traditional escape rooms, can also act as an educational tool, allowing teachers to creatively customize content to fit students' needs by using resources within the virtual escape rooms [7].

The Gap in Heritage Tourism

Despite the growing interest in developing various escape room forms, research on using virtual escape rooms to promote tourism at heritage sites remains limited. While escape rooms have been explored for educational purposes and as standalone tourist attractions, their potential in heritage tourism is under-explored. This project seeks to address this gap by creating a hyper-realistic, interactive VR Escape Room

centred around Kellie's Castle that entertains and educates players about this iconic heritage site's history and cultural significance.

1.2 Problem Statement

Several problem statements have been justified after reviewing related articles and similar applications. The problem statements will be listed below:

1. **Limited engagement with historical sites**

   Traditional tours of historical places like Kellie's Castle often fail to fully engage visitors, particularly teenagers, who are attracted to dynamic and visually stimulating content found on social media. The absence of interactive and immersive elements in these tours can result in a lack of connection and appreciation for the site's historical significance, making it less appealing to younger audiences.

2. **Underutilization of virtual reality in tourism**

   Although virtual reality technologies have seen widespread use in various sectors, including popular applications like Pokémon Go, integrating these technologies in the tourism industry remains limited. This underutilization fails to fully capture the interest of tech-savvy tourists, particularly young people and can result in a less engaging visitor experience

3. **Lack of gamified learning experiences**

   Gamified learning is a proven approach to making education more engaging and effective, yet its application in historical and cultural education remains limited. The lack of gamified experiences, such as escape rooms, at sites like Kellie's Castle may fail to captivate visitors who seek more interactive and enjoyable ways to learn about history.

1.3 Motivation

The motivations for addressing the gaps listed in the problem statement are outlined below:

1. **Enhancing visitor engagement**

Creating an immersive and interactive escape room experience at Kellie's Castle is motivated by enhancing visitor engagement. By integrating puzzles, challenges, and storytelling into the experience, the project aims to attract a broader audience, encouraging them to explore Malaysia's rich historical culture through a modern and dynamic format

2. **Leveraging modern technologies**

   The project is driven by the desire to leverage the latest VR and 3D modelling technologies to create a cutting-edge tourism experience that blends gamification, education, and adventure. This approach modernizes the promotion of historical sites like Kellie's Castle, aligning with the expectations of contemporary visitors who value education and entertainment.

3. **Promoting gamified learning**

   The project is motivated by the effectiveness of gamified learning. It aims to make the history of Kellie's Castle more enjoyable and accessible. By fostering critical thinking and problem-solving skills through interactive puzzles and challenges, the project seeks to transform the learning experience into one that is both engaging and educational.

1.4 Project Objectives

The primary objective of this project is to develop an escape room based on the virtual 3D model of Kellie Castle, adding value to users and promoting tourism. The sub-objectives that needed to be fulfilled to complete the ultimate objective of this project are listed below:

1. **To enhance visitor engagement by providing virtual accessibility.**

   To enhance visitor engagement by offering virtual accessibility, enabling people who cannot visit Kellie's Castle in person to explore and experience it remotely, thereby fostering a deeper appreciation and understanding of Malaysia's culture and heritage.

2. **To demonstrate the effectiveness of virtual reality as a tool for heritage tourism.**

To develop and evaluate a virtual reality experience of Kellie's Castle that showcases how VR technology can be utilised to present cultural and historical sites in a tourism context, addressing the underutilization of cutting-edge technologies in the tourism industry.

3. **To integrate learning through gamification**

   To integrate learning through gamification by incorporating educational content into puzzles and challenges, fostering critical thinking and problem-solving skills while making the learning experience enjoyable and immersive.

1.5 Project Scope and Direction

The scope of this project is to develop an immersive virtual escape room set within Kellie's Castle, which leverages cutting-edge technologies such as VR technology and aims to educate players about the historical and cultural significance of Kellie's Castle while simultaneously promoting tourism to this historical site. The development of the project will mainly focus on creating a realistic, historically accurate 3D game environment based on the real-world setting of Kellie's Castles to create an immersive, hyper-reality virtual escape room. The immersive experience will be further enhanced with an engaging storyline based on the castle's history, complemented by authentic sound effects. By the end of the project, the proposed system will serve as both an educational tool and a promotional platform for heritage tourism, offering players an interactive and engaging way to explore the history and cultures of Kellie's Castle.

1.6 Contributions

The main goal of this project is to innovate in the field of cultural tourism by developing a virtual escape room that leverages the immersive capabilities of VR. Given the popularity of escape rooms as collaborative and recreational activities in recent years, this project seeks to create a unique experience that combines the thrill of escape room challenges with educational exploration of historical sites. The storyline, inspired by the mysterious and intriguing history of Kellie's Castle, aims to captivate users and

encourage further interest in historical sites. The proposed system will be designed with cross-platform compatibility, ensuring accessibility on various devices, including mobile phones and desktops. This cross-platform support is intended to attract a broader audience, making the experience widely accessible and promoting tourism to Kellie's Castle.

1.7 Report Organization

The structure of this report is organised as follows. Chapter 2 presents the background of the study, including a review of related works and existing systems, in order to identify the gaps that the proposed system aims to address. Chapter 3 describes the research methodology, detailing the overall system design and development approach adopted for this project. Chapter 4 outlines the system design in detail, covering the system block diagram, system flowchart, tools and technologies used, user requirements, and the project timeline. Chapter 5 explains the system implementation, including the hardware and software setup, preliminary results, system operations, as well as the implementation issues and challenges encountered. Chapter 6 focuses on system evaluation and discussion, which includes a detailed evaluation of the proposed system, user acceptance testing (UAT), and objective evaluation. Finally, Chapter 7 concludes the report by summarising the overall project and presenting recommendations and potential future work for further improvement of the system.

CHAPTER 2

Literature Review

2.1 Previous Work

2.1.1 Educational Escape Room

The COVID-19 pandemic has accelerated the adoption of distance learning, offering flexibility in time, location, and personalised learning pace. However, this mode of education also presents challenges, including a higher likelihood of distractions, which necessitates greater self-discipline and time management from students.

In response to these challenges, educational gamification, which refers to applying game design elements in the learning process to enhance the learner's experience, has emerged as a promising solution. Research by Smiderle et al. [8], demonstrated that learners in gamified environments obtained a higher accuracy in submitted solutions than in non-gamified settings. Furthermore, several studies also suggest that gamification positively affects students' motivation, engagement, and academic performance [9,10].

One notable example of gamification in education is the virtual escape room, which has become increasingly popular due to its accessibility and flexibility. Virtual escape rooms, the digital version of physical escape rooms, require players to solve puzzles in order to complete the game. As escape rooms usually include storylines to enhance the immersive experience, virtual escape rooms, which have similar settings as physical escape rooms, can act as an educational tool to educate players while providing an active learning experience by using educational content as narrative. This approach enhances student motivation and improves problem-solving skills, as supported by studies [11,12].

2.1.2 Virtual Reality (VR) in Gaming and Education

Virtual Reality (VR) is a technology that creates a 3D environment using computer software and hardware. It enables users to explore and interact with the virtual world, stimulating reality through sensory experience [13]. VR systems are categorized into several types [13]:

1. **Non-immersive VR:** Offers limited VR experience where the environment does not interact directly with users.
2. **Semi-immersive VR:** Provides a partial VR experience, typically accessed via a computer screen or headset, allowing some level of interaction.
3. **Fully immersive VR:** Delivers the highest level of immersion, where users can fully engage with a simulated 3D world using equipment such as headsets and gloves.
4. **Collaborative VR:** Allows multiple users, represented by avatars, to interact and communicate in a shared virtual environment using headsets or microphones.
5. **Augmented Reality (AR):** Overlays virtual simulations onto the real world, enhancing the physical environment.
6. **Mixed Reality (MR):** Combines elements of AR and VR, blending real and virtual worlds.

VR technology has gained popularity as a teaching and learning tool because it enables users to interact with real-time phenomena, which may not be feasible in traditional classroom settings [14]. VR learning, which involves using multiple senses, like touch, can increase learners' activeness and engagement [14], supported by research [15]; the author concluded that learners in VR-based learning environments outperformed learners in traditional settings. In addition, [15] also found a significant interaction between spatial ability and learning mode, indicating that VR can enhance educational outcomes.

In the gaming industry, VR is also widely used to create immersive 3D environments in computer games using VR software. VR gaming supports cross-platform, allowing users to play VR games on gaming consoles, smartphones, PCs, and

laptops. [16]. With the advancement of technology, VR hardware, such as VR headsets, has evolved to enhance the immersive experience, creating a hyper-realistic environment where players think they are interacting with the real world.

2.1.3 Cultural Tourism and Heritage Sites

Cultural Tourism refers to the participation of visitors in cultural activities such as visiting cultural sites and participating in cultural tours [17]. A significant subset of this is heritage tourism, which focuses on visits to archaeological and historical sites. However, promoting heritage tourism can be challenging as modern visitors often seek experiences that are not only fascinating but also offer opportunities for skill-building. Thus, this demand has driven the transformation of traditional tourism into digital and virtual tourism.

Due to COVID-19, people's movement is restricted during the lockdown period, accelerating the development of virtual tourism. This form of tourism allows people to experience cultural and heritage sites from the comfort of their homes using technology, offering an immersive experience that can be enhanced with a virtual reality (VR) headset. However, without a headset, users can still engage with the virtual content via computers or mobile devices [18].

Virtual tourism can take many forms, from simple videos of tourist destinations that tourists can watch through their sight and hearing senses to fully immersive experiences using VR headsets and simulators [19]. While virtual tourism may raise concerns about diminishing the authenticity of the physical sites, studies show that tourists generally have positive attitudes towards virtual tourism [20]. However, this attitude is significantly affected by the quality of technology leveraged and the content design of virtual tourism[20].

An example of successful virtual tourism on heritage sites is the Palace Museum, which launched a virtual tourism project to maintain visitor engagement while coping with the falling number of visitors due to COVID-19 [20]. By 2021, more than 33 million people visited the Palace Museum virtually [20], demonstrating the effectiveness of virtual tourism in promoting heritage sites

In another innovative approach, the museum Sistema Museo in Italy combined gamification with heritage tourism by creating a cultural escape room inside this archaeological site [21]. The escape room is centred on the museum's culture and history, using ancient legends and historical enigmas as part of its puzzles[21]. While exploring the escape room, the visitor will be able to gain a deeper understanding of the Roman era [21]. The initiative received positive feedback, especially from visitors previously unaware of the Roman cisterns, highlighting the potential of gamified experiences in enhancing cultural tourism.

2.1.4 Gap Analysis

Under this digital background, integrating gamification, such as virtual escape rooms, into an educational context enhances the learning experience in distance learning; however, the existing research has predominantly focused on the effectiveness of these tools as educational aids and their impact on learner engagement. Thus, there is a notable gap in studies exploring the use of historical and cultural narratives within these educational escape rooms.

Despite the fact that virtual tourism has been effectively employed to promote heritage tourism, which is evident in the success of the Palace Museum, there is limited research on combining gamification with virtual tourism. The integration of virtual escape rooms into virtual tourism, particularly in promoting heritage sites, remains under-explored. Despite the proven educational benefits of virtual escape rooms and the successful application of virtual tourism, the potential for combining these elements to create educational virtual tourism experiences has not been fully investigated.

Therefore, this project aims to address this gap by introducing a virtual escape room that leverages VR technology, using the historical and cultural significance of heritage sites like Kellie’s Castle as its narrative. In addition, this project aims to explore how such an integration can promote tourism while improving the historical understanding of visitors to heritage sites such as Kellie’s Castle.

2.2 Existing System Review

2.2.1 Prison of Word

Figure 2.2.1 Prison of Word

Prison of Word is an innovative escape room game in which players need to assist the protagonist in escaping from prison by forming sentences using word cards. Players are provided with a limited set of nouns and verbs, which they must combine to create valid and logical commands. These commands will direct the protagonist's actions within the game. The game challenges the player's ability to think logically and imagination to visualize the environment, as the visual context is deliberately minimal.

Strength:

"Prison of Word" introduces a novel twist to the escape room genre by combining it with text-adventure elements. The game's reliance on sentence construction rather than traditional visual clues challenges players to engage their logical thinking and imaginative skills more deeply than in typical escape room games. This mode of interaction can be particularly beneficial for cognitive development, encouraging players to think critically and abstractly about the scenarios presented based on the collected word cards. The emphasis on imagination over visuals also sets it apart from more graphically dependent escape room experiences, offering a unique mental challenge. Besides, Prison of Word provides educational value for players, as players need to construct valid and meaningful sentences using one action card and two noun cards, enhancing their ability to form coherent sentences.

Weakness:

Despite the innovative approach, the games face several challenges that may limit their appeal. While intellectually stimulating, the text-based nature of the game

can lead to a less immersive experience for players than traditional escape rooms with rich graphical environments like The Room. Besides, the game currently supports only Mandarin, presenting a significant barrier of entry for non-Mandarin speakers or beginners, reducing its accessibility and appeal to a global audience.

The visual context in "Prison of Word" is also limited, with only a few visual elements corresponding to specific word cards collected, as shown in Figure 2.2.2. These sparse visuals provide minimal assistance to players in imagining and immersing themselves in the storyline's setting.

Figure 2.2.2 Visual Context

Moreover, the game provides simple textual clues, such as "climb on the bamboo stick to reach the ceiling", as illustrated in Figure 2.2.3. However, these clues can be confusing, as players might struggle to understand the reasoning behind them without visual cues to aid their imagination. This lack of clear guidance can lead to frustration, particularly for players who prefer intuitive gameplay, as the clues often fail to directly assist players in solving the puzzles.

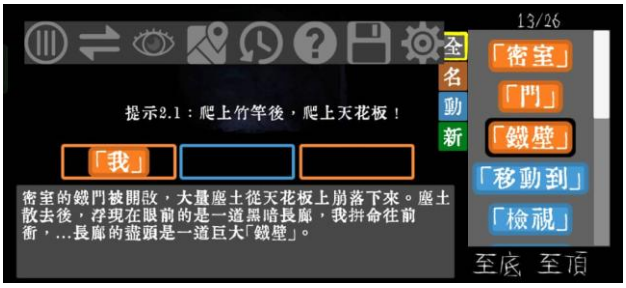


Figure 2.2.3 Textual Clues

2.2.2 VR Escape Room

Figure 2.2.4 VR Escape Room

VR Escape Room is an engaging escape room game in which players are trapped in a meticulously crafted room filled with puzzles and mind-bending challenges that train their cognitive abilities. The game leverages the capabilities of a VR headset to create an immersive experience, allowing players to explore and interact with their surroundings in a lifelike manner. In addition, the unique feature of this game, which is the absence of controllers, also added a unique twist to the gameplay, as players need to use their hand or body movements to interact with the virtual world. This intuitive control scheme enhances immersion, creating a seamless and natural gameplay experience that differentiates it from other escape room games.

Strengths:

The VR Escape Room offers versatile gameplay, accommodating both with and without VR headset players, making it accessible to a broader audience. Its atmospheric soundscapes also significantly enhance immersion, creating a dynamic experience that surpasses traditional, static escaper rooms. The intuitive, controller-free interaction further enhances the players' immersion, allowing them to engage with the virtual environment more naturally and hyper-realistically.

Weakness:

Despite leveraging VR technologies to provide an immersive experience, VR Escape Room lacks a compelling storyline that could make the experience more

captivating. In addition, the game's graphics fall short of creating a hyper-realistic setting; the lack of detailed, naturalistic visuals diminishes the overall experience, as players may not be fully convinced that they are trapped in the virtual environment. The graphics of the VR Escape Room are shown in Figure 2.2.5.

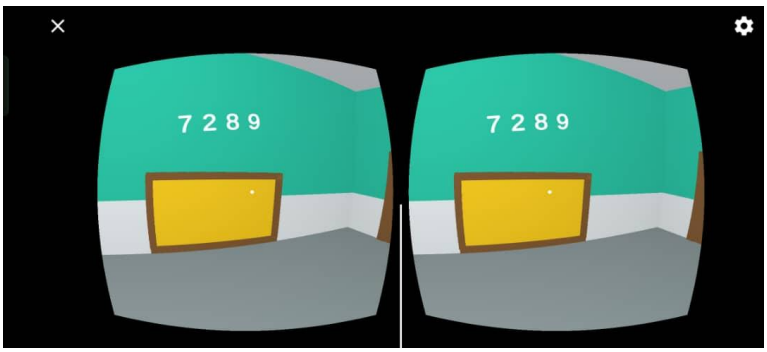


Figure 2.2.5 Graphics of VR Escape Room

2.2.3 The Room

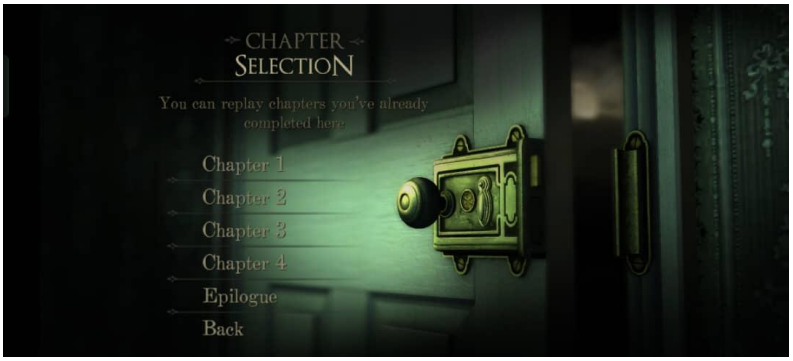


Figure 2.2.6 Levels of The Room

The Room is a BAFTA award-winning 3D puzzler game from Fireproof Games, which is available on multiple platforms, including mobile phones, PC and Nintendo Switch [22]. Mobile phone users can download the app through Google Play Store, Apple App Store, and Stream after purchase. Although The Room is a paid app, its pricing is reasonable, considering the quality of the experience. The game includes a brief tutorial to help new players familiarize themselves with the controls and settings. It features 5 levels: Chapter 1 to Chapter 4, with the last level titled “Epilogue”, where players must solve all the intricate puzzles in the puzzle boxes to complete the game.

The game also provides a unique feature named the ornate eyepiece, allowing players to uncover hidden messages, decipher codes, and unlock sophisticated mechanisms.

Figure 2.2.7 displays the textual clues provided to assist users in solving the puzzles, while Figure 2.2.8 presents object descriptions to give users a basic understanding of the objects.

Figure 2.2.7 Textual Clues

Figure 2.2.8 Object Description

Strength:

The Room offers exceptionally realistic and natural-looking visuals, significantly enhancing the gameplay experience. Combined with spine-tingling sound effects, these graphics create an atmospheric tension that draws players deeper into the game. The intuitive one-touch control of the game is highly responsive, adding a sense of hyper-reality and making the game feel smooth and engaging. Besides, the game supports multiple languages, which makes it accessible to a broader audience and increases its global appeal by removing the language barrier.

Weakness:

Despite the fact that the textual clues provided are helpful, they can sometimes be confusing and insufficient for guiding players through particularly challenging

puzzles. In addition, the limited visual clues to assist the players in exploring the games might cause them to lose interest when stuck in certain puzzles, potentially leading them to quit the game. Although the escape room is well designed to challenge the logical thinking of players, the puzzles lack educational value in enhancing users' general knowledge. The game does not encourage players to explore new areas of knowledge, which could have added an educational dimension. Furthermore, the game's storyline is primarily conveyed through messages found in envelopes. Many players may not take the time to read these messages, which can diminish the immersive experience. The storyline could be supplemented with sound effects or audio recording to enhance immersion, allowing players to listen to recordings or read the messages themselves.

2.3 Proposed Solution

The proposed solution addresses the two critical gaps, which are the need for deeper cultural education in escape rooms and the potential for gamification in promoting heritage tourism. As current escape rooms often lack depth in cultural storytelling, this project will bridge this gap by embedding cultural and historical narratives into the escape room, allowing users to discover the historical significance of Kellie's Castle while solving the puzzles. At the same time, this project also aims to leverage gamification to enhance user engagement and demonstrate effectiveness of VR in tourism. By creating a compelling experience, the escape room not only educates the users but also entices them to visit the castle in person.

The design of the VR-based educational escape room will be centered on the historical significance of Kellie's Castle, allowing users to navigate through the realistic 3D model while solving the puzzles. The key features of the proposed system include a realistic 3D environment of Kellie's Castle, interactive learning elements of the castle's history, gamification elements such as scoring and achievement badges, and an immersive VR experience.

While exploring the virtual escape room, users will be able to enhance their cultural knowledge of Kellie's Castle. The proposed system is also a powerful promotional tool for Kellie's Castle, as users may be compelled to visit the real castle

after the game. Moreover, this project demonstrates an innovative use of gamification in heritage tourism, setting a precedent for future initiatives.

2.4 Comparison between Existing Systems and Proposed System

Table 2.4.1 provides a comprehensive feature comparison between the existing and proposed systems.

Table 2.4.1: Comparison of Existing Systems and the Proposed System

Feature	Prison of Word	VR Escape Room	The Room	Proposed System
Gameplay Concept	Text-based Escape Room focusing on sentence formation	VR-based Escape Room	3D puzzler Escape Room with intricate puzzle boxes	VR-based Educational Escape Room centered on the historical exploration of Kellie's Castle
Interaction Style	Sentence construction using word cards	Hand or body movements (controller-free)	One-touch intuitive controls	Intuitive controls
Graphics	Limited visuals	Immersive but lacks details	Realistic, natural-looking visuals	Realistic, historically accurate visuals of Kellie's Castle
Graphical Clues	No	No	No	Yes
Immersion	Low	High with VR headset and sound	High with detailed graphics and sound	High with detailed graphics, sound, and VR

Educational Value	Medium	Low	Medium	High, with a strong focus on educating players about the history and significance of Kellie's Castle
Accessibility	Cross-Platform	Cross-Platform	Cross-Platform	Cross-Platform
Storyline Presentation	Medium	Low	Medium	High, with a narrative centered on the history and mysteries of Kellie's Castle
Language Support	Mandarin	English	Multilingual	English
Historical Accuracy	Not applicable	Not applicable	Not applicable	High, with detailed research to ensure accurate representation of Kellie's Castle

CHAPTER 3

System Methodology

3.1 Methodologies Used

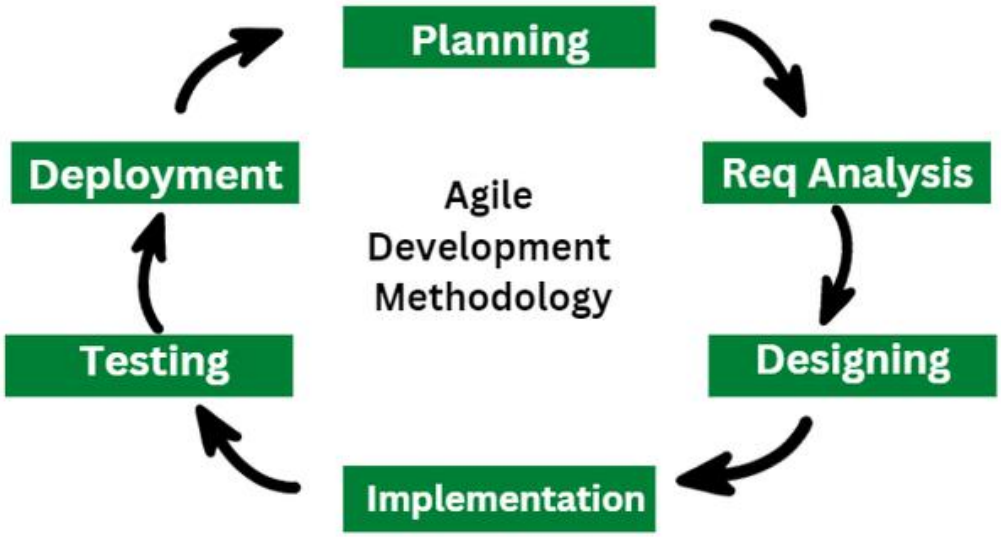


Figure 3.1.1 Life Cycle of Agile Methodologies[23]

The proposed system will use the Agile methodology to guide the development process. Agile methodologies is a widely recognized software development and project management approach that emphasizes collaboration, flexibility and customer-centricity[23].This methodology is particularly suited for projects where requirements may evolve over time, as it allows for iterative and incremental development. Unlike traditional approaches such as the Waterfall model, where system requirements are locked after the initial phases, Agile methodologies enable ongoing adjustments and refinements, making them ideal for the proposed system's dynamic development environment.

Planning

During this phase, the proposed system's functional and non-functional requirements will be gathered, documented and prioritised. This involves defining the project scopes, objectives and key feature requirements. A product backlog will also be created to manage and prioritize the tasks that need to be addressed in subsequent sprints.

Analysis

During the analysis stage, various studies will be conducted to analyse the proposed system features and assess their economic and technical feasibility. This phase also involves a detailed examination of the market trends and potential technical challenges that might arise during the development phase.

Design and Implementation

The 3D game scene based on Kellie's Castle will be designed during the design phase. For the implementation phase, the proposed features identified during the analysis phase will be prioritised and implemented by focusing on the core functional requirements first. The interactive nature of agile methodologies enables the continuous refinement and enhancement of the proposed system's features.

Testing and Deployment

During the testing phase, the proposed system will undergo a comprehensive suite of testing processes, namely integration testing, system testing, user acceptance testing, and performance testing, to ensure the system's stability, functionality and alignment with the proposed requirements.

- Integration Testing
    - To ensure the interaction between different modules is seamless and without any flaws.
- System Testing

- To test the entire system as a whole and validate that the system meets all specified functional and non-functional requirements

- User Acceptance Testing
  - To ensure that the system meets the end-user expectations
- Performance Testing
  - To assess the systems' performance and stability

Once all the features have been thoroughly tested and validated, the proposed system will be deployed, and continuous monitoring and maintenance will be performed to ensure the system remains functional, with any issues being promptly addressed.

3.2 System Design Diagram

3.2.1 System Architecture Diagram

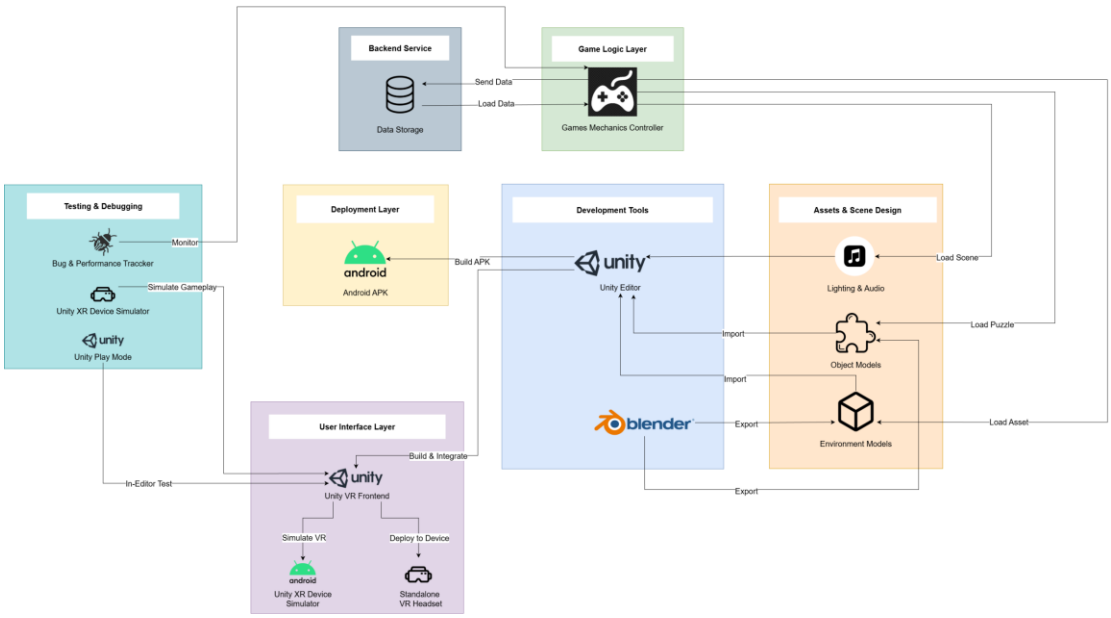


Figure 3.2.1 System Architecture Diagram

The figure above illustrates the system design for the proposed 3D VR Escape Room game. Blender serves as the primary tool for modeling the 3D environment of Kellie's Castle, helping create realistic scenes and objects. These environment and object models are then exported to the Unity Editor, which acts as the central hub for integrating all game elements.

Within Unity, various components such as lighting, audio, game logic, and UI are combined to build an immersive VR experience. Version control is handled via GitHub, ensuring organized and collaborative development.

The User Interface Layer, developed in Unity, supports both in-editor simulations and testing on physical devices, including Unity XR Device Simulator and mobile VR headsets.

The Game Logic Layer features a core Game Mechanics Controller, which interacts with the Backend Service to manage player data, and with the Assets & Scene Design Layer to access scenes, puzzles, and audio elements required for gameplay.

To ensure smooth performance, the Testing & Debugging Layer continuously monitors gameplay using tools like the Unity Play Mode and XR Device Simulators to detect bugs and optimize performance.

The final phase is the Deployment Layer, where the fully tested game is compiled into an Android APK, ready for testing on Meta Quest VR devices.

3.2.2 System Design Flow Chart

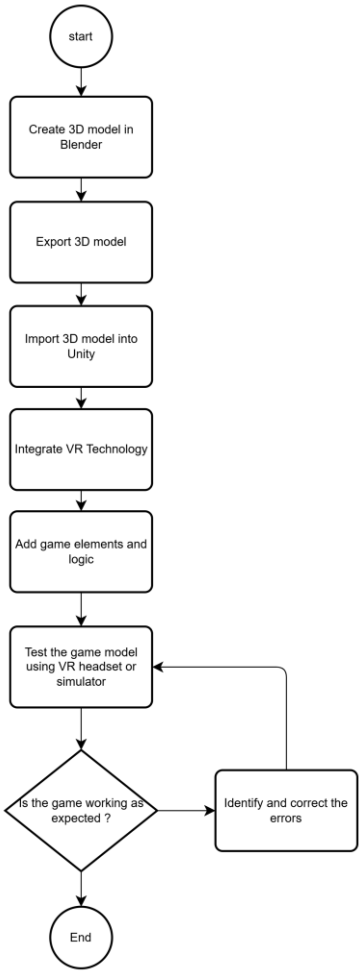


Figure 3.2.2 System Design Flow Chart

As the proposed system is a 3D VR escape room that incorporates 3D modelling, VR technologies, and interactive gameplay, the development process will begin with Blender to create realistic 3D assets. The development process starts with creating 3D models in Blender, chosen for its advanced modelling features and precise control over mesh editing, which enables the creation of realistic scenes such as Kellie's Castle environment. Once the 3D models are completed using Blender, they will be exported to Unity, where VR functionalities and interactive, gamified elements will be implemented to create an immersive and engaging experience.

3.2.3 Use Case Diagram and Diagram

Use Case Diagram

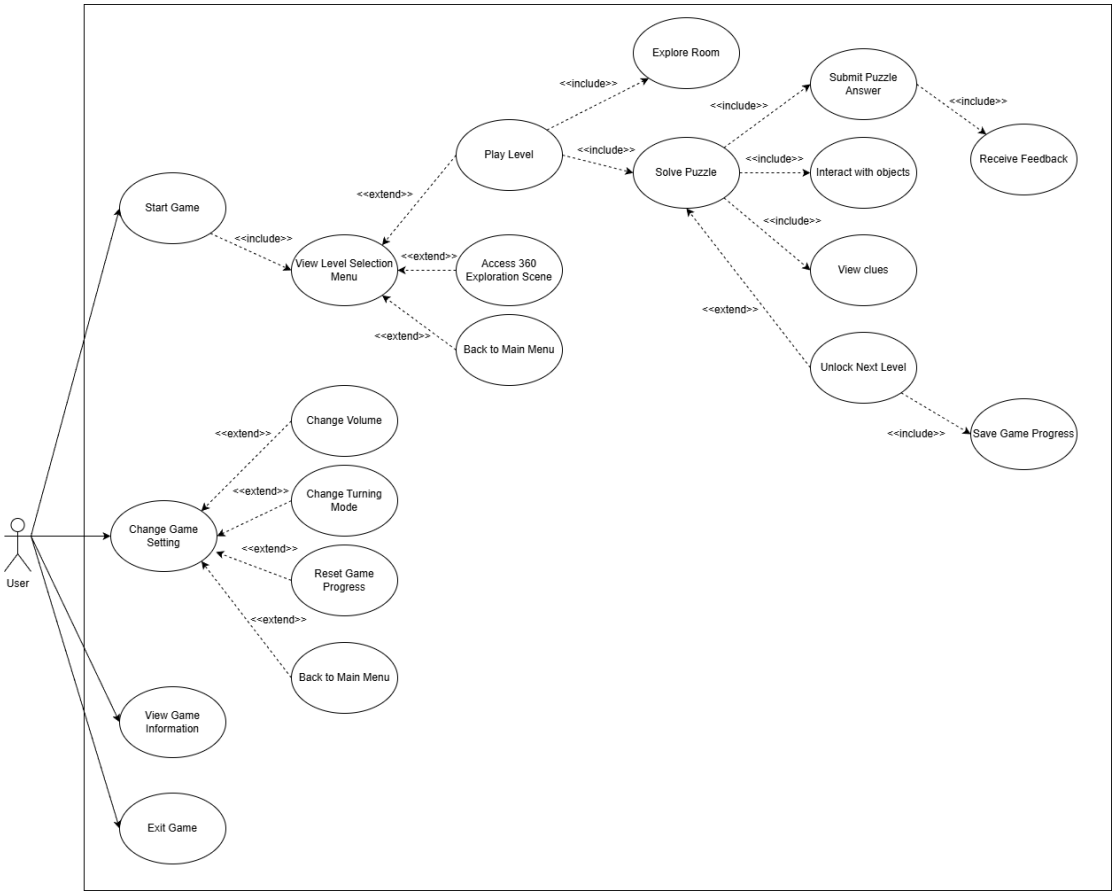


Figure 3.2.3 Use Case Diagram

Use Case Description

Table 3.2.3.1 Use Case Description of Start Game

ID	UC01	**Importance Level**	High
Use Case Name	Start Game	**Use Case Type**	Detail, Essential
Primary Actor	Player		
Stakeholders and Interests	Player - wants to begin gameplay by entering the level selection interface		
Brief Description	This use case describes how the system responds when the player starts gameplay from the main menu.		
Trigger	Player selects Start Game from main menu.		
Type	External		
Relationship	**Association**	None	
	Include	UC08 – Select Level	
	Extend	None	
	Generalization	None	
Normal Flow of Events	**1**	Player selects Start Game.	
	2	System displays Level Selection Menu.	
	3	System prompts the player to choose a level through UC08 Select Level.	
	4	System proceeds to initiate level loading after the selection.	
Sub Flow	Not Applicable		
Alternate / Exceptional Flow	Not Applicable		

Table 3.2.3.2 Use Case Description of Open Option Menu

ID	UC02	**Importance Level**	Medium
Use Case Name	Open Option Menu	**Use Case Type**	Detail, Essential
Primary Actor	Player		
Stakeholders and Interests	Player - wants to change gameplay setting by entering the option menu		
Brief Description	This use case describes how the system responds when the player wants to access the option menu		
Trigger	Player selects Options from main menu.		
Type	External		
Relationship	**Association**	None	
	Include	None	
	Extend	None	
	Generalization	None	
Normal Flow of Events	**1**	Player selects Options.	
	2	System displays the Options Menu with configurable settings.	
Sub Flow	Not Applicable		
Alternate / Exceptional Flow	Not Applicable		

Table 3.2.3.3 Use Case Description of Quit Game

ID	UC03	**Importance Level**	Medium
Use Case Name	Quit Game	**Use Case Type**	Detail, Essential
Primary Actor	Player		
Stakeholders and Interests	Player - wants to exit the application		
Brief Description	This use case describes how the system responds when the player wants to exit the application		
Trigger	Player selects Quit from main menu.		
Type	External		
Relationship	**Association**	None	
	Include	None	
	Extend	None	
	Generalization	None	
Normal Flow of Events	**1**	Player selects Quit.	
	2	System closes the game.	
Sub Flow	Not Applicable		
Alternate / Exceptional Flow	Not Applicable		

Table 3.2.3.4 Use Case Description of View About Information

ID	UC04	**Importance Level**	Low
Use Case Name	View About Information	**Use Case Type**	Detail, Essential
Primary Actor	Player		
Stakeholders and Interests	Player - wants to view game information		
Brief Description	This use case describes how the system responds when the player wants to read game information		
Trigger	Player selects About from main menu.		
Type	External		
Relationship	**Association**	None	
	Include	None	
	Extend	None	
	Generalization	None	
Normal Flow of Events	**1**	Player selects About.	
	2	System displays game information page.	
	3	Player selects Back.	
	4	Player returns to main menu	
Sub Flow	Not Applicable		
Alternate / Exceptional Flow	Not Applicable		

Table 3.2.3.5 Use Case Description of Change Volume

ID	UC05	**Importance Level**	Medium
Use Case Name	Change Volume	**Use Case Type**	Detail, Essential
Primary Actor	Player		
Stakeholders and Interests	Player – wants to adjust the game's audio volume.		
Brief Description	This use case describes how the system responds when the player modifies the game's audio volume level.		
Trigger	Player adjusts the volume slider in the Options Menu.		
Type	External		
Relationship	**Association**	None	
	Include	None	
	Extend	None	
	Generalization	None	
Normal Flow of Events	**1**	Player adjusts the volume slider to change the audio level.	
	2	System updates the audio volume.	
	3	Player saves the change.	
	4	System stores new volume value in saved settings.	
Sub Flow	Not Applicable		
Alternate / Exceptional Flow	Not Applicable		

Table 3.2.3.6 Use Case Description of Change VR Turning Mode

ID	UC06	**Importance Level**	Medium
Use Case Name	Change VR Turning Mode	**Use Case Type**	Detail, Essential
Primary Actor	Player		
Stakeholders and Interests	Player - wants to change VR turning mode (smooth turn or snap turn)		
Brief Description	This use case describes how the system responds when the player changes the VR turning mode in the locomotion settings.		
Trigger	Player changes the VR turning mode		
Type	External		
Relationship	**Association**	None	
	Include	None	
	Extend	None	
	Generalization	None	
Normal Flow of Events	**1**	Player chooses a new turning mode.	
	2	System applies the new turning mode.	
	3	Player saves settings.	
	4	System stores updated turning mode	
Sub Flow	Not Applicable		
Alternate / Exceptional Flow	Not Applicable		

Table 3.2.3.7 Use Case Description of Reset Game Progress

ID	UC07	**Importance Level**	High
Use Case Name	Reset Game Progress	**Use Case Type**	Detail, Essential
Primary Actor	Player		
Stakeholders and Interests	Player - wants to reset game progress		
Brief Description	This use case describes how the system responds when the player wants to reset all game progress and return game to its initial state.		
Trigger	Player selects Reset Game Progress		
Type	External		
Relationship	**Association**	None	
	Include	None	
	Extend	None	
	Generalization	None	
Normal Flow of Events	**1**	Player selects Reset Game Progress.	
	2	System displays a confirmation prompt.	
	3	Player confirms reset.	
	4	System deletes all save data.	
	5	System returns to Options Menu.	
Sub Flow	Not Applicable		
Alternate / Exceptional Flow	3a: If the player cancels the confirmation, the system aborts the reset process and returns to the Options Menu.		

Table 3.2.3.8 Use Case Description of Select Level

ID	UC08	**Importance Level**	High
Use Case Name	Select Level	**Use Case Type**	Detail, Essential
Primary Actor	Player		
Stakeholders and Interests	Player – wants to choose a gameplay level.		
Brief Description	This use case describes how the system allows players to select a level.		
Trigger	Player is displayed with the Level Selection Menu.		
Type	External		
Relationship	**Association**	UC01 Start Game	
	Include	UC09 Load Level	
	Extend	None	
	Generalization	None	
Normal Flow of Events	**1**	Player views the available levels	
	2	Player selects a desired level. If the level button is locked, the SF-1: Locked Level Case sub flow is performed	
	3	System validates that the level exists and is unlocked.	
	4	System initiates Load Level (UC09).	
Sub Flow	SF-1: Locked Level Case 1. System detects level is locked. 2. System disables the locked level button. 3. Player remains in Level Selection Menu.		
Alternate / Exceptional Flow	Not Applicable		

Table 3.2.3.9 Use Case Description of Load Level

ID	UC09	**Importance Level**	High
Use Case Name	Load Level	**Use Case Type**	Detail, Essential
Primary Actor	System		
Stakeholders and Interests	System – wants the level to be loaded quickly and accurately. Player – wants fast and accurate level loading.		
Brief Description	This use case describes how the system loads the selected level, prepares the environment, and spawns the player at the correct location.		
Trigger	UC08 Select Level requests a level load.		
Type	Internal		
Relationship	**Association**	UC08 Select Level	
	Include	None	
	Extend	None	
	Generalization	None	
Normal Flow of Events	**1**	System initializes level loading.	
	2	System loads environment models, textures, lighting, and scripts.	
	3	System verifies no missing assets.	
	4	System spawns location points for locomotion.	
	5	System starts the gameplay session.	
Sub Flow	Not Applicable		
Alternate / Exceptional Flow	Not Applicable		

Table 3.2.3.10 Use Case Description of Interact with Puzzle

ID	UC10	**Importance Level**	High
Use Case Name	Interact with Puzzle	**Use Case Type**	Detail, Essential
Primary Actor	Player		
Stakeholders and Interests	Player – wants to interact with puzzle objects.		
Brief Description	This use case describes how the system handles the interaction between the player and the puzzle		
Trigger	Player interacts with puzzle objects.		
Type	External		
Relationship	**Association**	None	
	Include	None	
	Extend	None	
	Generalization	None	
Normal Flow of Events	**1**	Player interacts with puzzle components.	
	2	The system updates the puzzle's internal state.	
	3	System checks completion status.	
Sub Flow	Not Applicable		
Alternate / Exceptional Flow	Not Applicable		

Table 3.2.3.11 Use Case Description of Complete Puzzle

ID	UC11	**Importance Level**	High
Use Case Name	Complete Puzzle	**Use Case Type**	Detail, Essential
Primary Actor	System		
Stakeholders and Interests	System – update game state after puzzle completion.		
Brief Description	This use case describes how the system updates game state after puzzle completion.		
Trigger	System detects puzzle completion.		
Type	Internal		
Relationship	**Association**	None	
	Include	None	
	Extend	None	
	Generalization	None	
Normal Flow of Events	**1**	System unlocks next level.	
	2	System saves progress.	
	3	System displays congratulation message.	
	4	System prompts player to continue or quit.	
Sub Flow	Not Applicable		
Alternate / Exceptional Flow	Not Applicable		

Table 3.2.3.12 Use Case Description of Proceed to Next Level

ID	UC12	**Importance Level**	High
Use Case Name	Proceed to Next Level	**Use Case Type**	Detail, Essential
Primary Actor	Player		
Stakeholders and Interests	**Player** – wants to proceed to next level		
Brief Description	This use case describes how the system handles player's request to load next level.		
Trigger	Player selects Next Level.		
Type	External		
Relationship	**Association**	None	
	Include	None	
	Extend	None	
	Generalization	None	
Normal Flow of Events	**1**	Player chooses Next Level.	
	2	System loads the next level (UC09).	
Sub Flow	Not Applicable		
Alternate / Exceptional Flow	1a: When player selects Quit, system returns to Level Selection screen.		

3.2.4 Activity Diagram

Main Menu

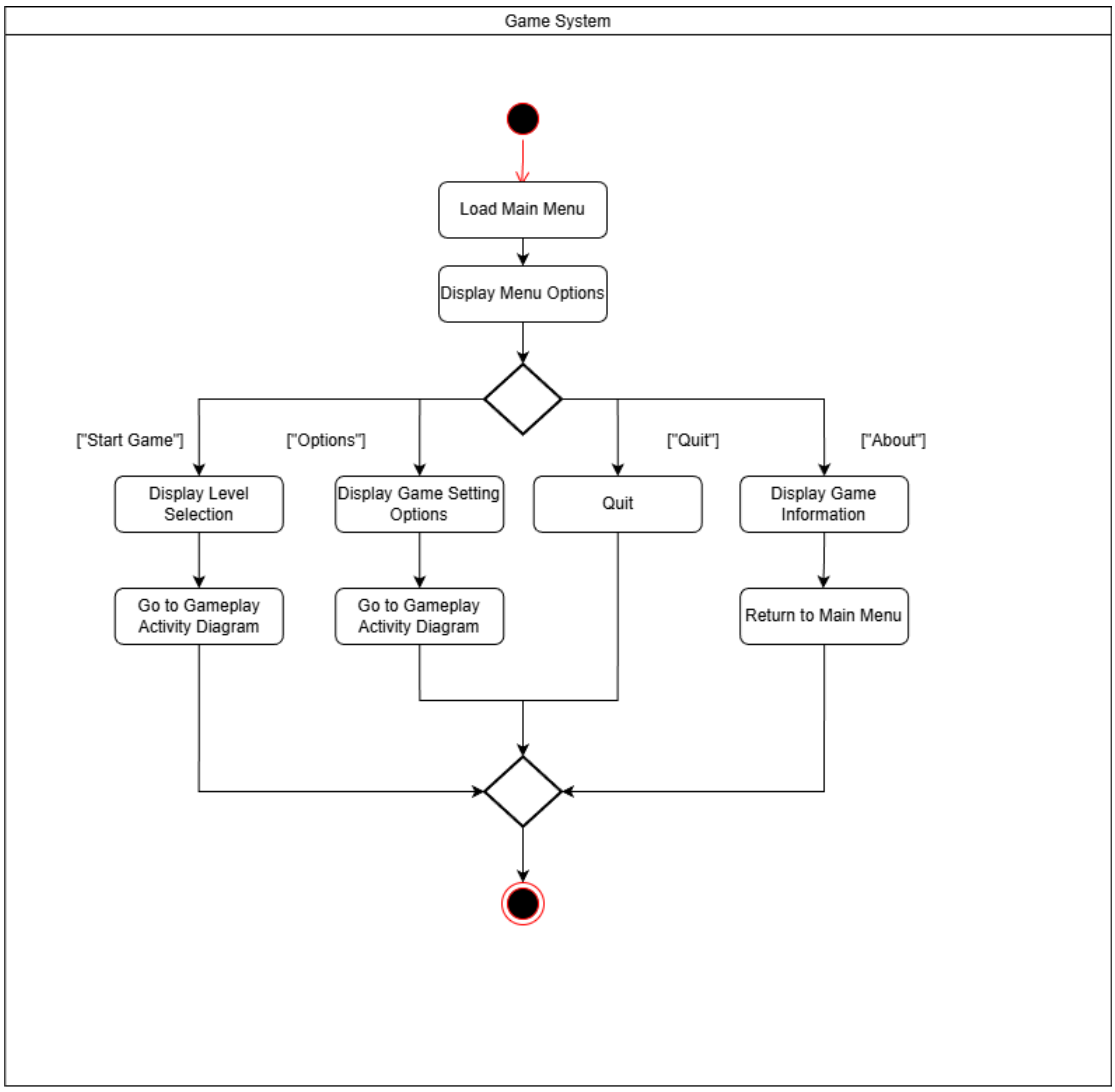


Figure 3.2.4.1 Main Menu Activity Diagram

Gameplay

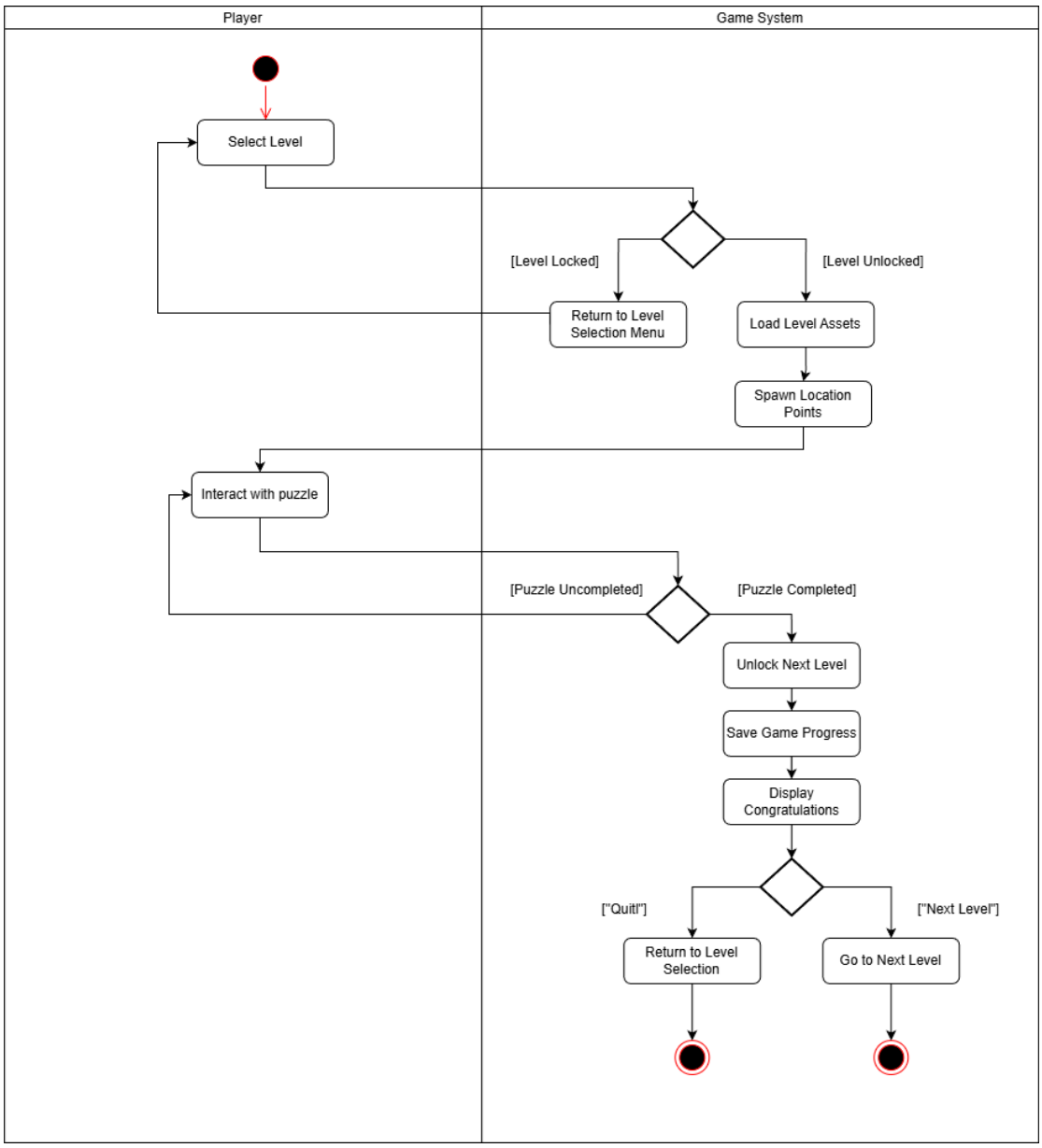


Figure 3.2.4.2 Gameplay Activity Diagram

Options Menu

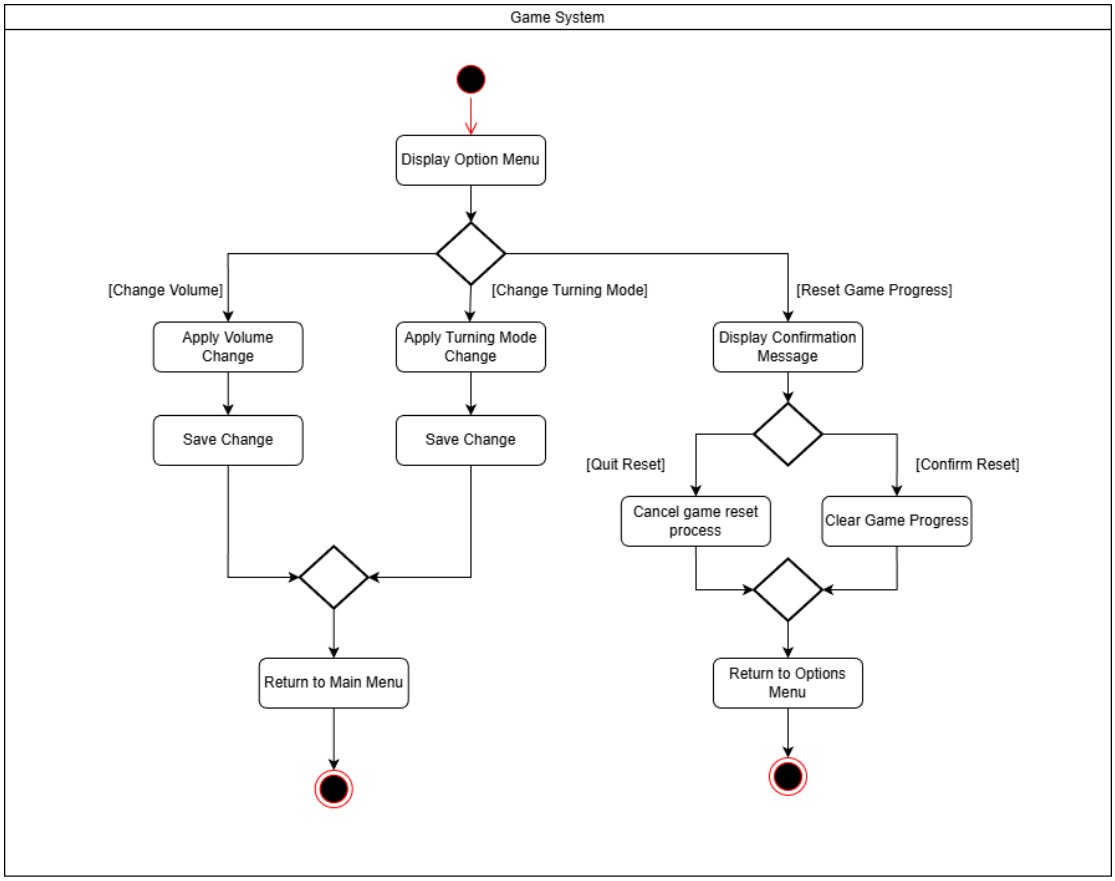


Figure 3.2.4.3 Options Activity Diagram

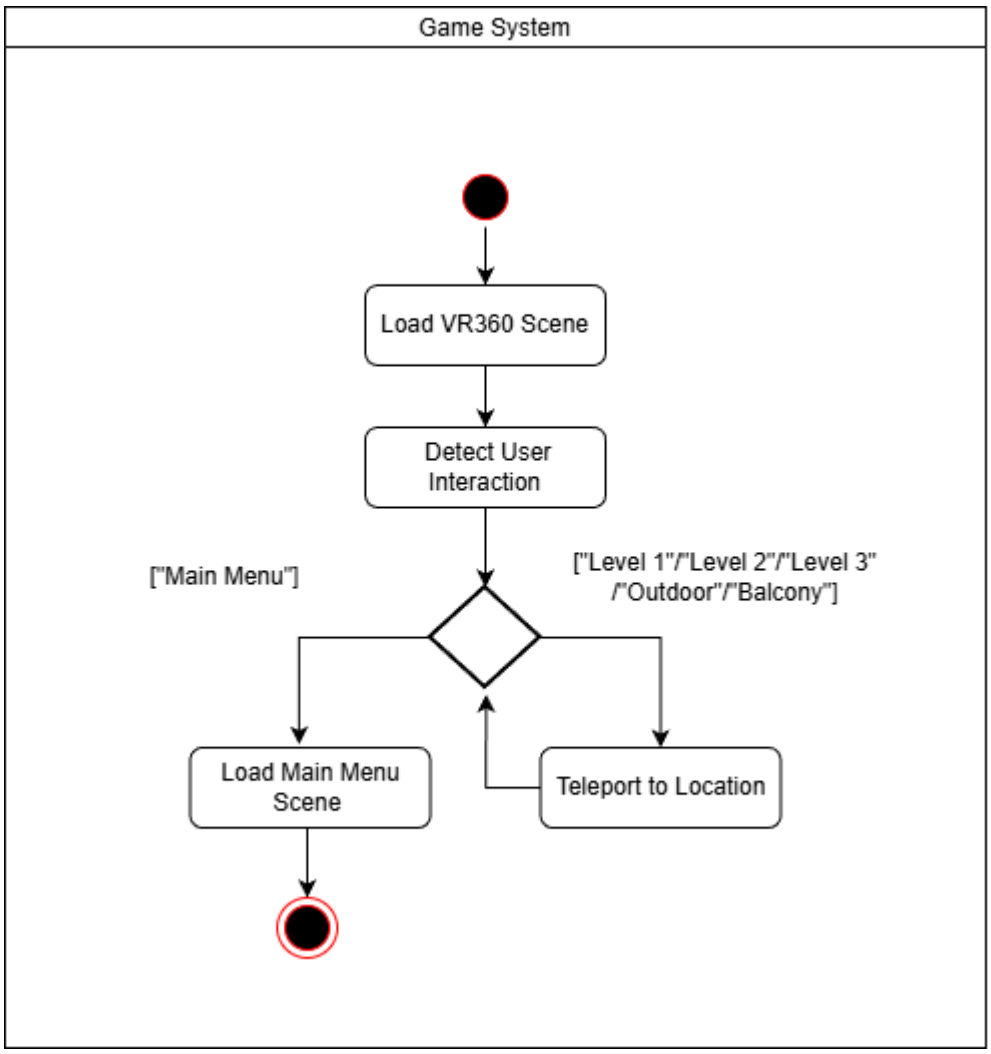


Figure 3.2.4.4 VR360 Scene Activity Diagram

CHAPTER 4

System Design

4.1 System Block Diagram

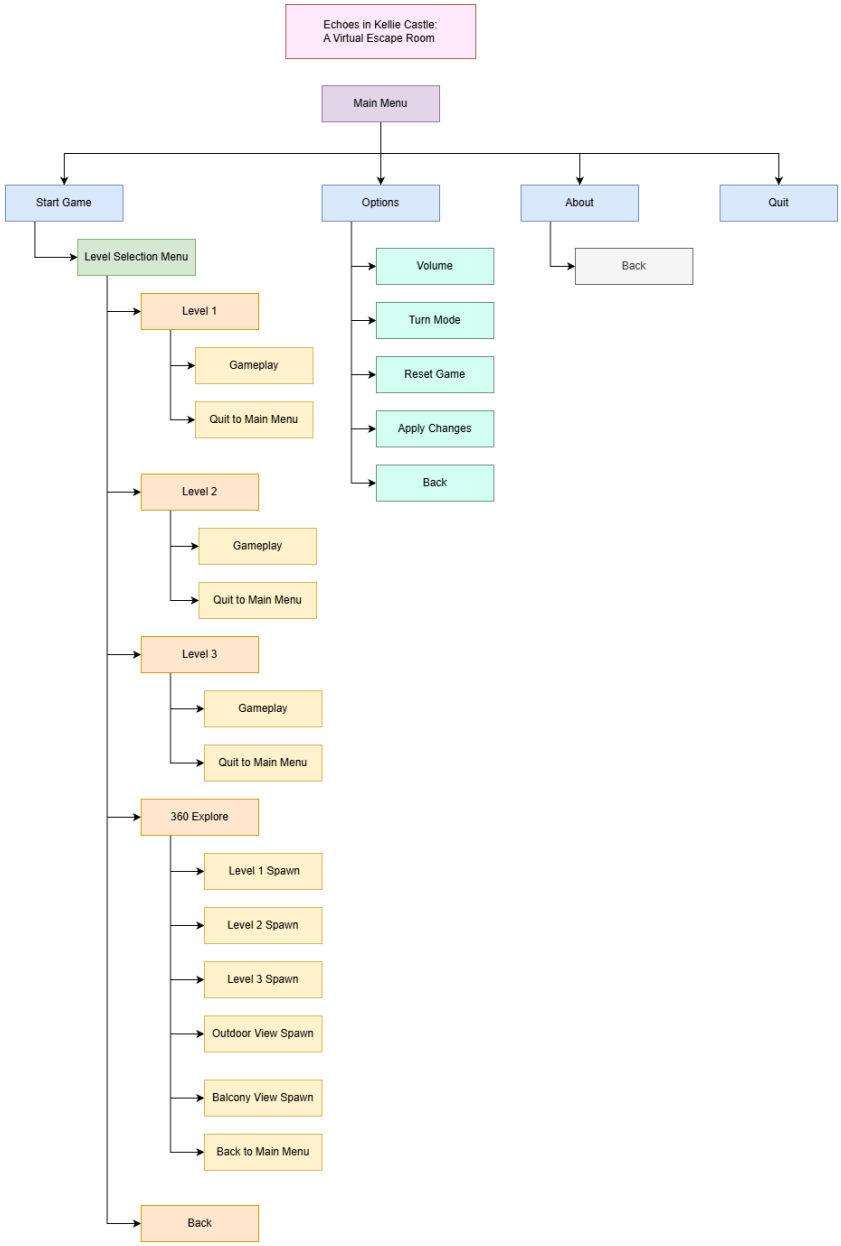


Figure 4.1.1 System Block Diagram

4.2 System Flowchart

Overall System Flowchart

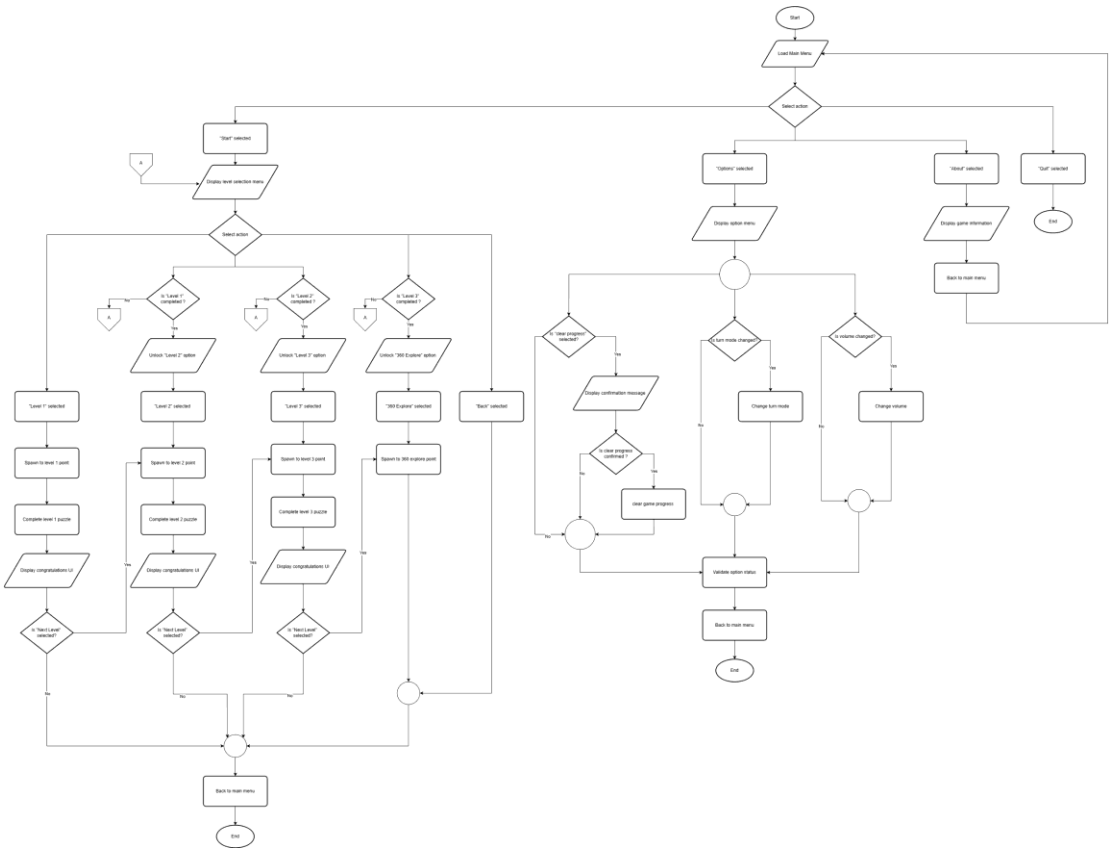


Figure 4.2.1 Overall System Flowchart

Level 1 Puzzle Flowchart

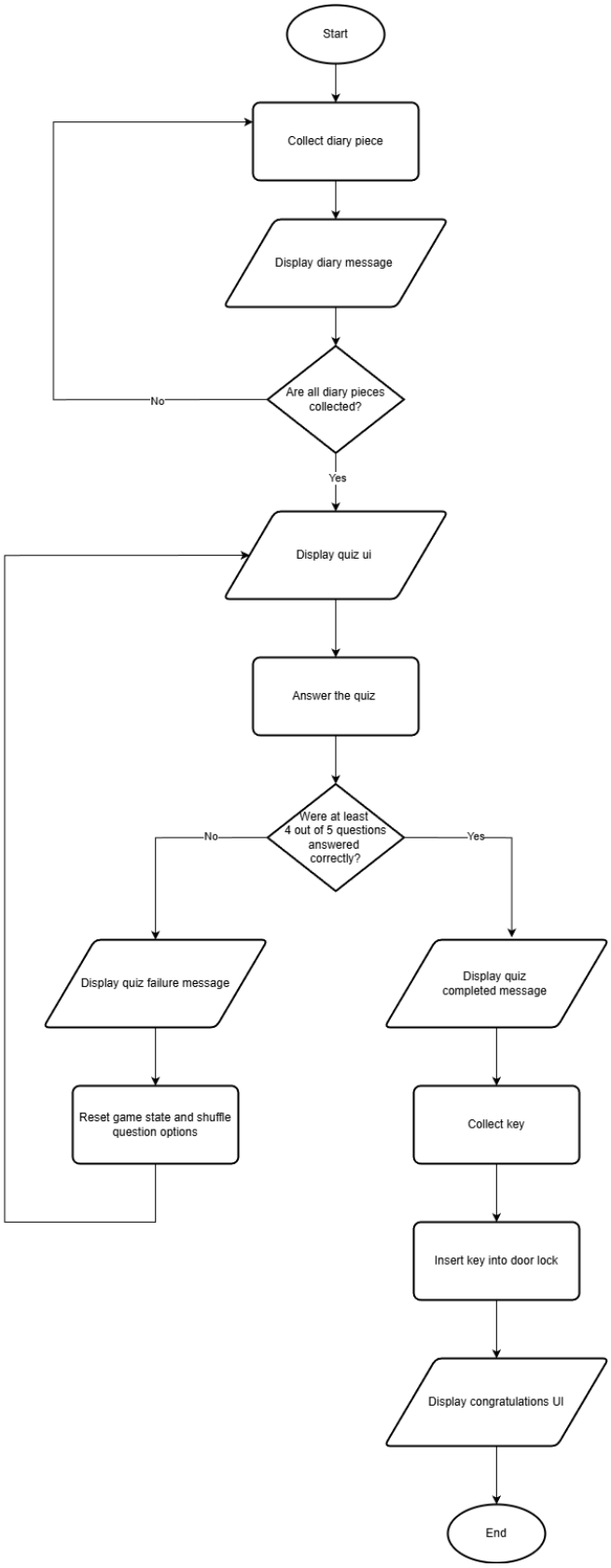


Figure 4.2.2 Level 1 Puzzle Flowchart

Level 2 Puzzle Flowchart

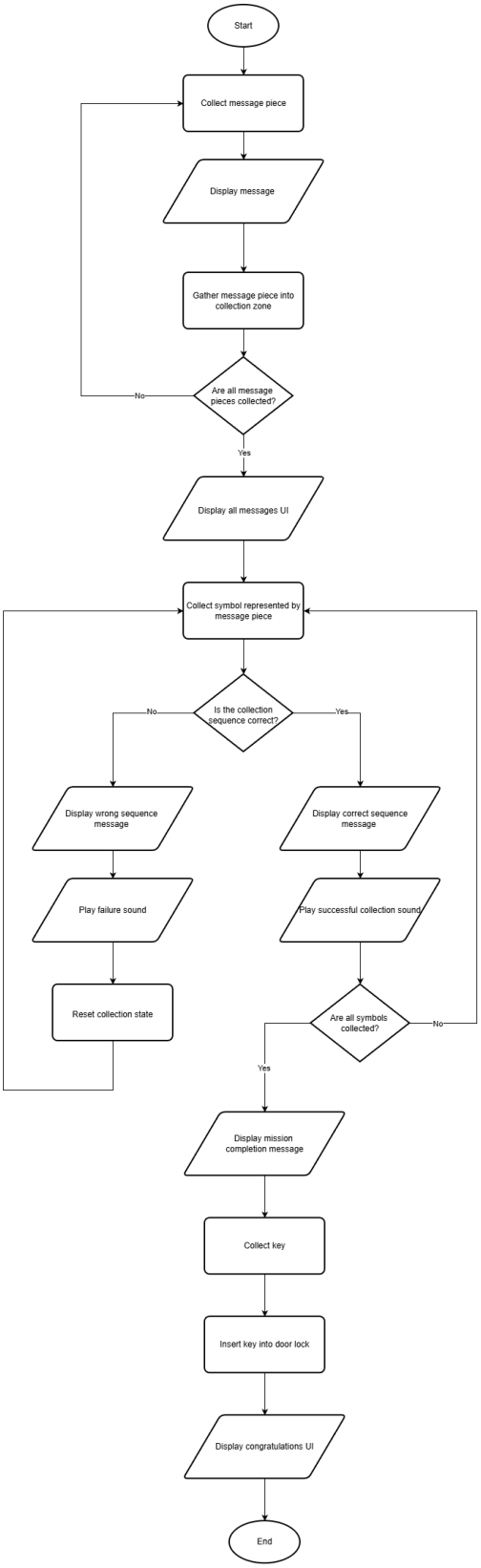


Figure 4.2.3 Level 2 Puzzle Flowchart

Level 3 Puzzle Flowchart

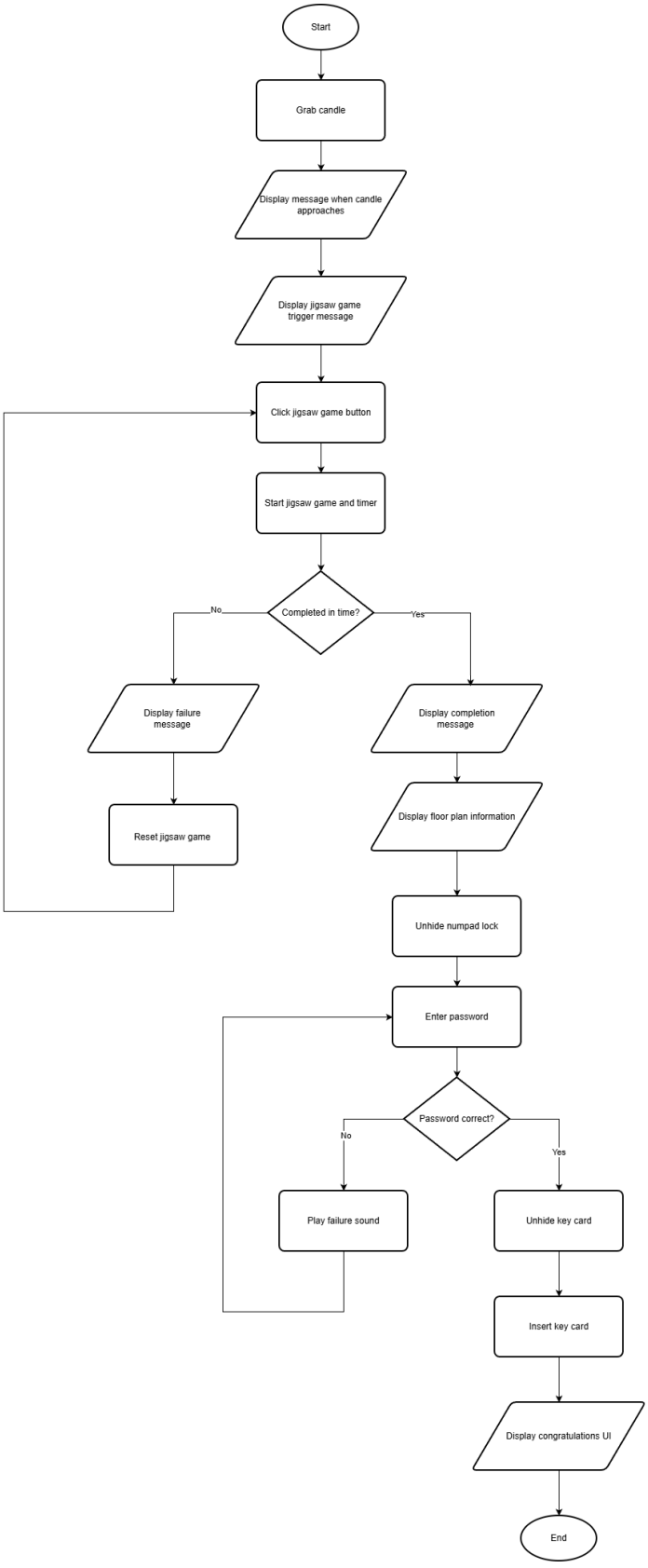


Figure 4.2.4 Level 3 Puzzle Flowchart

VR360 Scene Flowchart

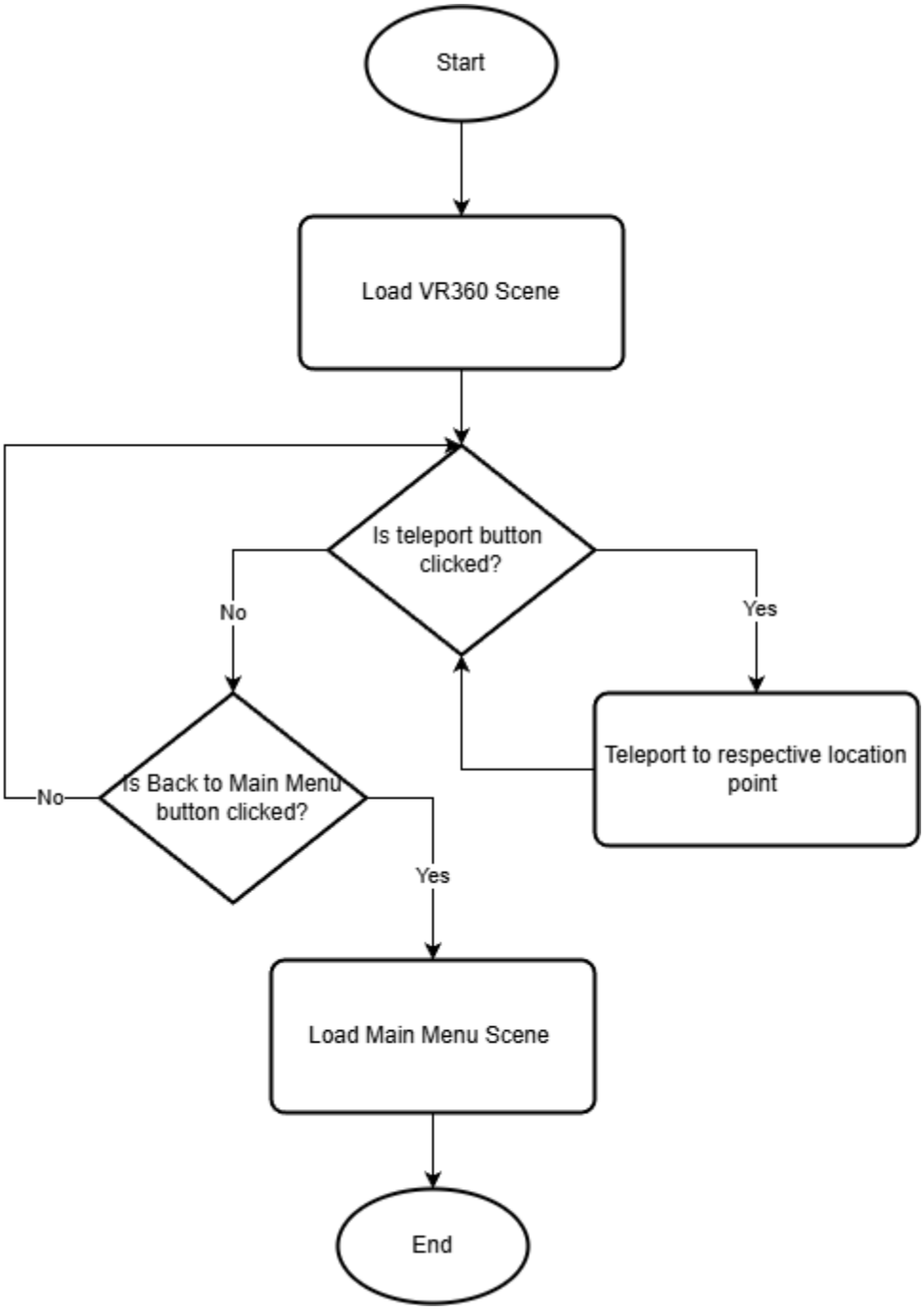


Figure 4.2.5 VR360 Scene Flowchart

4.3 Tools and Technology

4.3.1 Hardware Platform

The hardware involved in this project is a laptop and a VR device. A laptop is issued for building and modelling 3D objects, and a VR device is used to test the proposed systems' compatibility with VR devices.

Table 4.3.1.1 Specifications of laptop

Description	Specifications
Model	Lenovo LOQ 15ARP9 83JC00G4MJ
Processor	AMD Ryzen 7 7435HS
Operating System	Microsoft Windows 11 Home Single Language
Graphic	NVIDIA GeForce RTX 4050 6GB GDDR6
Memory	28.0 GB DDR5-4800 SO-DIMM
Storage	1.5 TB SSD

Table 4.3.1.2 Specifications of VR Device

Description	Specifications
Model	Meta Quest 2
Device Type	Standalone VR
Tracking Type	6DoF Inside-Out via 4 integrated cameras
Operating System	Android 10
Chipset	Qualcomm Snapdragon XR2
Memory	6GB
Storage	128GB
Wi-Fi	Wi-Fi 6
Speakers	Integrated stereo speakers
Resolution	1832x1920 per-eye
Refresh Rate	120Hz
Weight	503g (with head strap)

Meta Quest 2 is a standalone VR headset that offers high mobility and freedom of movement compared to PC-tethered VR systems, although its processing

power is relatively lower. The cameras, inside-out tracking sensors, and audio system are built directly into the headset, allowing the device to track the player's position without requiring any external sensors.

Meta Quest 2 supports full 6 Degrees of Freedom (6DoF) tracking, allowing the system to detect user movements forward, backward, up, down, left, and right, as well as rotational movement along the X, Y, and Z axes [24]. This provides users with natural, intuitive interaction with virtual environments and objects, enhancing immersion and realism

4.3.2 Operating System

Microsoft Windows

Microsoft Windows is the world's most widely used operating system for personal computers. It manages hardware and software resources, facilitates user-computer interaction, controls data storage, and supports multitasking [25]. Compared to macOS, Windows offers broader hardware compatibility, greater user customization, and extensive support for software and gaming [25].

Horizon OS

The Meta Quest 2 runs on Horizon OS, an Android-based operating system designed and optimized for Unity apps developments for Meta Quest VR headsets [26]. Horizon OS integrates seamlessly with Unity through the Meta XR Core SDK, which provides essential tools such as the XR Rig, XR Interaction components, and movement systems to simplify VR application development for Quest headsets [26].

Developers can also use Meta Quest Link to stream and test their applications on the headset via a USB-C cable or Wi-Fi [26]. Moreover, the Meta XR Simulator offers a desktop simulation environment that allows developers to preview and test scenes directly on their computer without wearing the VR headset.

4.3.3 Database

PlayerPrefs

PlayerPrefs is a local data storage class in Unity that stores player preferences between game sessions [27]. Instead of using an external database, it relies on a shared preferences API, providing fast access to stored data. It is suitable for storing simple data such as user settings and preferences, and is lightweight, minimizing impact on processing performance [28].

ScriptableObjects

ScriptableObjects act as containers to store data that can be shared across multiple objects at runtime, reducing memory usage by avoiding duplicate copies of values [29]. Unlike MonoBehaviours, ScriptableObjects are not attached to GameObjects as components; instead, they exist as assets in the project, independent of any GameObject [29].

4.3.4 Programming Language

C#

C# is an object-oriented programming language that runs on the .NET framework, enabling cross-platform compatibility [30]. It can be used for mobile apps, desktop applications, cloud-based services, and is extensively used in game engines such as Unity [30].

4.3.5 Software

The development of the proposed system involves two primary software tools:

Blender

Figure 4.3.5.1 Blender Logo

Blender is a free, open-source 3D creation suite that supports the entire 3D pipeline, including modelling, animation, simulation, rendering, compositing, motion tracking, video editing, and game asset creation [31]. It is popular for its ability to create ultra-realistic 3D models, making it an ideal tool for creating detailed virtual environments. Additionally, Blender also offers abundant resources like online tutorials, documentation, and community support, making it accessible even to beginners.

Unity

Figure 4.3.5.1 Unity Logo

Unity is a versatile game development engine that supports a wide range of platforms, including desktop, mobile, augmented reality (AR), and virtual reality (VR). It is particularly recognised for Android and ios mobile game development due to its user-friendly interface and ease of use, especially when compared to other engines like Unreal Engine. Unity not only supports the development of 2D and 3D games but also interactive simulations. It also offers various learning materials, including a dedicated learning platform called Unity Learn and comprehensive community support.

4.3.6 Software Development Kits (SDKs)

OpenXR SDK

OpenXR is an open, royalty-free standard designed to simplify AR/VR development [32]. It supports a wide range of devices, including Windows Mixed Reality, Meta Quest, and SteamVR, enabling developers to create cross-platform XR applications.

Unity XR Interaction Toolkit

The XR Interaction Toolkit is a component-based system for creating VR/AR experiences in Unity[33]. It provides a framework for 3D and UI interactions using Unity input events[33]. Key features include cross-platform XR controller input (e.g., Meta Quest, Windows Mixed Reality), object selection, grabbing, hovering, haptic feedback, basic canvas interactions, and integration with XR Origin for both stationary and room-scale VR experiences[33].

Android Build Support (SDK+NDK+OpenJDK)

Android Build Support is a set of modules installed via Unity Hub that enables Unity applications to be built for Android devices[34]. Since Meta Quest runs on Horizon OS, an Android-based operating system, Android Build Support is required to ensure compatibility with the headset.

4.3.7 Summary of the Technologies Review

Table 4.3.7.1 Technology review summary table

Category	Technology	Description
Hardware	Laptop	Used for 3D modelling and development
	VR Device	Used for testing VR application (Meta Quest 2, 6DoF tracking).
Operating System	Windows	PC operating system for development
	Horizon OS	Android-based OS for Meta Quest VR device
Database	PlayerPrefs	Stores player preferences locally
	ScriptableObjects	Share data across multiple objects at runtime
Programming Language	C#	Language used for Unity development
Software	Blender	3D modelling and asset creation
	Unity	Game engine for 2D/3D, VR/AR, simulations
SDKs	OpenXR SDK	Standard for cross-platform AR/VR development
	Unity XR Interaction Toolkit	VR/AR interaction system in Unity
	Android Build Support	Modules for building Unity apps on Android

4.4 User Requirements

Main Menu & Navigation

- As a user, I want to start gameplay from the main menu so that I can begin playing immediately.
- As a user, I want to access the level selection menu from the main menu so that I can choose which level to play.
- As a user, I want to select a level so that I can decide which stage of the game to experience.
- As a user, I want a fade-in or fade-out screen transition between levels so that the gameplay experience feels smooth and cinematic.
- As a user, I want to access an information screen so that I can learn essential details about the game.

VR & Accessibility Settings

- As a user, I want to adjust VR movement settings so that I can move comfortably according to my preferences.
- As a user, I want to change the turning mode so that the VR experience feels natural to me.
- As a user, I want to modify audio volume so that I can tailor the sound to my preference.
- As a user, I want audio, haptic, or visual feedback for each UI interaction so that I can clearly confirm my selections.
- As a user, I want to experience gameplay using a VR headset for maximum immersion.
- As a user, I want an option to experience the game in a non-VR mode so that I can still play without owning a VR headset.

Gameplay & Interaction

- As a user, I want to interact with puzzle objects so that I can attempt to solve the puzzles in the environment.
- As a user, I want auto-snapping when placing objects near their correct positions so that puzzle interactions feel smoother and more intuitive.
- As a user, I want an introductory panel for each level so that I can receive clues related to solving the puzzles.
- As a user, I want to reset my game progress so that I can restart the game from the beginning.

Educational & Heritage Content

- As a user, I want to access a VR 360° scene so that I can freely explore the heritage environment.
- As a user, I want to learn about the heritage site so that I gain motivation to explore the real-world location.
- As a user, I want educational and historical content integrated seamlessly with gameplay so that learning about places like Kellie's Castle feels interesting and immersive.

4.5 Timeline

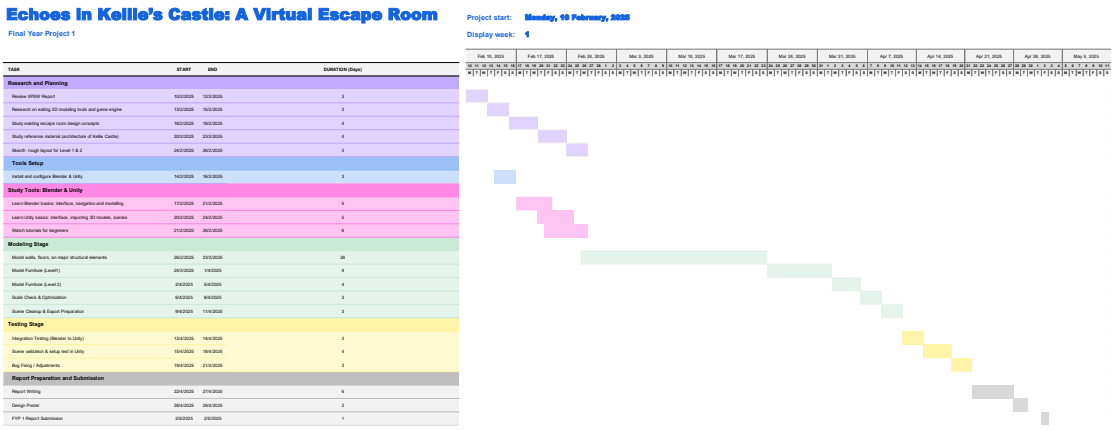


Figure 4.5.1 FYP 1 Timeline Gantt Chart

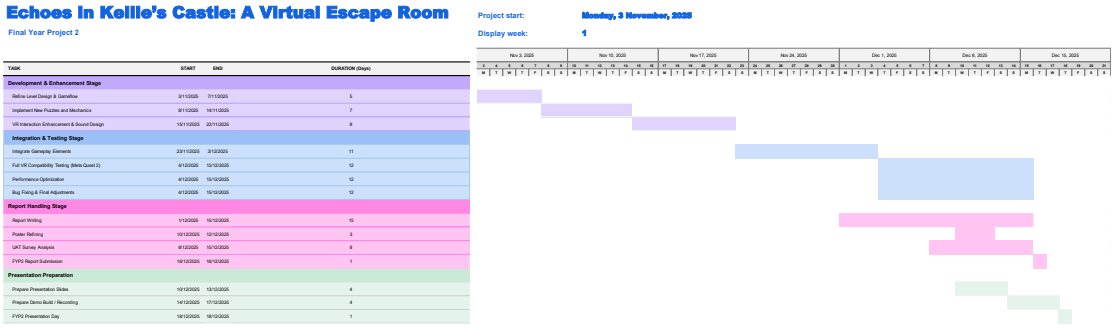


Figure 4.5.2 FYP 2 Timeline Gantt Chart

CHAPTER 5

System Implementation

5.1 Hardware Setup

Several steps are needed before connecting Meta Quest 2 for testing. The following are the steps to connect to Meta Quest.

1. Download Meta Horizon Link App

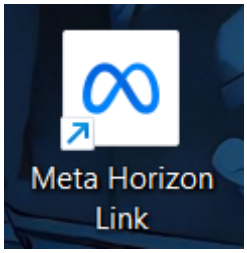


Figure 5.1.1 Meta Horizon Link Logo

2. Log in using a Meta account and complete the Horizon profile setup.
3. Power on the Meta Quest 2 headset.
4. Connect the headset to a stable Wi-Fi network.
5. Pair the Meta Quest 2 headset with the Meta Horizon Link using Air Link mode or USB cable.
    - Connection Using Air Link Mode
        1. Ensure that the PC and Meta Quest 2 are connected to the same Wi-Fi network
        2. Open settings in Meta Quest 2
        3. Select Link and pair the PC with pairing code.
        4. Once confirmed, select launch to start Air Link
        5. Open the project file in Unity Editor, select Play and the VR device is ready for testing.
    - Connection Using USB Cable Mode
        1. Plug one end of the USB 3 cable to a USB 3.0 port on PC, and the other hand to the headset.

2. Open the project file in Unity Editor.
3. Navigate to Build Settings, and under Run Device, select Oculus Quest 2.
4. Click Build and Run, and the VR device is ready for testing.

5.2 Software Setup

Before beginning the development of the proposed 3D VR escape room, the required software tools must be installed and configured properly.

The list of software used in this project is as follows:

- Blender (v 4.4.1)
- Unity Hub (v 3.11.1)

The list of modules used when installing Unity Editor in this project is as follows:

- Microsoft Visual Studio Community 2022
- Windows Build Support (IL2CPP)
- Android Build Support
    - Android SDK & NDK Tools
    - Android JDK
- Documentation

5.2.1 Blender

Blender Installation Steps

The following are the steps to install Blender:

1. Navigate to the official Blender website at https://www.blender.org/download/ and click the “Download Blender” button.

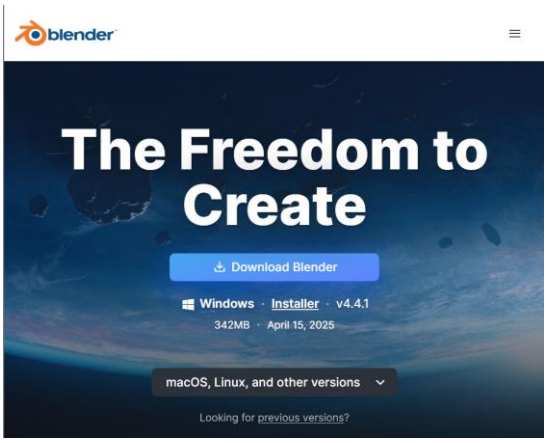


Figure 5.2.1 Blender Official Website

2. The download will begin automatically. Wait for the process to be completed.

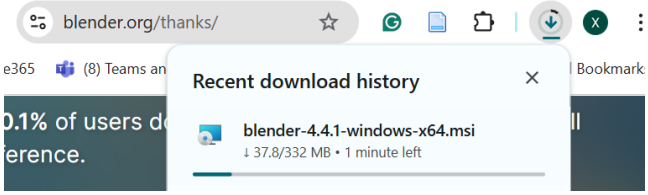


Figure 5.2.2 Blender Download

3. Once the download is finished, run the installer file. The **Blender Setup Wizard** will appear. Click **“Next”** to proceed.

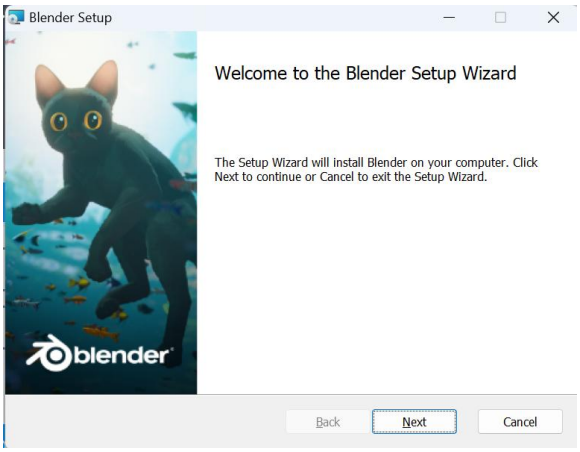


Figure 5.2.3 Blender Setup Wizard

4. Users may change the installation directory by clicking “Change...”. If no changes are needed, click “Next” to continue.

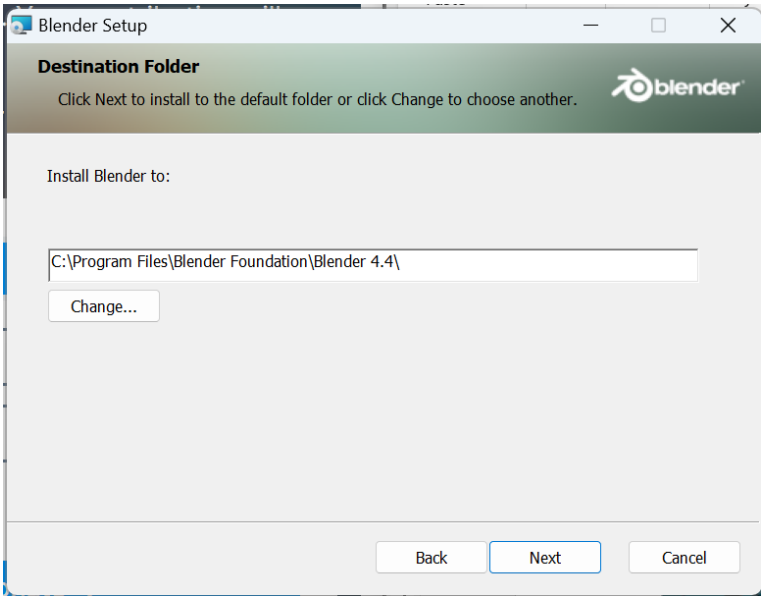


Figure 5.2.4 Installation Directory

5. Click the “Install” button to begin the installation process.

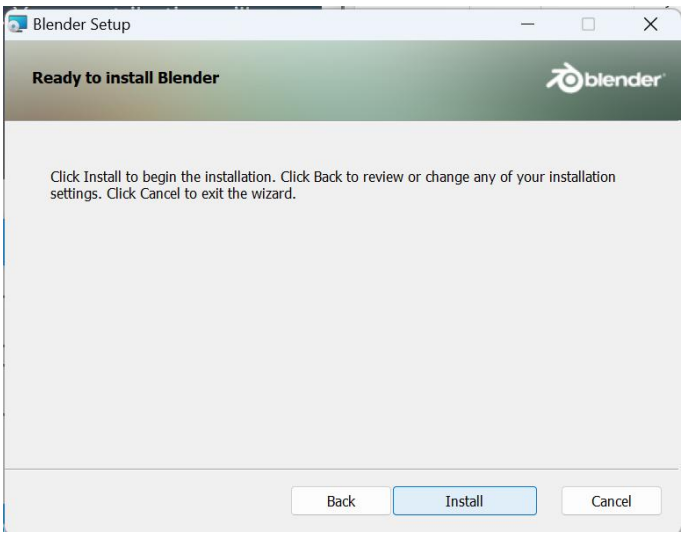


Figure 5.2.5 Start Installation

6. After installation, A message stating “Completed the Blender Setup Wizard” will appear. Click “Finish” to complete the setup.

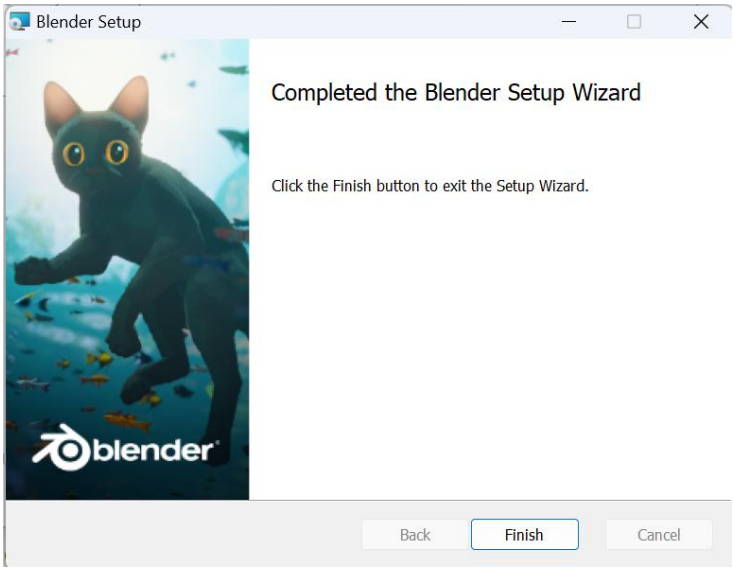


Figure 5.2.6 Completed Blender Setup Wizard

7. Upon launching Blender, the user will be presented with the default start-up screen, as shown in Figure

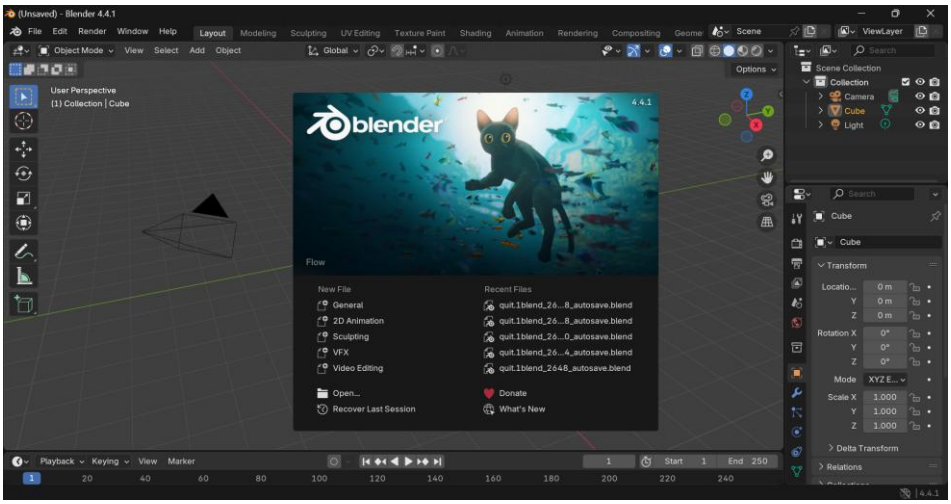


Figure 5.2.7 Blender Start-up Screen

5.2.2 Unity

Unity Hub Installation Steps

The following are the steps to install Unity Hub:

1. Navigate to the official Unity Website at https://unity.com/products/unity-personal and click “Get started”

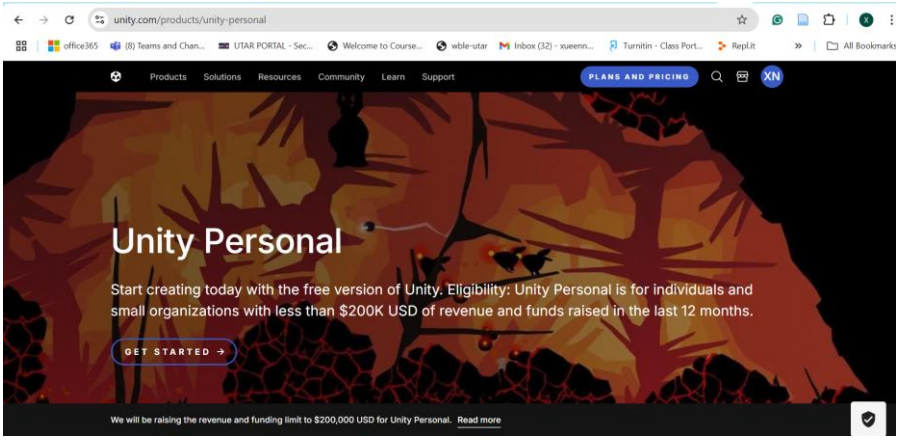


Figure 5.2.8 Official Unity Website

2. On the next page, click “Download for Windows” to download the Unity Hub installer.

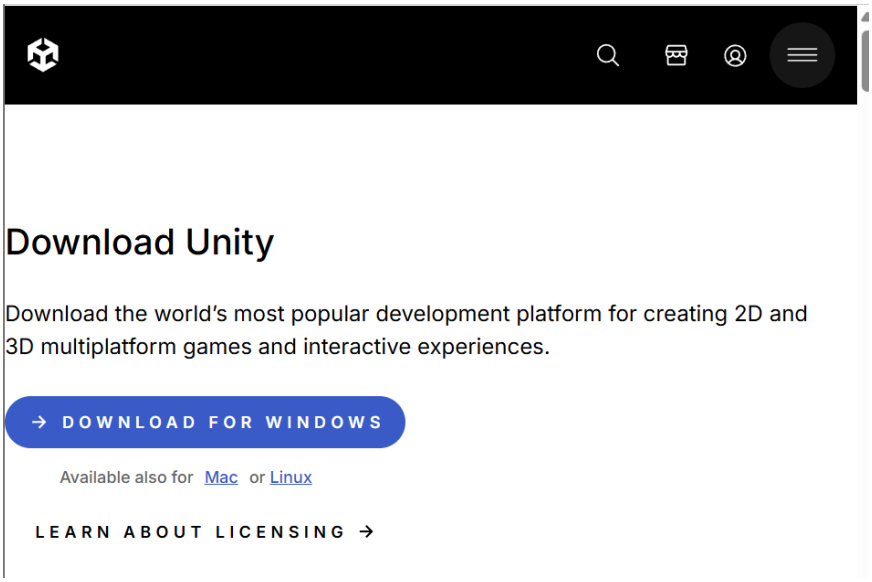


Figure 5.2.9 Download Unity

3. Once the download is complete, run the installer file. The Unity Hub Setup window will appear. Click “I Agree” to accept the license terms and proceed.

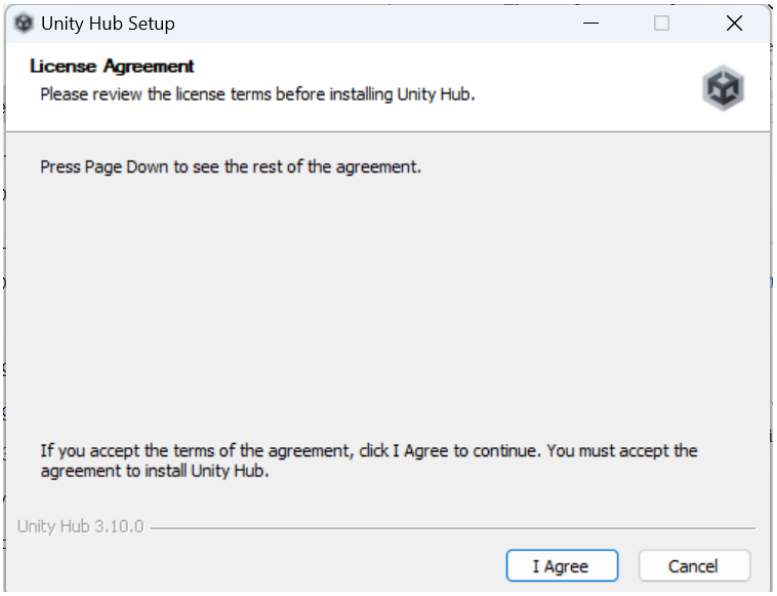


Figure 5.2.10 License Agreement

4. To change the installation directory, click “Change” and select your preferred location. Otherwise, click “Install” to proceed with the default settings.

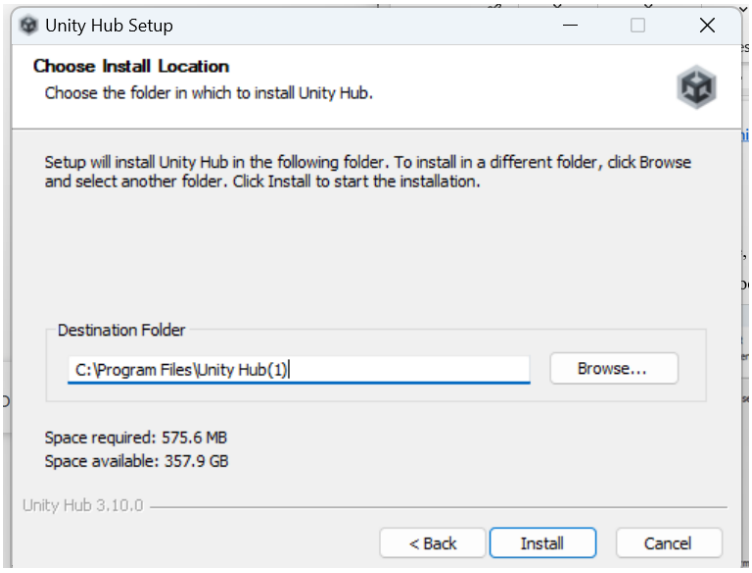


Figure 5.2.11 Installation Directory

5. The user will receive a “Completing Unity Hub Setup” message once the installation is completed. Click “Finish” to launch the Unity Hub.

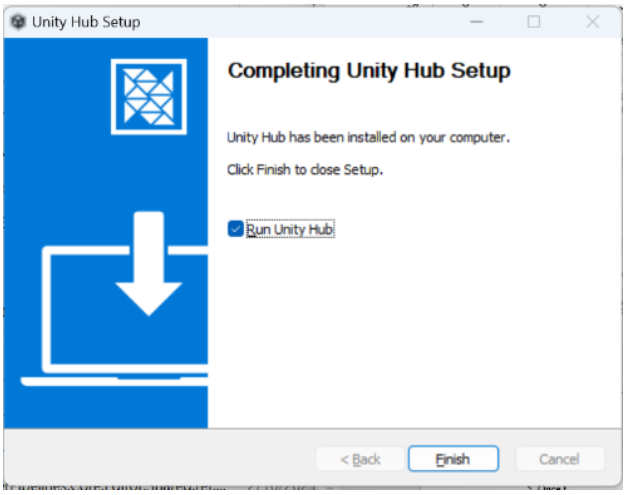


Figure 5.2.12 Completing Unity Hub Setup

Unity Configuration Steps

Unity Account Creation and Sign-In

The following are the steps to create and log in with Unity ID:

1. In Unity Hub, click “Create Account” to register a new Unity ID.

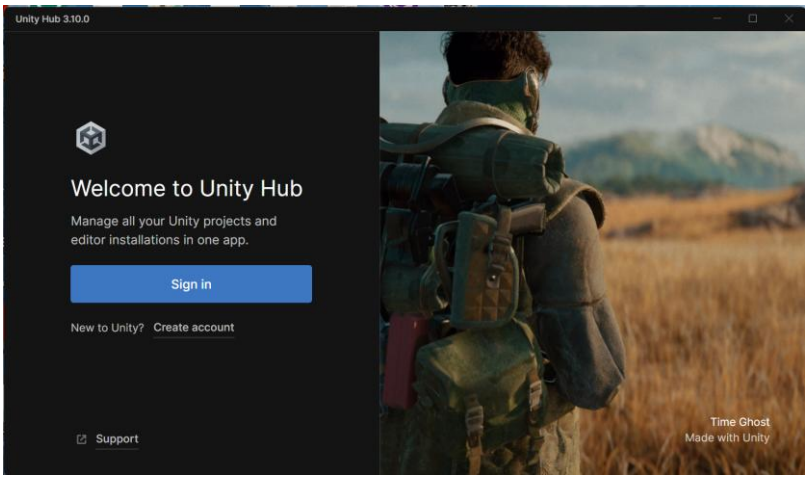


Figure 5.2.13 Unity Hub Login Page

2. The user will then be directed to a webpage titled Unity ID. Click “create one” to begin account registration.

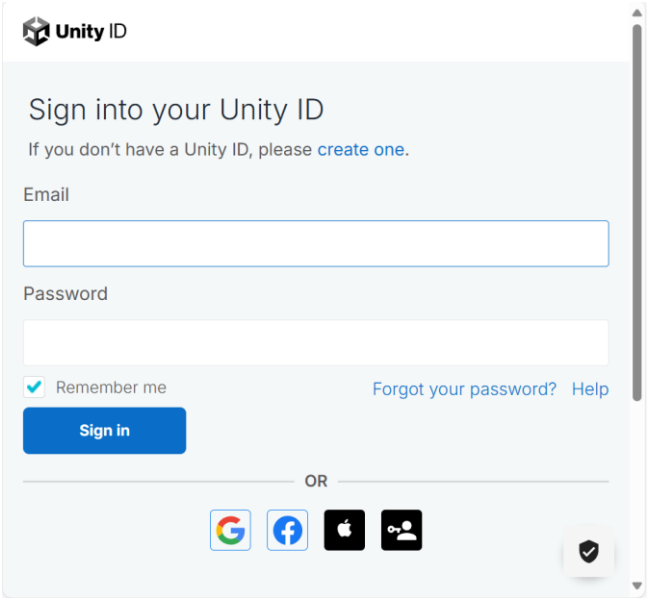


Figure 5.2.14 Unity Sign-in Webpage

3. Enter all the required details and click “Create a Unity ID”.

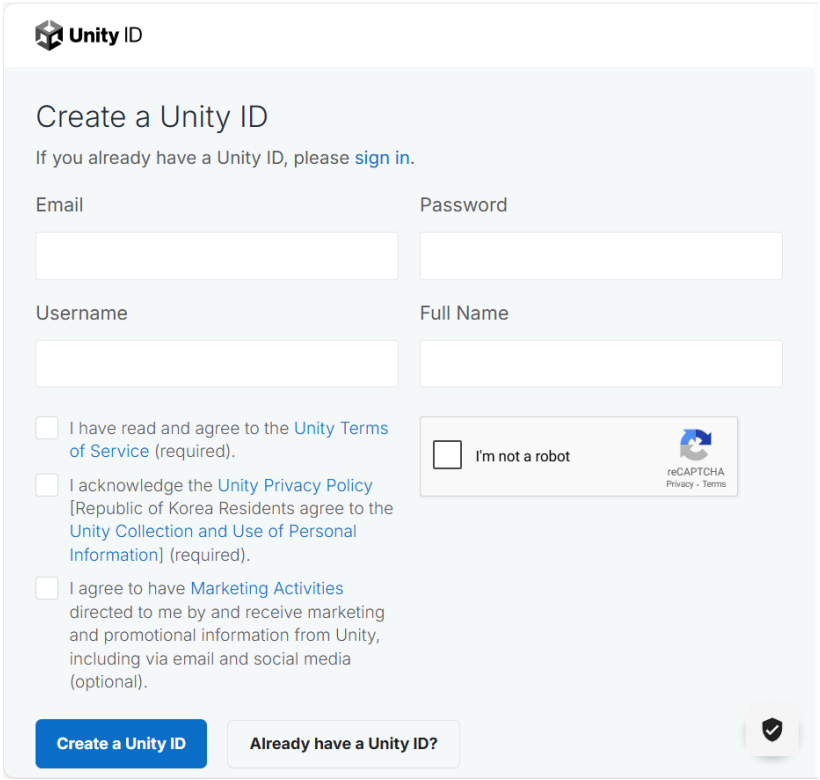


Figure 5.2.15 Creating Unity ID

4. The user will receive a confirmation email sent to their registered email address.

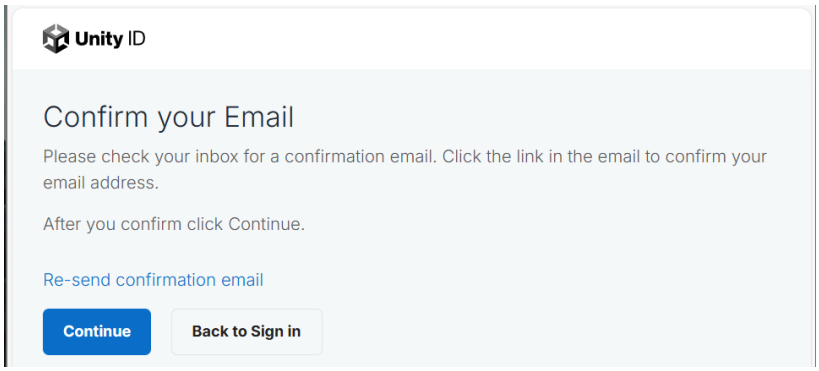


Figure 5.2.16 Email Confirmation

5. Open the email and click “verify” to complete the confirmation.

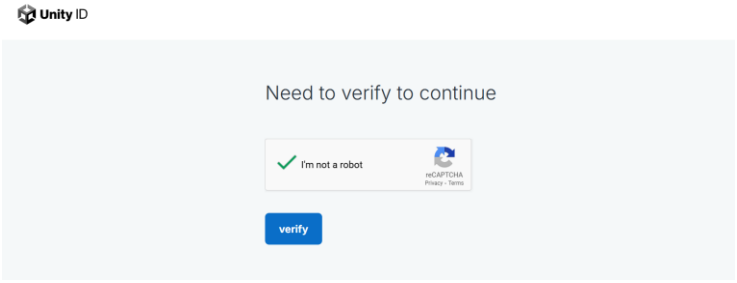


Figure 5.2.17 Completed Email Confirmation

6. After verification, the user will then be redirected to the sign-in page. Enter all the credentials needed to access their Unity account.

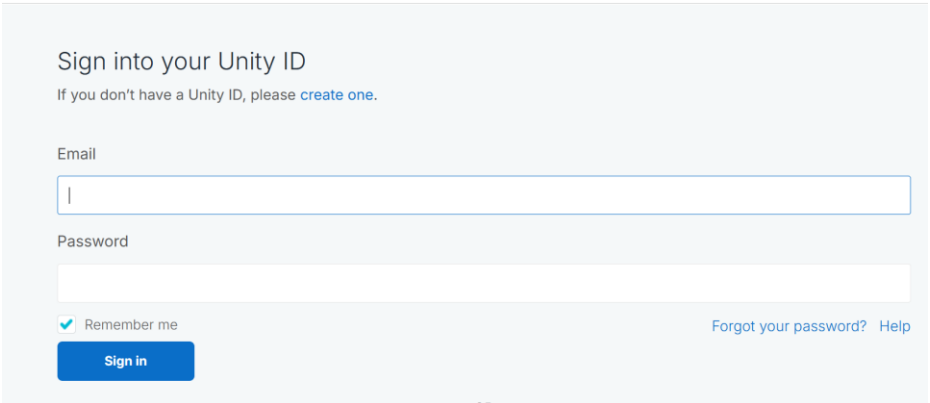


Figure 5.2.18 Unity Account Sign In

7. Click “open” when prompted to allow the browser to launch Unity Hub.

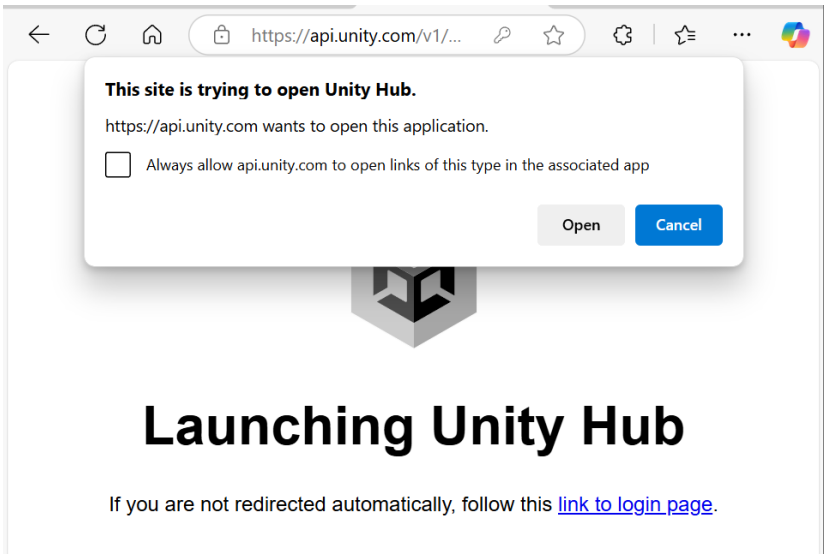


Figure 5.2.19 Launching Unity Hub by Browser

Unity Editor Installation Steps

The following are the steps to install Unity Editor.

1. Upon first login, click” agree” to accept the terms and conditions.

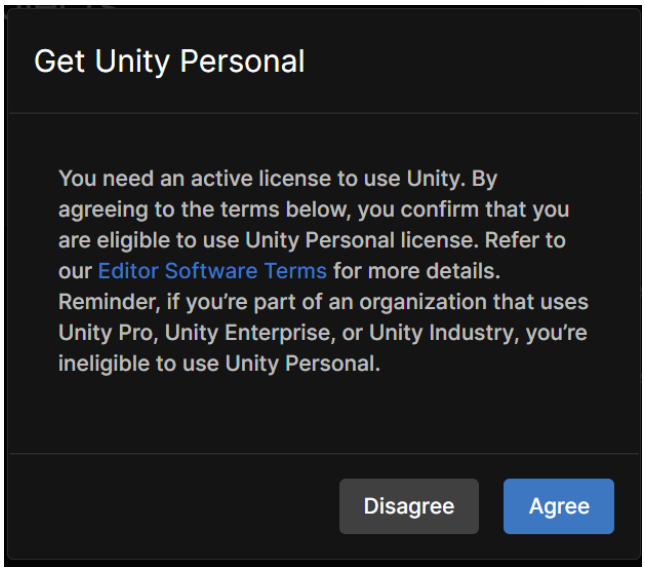


Figure 5.2.20 Unity Personal Terms and Conditions

2. Navigate to the “Installs” tab and click “Install Editor” within Unity Hub to install the Unity editor.

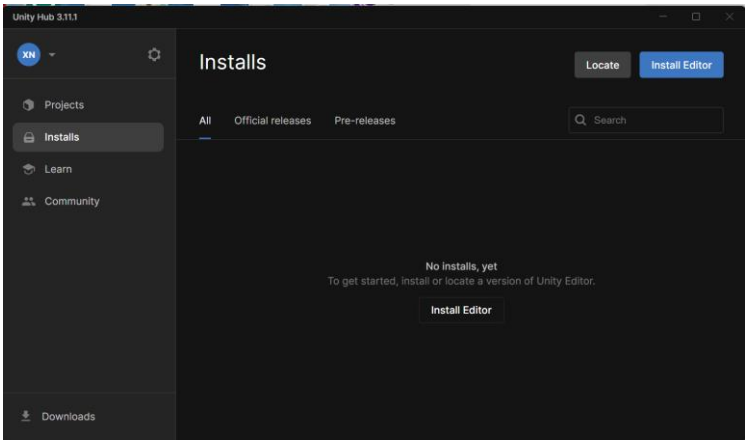


Figure 5.2.21 Unity Installs Tab

3. Select the desired version and click the “install” button

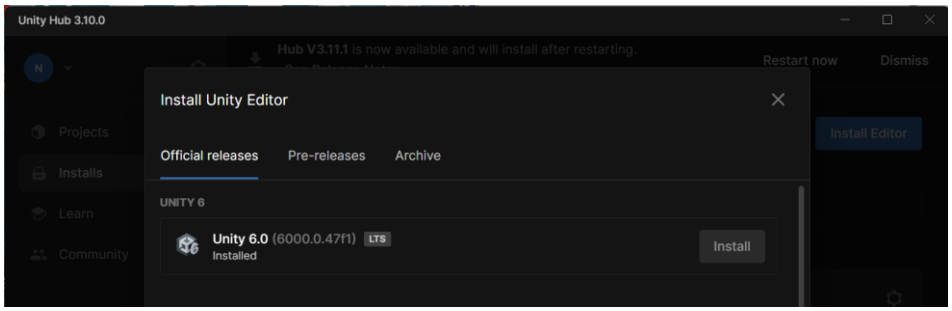


Figure 5.2.22 Install Unity 6.0

4. Select all required modules and versions. Click “continue” to proceed.

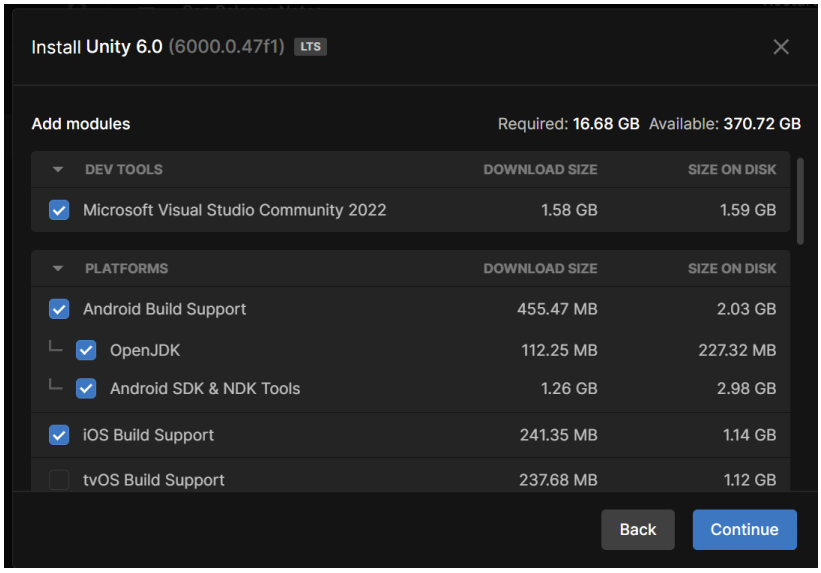


Figure 5.2.23 Unity Module Part 1

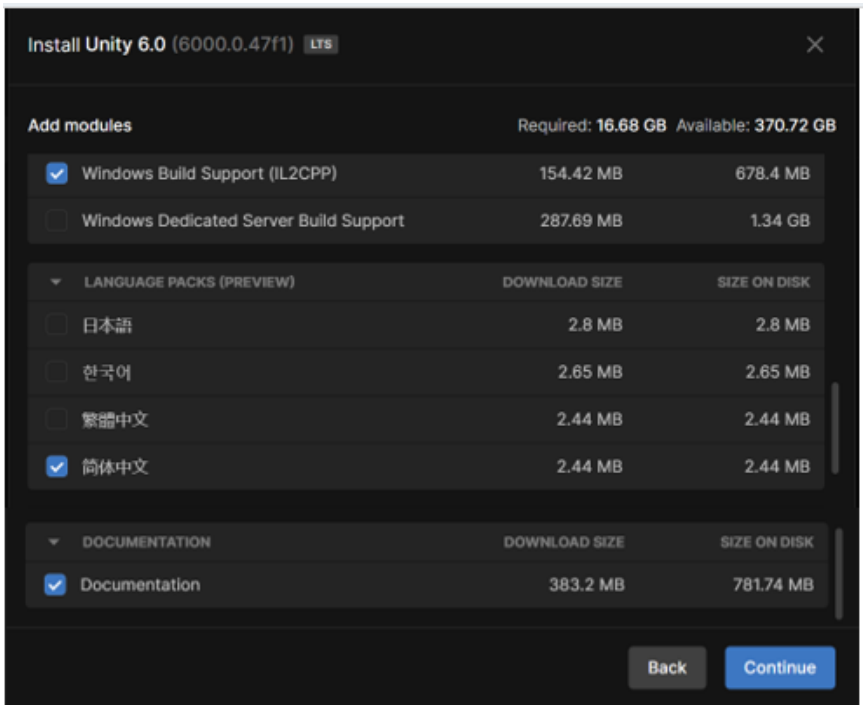


Figure 5.2.24 Unity Module Part 2

5. Review and accept the terms and conditions, then click “Continue” to proceed.

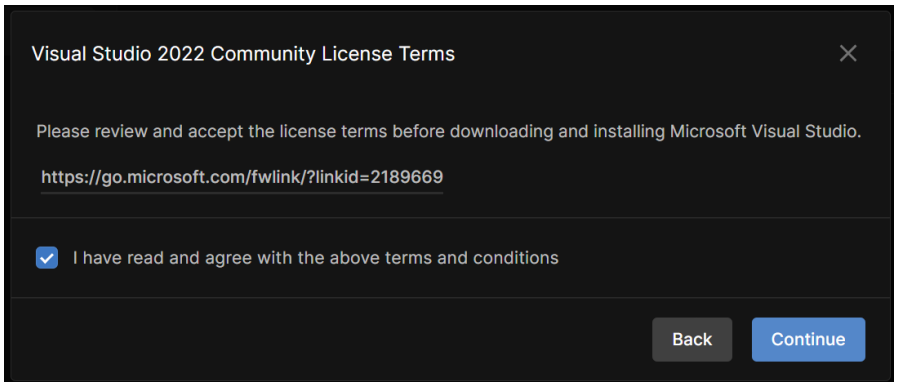


Figure 5.2.25 Visual Studio License Terms

6. Tick the checkbox to agree to all terms, then click “install”

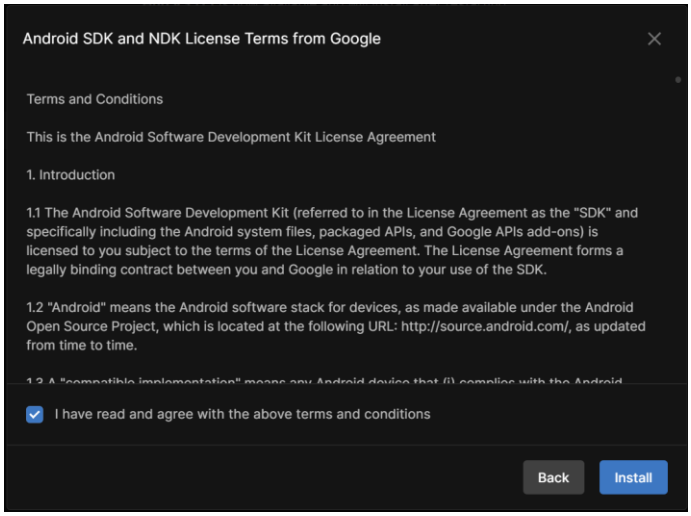


Figure5.2.26 Android SDK Terms

7. Wait for the installation process to be completed. Once done, Unity is ready for use.

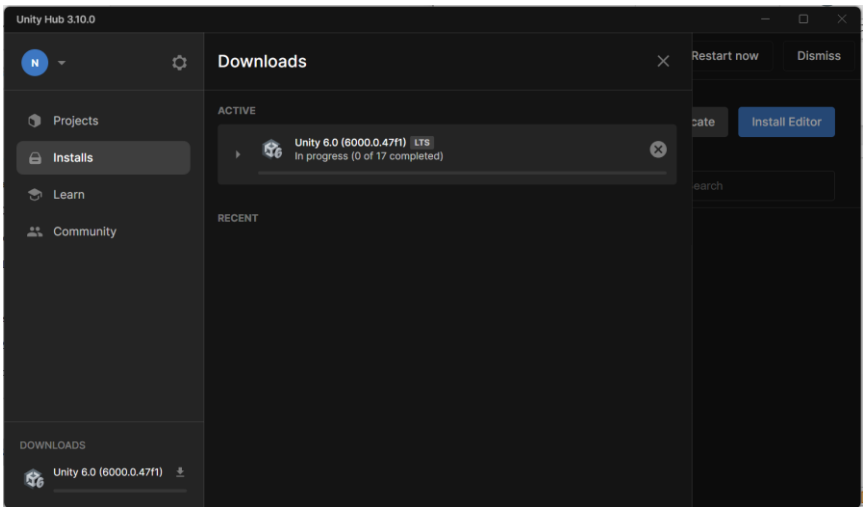


Figure 5.2.27 Downloading Installs

5.3 Preliminary Work Results

5.3.1 3D Modelling

The initial phase of 3D modelling work was carried out using Blender.

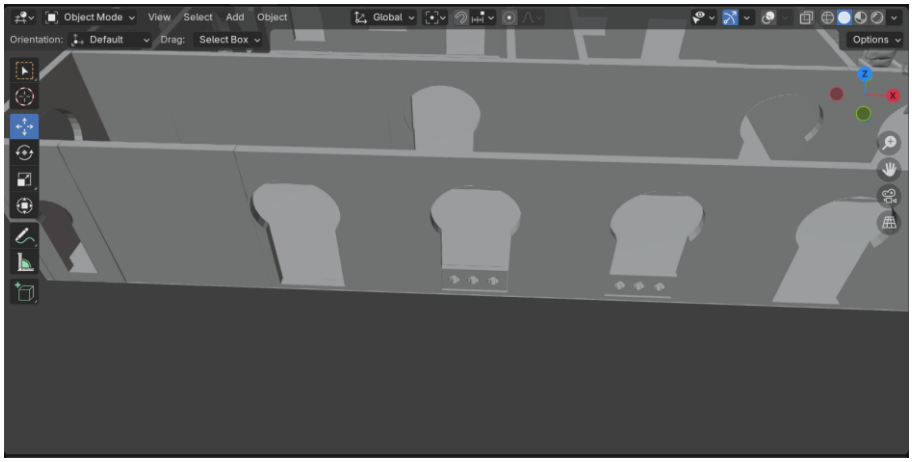


Figure 5.3.1 Building Façade

As shown in Figure 5.3.1, the preliminary structure of the building façade has been developed, laying the groundwork for further detailing and texturing in later stages.

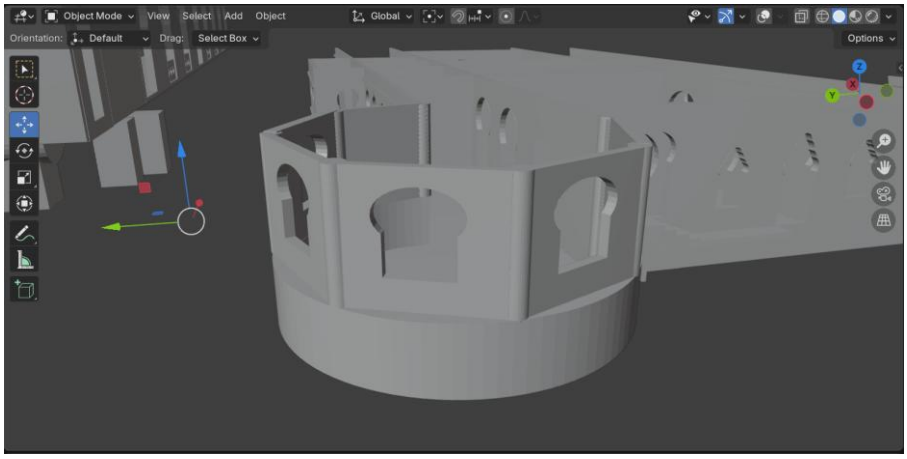


Figure 5.3.2 Semi-circular Tower

The figure above shows the semi-circular tower section of Kellie's Castle. The tower is modelled to closely resemble the original structure of Kellie's Castle.

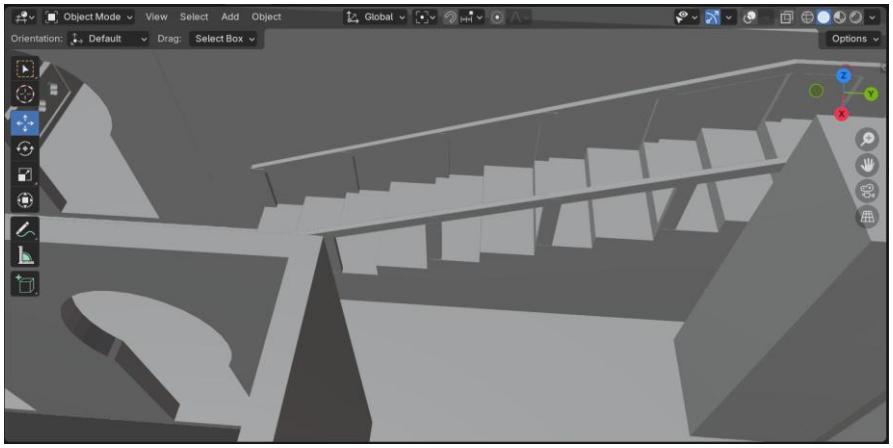


Figure 5.3.3 Staircase

The figure 5.3.4 above shows the staircase which connects the first and second floors. This component is essential for the navigation within the VR space.

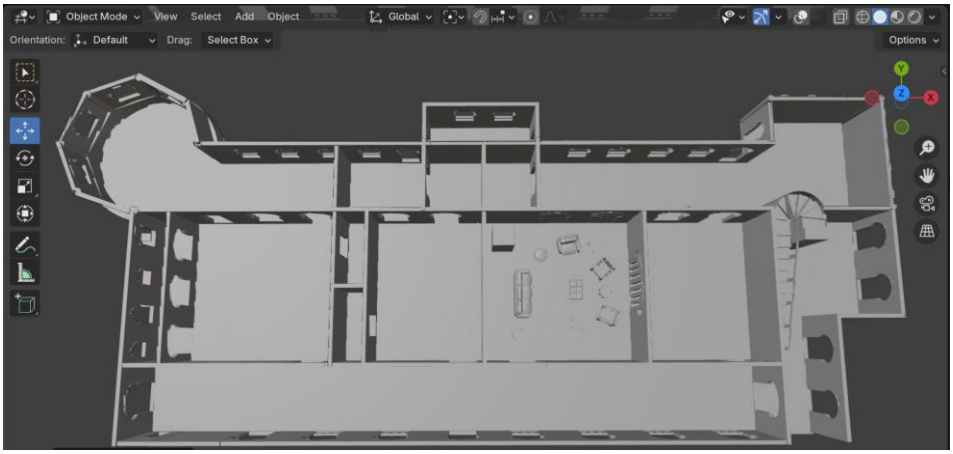


Figure 5.3.4 Interior Layout of 1st Floor

Figure 5.3.5 above shows the top-down view of the 3D Architectural model created using Blender. The model represents the interior layout of the first floor of Kellie's Castle, which includes the key structural components such as rooms and hallways, staircase, central living space and the semi-circular tower section.

5.3.2 Unity Import Testing

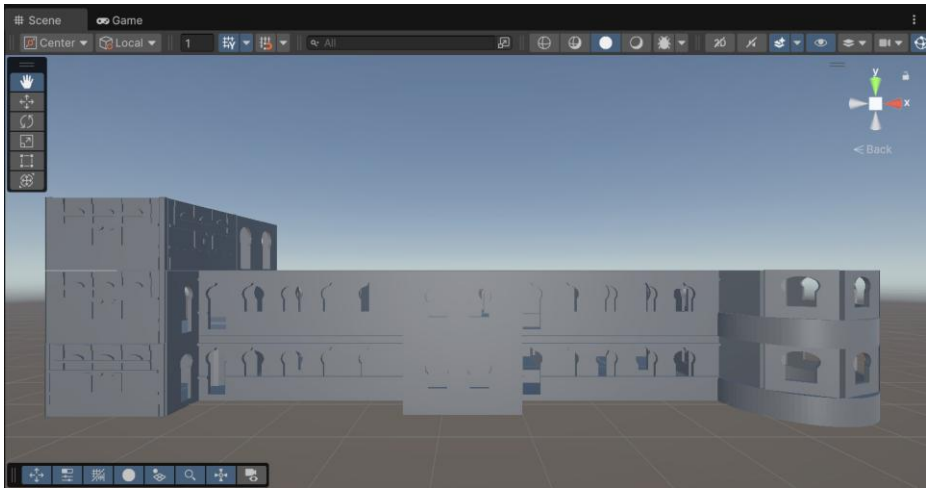


Figure 5.3.5 Import to Unity

The figure 5.3.6 above shows the 3D model was imported into Unity for preliminary testing purposes. The import was conducted to verify the basic scale, structure, and compatibility of the model with Unity's VR integration requirements.

5.4 System Operation

Main Menu

Figure 5.4.1 Main Menu

Upon entering the game, the Main Menu screen is displayed. From the Main Menu, the user can navigate to several interfaces, including Start, Options, and About.

Level Selection Menu

Figure 5.4.2 Level Selection Menu

When the Start button is clicked, the Level Selection Menu appears. Gameplay levels are progressively unlocked, meaning a level can only be accessed after the previous

level has been successfully completed. The user is allowed to select any unlocked level. By pressing the Back button, the user is redirected to the Main Menu.

Options Menu

Figure 5.4.3 Options Menu

The Options button will open the Options Menu, where users can customize gameplay settings.

Figure 5.4.4 Changing Turn Mode in Options Menu

Users can change the locomotion mode between snap Turn and continuous Turn to suit their comfort.

Figure 5.4.5 Reset Progress Confirmation Message

A Clear Progress button is also available; when clicked, a confirmation dialog appears. If the user confirms the reset, all game progress will be cleared. If the user cancels the action, the existing progress remains unchanged.

About Game

Figure 5.4.6 About Game

When the About button is clicked, the About Screen appears, displaying general information about the game.

Level 1 Environment

Figure 5.4.7 Level 1 Environment Picture 1

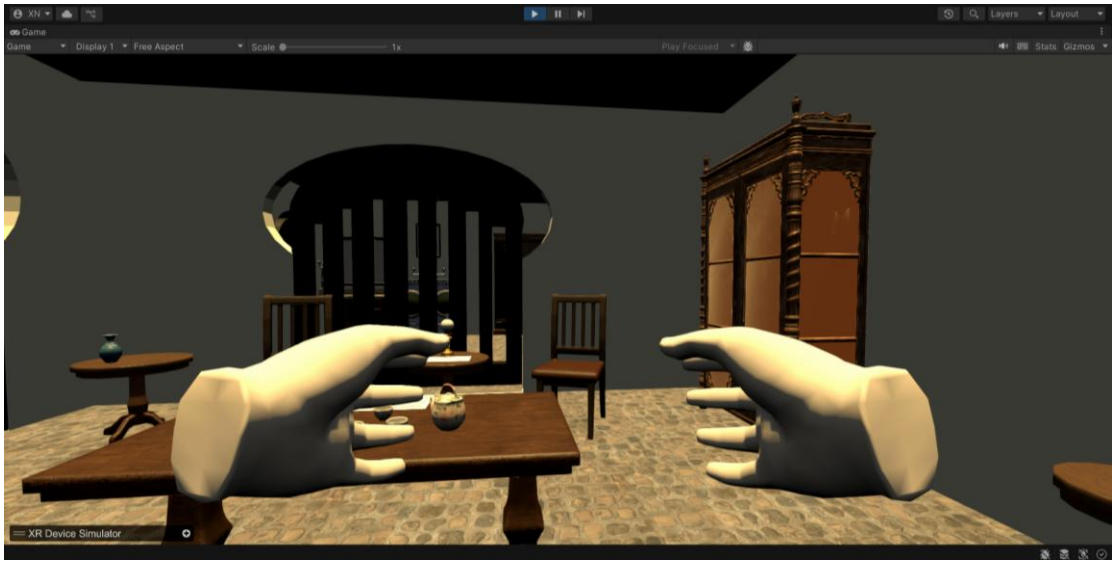


Figure 5.4.8 Level 1 Environment Picture 2

Figure above shows the environment setting for Level 1.

Level 1 Diary piece

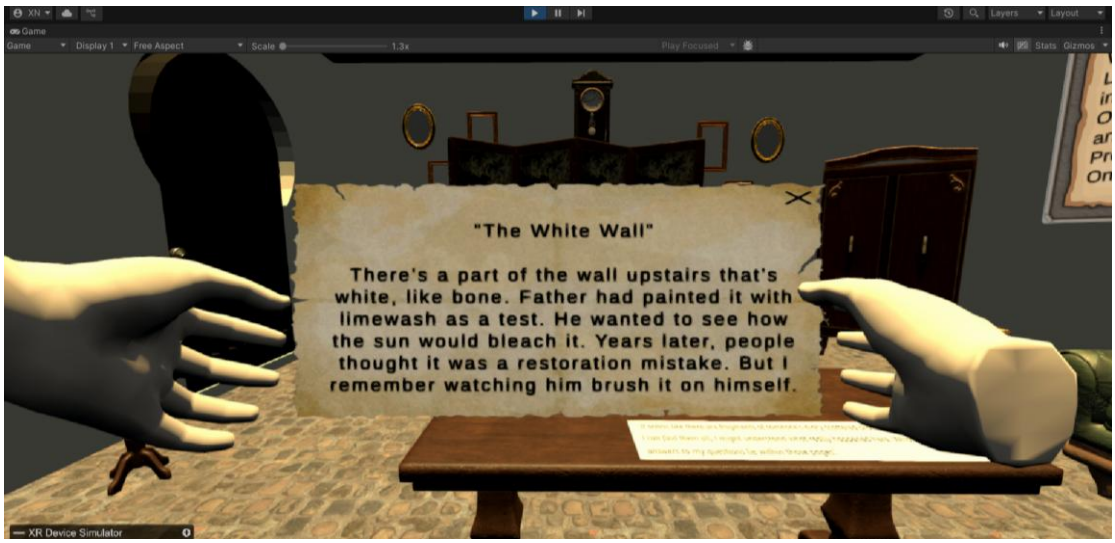


Figure 5.4.9 Diary Piece

During gameplay, diary messages are displayed whenever a diary piece is collected. The user is required to collect all three diary pieces to proceed to the next puzzle.

Level 1 Quiz Puzzle

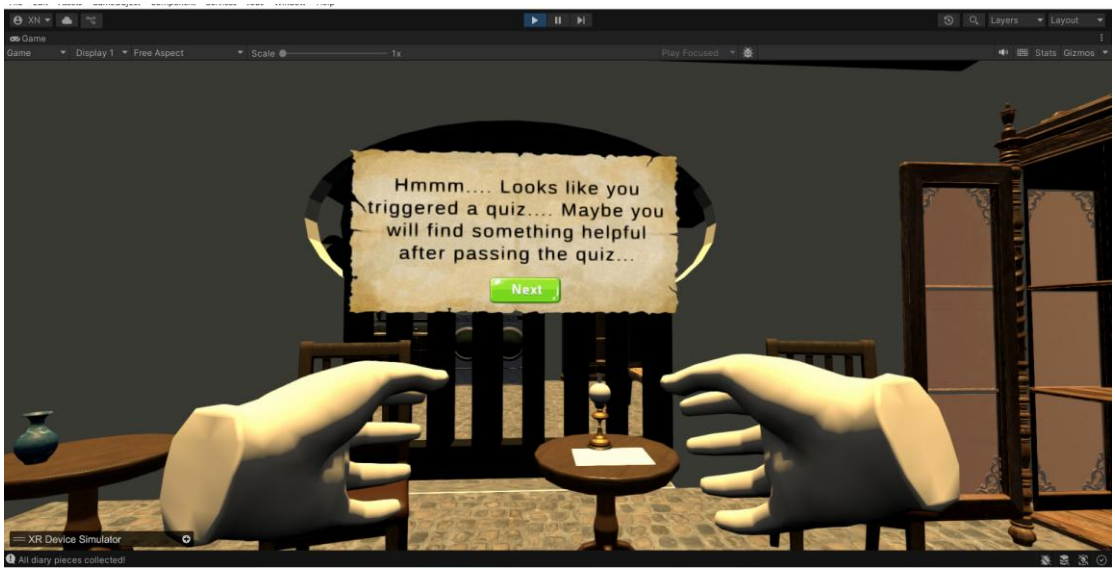


Figure 5.4.10 Quiz Puzzle

After collecting all three diary pieces, user need to answer a quiz.

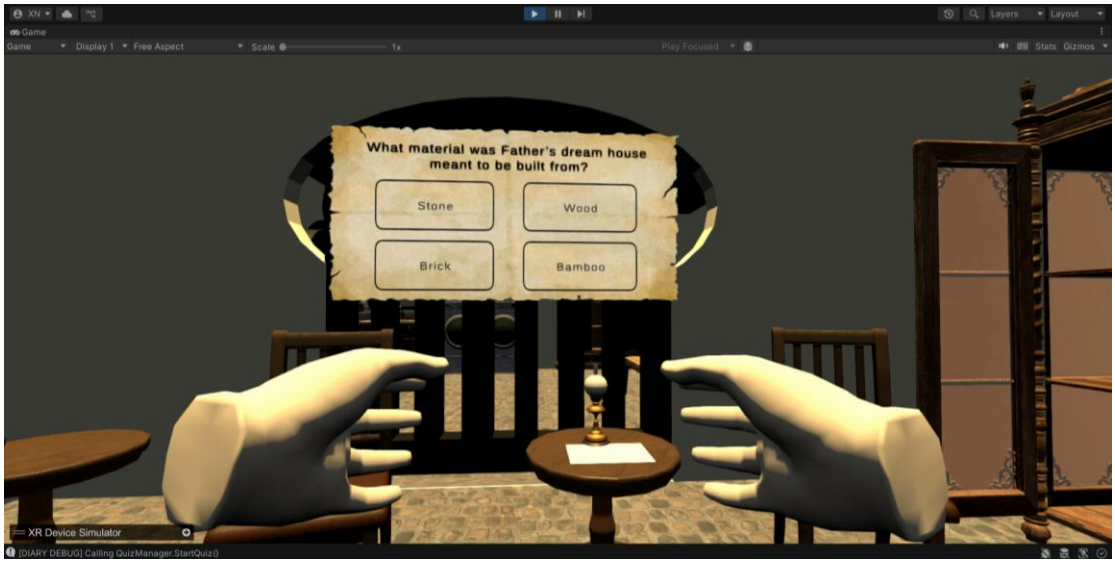


Figure 5.4.11 Quiz Puzzle Question

After collecting all diary pieces, a quiz interface appears. The quiz questions are based on the historical information related to Kellie's Castle obtained from the diary pieces.

Figure 5.4.12 Quiz Puzzle Retry

The user must answer at least 4 out of 5 questions correctly to proceed. If the Retry button is clicked, the quiz questions are shuffled randomly.

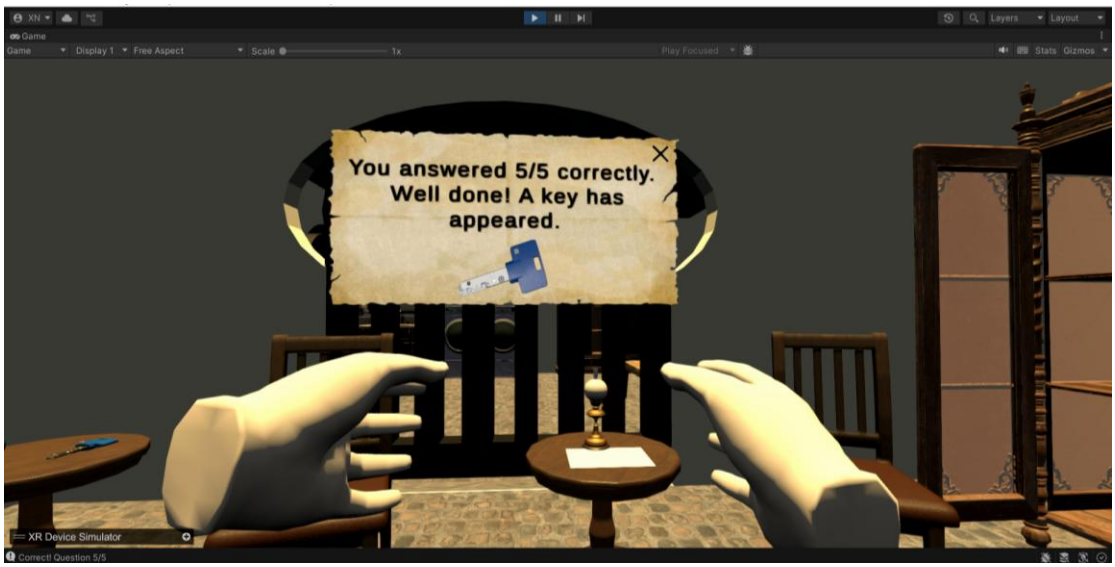


Figure 5.4.13 Quiz Puzzle Question

Upon successfully answering the quiz, a key object appears. The user must collect the key to unlock the door and escape the room, completing Level 1.

Level 2 Environment

Figure 5.4.14 Level 2 Environment Picture 1

Figure 5.4.15 Level 2 Environment Picture 2

Figure above shows the environment setting for Level 2. Message prompts appear when message pieces are collected.

Level 2 Message Piece

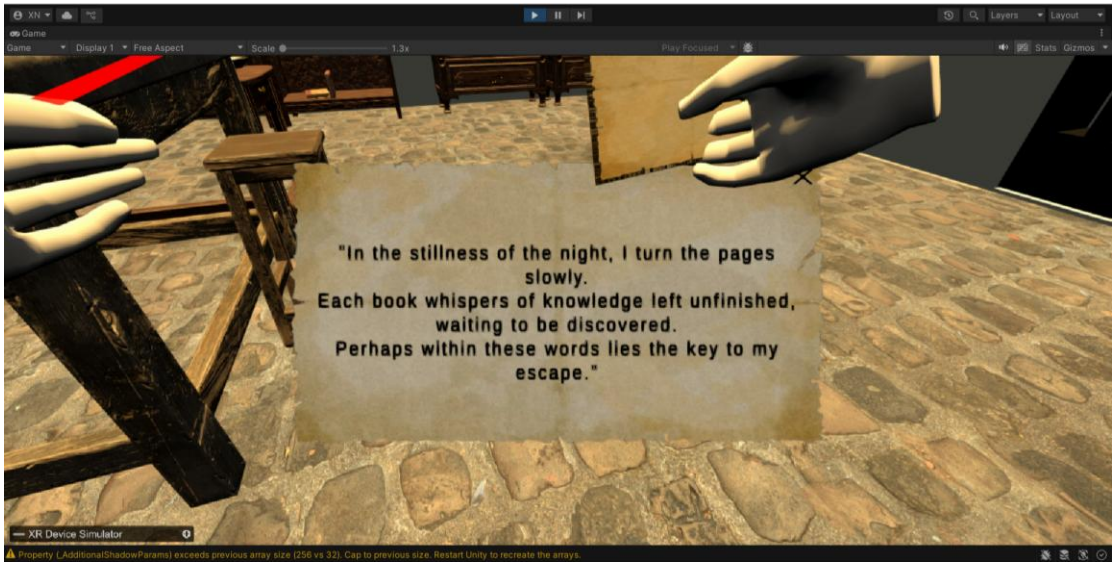


Figure 5.4.16 Message Piece

The user must collect three message pieces and throw them into a collection zone.

Level 2 Collection Zone

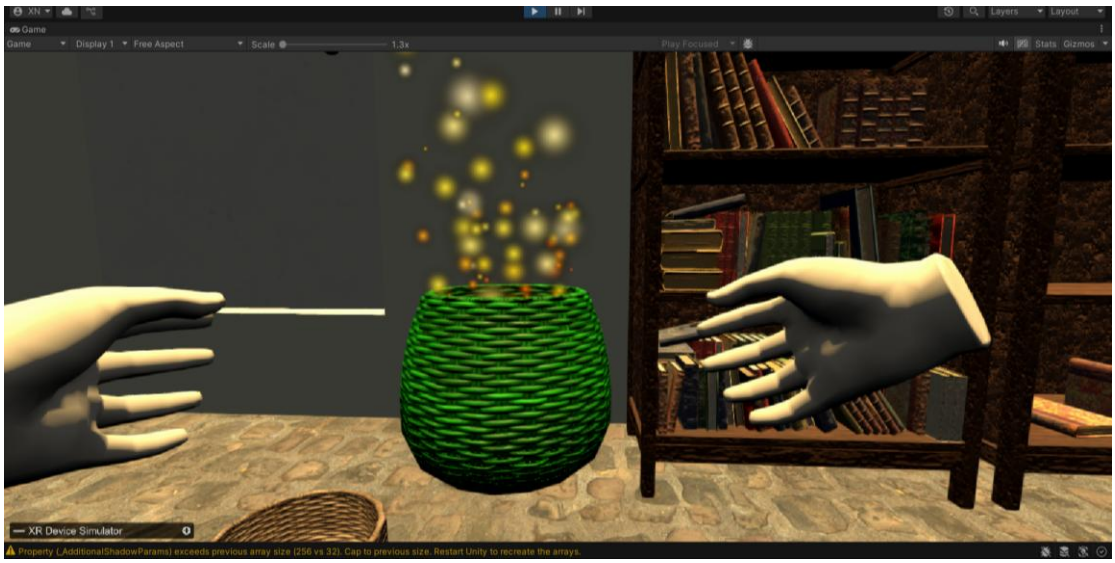


Figure 5.4.17 Collection Zone

When a message piece is successfully received, the collection zone turns green to indicate confirmation.

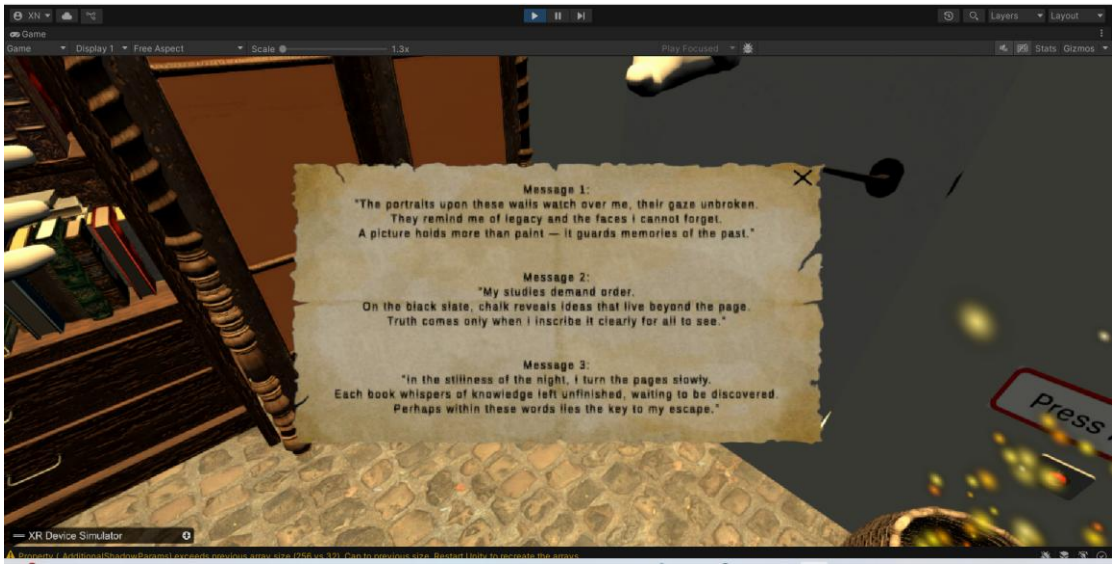


Figure 5.4.18 Message

After all message pieces are placed correctly, a message UI displaying the complete message appears. The user must identify and interact with symbol objects in the correct sequence based on the displayed message.

Press Here Review Message Button

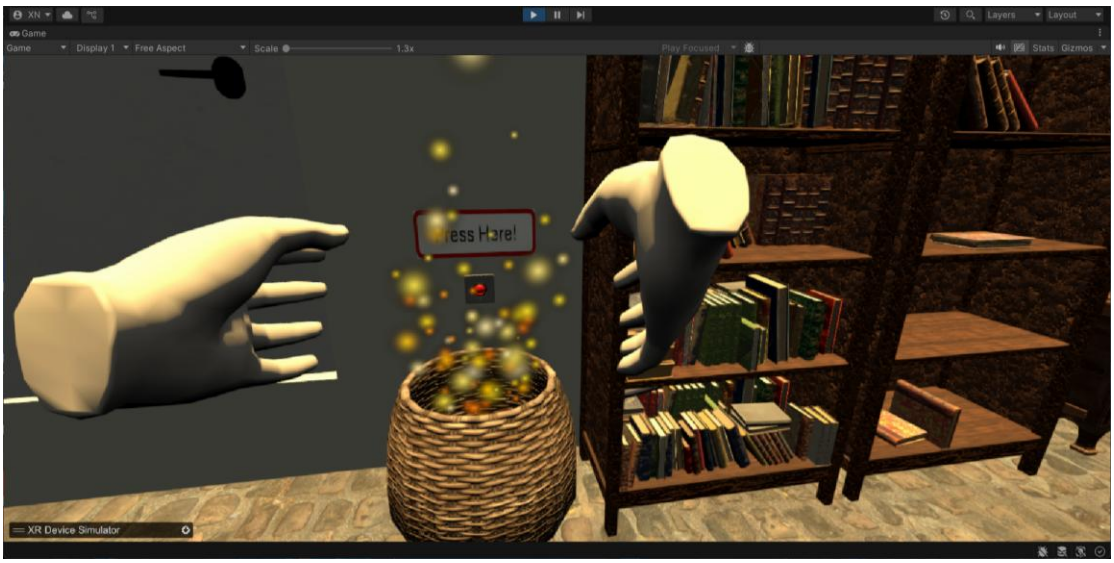


Figure 5.4.19 Press Here Review Message Button

The user can review the message at any time using the "Press Here" button.

Level 2 Symbol Collection Puzzle

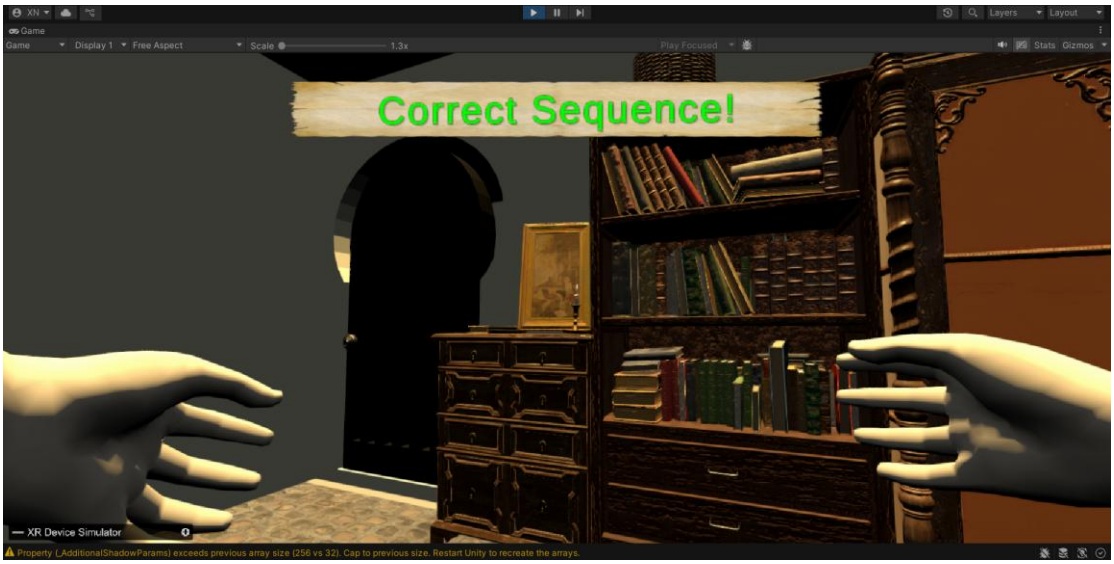


Figure 5.4.20 Correct Sequence Message

If the symbols are selected in the correct sequence, a correct sequence message is displayed.

Figure 5.4.21 Wrong Sequence Message

Otherwise, a wrong sequence message is shown.

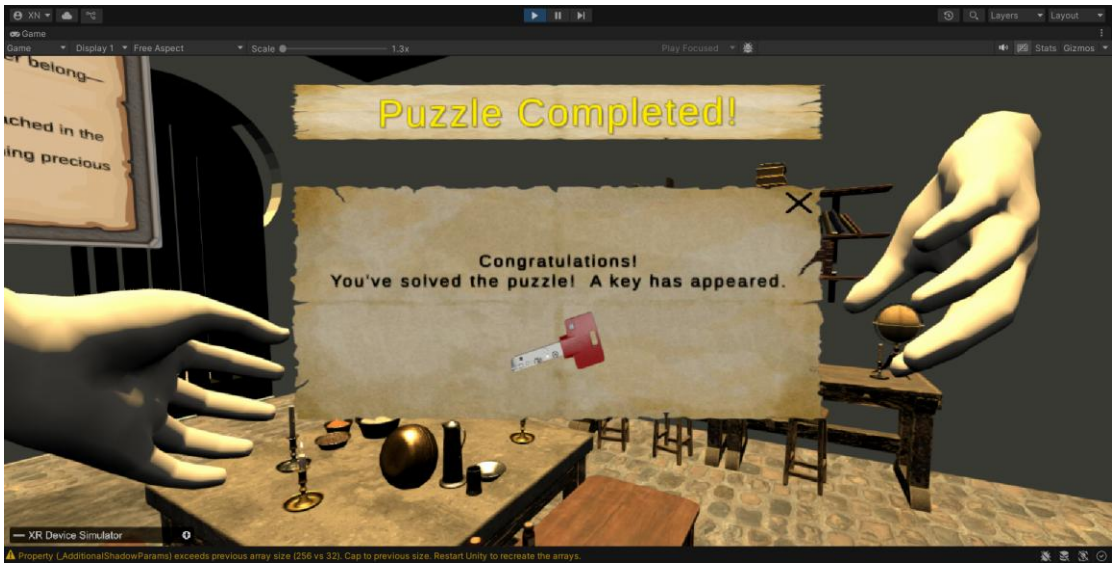


Figure 5.4.22 Congratulations Message

Once all puzzles are completed successfully, a congratulations message appears, and a key is spawned to allow the user to escape the room.

Level 3 Environment

Figure 5.4.23 Level 3 Environment Picture 1

Figure 5.4.24 Level 3 Environment Picture 2

Figure above shows the environment setting for Level 3.

Level 3 Candle Triggered Hidden Message Puzzle

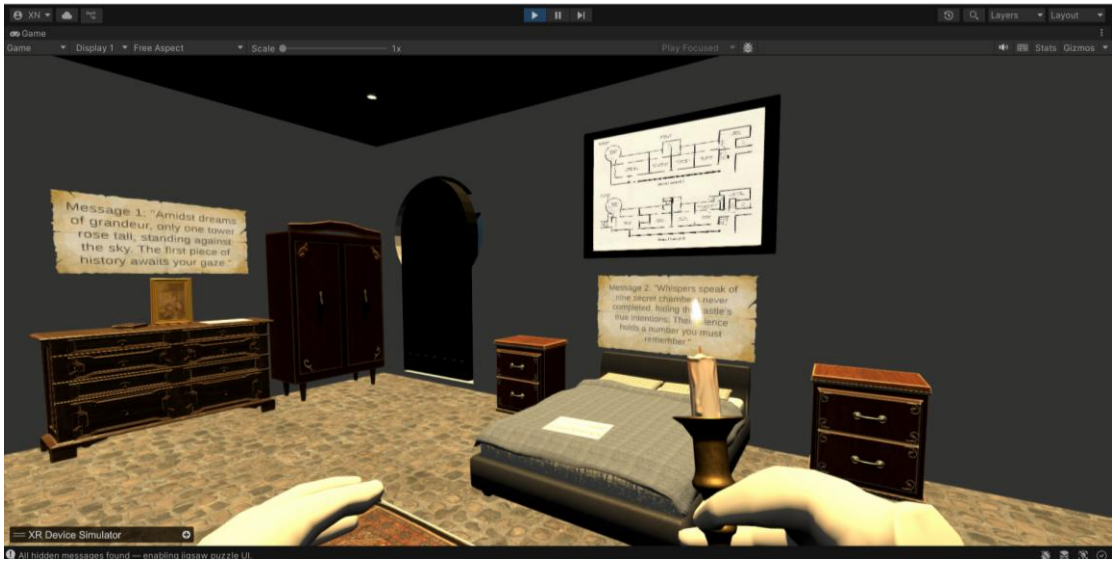


Figure 5.4.25 Candle Triggered Hidden Message Puzzle

Message dialogs are triggered when the user interacts with candles to reveal hidden messages.

Jigsaw Puzzle

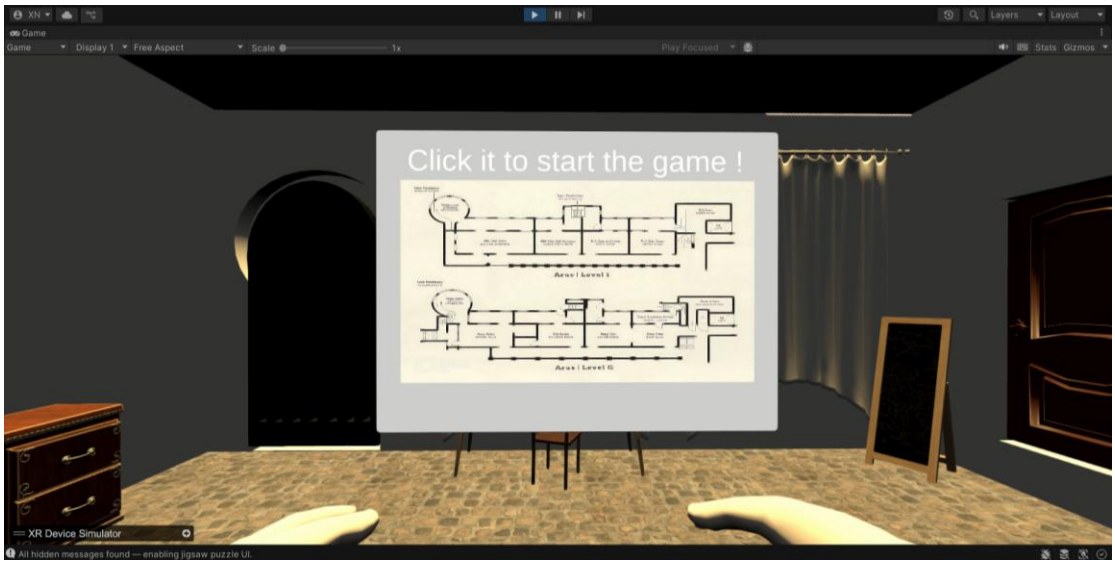


Figure 5.4.26 Jigsaw Puzzle

After discovering all three hidden messages, a jigsaw puzzle is activated.

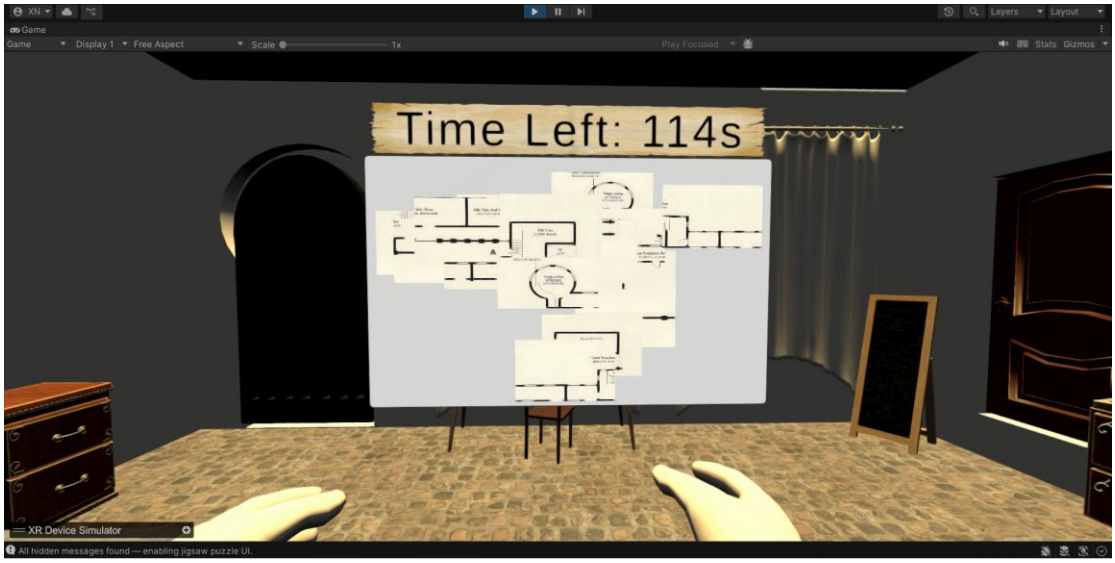


Figure 5.4.27 Jigsaw Puzzle Countdown Timer

A countdown timer is used for the jigsaw puzzle.

Figure 5.4.28 Times's Up Message

If the user fails to complete the puzzle within two minutes, they must click the Retry button to attempt again.

Figure 5.4.29 Jigsaw Puzzle Completion Status

If user able to complete the jigsaw puzzle within the time limit, then user is allowed to proceed to the next puzzle.

Level 3 Floor Plan Information Panel

Figure 5.4.30 Floor Plan Description

The user can also view a description of the floor plan.

Level 3 Numpad Lock

Figure 5.4.31 Numpad Lock

Next, a numpad lock appears. The user must enter a four-digit password obtained from the hidden messages. The system validates the entered code and plays either a success or failure sound accordingly.

Level 3 Key Card Object

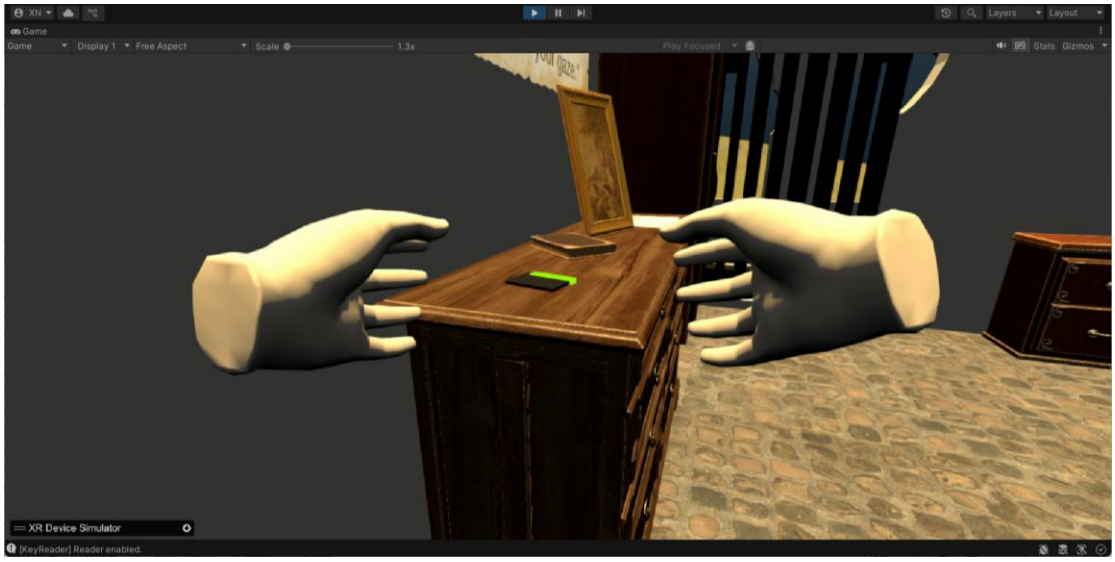


Figure 5.4.32 Key Card Object

When the correct password is entered, a key card object appears.

Figure 5.4.33 Inset Key Card Object

The user must insert the key card to unlock the door and complete the level.

Congratulations Panel

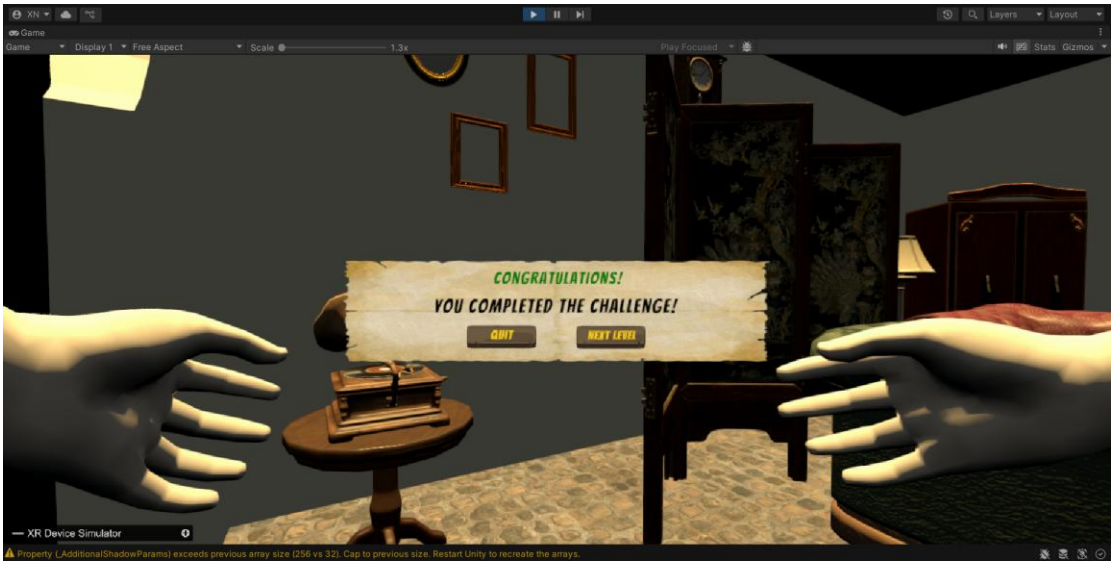


Figure 5.4.34 Congratulations Panel

Upon completing any level, a Congratulations panel is displayed, allowing the user to either return to the Main Menu or proceed to the next level.

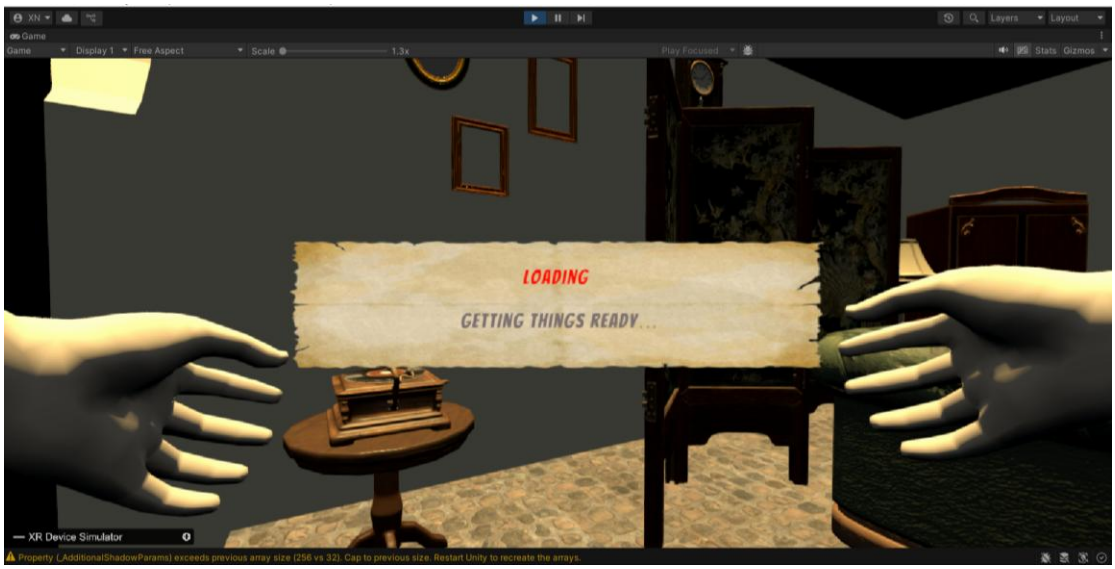


Figure 5.4.35 Loading Panel

If the Next Level button is selected, a loading panel is shown.

VR 360 Scene View

Figure 5.4.36 VR360 Scene View

After completing all three levels, the 360° Explore Mode is unlocked. In this mode, users can freely explore the VR environment and teleport to different points by clicking on available buttons. Users may also choose to return to the Main Menu at any time.

5.5 Implementation Issue and Challenges

During the development of the 3D VR Escape Room project, several challenges were encountered, particularly in the setup and integration stages involving Unity and Blender.

Unity Installation and Setup Issue

One initial challenge was the installation and configuration of the Unity development environment. For first-time users, the installation process is quite confusing due to the multiple steps in setting up Unity Hub and Unity Editor.

After installing Unity Hub, users are required to install the Unity Editor before starting a new project. However, a recurring bug was encountered during this stage, where the editor installation process hung indefinitely, displaying the "installation failed: an unexpected error occurred during installation" error message.

The issue was resolved by installing only the Unity Editor first, and then adding the required modules like Android Build Support separately after the editor was installed successfully.

Blender to Unity Model Import Error

Another significant challenge encountered during the development process was the import of 3D models from Blender into Unity using the FBX file format. Upon importing the models, Unity generated multiple errors, including the message: "A polygon is self-intersecting and has been discarded."

This error was caused by the overlapped geometry or improperly joined meshes within Blender models. The issue was solved by performing a cleanup process in Blender, like merging duplicate vertices by distance, deleting loose geometry and applying degenerate dissolve operations to ensure that the models were optimised correctly and compatible with Unity's mesh import pipeline.

VR device testing on Meta quest 2

Besides, another significant challenge encountered during the implementation phase was testing and deploying the system on the Meta Quest 2 VR headset. While the system functioned correctly during development and testing in the Unity Editor and XR Device Simulator, several compatibility and interaction issues emerged when running the application on the actual VR device. These issues included the inability to detect UI button interactions on the canvas, incorrect canvas scaling resulting in oversized UI elements in the VR environment, and ray-based interaction being blocked by rigid objects within the scene.

These problems were primarily caused by differences between the simulated environment and the actual VR hardware interaction system. The issues were resolved through iterative testing and refinement of the interaction and UI systems. The canvas layout and scaling ratios were adjusted to ensure correct visual proportions within the VR headset. Additionally, the interaction detection mechanism was improved by implementing tracked device graphics in Unity. After these modifications, the UI interaction and ray detection functioned as intended on the Meta Quest 2, resulting in a stable and usable VR experience.

CHAPTER 6

System Evaluation and Discussion

6.1 System Testing and Performance Metrics

The performance of the target application was evaluated using key technical metrics including frame rate, CPU frame time, render thread time, draw calls, and scene and interaction responsiveness.

Table 6.1.1 Performance Metrics Table

Metric	**Value**	**Standard / Target**	**Meets Standard?**
Frame Rate (FPS)	~90–200 (spikes up to 400)	≥ 72FPS [35]	**YES**
CPU frame time	~10.6 ms	≤ 13.88 ms [35]	**YES**
Render thread	~8.9 ms	≤ 13.88 ms/frame [35]	**YES**
Scene load time	< 5 seconds	N/A	**N/A**
Teleport response	< 1 second	N/A	**N/A**
Memory usage	~18.8 MB	N/A	**N/A**
Draw calls / SetPass	~335	• 80-200 (Busy Simulation)[36] • 200-300 (Medium Simulation)[36] • 400-600 (Light Simulation)[36]	**YES (Medium)**

The target application demonstrates high overall performance, maintaining a stable frame rate above 90 FPS which exceeds the recommended threshold of 72 FPS. Both the CPU frame time(10.6ms) and render thread time (8.9ms) fall within acceptable range for smooth VR rendering. The draw call count of approximately 335 places the application to medium simulation category, indicating an optimized scene. The teleportation actions respond in less than 1 second and the scene loads complete in less than 5 seconds, providing user with smooth VR experience.

Figure 6.1.1 Gameplay Statistics

Figure 6.1.1 illustrates the real-time in-game statistics captured during gameplay, supporting the measured performance values reported in Table 6.1.1.

6.2 Testing Setup and Result

Table 6.2.1 Test Case Table

ID	Test Case Name	Expected Result	Actual Result	Status
TC01	Load Main Menu	Main Menu screen appears as the entry UI	Main Menu displayed as the entry screen	**PASS**
TC02	Load Level Selection Menu	Level Selection Menu loads after clicking **Start Game**	Level Selection Menu displayed after clicking **Start Game**	**PASS**
TC03	Load Options Menu	Options Menu loads after clicking **Options**	Options Menu displayed after clicking **Options** in Main Menu	**PASS**
TC04	Load About UI	About UI displaying game information appears	About screen displayed after clicking **About** in Main Menu	**PASS**
TC05	Quit Function	Application terminates when **Quit** is clicked	Application closed successfully	**PASS**
TC06	Level Selection	Selected game scene loads and user spawns at correct location	Level selection and spawn points functioned as intended	**PASS**
TC07	Level Progress Button Lock	Uncompleted levels remain locked	Level buttons locked until previous level completion	**PASS**

TC08	Scene Loading	Scene loads during transitions	Scene loaded within 5 seconds during transitions	**PASS**
TC09	Teleportation	User teleports to designated spawn point	Teleportation completed in less than 1 second	**PASS**
TC10	Quiz Puzzle	Quiz UI and logic load correctly	Quiz loaded after collecting all diary pieces and functioned correctly	**PASS**
TC11	Grabbable Object	Objects can be grabbed	Objects successfully collected using ray or hand interaction	**PASS**
TC12	UI Feedback	UI feedback displayed when required	UI feedback shown based on puzzle completion progress	**PASS**
TC13	Audio Feedback	Audio feedback plays on puzzle success or failure	Audio feedback played correctly based on puzzle outcome	**PASS**
TC14	Haptic Feedback	Haptic feedback provided via controller	Haptic feedback triggered when clicking menu buttons and numpad	**PASS**
TC15	Collection Zone	Visual change occurs when message piece is collected	Message piece color changed upon collection	**PASS**

TC16	Candle Hidden Message Puzzle	Candle reveals hidden message when triggered	Hidden message displayed when candle entered trigger area	**PASS**
TC17	Jigsaw Puzzle	Puzzle pieces auto-snap when near correct position	Jigsaw pieces snapped correctly when aligned	**PASS**
TC18	Numpad Lock	System validates entered password	Numpad accepted 4-digit code and validated correctly	**PASS**
TC19	Time Counter	Countdown timer functions correctly	Timer counted down as expected	**PASS**
TC20	VR 360 Navigation	User can navigate freely in VR360 scene	Free navigation achieved within VR360 environment	**PASS**
TC21	Next Level Transition	Next level loads upon level completion	Level transition successful when **Next Level** clicked	**PASS**
TC22	Back to Main Menu	Main Menu scene loads	Main Menu loaded when **Back to Main Menu** clicked	**PASS**
TC23	Change Audio Volume	Audio volume adjusts based on user input	Volume changed according to slider value	**PASS**
TC24	Turning Mode	User can switch between snap turn and continuous turn	Turning mode changed according to user selection	**PASS**
TC25	Reset Progress	Stored level progress is cleared upon confirmation	Level progress successfully reset after confirmation	**PASS**

All 25 test cases passed successfully, indicating that the system meets the defined functional and usability requirements. All the core features such as menu navigation, level progression, puzzle mechanics, VR interaction, feedback systems such as UI, audio, and haptic, and user settings operated as expected. The results confirm that the application is stable, user-friendly, and suitable for deployment.

6.3 User Acceptance Testing (UAT)

A User Acceptance Testing (UAT) session was conducted for the proposed system, *Echoes in Kellie's Castle: A Virtual Escape Room,* to evaluate the system's usability, functionality, performance, and overall user experience. A pilot test was carried out by releasing a beta version of the application to selected participants, who were asked to experience the full gameplay. User feedback was collected through a structured Google Form consisting of nine sections. The collected data was then analysed to determine whether the system aligns with the project objectives and to assess its readiness for deployment or official use.

Participants were required to complete all nine sections of the questionnaire, which covered:

1. Personal Information
2. System Functionality
3. Usability and Interaction
4. Visuals and Environment Design
5. Educational Content
6. Gameplay and Engagement
7. Performance and Technical Quality
8. UAT Acceptance
9. Additional Feedback for System Improvement

Section 1: Personal Information

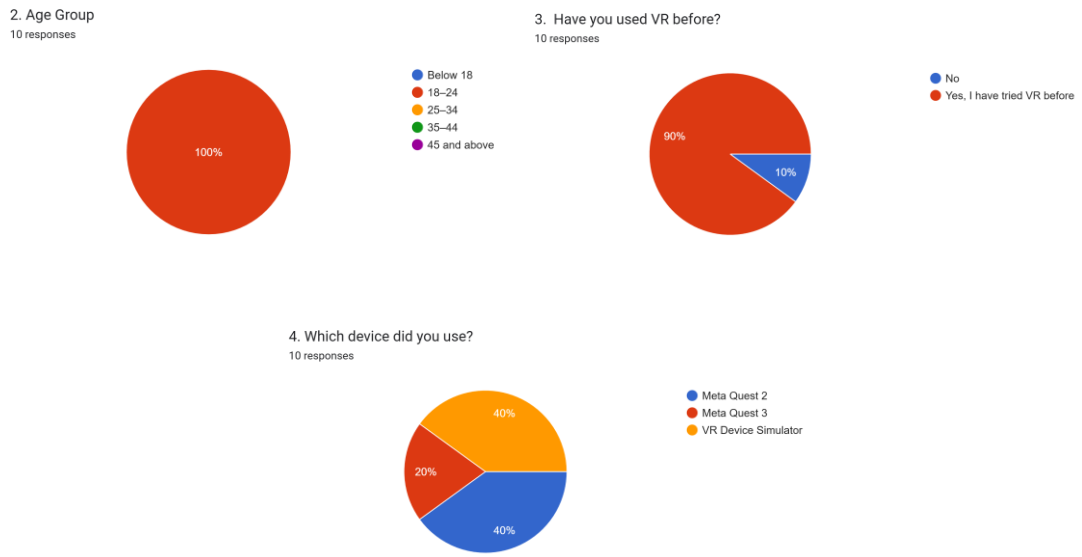


Figure 6.3.1 Personal Information

A total of 10 participants aged 18 to 24 were invited to take part in the beta testing session of the VR escape room application. This age group was selected intentionally to evaluate whether the integration of VR-based gamification can successfully attract younger audiences and potentially increase their interest in physically visiting Kellie's Castle as a heritage tourism site.

The results indicate that 90% of the participants had prior VR experience, while only one participant (10%) had never used VR before. This distribution allows the evaluation to consider both experienced VR users, who can better judge interaction quality and new users, who can provide insight on accessibility and ease of learning.

Section 2: System Functionality

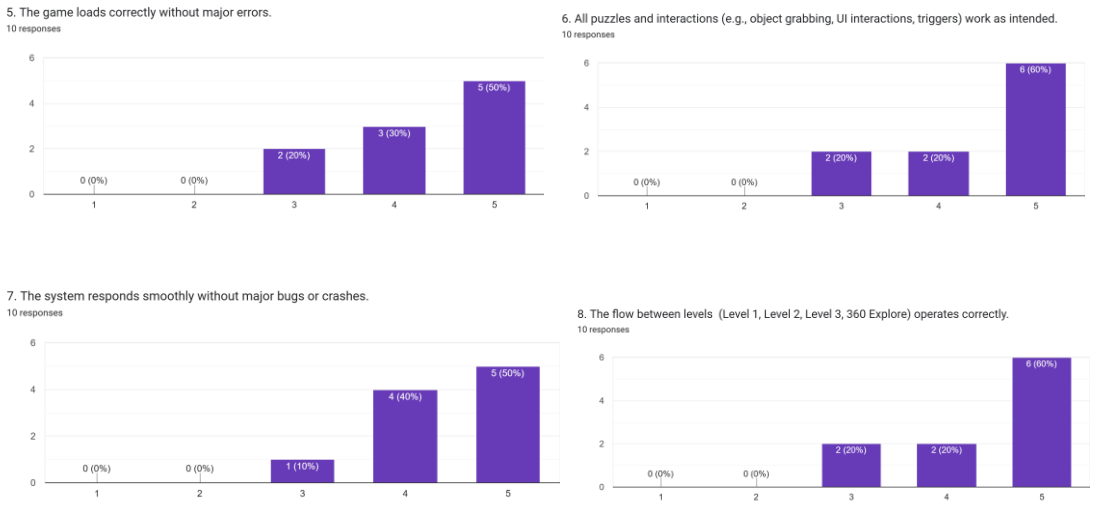


Figure 6.3.2 System Functionality

Based on the bar chart results, all participants rated the system functionality aspects with a score of 3 and above, indicating a generally positive response. This suggests that the game system, including puzzle mechanics, object interactions, and level transition flow, operates smoothly without major functional errors. The consistently moderate to high ratings reflect that the core features of the virtual escape room are stable and functioning as intended during the beta test.

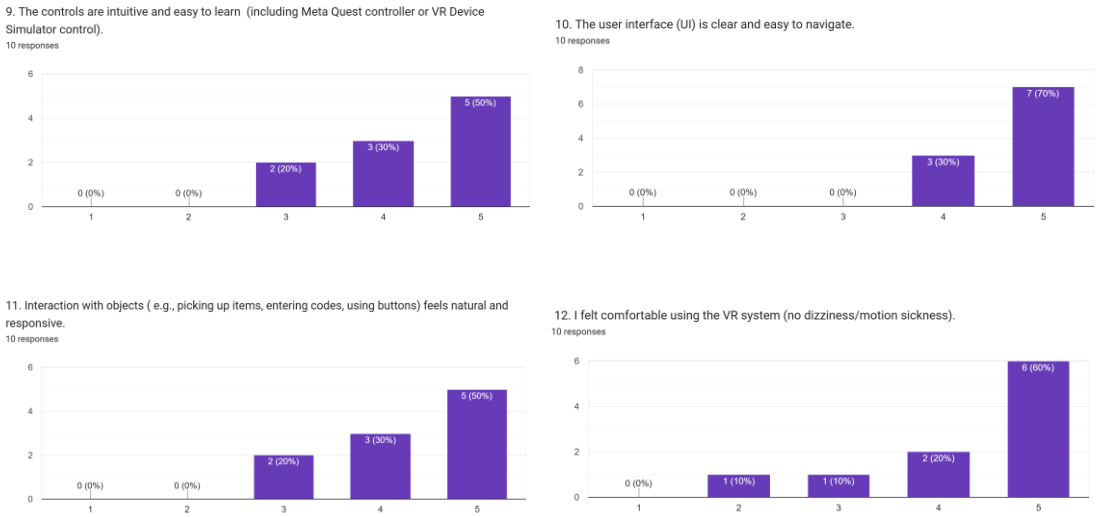


Figure 6.3.3 Usability & Interaction

For the usability and interaction evaluation, most participants rated 3 and above, indicating that the majority found the gameplay comfortable and easy to interact with. Participants generally agreed that the user interface (UI) is clear and intuitive, while the interaction with grabbable objects feels natural and responsive. These responses suggest that the VR escape room successfully provides an immersive and realistic interaction experience that aligns closely with real-world behaviour.

However, one participant, who had no prior VR experience, gave a rating of 2 for comfort when using the VR system. During a face-to-face discussion, the participant reported that the VR headset felt heavy, and the turning motion within the VR environment caused slight dizziness. This reaction is common among first-time VR users, particularly due to unfamiliarity with headset weight and VR locomotion.

Despite this being an isolated case, it highlights the importance of ensuring comfort for non-VR-experienced users, especially if the system is intended for public deployment. Additional usability refinement such as offering alternative movement modes, reducing motion sensitivity, or integrating comfort settings is recommended. Further testing focusing specifically on first-time VR users should be carried out before the gameplay is released for official use.

Section 4: Visuals & Environment Design

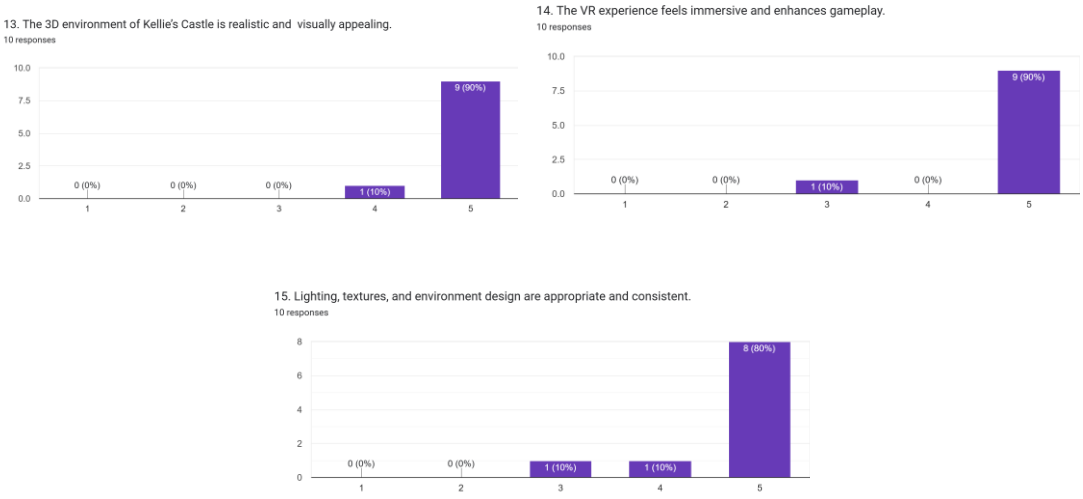


Figure 6.3.4 Visuals & Environment Design

In terms of visuals and environment design, most participants (90%) rated the section 4 and above, demonstrating strong positive feedback. These high ratings indicate that the 3D environment of Kellie's Castle, along with the level-specific game environments, is visually appealing and enhances user immersion. The realistic modelling, texture quality, lighting, and environmental details appear to effectively support the intended atmosphere of the virtual escape room.

Section 5: Educational Content

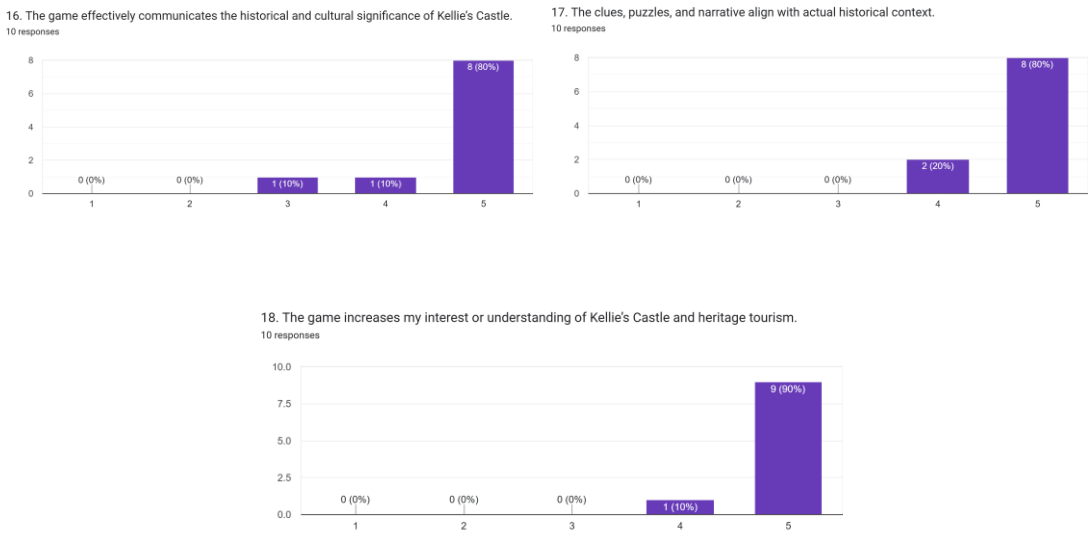


Figure 6.3.5 Educational Content

For the educational content section, the majority of participants rated this section 4 and above, showing that the application effectively communicates the historical and cultural significance of Kellie's Castle. This positive response demonstrates that the integration of educational elements within the game such as narrative clues, puzzle themes, and environmental storytelling successfully aligns with the project's objective of embedding meaningful educational context through gamification.

Notably, all participants expressed strong agreement that the gameplay enhanced their interest and understanding of Kellie's Castle and heritage tourism, with 90% rating this aspect as 5 and the remaining 10% rating it as 4. This finding reflects a strong achievement of the project's core objective which is to enhance visitor engagement by offering a virtual experience that combines exploration with interactive learning. The positive educational impact suggests that the VR escape room not only serves as an immersive entertainment medium but also functions effectively as a tool for promoting heritage appreciation and tourism interest among younger audiences.

Section 6: Gameplay & Engagement

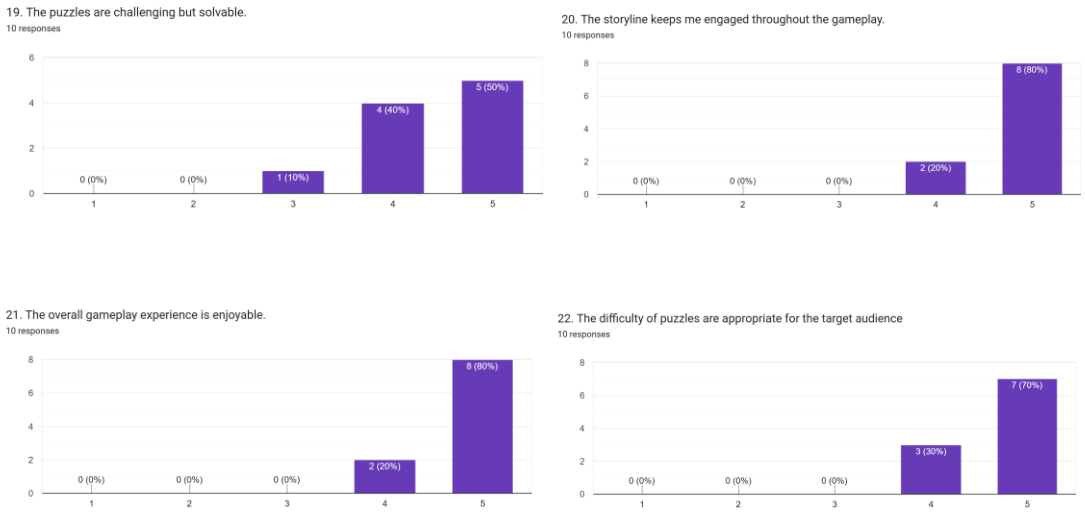


Figure 6.3.6 Gameplay & Engagement

For the gameplay and engagement section, most participants provided positive ratings, indicating that they found the overall gameplay experience enjoyable. Participants also agreed that the puzzle difficulty was appropriate and balanced, neither too easy nor too challenging. This feedback suggests that the puzzle mechanisms were well-designed and capable of maintaining user engagement throughout the experience.

The positive responses reflect that the gameplay structure, storyline progression, and interactive elements work cohesively to deliver an engaging virtual escape room experience. These findings confirm that the game successfully meets its objective of providing an enjoyable and immersive interactive environment that keeps players motivated to progress.

Section 7: Performance & Technical Quality

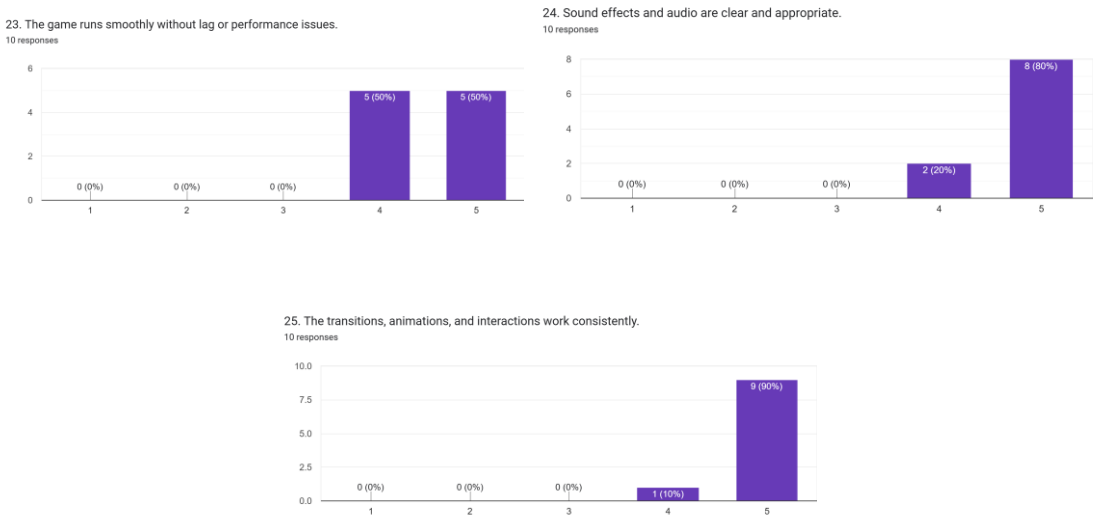


Figure 6.3.7 Performance & Technical Quality

For the performance and technical quality section, all participants rated the system 4 and above, demonstrating a strong level of satisfaction with the application's technical performance. The results indicate that the system operates smoothly without noticeable flaws, lag, or interruptions during gameplay.

Participants also confirmed that the audio cues, haptic responses, and visual feedback functioned as intended, contributing to a responsive and stable user experience. These findings suggest that the technical implementation meets the performance requirements of the target application and supports reliable interaction within the VR environment.

Section 8: UAT Acceptance

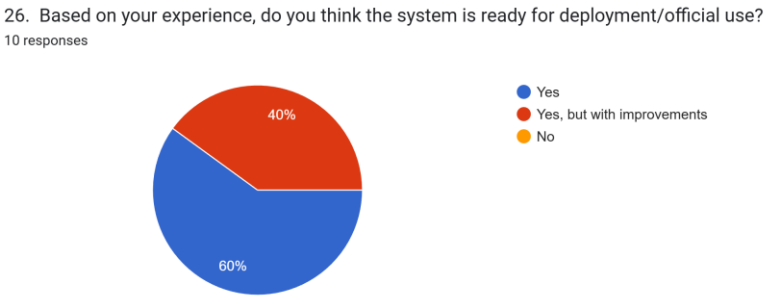


Figure 6.3.8 UAT Acceptance Towards Deployment

Based on the pie chart above, 60% of participants indicated that the system is ready for deployment, while the remaining 40% agreed that the system is deployable but would benefit from further improvements. This suggests that the application has achieved a functional and stable state, with only minor refinements required to further enhance user experience and usability before official release.

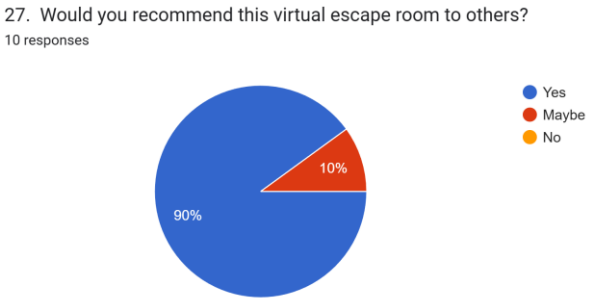


Figure 6.3.9 UAT Acceptance Towards Recommendation

Additionally, based on the feedback chart, 90% of the participants stated that they would recommend this virtual escape room to others. This reflects a high level of overall acceptance toward the application and demonstrates its potential to successfully attract and engage users, particularly in the context of promoting heritage tourism through virtual experiences.

Section 9: Additional Feedback

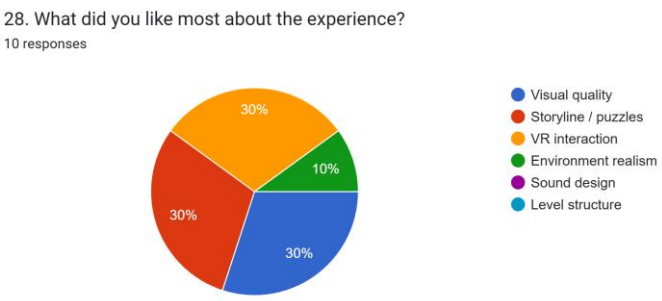


Figure 6.3.10 Additional Feedback Regarding Experience

Based on the feedback collected, there was no dominant preference regarding what participants liked most about the experience. Approximately 30% of participants highlighted the storyline and puzzles, 30% like the visual quality, and another 30% are attracted to the VR interactions. Only one participant specifically mentioned that the environmental design as the favourite aspect. This distribution suggests that the application delivers a balanced experience across narrative, visual, and interactive elements.

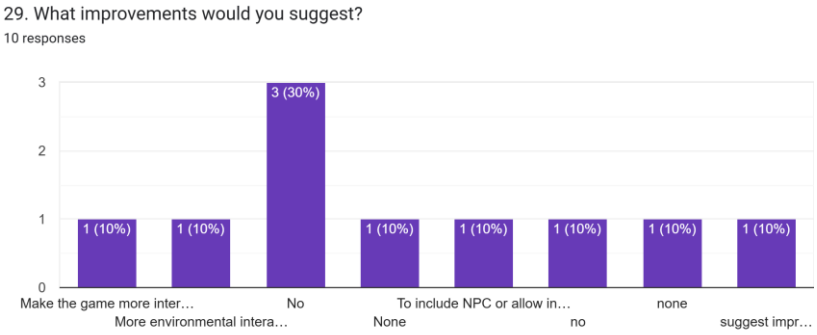


Figure 6.3.11 Additional Feedback Regarding Improvement

Regarding suggestions for improvement, 6 out of 10 participants reported no additional recommendations, indicating overall satisfaction with the system. The remaining participants suggested several potential enhancements, including:

- Making the gameplay more interesting with additional interactive elements

- Introducing NPCs or enabling multiplayer interaction
- Increasing environmental interaction
- Improving hand-tracking reliability and object-grabbing accuracy
- Enhancing visual clarity for interactable objects

All feedback will be carefully evaluated and implemented where necessary in future updates to ensure the continuous improvement of the application.

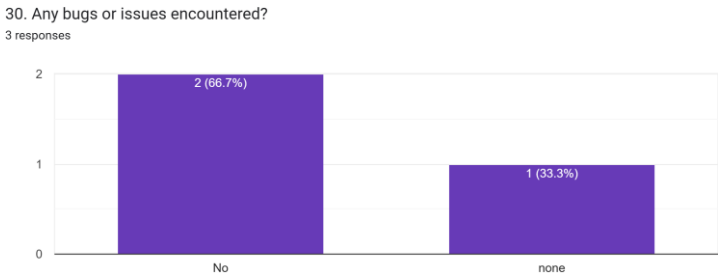


Figure 6.3.12 Additional Feedback Regarding Issues Encountered

According to the feedback illustrated in the diagram, none of the participants reported experiencing bugs or technical issues while playing the game. This indicates that the system demonstrates strong operational stability and that the core gameplay, interaction mechanics, and environment rendering function as intended. The absence of errors further validates the system's readiness for deployment, with only minor enhancements required to improve overall user experience.

Conclusion for UAT Survey

In conclusion, the UAT findings reveal strong user satisfaction across all evaluated dimensions. The system demonstrates solid usability, reliable functionality, and effective delivery of educational content. Furthermore, the results confirm that the project's key objectives which is enhancing visitor engagement, promoting heritage tourism through virtual accessibility, and integrating learning through gamification have been successfully fulfilled.

The feedback also verifies that the VR application meets user expectations for an educational and immersive virtual escape-room experience. Overall, the system performs effectively as a digital medium for promoting heritage learning through interactive gamified exploration and is suitable for deployment with minor refinements in future iterations.

6.4 Objective Evaluation

This project was developed with three key objectives. The following evaluation assesses whether each objective was successfully achieved based on user acceptance testing (UAT) results, system implementation outcomes, and observed user interactions.

Objective 1: To enhance visitor engagement by providing virtual accessibility

This objective was successfully achieved. User acceptance testing results indicate a strong positive response toward the gameplay and engagement aspects of the system. Specifically, 90% of participants rated the highest score when asked whether the application increased their interest and understanding of Kellie's Castle and heritage tourism, while the remaining participants provided positive ratings. These results demonstrate that the immersive VR environment effectively enhances visitor engagement and enables users to explore the heritage site regardless of physical location, fulfilling the objective of providing virtual accessibility.

Objective 2: To demonstrate the effectiveness of virtual reality as a tool for heritage tourism

This objective was achieved through the successful deployment and testing of the system on a standalone VR device, namely the Meta Quest 2. The application allows users to navigate and explore the virtual environment of Kellie's Castle in an immersive and interactive manner. Through realistic 3D modelling, interactive environments, and smooth VR navigation, the system demonstrates how virtual reality can be effectively utilised to present historical and cultural heritage sites in a tourism context. Performance and usability evaluations further support the feasibility of VR as a suitable technological tool for heritage tourism applications.

Objective 3: To integrate learning through gamification

This objective was successfully achieved by incorporating educational content into multiple gamified elements within the system. These include the collection of diary messages that convey historical information about Kellie's Castle, quiz-based assessments that evaluate users' understanding, a floor plan jigsaw puzzle, and information panels that provide additional contextual explanations. These gamified components encourage users to apply problem-solving and critical thinking skills while learning about the site's historical and cultural significance. User feedback indicates

that the learning process was both engaging and enjoyable, demonstrating the effectiveness of gamification in enhancing educational outcomes.

CHAPTER 7
Conclusion

7.1 Conclusion

In a nutshell, this project introduces a 3D VR Escape Room designed based on the architecture and history of Kellie's Castle. Due to the pandemic, restrictions on movement during lockdown periods significantly accelerated the development of virtual tourism, allowing people to "travel" and explore new places through digital technologies. However, the combination of virtual tourism and gamification remains underexplored. Thus, this project aims to bridge the gap by offering a hyper-realistic, interactive VR experience that educates users on historical sites like Kellie's Castle through engaging gameplay mechanics.

By integrating tools such as Blender for high-quality 3D modeling and Unity for VR environment and game development, the project immerses users in a rich, story-driven environment. Sound design further enhances the sense of realism and immersion, creating an engaging and educational experience, especially for younger audiences who might find traditional historical tours less appealing. This project serves as both an educational tool and demonstrates the effectiveness of VR in tourism, encouraging players to visit the actual location after experiencing it virtually.

7.2 Recommendation and Future Work

To further improve and extend the functionality of the project, several potential enhancements are proposed for future development:

Cross-Platform Compatibility

The application can be enhanced to support additional platforms such as iOS and web-based environments, enabling users to access the experience across a wider range of devices. Future versions may also include support for Windows desktop applications and testing across multiple VR devices, in addition to the Meta Quest 2 used during this project, to ensure broader compatibility and consistent performance.

Real-World Scaling

Future development may incorporate accurate real-world scaling by adjusting the 3D models to match the actual dimensions of Kellie's Castle. Implementing precise spatial measurements would enhance realism and improve users' perception of scale, which is essential for delivering an immersive and authentic VR experience.

Enhanced Visual Details

The visual quality of the environment can be further improved by incorporating higher-fidelity textures, architectural details, and decorative elements that closely reflect the heritage and historical features of Kellie's Castle. Additionally, modelling surrounding buildings and environmental settings would contribute to a more realistic virtual environment.

Multilingual Support

To accommodate a broader audience, future iterations of the system may include multilingual language options. Since the current application supports only English, adding support for multiple languages would improve accessibility for international tourists, students, and users from diverse linguistic backgrounds.

REFERENCES

[1] "Global Escape Room Market Analysis Report 2022-2023 & 2032: Social Media and Travel Blogging Propel the Popularity of Escape Rooms to a Multi-Billion Industry." Accessed: Aug. 09, 2024. [Online]. Available: https://www.prnewswire.com/news-releases/global-escape-room-market-analysis-report-2022-2023--2032-social-media-and-travel-blogging-propel-the-popularity-of-escape-rooms-to-a-multi-billion-industry-301957311.html

[2] R. and M. ltd, "Escape Room Market By Type, By End User: Global Opportunity Analysis and Industry Forecast, 2023-2032." Accessed: Aug. 09, 2024. [Online]. Available: https://www.researchandmarkets.com/reports/5879098/escape-room-market-type-end-user-global

[3] A. Stasiak, "'Escape rooms' and cultural tourism in Poland," 2022, pp. 200–217. doi: 10.4337/9781839100185.00027.

[4] A. jyotishaw, "Visitor Experience and Perceptions of Hyperreality at Cultural Attractions | Applied Marketing Research Group blog." Accessed: Aug. 31, 2024. [Online]. Available: https://blogs.uwe.ac.uk/applied-marketing/visitor-experience-and-perceptions-of-hyperreality-at-cultural-attractions/

[5] U. P. Barzey, "Exploring the World of Virtual Tourism: Advantages, Disadvantages, and Frequently Asked Questions," Moxee Marketing. Accessed: Aug. 31, 2024. [Online]. Available: https://www.moxeemarketing.com/exploring-the-world-of-virtual-tourism/

[6] "How Simulation Escape Rooms Can Make Learning Stick," Laerdal Medical. Accessed: Aug. 09, 2024. [Online]. Available: https://laerdal.com/my/information/how-simulation-escape-rooms-can-make-learning-stick/

[7] M. S. E. Samantha Willis, "Escape Rooms: An Alternative to Traditional Forms of Assessment," Aug. 2020, Accessed: Sept. 11, 2024. [Online]. Available: https://open.library.okstate.edu/learninginthedigitalage/chapter/escape-rooms_an-alternative-to-traditional-forms-of-assessment/

[8] R. Smiderle, S. J. Rigo, L. B. Marques, J. A. Peçanha de Miranda Coelho, and P. A. Jaques, "The impact of gamification on students' learning, engagement and

behavior based on their personality traits," *Smart Learn. Environ.*, vol. 7, no. 1, p. 3, Jan. 2020, doi: 10.1186/s40561-019-0098-x.

[9] A. Manzano-León *et al.*, "Between Level Up and Game Over: A Systematic Literature Review of Gamification in Education," *Sustainability*, vol. 13, no. 4, Art. no. 4, Jan. 2021, doi: 10.3390/su13042247.

[10] C.-Y. Tsai, H. Lin, and S.-C. Liu, "The effect of pedagogical GAME model on students' PISA scientific competencies," *J. Comput. Assist. Learn.*, vol. 36, no. 3, pp. 359–369, 2020, doi: 10.1111/jcal.12406.

[11] R. Duggins, "Innovation and Problem Solving Teaching Case: The Breakout Box – A Desktop Escape Room," *J. Organ. Psychol.*, vol. 19, no. 4, Art. no. 4, Sept. 2019, doi: 10.33423/jop.v19i4.2294.

[12] J. M. P. Piernas, M. C. P. Meroño, and M. del P. F. Asenjo, "Virtual Escape Rooms: a gamification tool to enhance motivation in distance education," *RIED-Rev. Iberoam. Educ. Distancia*, vol. 27, no. 1, 2024, Accessed: Sept. 04, 2024. [Online]. Available: https://www.redalyc.org/journal/3314/331475280019/html/

[13] "What is Virtual Reality? How it is Used and How it Will Evolve," WhatIs. Accessed: Sept. 04, 2024. [Online]. Available: https://www.techtarget.com/whatis/definition/virtual-reality

[14] S. S. Oyelere, N. Bouali, R. Kaliisa, G. Obaido, A. A. Yunusa, and E. R. Jimoh, "Exploring the trends of educational virtual reality games: a systematic review of empirical studies," *Smart Learn. Environ.*, vol. 7, no. 1, p. 31, Oct. 2020, doi: 10.1186/s40561-020-00142-7.

[15] E. A.-L. Lee and K. W. Wong, "Learning with desktop virtual reality: Low spatial ability learners are more positively affected," *Comput. Educ.*, vol. 79, pp. 49–58, Oct. 2014, doi: 10.1016/j.compedu.2014.07.010.

[16] "What is virtual reality gaming (VR gaming)? -- Definition from TechTarget," WhatIs. Accessed: Sept. 04, 2024. [Online]. Available: https://www.techtarget.com/whatis/definition/virtual-reality-gaming-VR-gaming

[17] "What is Cultural Tourism? - Basic Information - Division of Arts and Culture - Florida Department of State." Accessed: Sept. 04, 2024. [Online]. Available: https://dos.fl.gov/cultural/info-and-opportunities/resources-by-topic/cultural-tourism-toolkit/what-is-cultural-tourism-basic-information/

[18] “Virtual Tourism: The Complete Guide | Cvent Blog.” Accessed: Sept. 04, 2024. [Online]. Available: https://www.cvent.com/en/blog/hospitality/virtual-tourism

[19] “What Is Virtual Tourism And Is It The Future? - Tourism Teacher.” Accessed: Sept. 04, 2024. [Online]. Available: https://tourismteacher.com/virtual-tourism/

[20] Z.-Y. Yin, A.-M. Huang, and Z.-Y. Huang, “Virtual tourism attributes in cultural heritage: Benefits and values,” *Tour. Manag. Perspect.*, vol. 53, p. 101275, Sept. 2024, doi: 10.1016/j.tmp.2024.101275.

[21] J. Richardson, “Creating an Escape Room in a Heritage Site,” MuseumNext. Accessed: Sept. 04, 2024. [Online]. Available: https://www.museumnext.com/article/creating-an-escape-room-in-a-heritage-site/

[22] “The Room • Fireproof Studios,” Fireproof Studios. Accessed: Sept. 03, 2024. [Online]. Available: https://www.fireproofgames.com/games/the-room

[23] “What is Agile Methodology?,” GeeksforGeeks. Accessed: Sept. 03, 2024. [Online]. Available: https://www.geeksforgeeks.org/what-is-agile-methodology/

[24] “What is 6DOF : 6DOF Definition,” Unity. Accessed: Dec. 07, 2025. [Online]. Available: https://unity.com/glossary/6dof

[25] “Difference between Windows and macOS,” GeeksforGeeks. Accessed: Dec. 07, 2025. [Online]. Available: https://www.geeksforgeeks.org/operating-systems/difference-between-windows-and-macos/

[26] “Develop Unity apps for Meta Quest VR headsets.” Accessed: Dec. 07, 2025. [Online]. Available: https://developers.meta.com/horizon/documentation/unity/unity-development-overview/

[27] U. Technologies, “Unity - Scripting API: PlayerPrefs.” Accessed: Dec. 07, 2025. [Online]. Available: https://docs.unity3d.com/6000.3/Documentation/ScriptReference/PlayerPrefs.html

[28] E. Software, “Delving into Android Data Storage | SharedPreferences,” Medium. Accessed: Dec. 07, 2025. [Online]. Available: https://medium.com/@EazSoftware/delving-into-android-data-storage-sharedpreferences-e39de269f7ba

[29] U. Technologies, “Unity - Manual: ScriptableObject.” Accessed: Dec. 07, 2025. [Online]. Available: https://docs.unity3d.com/6000.2/Documentation/Manual/class-ScriptableObject.html

[30] “What is C# (C Sharp) Programming? A Beginner’s Guide.” Accessed: Dec. 07, 2025. [Online]. Available: https://www.pluralsight.com/resources/blog/software-development/everything-you-need-to-know-about-c-

[31] B. Foundation, “Features,” blender.org. Accessed: Apr. 21, 2025. [Online]. Available: https://www.blender.org/features/

[32] “OpenXR Plugin | OpenXR Plugin | 1.16.0.” Accessed: Dec. 07, 2025. [Online]. Available: https://docs.unity3d.com/Packages/com.unity.xr.openxr@1.16/manual/index.html

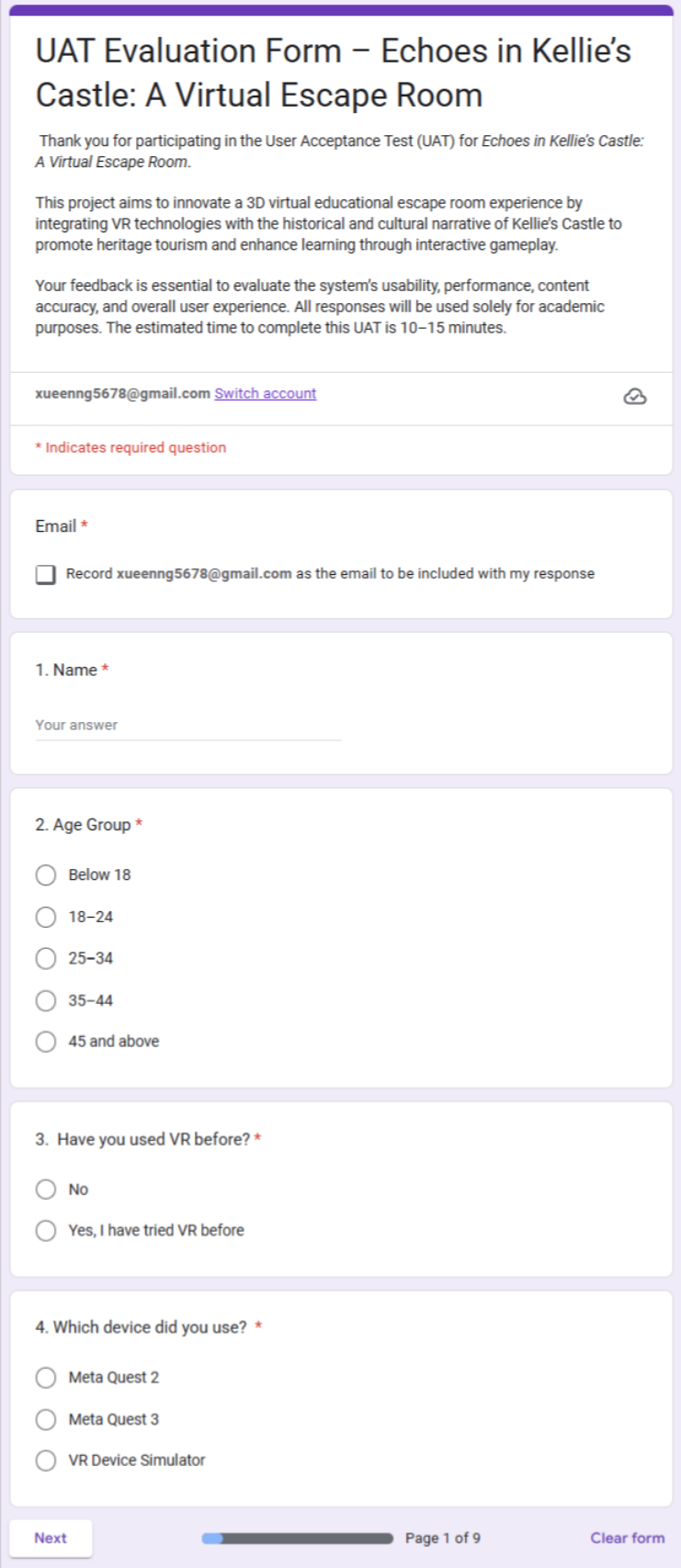
[33] “XR Interaction Toolkit | XR Interaction Toolkit | 3.0.9.” Accessed: Dec. 07, 2025. [Online]. Available: https://docs.unity3d.com/Packages/com.unity.xr.interaction.toolkit@3.0/manual/index.html

[34] U. Technologies, “Unity - Manual: Android environment setup.” Accessed: Dec. 07, 2025. [Online]. Available: https://docs.unity3d.com/6000.2/Documentation/Manual/android-sdksetup.html

[35] “Best practices for profiling game performance,” Unity. Accessed: Dec. 12, 2025. [Online]. Available: https://unity.com/how-to/best-practices-for-profiling-game-performance

[36] “Testing and performance analysis.” Accessed: Dec. 12, 2025. [Online]. Available: https://developers.meta.com/horizon/documentation/unity/unity-perf/

APPENDIX



UAT Evaluation Form – Echoes in Kellie's Castle: A Virtual Escape Room

Thank you for participating in the User Acceptance Test (UAT) for *Echoes in Kellie's Castle: A Virtual Escape Room*.

This project aims to innovate a 3D virtual educational escape room experience by integrating VR technologies with the historical and cultural narrative of Kellie's Castle to promote heritage tourism and enhance learning through interactive gameplay.

Your feedback is essential to evaluate the system's usability, performance, content accuracy, and overall user experience. All responses will be used solely for academic purposes. The estimated time to complete this UAT is 10–15 minutes.

xueenng5678@gmail.com Switch account

* Indicates required question

Email *

Record xueenng5678@gmail.com as the email to be included with my response

1. Name *

Your answer

2. Age Group *

- Below 18
- 18–24
- 25–34
- 35–44
- 45 and above

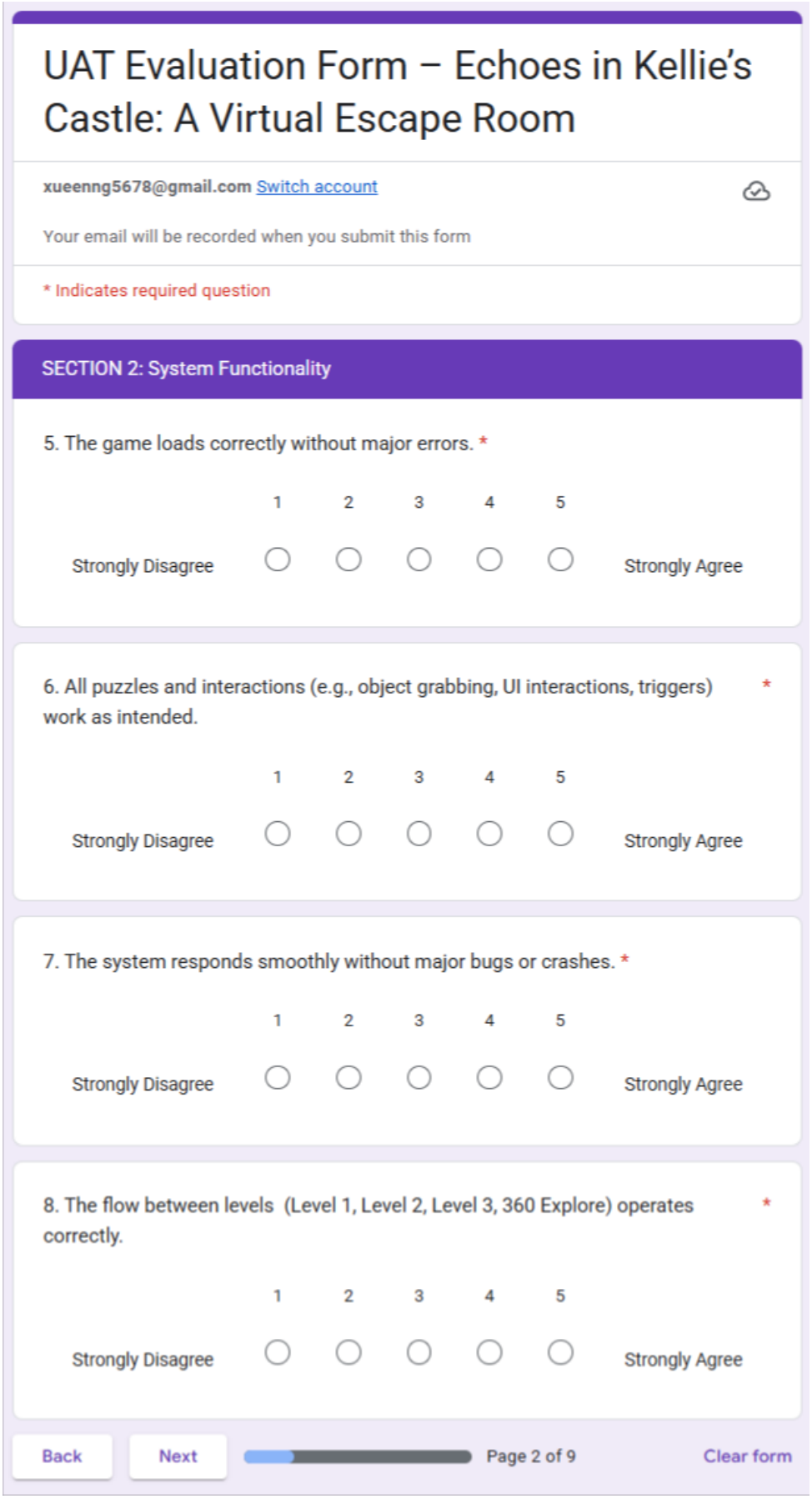
3. Have you used VR before? *

- No
- Yes, I have tried VR before

4. Which device did you use? *

- Meta Quest 2
- Meta Quest 3
- VR Device Simulator

Next Page 1 of 9 Clear form



UAT Evaluation Form – Echoes in Kellie's Castle: A Virtual Escape Room

xueenng5678@gmail.com Switch account

Your email will be recorded when you submit this form

* Indicates required question

SECTION 2: System Functionality

5. The game loads correctly without major errors. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

6. All puzzles and interactions (e.g., object grabbing, UI interactions, triggers) work as intended. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

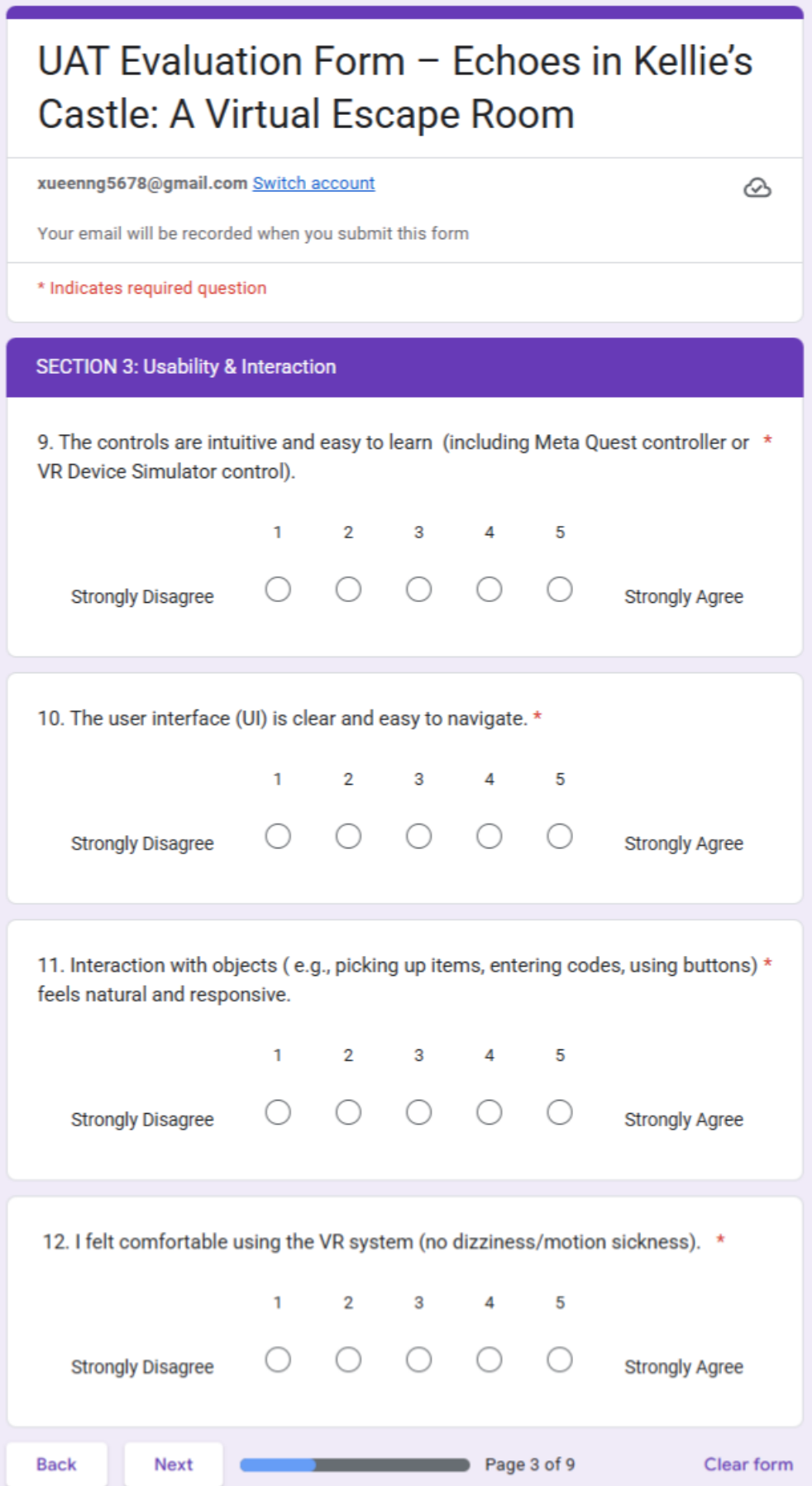
7. The system responds smoothly without major bugs or crashes. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

8. The flow between levels (Level 1, Level 2, Level 3, 360 Explore) operates correctly. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Back Next Page 2 of 9 Clear form



UAT Evaluation Form – Echoes in Kellie's Castle: A Virtual Escape Room

xueenng5678@gmail.com Switch account

Your email will be recorded when you submit this form

* Indicates required question

SECTION 3: Usability & Interaction

9. The controls are intuitive and easy to learn (including Meta Quest controller or VR Device Simulator control). *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

10. The user interface (UI) is clear and easy to navigate. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

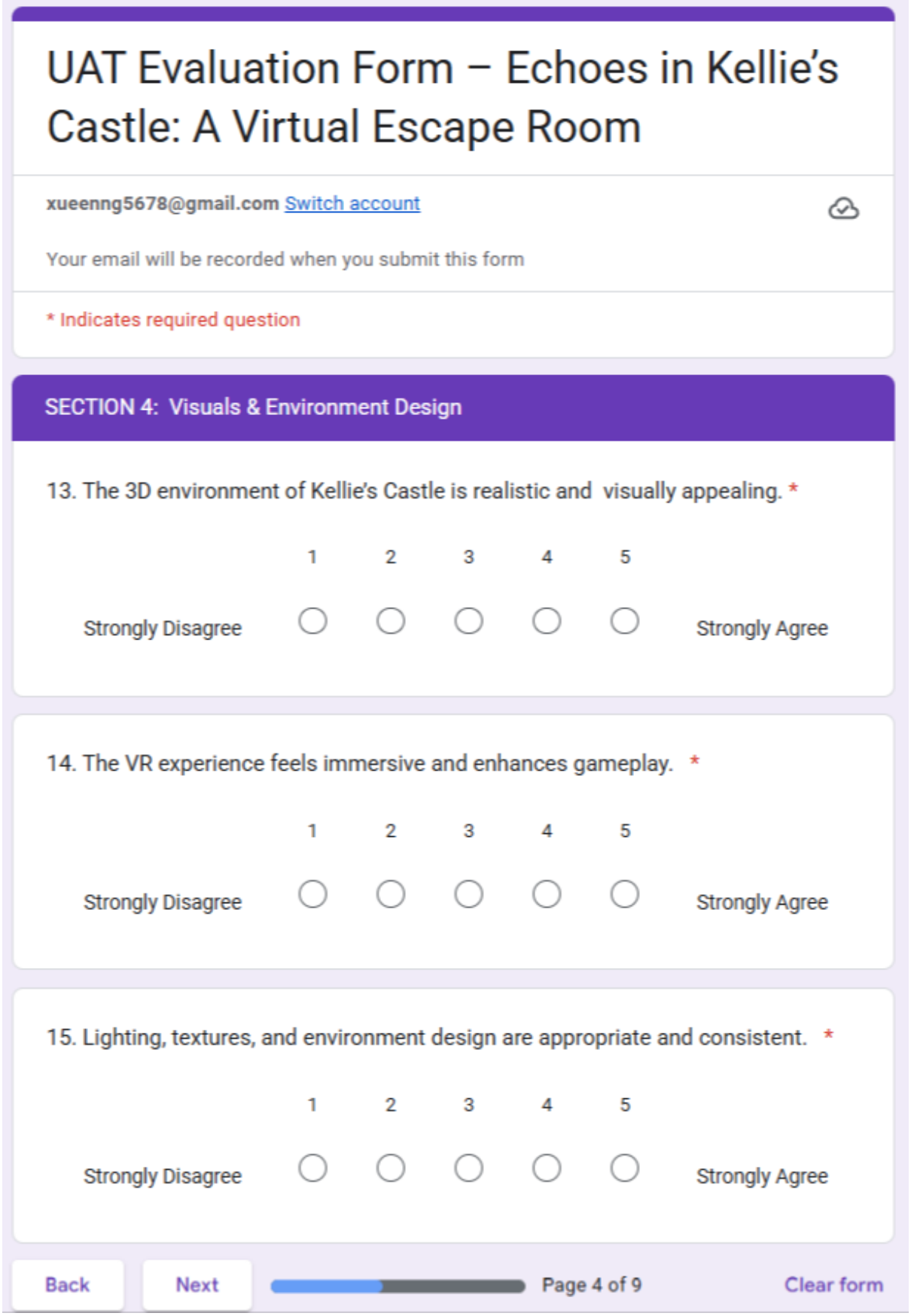
11. Interaction with objects (e.g., picking up items, entering codes, using buttons) * feels natural and responsive.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

12. I felt comfortable using the VR system (no dizziness/motion sickness). *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Back Next Page 3 of 9 Clear form



UAT Evaluation Form – Echoes in Kellie's Castle: A Virtual Escape Room

xueenng5678@gmail.com Switch account

Your email will be recorded when you submit this form

* Indicates required question

SECTION 4: Visuals & Environment Design

13. The 3D environment of Kellie's Castle is realistic and visually appealing. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

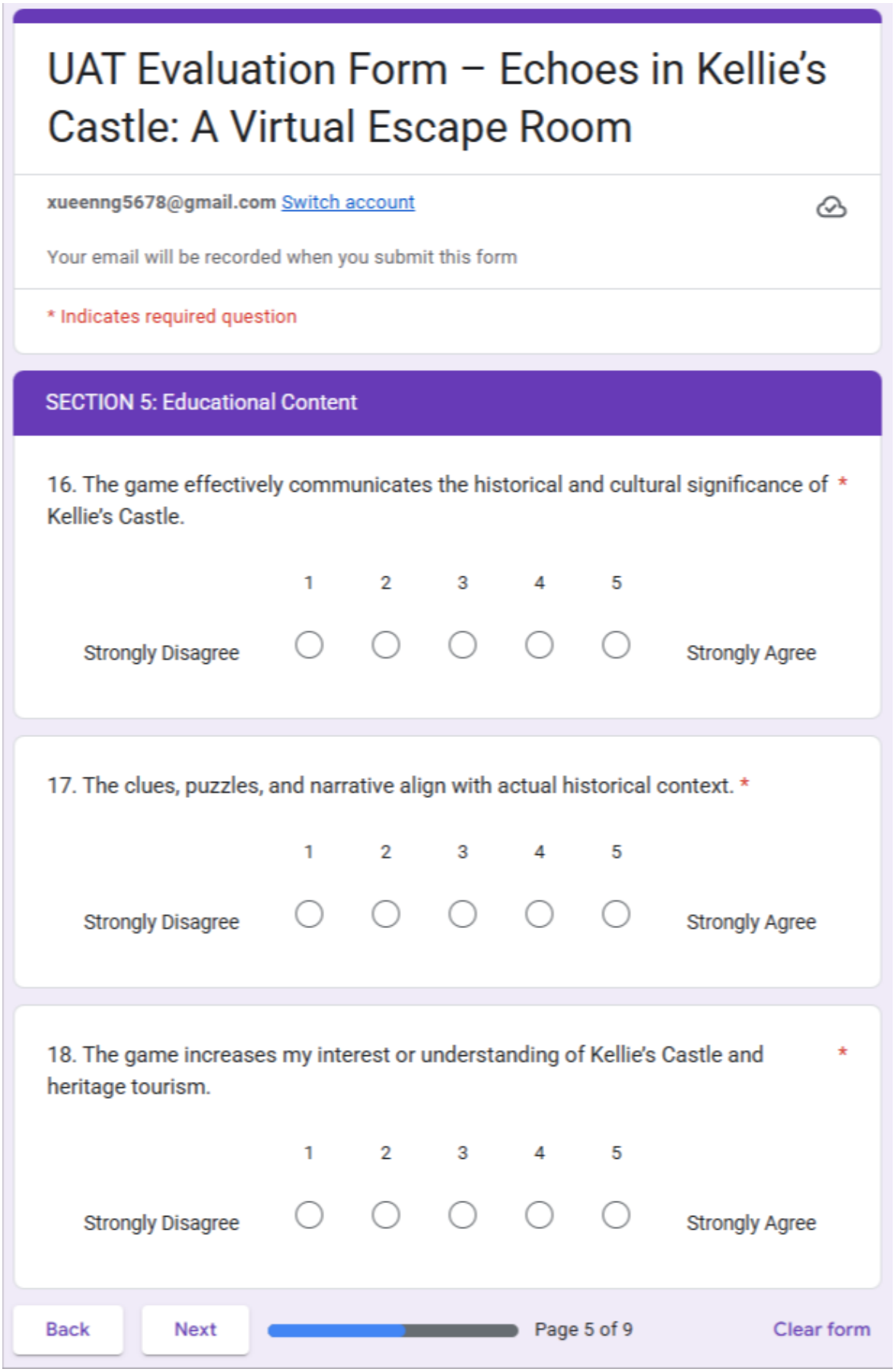
14. The VR experience feels immersive and enhances gameplay. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

15. Lighting, textures, and environment design are appropriate and consistent. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Back Next Page 4 of 9 Clear form



UAT Evaluation Form – Echoes in Kellie's Castle: A Virtual Escape Room

xueenng5678@gmail.com Switch account

Your email will be recorded when you submit this form

* Indicates required question

SECTION 5: Educational Content

16. The game effectively communicates the historical and cultural significance of Kellie's Castle. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

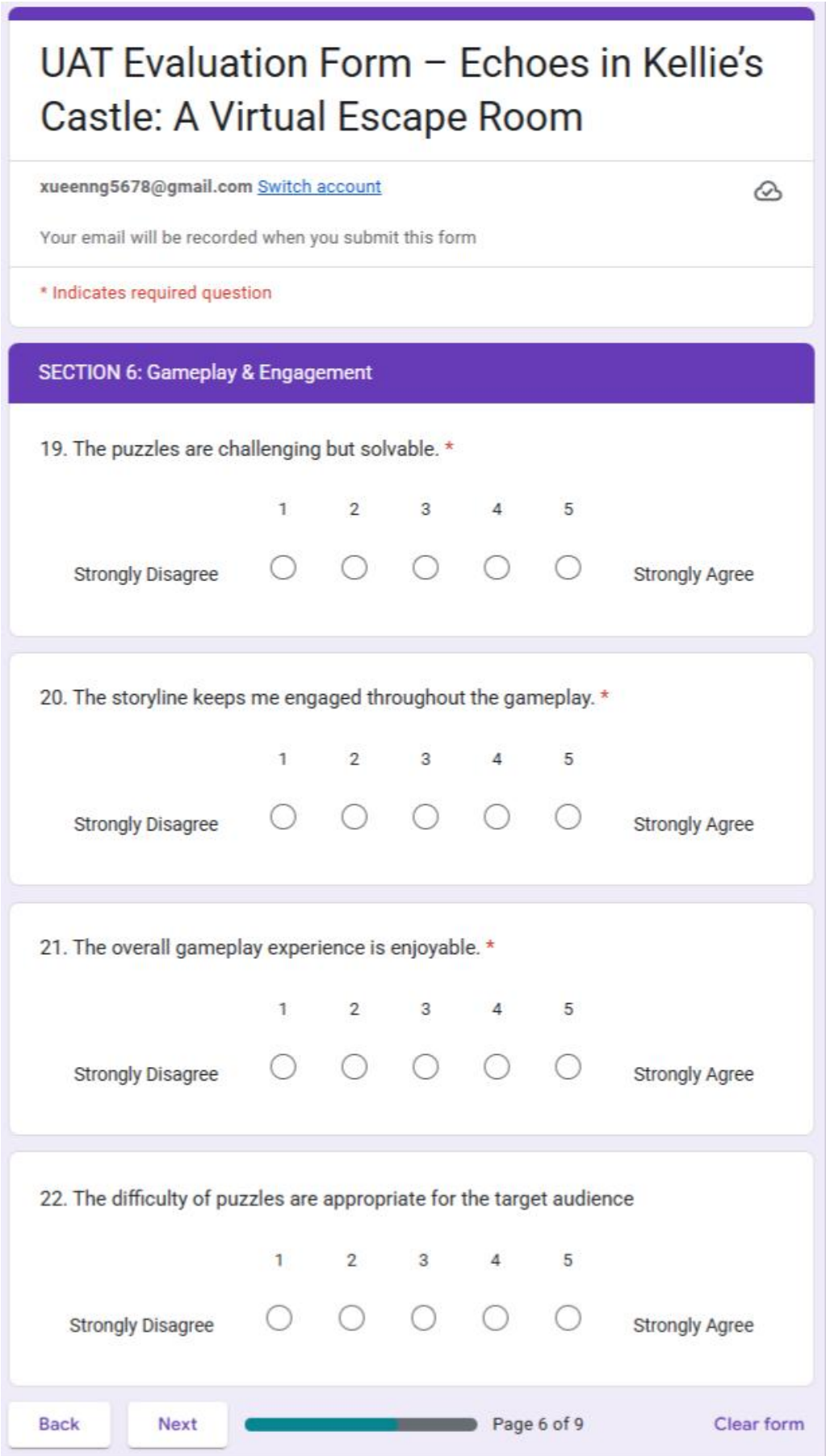
17. The clues, puzzles, and narrative align with actual historical context. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

18. The game increases my interest or understanding of Kellie's Castle and heritage tourism. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Back Next Page 5 of 9 Clear form



UAT Evaluation Form – Echoes in Kellie's Castle: A Virtual Escape Room

xueenng5678@gmail.com Switch account

Your email will be recorded when you submit this form

* Indicates required question

SECTION 6: Gameplay & Engagement

19. The puzzles are challenging but solvable. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

20. The storyline keeps me engaged throughout the gameplay. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

21. The overall gameplay experience is enjoyable. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

22. The difficulty of puzzles are appropriate for the target audience

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Back Next Page 6 of 9 Clear form

UAT Evaluation Form – Echoes in Kellie's Castle: A Virtual Escape Room

xueenng5678@gmail.com Switch account

Your email will be recorded when you submit this form

* Indicates required question

Section 7: Performance & Technical Quality

23. The game runs smoothly without lag or performance issues. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

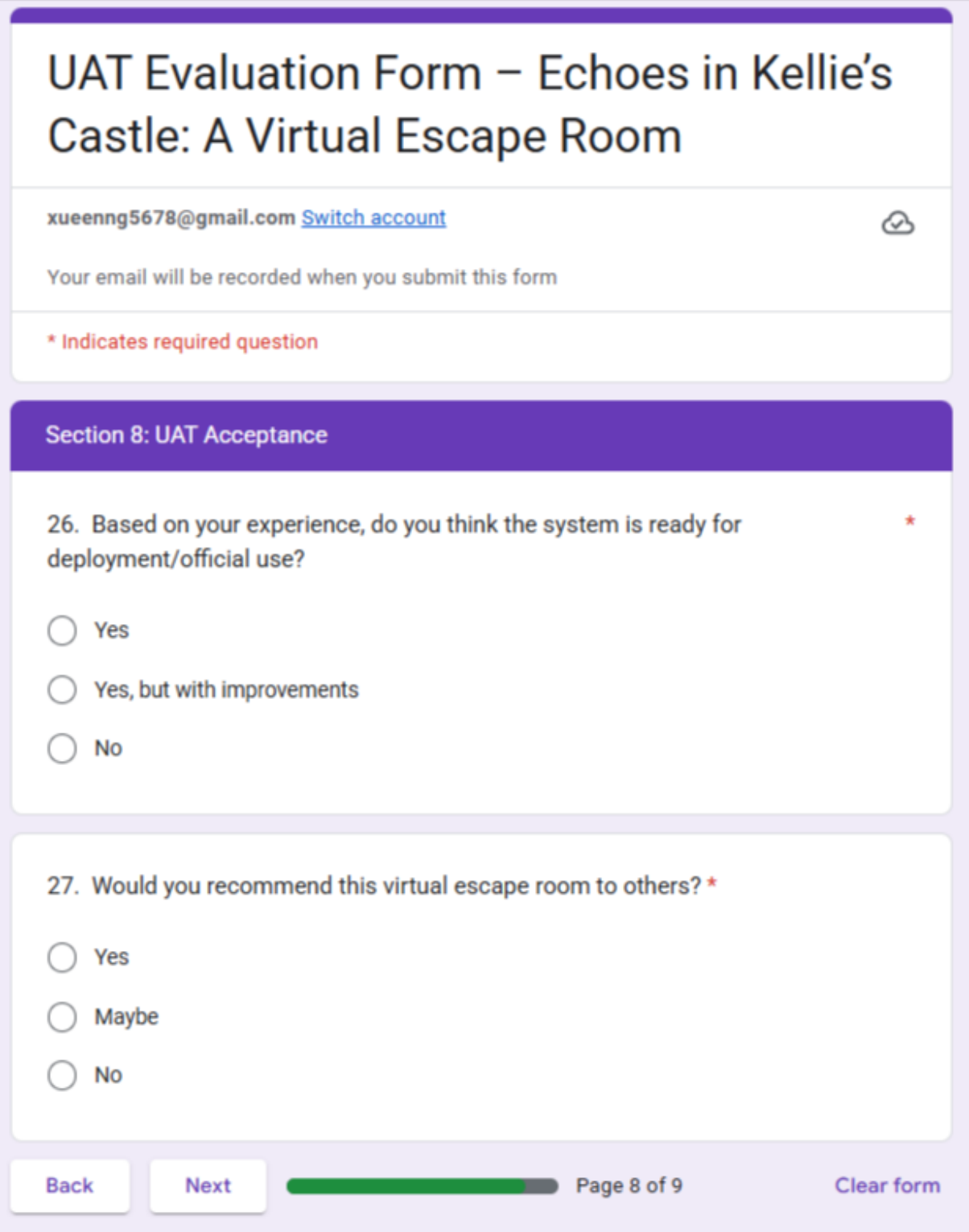
24. Sound effects and audio are clear and appropriate. *

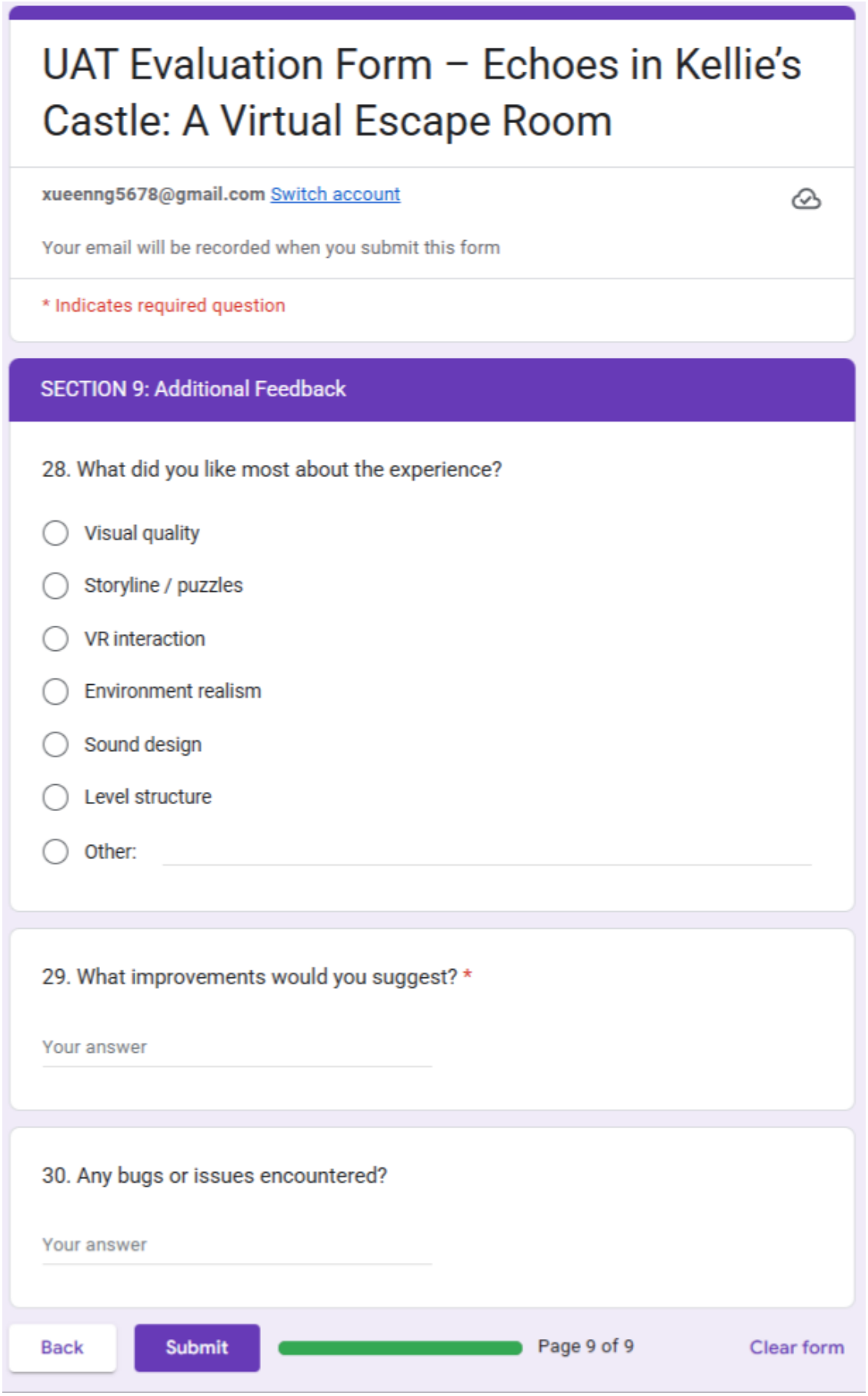
	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

25. The transitions, animations, and interactions work consistently. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Back Next Page 7 of 9 Clear form


UAT Evaluation Form – Echoes in Kellie's Castle: A Virtual Escape Room
xueenng5678@gmail.com Switch account
Your email will be recorded when you submit this form
* Indicates required question
Section 8: UAT Acceptance
26. Based on your experience, do you think the system is ready for deployment/official use? *
Yes
Yes, but with improvements
No
27. Would you recommend this virtual escape room to others? *
Yes
Maybe
No
Back
Next
Page 8 of 9
Clear form



UAT Evaluation Form – Echoes in Kellie's Castle: A Virtual Escape Room

xueenng5678@gmail.com Switch account

Your email will be recorded when you submit this form

* Indicates required question

SECTION 9: Additional Feedback

28. What did you like most about the experience?

- ◯ Visual quality
- ◯ Storyline / puzzles
- ◯ VR interaction
- ◯ Environment realism
- ◯ Sound design
- ◯ Level structure
- ◯ Other:

29. What improvements would you suggest? *

Your answer

30. Any bugs or issues encountered?

Your answer

Back Submit Page 9 of 9 Clear form

POSTER


ECHOES IN KELLIE'S CASTLE
A Virtual Escape Room
INTRODUCTION
This project aims to bridge the gap between tourism and escape rooms by creating a hyper-realistic, interactive VR escape room experience set at Malaysia's iconic heritage site — Kelli's Castle.
KEY FEATURES
Realistic 3D Environment
Historical Story Lines
Interactive Puzzles
METHODOLOGY
3D Modelling
VR Integration
Game Mechanics
RESULTS
[ECHOES IN KELLIE CASTLE]
A Virtual Escape Room
Main Menu
Time Left: 114s
Interactive Puzzle
OUTDOOR
BALCONY
MAIN MENU
VR360 Scene View
CONCLUSION
By blending cultural heritage with immersive VR and 3d technologies, this project redefines how tourism can be experienced.
NG XUE EN | SUPERVISOR: DR SAYED