UNIVERSITY OF HULL

Forest Hero Quest Virtual Reality Game

Final report

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by

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Abstract

This paper discusses virtual reality and its use to create a positive impact and provide research to fight dementia. We investigate the studies that are performed on users with Alzheimer's and how they react to the technology, also how they perform in comparison to those without the illness, finding that those with dementia have struggle with their navigation and spatial awareness which subsequently, affects their performance. We further investigate the results of the studies and provide evidence that virtual testing provides a valid assessment of navigational skills. The paper then goes on to present the development of this project 'Forest Hero Quest', a fun virtual reality game that immerses a user into a forest environment. The game is to use sense of direction to walk through the paths, collect items and return back to proceed onto the next level, with the aim to create a fun experience and also potentially contribute to dementia research.

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Contents

1 Introduction

What is virtual reality (VR)? A clue is in the name, a reality that is virtual. Of course, this could mean anything but generally, virtual reality aims to simulate a specific type of reality that can be used for pleasure or education. In technical terms virtual reality is the term used to describe a three-dimensional, computer generated environment which can be explored and interacted with by a person, a virtual world. That person becomes involved with this virtual world and is immersed within this environment. (Virtual Reality Society, 2000)

Headsets are used to immerse the user into the virtual world and create an illusion of that reality; this type of technology is becoming cheaper which means more people will be able to access and make use of this fantastic experience.

Virtual reality has many uses and there is a lot of study to suggest VR might be the next big thing for mental health. “New psychological research is trying to develop VR to diagnose and treat medical conditions from social anxiety to chronic pain to Alzheimer’s disease.” A number of these developments are still in testing, but some are already making their way into hospitals and therapists’ offices. (Scientific American Blog Network, 2019) Sea Hero Quest is an example of a virtual reality game which contributes research on dementia by accessing spatial awareness and memory; the equivalent of 230 years of similar lab-based research has already been generated.

The purpose of this project is to develop a virtual reality game that successfully immerses a user into a forest environment. In the forest the player will be tasked to collect items which will be located in different areas; The game is to use sense of direction to walk through the paths, collect the items and return back to proceed onto the next level.

This report will begin by outlining the aims and objectives of the project followed by a literature review which will highlight the work and studies that show virtual reality to aid in any known dementia research. The report will then examine the requirements of the software, explaining what features are required and why. Then the design of the software will be presented, detailing on the choices that were made and how each design helped towards the development. Following on from the design is the implementation section which describes how the software was created with explanation of the technical details and other features implemented. After that is the testing section which will describe the methods of testing, these methods consist of functional testing and user testing and showcases the results of these tests. The final part of the report will be the evaluation and conclusion, this will be time to reflect and review the project as whole to conclude if it was a success and the reasoning towards this.

1.1 Background to the project

'The first functioning computer-generated VR environment came in 1968, at the labs of computer scientist Ivan Sutherland. The device was dubbed the "Sword of Damocles" because it was too heavy to be supported by the human neck, instead hanging above the wearer from a mechanical arm.' (K. Thor Jensen, 2016). With other devices trying to break into virtual reality such as the Segascope 3-D, Jagur VR and the Virtual Boy, none really made an impact until the release of the oculus rift in 2012. The Oculus Rift really kickstarted the modern age of virtual reality gaming and after just a small number of prototypes were shown, Facebook acted quickly to buy the company for an enormous amount of $2 billion. Shortly after the release of the oculus the HTC Vive and Playstation Vr also made a stand in the virtual reality market and continue to make an impact today. The future of virtual reality is very exciting as the technology is becoming more advanced and the market is growing exponentially as devices are becoming cheaper and more widespread.

As well as making a huge impact in the gaming industry, virtual reality has also made its way into the medical field, educating staff and possibly even diagnosing/ treating patients with mental health issues or physical pain.

Inspired by Sea Hero Quest, the game in which players provide the research to help scientists understand how diseases like Alzheimer's affect the brain, this project will attempt to create a virtual reality experience to challenge the player to access important parts of their brain such as navigation and spatial memory whilst taking pleasure making their way through a fantasy forest.

1.1.1 Software and Programming Languages

Before implementing the project, a selection of software and programming languages were available to create on, each would require understanding and skill. Below is a table showing the selections and a breakdown of the developer's personal experience and resources available.

Software/Language	**Experience**	**Resources**
Unity	Some	Many
C#	Experienced	Many
VC++	None	Many
OpenGL/DirectX	None	Fewest

Conclusively, the decision to select which software to use was based around the developers experience and the availability of online resources. Selecting the software, the developer has more knowledge on seemed a lot wiser than choosing a new approach and possibly delaying the development due to lack of skill in the certain area.

To prepare for implementation, practise was executed prior to this to develop and grow skills that may help upon creation of the project. This provided very useful as obstacles were

hit and took time to get around, which when implementing saved a lot of time because the repeated obstacles were overcome quickly.

1.2 Aims and objectives

The project aims to develop a Virtual Reality (VR) game for forest quest.

The aim of this project is to create a 3D forest environment in which the player will be required use their navigation and spatial memory to collect items in different locations and return, to proceed to the next level. Other factors including story creation and data collection will also be considered.

Primary Objectives

Objective 1- Create 3D environments

The aim of this objective is to create a 3D forest environment. The forest should be covered with trees and other scenery. A path will direct the player to different areas of the forest and should maintain a sense of navigation that the player should always follow. The environment will be overshadowed by a dimmed moonlight to create the sense of a dark gloomy night. There will be several environments getting more complex and larger each time.

Objective 2-Create player movement

The aim of this objective is to allow the player to move freely within the game. Different variables will be analysed to set the speed of walking movement, so the user isn't moving too fast/slow. The camera will act as the players eyes as they are venturing through the forest.

Objective 3-Level Progression

The aim of this objective is to create level progression, this will be achieved when a condition is met, the player will then proceed to the next environment. Objects in the scene will be visible for the player to collect, when these objects are picked up the level will be complete and load the next one.

Secondary Objectives

Objective 4-Story Creation

The aim of this objective is to create a basic story for the player to follow and understand. This is to create an image around the game itself and to give a sense of purpose for the user to follow.

Objective 5-UI to collect data

The aim of this objective is to collect data from the player such as gender and age. This will be done by using simple UI buttons for the user to select. The data can be used to determine results if need be.

1.3 Research question

How is VR used to create a positive impact and provide research to fight dementia?

A recent study shows how VR can help even those with advanced dementia disease like Alzheimer's disease. The study showed that the VR helped the participants recall old memories by offering new stimuli that they could not otherwise due to illness. This suggested to researchers that VR has a positive impact. The study itself didn't specifically study memory but instead was interested in the participants enjoyment, it can allow them to experience a life they can no longer live (Fischer, 2019).

Another study showed that the patients reported the VR sessions were a positive experience for them and boosted their mood and engagement levels with the people around them. Caregivers also reported that the VR experiences deepened and improved their interactions with the participants, as the experiences from these sessions helped the caregivers gather information about the participants' lives before they entered into care. (Medicaltrick.com, 2019)

'The VR game Sea Hero Quest is being used to collect widespread data about human spatial navigation that will be used in the future to help detect dementia in earlier stages by cross-examining navigation data from healthy players and players with dementia to determine the subtle, early onset navigational troubles in people with dementia that are currently unknown.' (VRScout, 2017). So, by immersing a user into a virtual world, they are able to use the same senses they would in the real world, including navigation and spatial awareness which patients with dementia have struggle with in the early signs of the disease. By collecting this data, valuable research is provided to dementia research; Two minutes of active gameplay is said to be equalled to up to five hours of lab-based research.

From navigation and spatial awareness collection data to teleporting dementia patients to memories of old, VR is taking on a very significant role in the fight against dementia.

2 Literature review

2.1 Introduction

Many studies have shown the effectiveness of virtual reality and its impact on illnesses such as dementia. Although the literature covers a variety of studies, this review will focus on the research that is delivered as well as the impact virtual reality is making and the positive impacts which arise repeatedly throughout.

This review was conducted on three databases, Google Scholar, ScienceDirect and Scopus. The following keywords were used: “VR”, “Virtual Reality”, “Dementia”, “Alzeimer’s”, “Virtual”.

The first step when researching this topic was to find studies that proved virtual reality as a beneficial source of assessing people, to find indications of early stages of dementia and Alzheimer’s. The information gathered supports this and shows that the participants with the illness had much worse results as opposed to other participants, which established to the developer that virtual reality is an effective tool in their findings.

2.2 Discussion

In relation to this project, it was crucial to research studies that helped to gain an insight of what defects are considered to be most important to look out for when detecting early signs of dementia/Alzheimer’s so that the game could be designed to test and challenge the user. It was also important to determine the factors which affect a user’s performance, which would show when person is likely to underperform.

(Serino Silvia, Morganti Francesca, Di Stefano Fabio, Riva Giuseppe 2015) Examined a study using a virtual reality (VR)-based procedure for assessing the abilities in encoding, storing and syncing different spatial representations on three groups of participants. The first group suffered from amnestic mild cognitive impairment, the second were patients with Alzheimer’s disease (AD) and lastly a control group (CD). The first task, the participants were asked to indicate on a real map the position of an object they had memorized, in the second task they were asked to locate and retrieve this object from the same but empty virtual room, whilst starting from a different position. The authors found that the AD patients performed considerably more poorly when compared to the CG in the second task, this provided indication that the people with AD struggled with allocentric spatial processing. Allocentric spatial processing is when a person encodes information about the location of an object based off another object. They concluded that this virtual reality experiment provided an insight on the cognitive impairment of the AD patients and the potential VR would offer to detect the early stages of AD. This suggests that virtual reality is an effective and accurate tool to utilise for detecting trends in behaviour and that allocentric spatial processing is a factor that AD patients struggle with.

(Kessels, van Doormaal and Janzen, 2011) Found that “Previous fMRI research in healthy adults showed higher medial-temporal lobe (MTL) activation for objects placed at decision points compared to non-decision points, even at an implicit level”. A study included 21 AD (Alzheimer’s Disease) patients and 20 people without the illness but age and education matched to participate in. The instruction given to the participants was to pay attention to the toys(objects). The results showed a better performance for the objects that were placed at decision points, for example at a corner or a left turn/right turn, than non-decision points, the study also revealed that AD patients have implicit memory for object information that is relevant for navigation. This could suggest that by placing objects at a decision point, it is beneficial for memory; This method could also be implemented into the development of this project, by placing a specific object at a decision point could help provide navigation or it could also be a way of signifying a defect in the participants navigation and memory which is an indication of an early stage.

A study on spatial navigation in preclinical Alzheimer’s disease by (Allison et al., 2016) examined performances on tasks of wayfinding and route learning in a virtual reality environment. Comparisons were made across the following three groups: Clinically normal without preclinical AD (Alzheimer’s Disease), clinically normal with preclinical AD, and early-stage symptomatic AD groups. Preclinical AD was associated with deficits in the use of a wayfinding strategy, but not a route learning strategy. Results confirmed early-stage symptomatic AD-related deficits in the use of both wayfinding and route learning strategies. The results of this study suggest that aspects of spatial navigation may be one of the most important factors at detecting the earliest deficits of Alzheimer’s Disease.

(Zakzanis, K.K., Quintin, G., Graham, S.J., Mraz, R. Age, 2009) Analysed a study that examined the age- and Alzheimer’s disease- related differences in route learning and memory whilst using virtual reality. Participants were shown a path within a city and then had to navigate it as quick and accurate as possible. The study found that young adults were much quicker consistently than the older participants and the patients with Alzheimer’s disease made more mistakes. This study suggests that spatial navigation is affected due to the both aging and Alzheimer’s Disease, for this project it is important to consider the age range of players and will try to implement as many features as possible to increase the usability of the software.

Based off these studies, it is clear to see that elderly people are to take into consideration when developing a virtual reality game, this signifies to the developer that usability is a major factor when implementing a game designed for a variety of ages. (Shamsuddin, S.W., Lesk, V. and Ugail, H., 2011) state in their research that the design of a virtual environment needs to be considered because the effectiveness of the technology relies on the ability of the end user to use it. There are several guidelines highlighted in the research, these include programming boundaries to prevent elderly people from navigating beyond the route given. The simplicity of a virtual environment is also essential when spatial memory for navigation is used. The font sizes in the display should be clear and large enough so that people with visual decline are able to detect and read. To conclude their research, they have stated that

creating an interface to support a high level of usability is essential in the development of a virtual environment for the elderly and had also proved feasible in their findings.

(Manera et al., 2016) Presented a study testing the feasibility of using highly realistic image-based rendered VR with patients with MCI and dementia. They had designed a task to train selective and sustained attention, the task included the use of VR versus a paper version of the same image. The results show that the participants with MCI and dementia reported to be greatly satisfied and interested, also reporting high feelings of security, comfort, low anxiety and fatigue. Additionally, the participants reported that they had preferred the VR task compared to the paper version, even when the task was more difficult. This study suggests that virtual reality can be considered as a tool to improve adherence to cognitive training. The results also suggest that interest is high and maintained longer whilst making use of the virtual reality technology, which is motivating for many people developing the technology even further, to help those in need and to provide a better experience altogether.

Some people may wonder if virtual reality is as effective as the real world and can deliver the same accuracy of results which is a valid argument, in a study (Cushman, Stein and Duffy, 2008) compared a previously described real-world navigation test with a virtual reality (VR) version simulating the same navigational environment, to compare the findings and gain an insight of just how effective VR is in comparison to real world. They had found close correlations between the real-world and virtual navigation which suggested in their conclusion that virtual environment testing provides a valid assessment of navigational skills.

The game Sea Hero Quest provides further evidence that virtual reality is an effective tool for dementia research. Partnered with Alzheimer's Research UK, this game is designed to collect data for navigational abilities from a large audience of people all around the world. Playing the game for a few minutes provides to help improve understanding of navigational cognition, from playing the game, it has generated over 12k years' worth of dementia research data which is incredible. (Dawood, 2019) mentions, whilst the game has been misinterpreted and labelled as a test for Alzheimer's, the creator says the aim was not to test and diagnose individuals but to gather a huge amount of research that can be analysed to show trends and patterns in the behaviour of the players to help doctors diagnose patients earlier in the future. Based on the collected data, first findings proved that spatial navigation abilities begin to decline from the age 19+ and that there are differences in the navigational strategies between men and women, with men performing better (AG, n.d.). With over 4.3 Million people downloading the game and playing, providing over 117 years of research it is outstandingly clear to suggest that virtual reality is a powerful and efficient tool for dementia research.

2.3 Evaluation

This research has provided the developer with increased knowledge around the subject of virtual reality and the way it used with illnesses such as dementia. Prior to research it was crucial to research studies that helped to gain an insight of what defects are considered to be most important to look out for when detecting early signs of dementia/Alzheimer's, two of the biggest factors to consider are spatial awareness and navigation as these are the most common indicators to detect early signs of dementia and Alzheimer's.

It was also important to determine the factors which affect a user's performance, which would show when person is likely to underperform. The findings in the studies suggest that performance starts to decline from the age of 19 and above and male participants performed better than women, this indicates to the developer that these two factors are important to find out about the player which could be used for potential research based on the performance of each user.

The study which presented VR to be of more interest to those participants with MCI and dementia was a surprising find, previous to research it was thought that those who are of old age would dislike the idea of VR and find it uncomfortable to use, but the research suggested that they had preferred the virtual reality method as opposed to looking at an image on paper. With this consideration, the development of the game must include increased usability as opposed to what was originally planned, this is to provide a better experience for the older generation and/or people with visual decline.

The main focus of this research was to gain an insight of the effectiveness virtual reality has to offer in terms of research the technology can provide and also the factors that indicate early stages of dementia, so that the developer has this in mind whilst implementing the different level of difficulties that will test and analyse the players performance at the same time as delivering a pleasurable experience for both young and old.

3 Requirements

In order to gather requirements, research on 'Sea Hero Quest' was completed, to gain an insight of the game and how the developer can use similar techniques to implement into this project, listed below were the main focuses of research:

- How the game is played/Game mechanics
- What experience does the player get whilst playing
- The methods of collecting data
- Level difficulty

After just a few short hours of playthrough, the research gathered was enough to create a list of requirements for this project 'Forest Hero Quest'. Below is a table with the requirements and the importance of each presented in a MoSCoW method of prioritisation.

Must Have	Should Have	Could Have
Set in a Forest Virtual Environment	Level Progression/ Difficulty increases	Data collection
Player Movement to be smooth, slow and steady	User Friendly/Increased Usability	Track movement in game

Below is the list of requirements and an explanation as to what each mean:

- Set in a Forest Virtual Environment

Inspired by 'Sea Hero Quest' this project will be similar but not the same. For this game to stand out, the setting of the virtual environment must take place in a forest. The player will be immersed into a magical forest with trees, rocks and glowing mushrooms in the aim that the user will not get threatened by the typical forest in the real world which is dark and gloomy.

- Player Movement to be slow and steady

To suit the needs of both young and old, the player movement must be consistent in speed. Virtual reality can be uncomfortable for some and to prevent this, the movement of the game will be slow and steady so that the player can feel comfortable throughout.

- Level Progression/ Difficulty increases

To keep the game entertaining and challenging, each level will increase in difficulty to test the players spatial awareness and navigation.

- User Friendly/Increased Usability

The game will be user friendly and will aim to have increased usability, meaning that any text shown will be increased in size to help people with visual decline and will not have any UI that will confuse any person playing.

- Data collection

As the game is played the player will be prompted with questions to answer, their age and gender. This data can be stored in a text file or database for future use if capable. Also a timer will be hidden from the player, this will keep a track of how long it has taken them to complete each level.

- Track movement in game

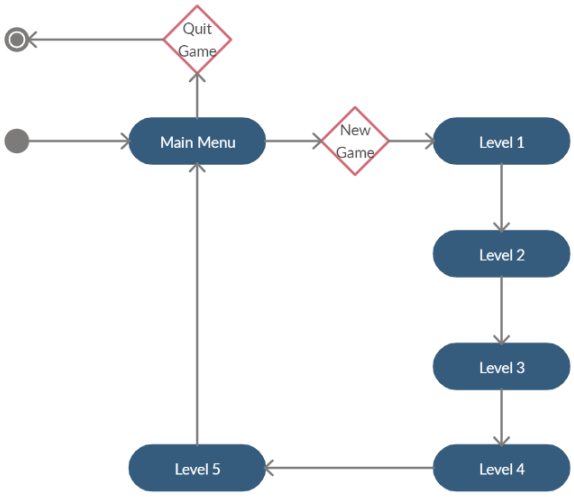
Increased analytics could be placed into the development so that more data can be collected from the player, such as tracking their movement in the game. This will get a real insight of the players behaviour and awareness.

3.1 Product requirements

- Purpose of the product

The purpose of the product is to create an experience a user will enjoy, whilst providing a basis for conducting medical research. The game should be a pleasurable experience for all ages and should also be usable for everybody. The game will feature levels, each level will increase in difficulty and in order for the player to proceed to the next level a task must be completed. The task presented to the player will require them to collect certain objects and return to the start, which will test the user's spatial awareness and navigational skills.

- Product flow



The UML activity diagram to the right illustrates the flow of activities throughout the game which defines the playthrough of the product.

By observing this diagram there is a clear understanding that the software will flow smoothly level by level and return to the main menu when the game has been completed. The player then has the same choice as they did at the beginning to start over.

- Who will use the product?

The audience for the game is for everybody of all ages, whether that be young children who want to explore a magical fantasy forest or a middle aged women that has been persuaded by her son to see if she can navigate through the forest at a faster rate, the game will aim to suit all. For this aim to be attained, usability requirements are to be defined.

- Usability Requirements

Usability requirements are requirements of the project that will improve the ease of use. User friendliness is an important type of requirement that will be involved in the development of this project, this can be done by making text in the scenes bigger for people to read clearly and including less buttons to create a smooth free flowing experience. Learnability is also a factor considered, by keeping the functions in the game as simple as possible this can increase the likelihood in which people learn to use the product.

3.2 Functional requirements

3.2.1 Functional Capabilities

The functional capabilities will describe the behaviour of the way the game is played. The player controller will be the main function which will allow the user to perform actions such as moving and selecting buttons using a laser pointer. Because of the nature of this software, there is not many functions that will be implemented in the development.

3.2.2 Security/Privacy

Within the game, data will be collected from the user at their own accord, the information gathered specifies the users age and gender so the player will always remain completely anonymous as their name is never required.

3.2.3 Performance requirements

To play the game in VR, the recommended requirements are listed below:

Oculus Rift S Recommended VR Specifications (Lang, 2019):

Video Card: NVIDIA GTX 1060 / AMD Radeon RX 480 or greater

CPU: Intel i5-4590 / AMD Ryzen 5 1500X or greater

Memory: 8GB RAM or greater

Video Output: DisplayPort

USB Ports: 1x USB 3.0 port

OS: Windows 10

The list above is taken from the website https://www.roadtovr.com/how-to-tell-pc-virtual-reality-vr-oculus-rift-htc-vive-steam-vr-compatibility-tool/ and is referenced above the list.

Take note, that is only the requirements for VR use, the game has also been developed to be playable without the use of VR.

3.3 Design constraints

To conduct this project the developer will require time and resources, which are all to be considered to develop a virtual reality game. Both factors play a huge part in the development and make such an impact if any are missing.

Time Constraint- Time is one of the most important considerations when taking on a project and it is crucial to estimate the time as accurately as possible so that plans can be made ahead to create a schedule of work to perform and deliver. The time this project must deliver is roughly seven months, which is a very large amount of time but with other work the developer has aside of this is quite compact in the broad view and must divide time and effort. With this in mind, the developer has a plan of realistic scheduled work to stick by, to ensure the project is complete.

Technical constraints- Technology is very important when developing on software and limitations of this can have a big impact on a project like this one. Access to a VR headset had been revoked due to the recent COVID 19 outbreak as the university has been shut down till further notice which would mean the development would have to be continued without the use of VR, this has had a very big impact on the development of the project as certain obstacles were hit and took time to overcome. The project will be altered to suit the needs of both using VR and without.

Software Requirements- The software requirements are listed as C# and Unity, OpenGL/Direct x, which may seem to be a constraint because the developer is limited on the programming language to be able to create the project. For instance, if the developer were skilled in another language such as Java then they would be restricted to use this.

4 Design

4.1 Project management

Identifying all the objectives (Chapter 1.2) helped to breakdown all the tasks including the research, implementation and testing. A full breakdown of tasks can be found in Appendix A. Once all tasks have been identified they can help to provide an estimated duration of the development which can be presented into a time plan as presented in Appendix C. The aim of the time plan is for the development to get the majority of tasks completed in the first half of the duration, the second half of development is then reserved for secondary objectives, testing and the final report. This way of time management allows primary objectives to be completed before developments starts on the secondary objectives so that if development of the project falls behind schedule, secondary objectives can be left out.

This project involves virtual reality which involves its own risks of use, for this reason it is important to conduct a risk assessment to identify the risks involved with this project and the counter measures to reduce the risk. This can be found in Appendix B.

4.2 Software Design

4.2.1 3D world design

The graphical representation of the 3D virtual environment will be detailed to create a realistic approach. The setting of the world will be in a forest environment, several environments will be created, each will vary in size and layout but will follow the same design. The design is set out to surround the player with trees to create a sense of closure and the path will always be the guide to follow for navigation through the towering trees, there is also several objects in each scene that will appear throughout.

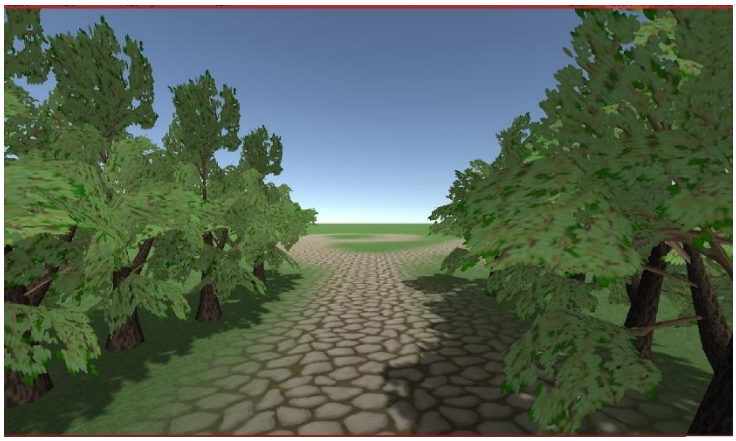


Figure 1 World Design

Before development began a quick draft of design was created to build a basis for implementation (see figure 1). This was to create a rough design to follow and provided the developer with a foundation to build on.

4.2.2 Player Movement

There is a lot of factors that was considered when designing the players movement in the game. Because of the immersive experience in virtual reality it is important for the movement to be smooth and steady for the user to have the best experience they can. For example, if the movement were not consistent in speed, this could cause motion sickness.

Before development begun, the design and aim for the movement functionality was to create a teleporting type of locomotion in which the player would point and aim where they wanted to teleport to and the screen would either turn black or blink for a second as the player was transported to that desired location.

However, after testing this method of movement it was found that teleporting caused the user to feel a little dizzy and disorientated after the action was made, which was a very negative response to the functionality and had to be altered to prevent any discomfort from happening.

The secondary option for player movement was to create a simple walking movement that would move slowly through the environment.

4.2.3 Level Design

In each of the levels in the game, the layout of the scene is different. This was done by creating a new layer of terrain that was then developed in the implementation. The layout of each scene is represented by the path flowing through the forest in which each scene has a different route to take. At first, the layout of the level is simple providing only one path to follow, as the player continues through the levels, the difficulty aims to get harder and provides the player with several routes to take which will test their navigational skills.

A rough design of the layout of the level (figure 2) was created to provide an insight of the way the path will be used as a guide for the scenes level design.

Figure 2 Level Design

4.2.4 UI Design

The UI elements were designed to be implemented in the world space. Other methods were tried and tested including buttons on the screen overlay and seemed to take the immersive experience away from the environment. The user interface elements include text which will be shown to the user to guide them on their journey and functionality will be implemented to allow the user to select their age and gender.

(Figure 3) shows the UI in world space. World space meaning that the elements are positioned in the world environment instead of positioned on the screen.

Figure 3 World Design

One of the key aspects of the user interface design was to make it clear to see and for the size to be scaled larger than usual to increase the user friendliness and usability.

4.2.5 UML class diagram

This UML Class Diagram (figure 4) shows the main class components of the game and how they link with one another. This graph is presented to show the inner workings of the game and how each class is organised in a design layout that can be easily understood.

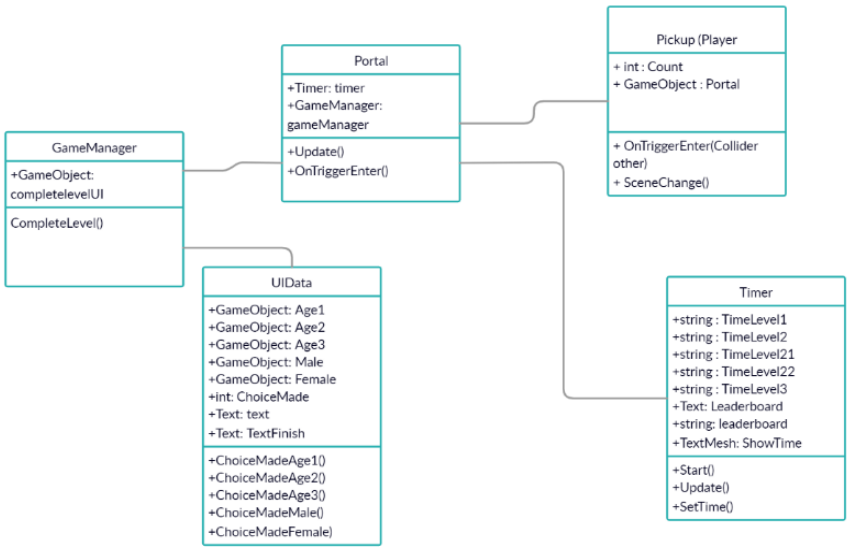


Figure 4 UML Class Diagram

These classes can be broken down into the functions in what they do/ how they act.

- Pickup (Player)

This script is placed onto the camera and will act as the player. By placing a collider on the player camera, the count will be modified by how many objects they pick up in the game using the OnTriggerEnter() method. When a specific count is reached on that level a portal will be set as active and will act as the gateway to the next level.

- Portal

When the player reaches the gameobject(portal) this will transport them to the next level. When approached, the timer for this level will come to a halt as it is the end.

- Timer

A timer will be created for each level and will kept track of to be shown at the end in the leader board.

- GameManager

The GameManager script will be used as the function to change scenes when the portal has been activated.

- UI Data

Each variable will contain the elements of UI that are presented to the user and stored.

5 Implementation

5.1 Graphics Implementation

As the software Unity3D was used to develop the game, there was lots of resources available to make use of, including models and assets. This took away the need to develop graphics to implement into the game which saved a lot of time that was used elsewhere. Several models were used to create the forest environment (see figure 5).

Figure 5 Example of 3D World with models

Model uses included

- Obtained from SkythianCat in the asset store:
  - Oak Tree's (figure 6)
  - Bridge (figure 7)
  - Mushrooms (figure 8)
  - Streetlight (figure 9)
  - Water (figure 10)
- Obtained from GreenForest in the asset store:
  - Rock (Figure 11)
- Obtained from JKT_art in the asset store:
  - Duck (Figure 12)

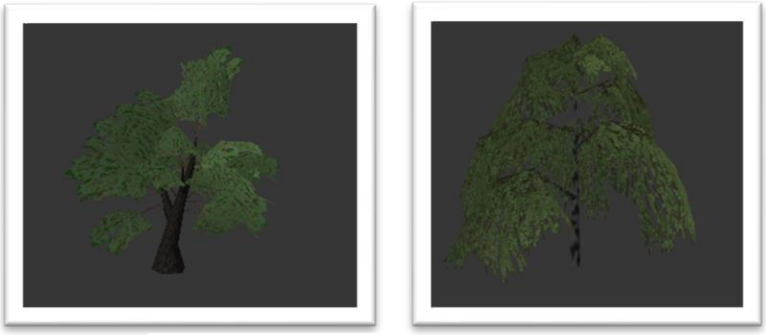


Figure 6 Tree Models

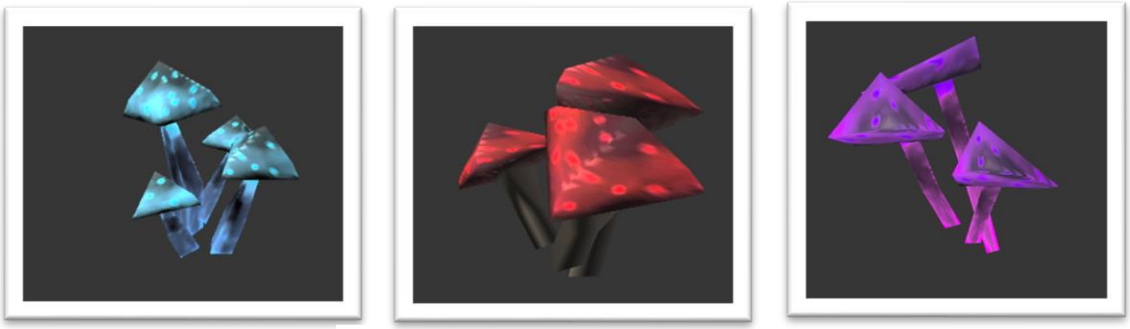


Figure 7 Mushroom Models

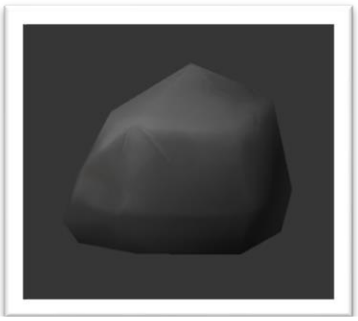


Figure 8 Rock Model

Figure 9 Streetlight Model

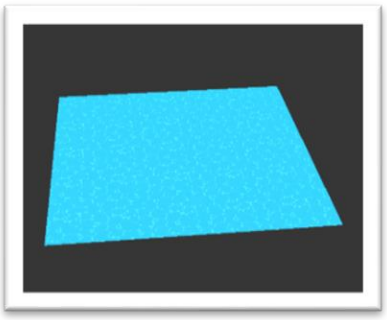


Figure 10 Water Model

Figure 11 Rock Model

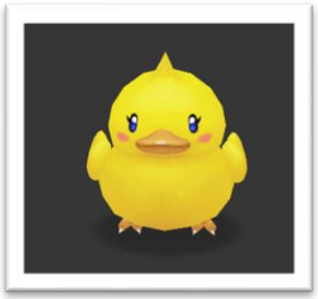


Figure 12 Duck Model

Skybox Used:

- “Skybox_NIGHT” obtained from GreenForest in the asset store

Textures Used:

- Grass from SkythianCat assets (Figure 13)
- Road from SkythianCat assets (Figure 14)
- Ground from SkythianCat assets (Figure 15)

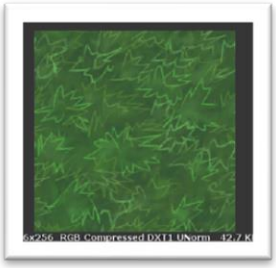


Figure 13 Grass Texture

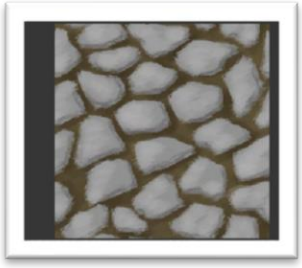


Figure 14 Road Texture

Figure 15 Ground Texture

- Portal Effect

To create the effect of a portal, a portal image from the web was obtained (Figure 16) and rendered in the software to change the texture to be of type sprite(2D). This image was placed onto a game object in the scene which was animated to create a spinning action, the code below (Figure 17) shows how this was implemented using a transform.Rotate command. Because the code is used in the Update() method, this will run once every frame.

```
void Update()
{
    transform.Rotate(new Vector3(0f, 0f, 1f));
}
```

Figure 17 Rotation implementation

Figure 16 Portal Image

- Magical Artifact (Cube)

To implement a ‘Magical Artifact’ into a game the developer wanted something that was simple but would stand out to the player. This was achieved by creating a spinning 3D floating cube that would light up the small area surrounding it. The spinning animation was developed by using a simple script (figure 18) just like the portal but this time, the object would spin in more than one direction.

```
void Update()
{
    transform.Rotate(new Vector3(15, 30, 45) * Time.deltaTime);
}
```

Figure 18 Cube rotation implementation

Figure 19 Cube

Making the cube light up was created by inserting a spotlight inside of the cube, projecting a bright yellow light source from the object onto the surrounding path. (see: Figure 19)

5.2 Player Implementation

Development using Unity meant there were lots of resources available to support virtual reality and types of locomotion. A VR toolkit obtained from VRTK provided the developer with the necessary functions to be able to fulfil this requirement.

To start with, the toolkit was used to implement the camera rig that would act as the player's point of view in the game. The toolkit supported the needs of both VR and without, this meant that the game could be played on a keyboard and mouse as well as in virtual reality. This was essential as midway through development the world was impacted by COVID-19 which meant the developer no longer had access to the university and a VR headset, so development had to be altered to suit the situation.

A view of the settings (Figure 20) shows the different setups which the VRTK toolkit provided. This setup detects what device the user is active on and will auto load to suit the need of the user, however only VR simulator was used to develop the game because of no access to VR technology in the final stages.

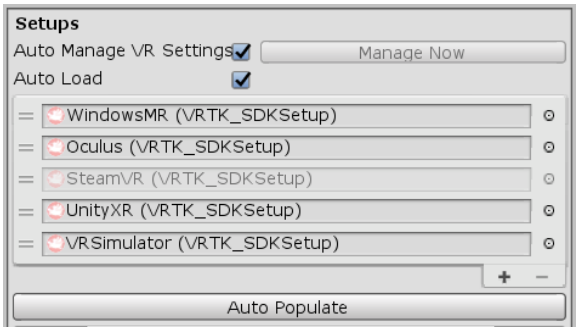


Figure 20 VRTK Setup

The players movement was included in the VRTK package/scripts which as stated earlier allowed the needs of both virtual reality and without. The variables were altered slightly to provide a slower, smoother movement and the choice to take out teleportation was decided as this caused the user to feel disoriented when the action was made. Equipped on the VRTK

Camera Rig are controller models which are visible to the player, these perform as regular controllers as seen in any other VR game with laser pointers that interact with the UI in game (see: Figure 21)

Figure 21 Controller Models

To interact with the objects in the game a collider was added to the camera(player), this would behave as the players body and will hit other colliders from the object in the game such as a tree or bridge, as a normal person would with an object in the real world.

The Pickup(player) class gives the player functionality in the game, these functions enable the magical artifacts to be 'picked up' and enter the portal that will be visible after the certain number of objects have been picked up. An overview of the player class is listed below:

- Pickup Class (Player)
    - Contains a variable 'count' that will add by one when a cube is 'picked up'.
    - When player collider is triggered with an object, the object will be set as false (will disappear).
    - Portal to change scene will be set as active when a specific number of variable 'count' is reached.
    - When player collider is triggered with Portal, the scene will change to the next loaded level.

5.3 Environment Implementation

The implementation of each environment was the most time-consuming element of the project development, as each environment had to follow the same theme whilst also altering, to provide the player with a new experience. The development of each

environment can be broken down into tasks in order of implementation, these are listed below and explained:

- Terrain

The first step of creating an environment was to design the layout of the level, each level is designed to get more challenging as the game goes on, so a new terrain was developed in every environment created. This was done by adding a terrain object into the scene and expanded to a larger size to fit the whole level on and then painting the entirety with the grass texture (Figure 13) as this was the forestry foundation to build on. Secondly, the road texture (Figure 14) is painted onto the terrain to create the layout of the level that the player will follow to navigate. As explained previously, the layout is altered in each level to become more challenging which led the development of paths to become longer and branch into different directions to achieve this. Lastly, the terrain surrounding the outline of the path is raised above the players height, this feature is used to give the playing environment a sense of closure as the player will not be able to see through the trees onto the empty terrain which is important because this adds to the experience of been stuck in a forest surrounded by the nature. (Figure 22) below shows the terrain after implementing.

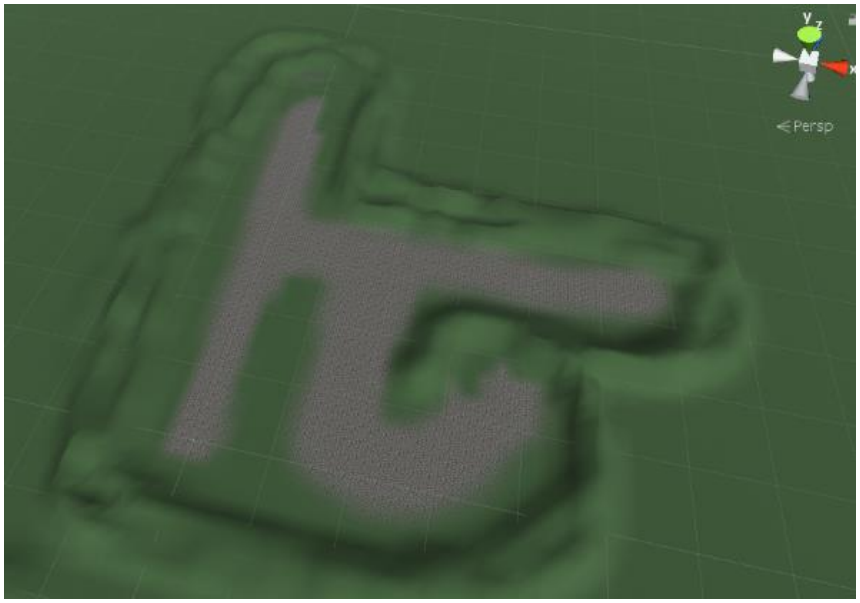


Figure 22 Terrain Development

- Scenery

Once the terrain has been added and features have been implemented in the section above, further development can be started as the environment layout has been completed and is used as the basis for the scene. To further develop the forest environments, several objects were used to create the scenery of the world with the aim to visually please the user and provide the best experience possible. Each object was implemented by pasting the object into the scene and positioned around the area to create the scenery.

Trees were implemented in the scene by using the tree models (figure 6) from the asset store. Each tree in the scene was simply copied and pasted and positioned next to the last, eventually outlining the whole of the path, this is to enclose the area and give the player the option to only navigate through the paths that are laid out. To give the trees extra depth, more were replicated and placed behind each other, in one scene alone there are a number of 580 trees that are used (see: figure 23). To make the trees not look exactly the same as each other, several were highlighted then scaled larger or smaller to create a variety of sizes and shape.

Figure 23 Tree Implementation

To create an element of fantasy within the game, glowing mushrooms were placed around the area which would light up the ground beneath them (see: figure 24). There are 3 types of mushroom in each scene, blue, red and purple, all of which follow the same theme in each of the scenes. The blue mushrooms are the most common and spread around the whole of the area, this is mainly to provide light in the dark areas of the game. The red mushrooms are only located underneath a specific tree to signify to the player they can only grow under special conditions. Similar to the red mushrooms, the purple mushrooms are only found on the rocks that are situated around the environments and are the least common type. The decision to include more than one colour of mushroom was made to deliver a variety of colour schemes to be visually appealing.

Figure 24 Example of Mushrooms in the scene

The lighting in the scene was created by adding a directional light and setting the intensity to a low value between the ranges of 0.1-0.3. This was to give the environment a very dark and gloomy setting that is normally represented when imagining of a forest area. Together with the skybox, the effect gives a remarkably dark night setting to create a weary presence (see: figure 25)

Figure 25 Lighting

Streetlights in the scene were added to provide light within the area, they were replicated and positioned at different areas of the environment (figure 26), most of them being placed at decision points which is linked to the research in the literature review under the (Kessels, van Doormaal and Janzen, 2011) study which explained the benefit of this method of placement. The implementation of the streetlights ultimately decided for the developer that the world would be set in the night-time, because this was another way of providing light for the player whilst also creating a fun forest experience.

Figure 26 Streetlight

5.4 Level Progression

Enabling level progression was crucial to the project as this gave the user a task to complete and when completed, could transition onto the next stage of the game. To implement this, a condition had to be met which as stated in the aims of objectives (section 1.2) the player is required to collect the artifacts and return to the portal to proceed to the next level.

Explained in the player implementation (section 5.1.2) the collider on the camera enables the objects to be picked up, this is executed in the OnTriggerEnter() method inside of the Pickup(player) class. Each time this method is executed the variable 'count' is added by one which represents how many artifacts have been 'picked up' by the player (see: figure 27). The SceneChange() method has specific conditions for each level in the game and is called each time a cube is picked up. When the variable 'count' has reached the condition needed, this will then set the game object portal to be active (see figure 28).

```
void OnTriggerEnter(Collider other)
{
    if (other.gameObject.CompareTag("Pickup"))
    {
        other.gameObject.SetActive(false);
        count = count + 1;
        SceneChange();
```

Figure 27 Object pickup implementation

```
if (SceneManager.GetActiveScene().name == "Level1")
{
    if (count >= 2)
    {
        Portal.gameObject.SetActive(true);


    }
}
```

Figure 28 example of SceneChange() method

The game object portal is what enables the player to transition onto the next level when they collide (enter) into it. When this collision is detected a call for the CompleteLevel() method is performed, this will then display a 'level complete' text to the user and the scene will slowly fade out to signify to the user they have indeed completed that level, this is achieved by creating an animation on the text object (see: figure 29), at the end of the animation LoadNextLevel() is called , this will cause the scene to end, and the player will then proceed to the next level. The process to fade out the scene was an important feature that was implemented in the later stages of development as it was believed the transitioning between levels ran more smoothly as opposed to the original method that would just transport the user to another environment in an instant.

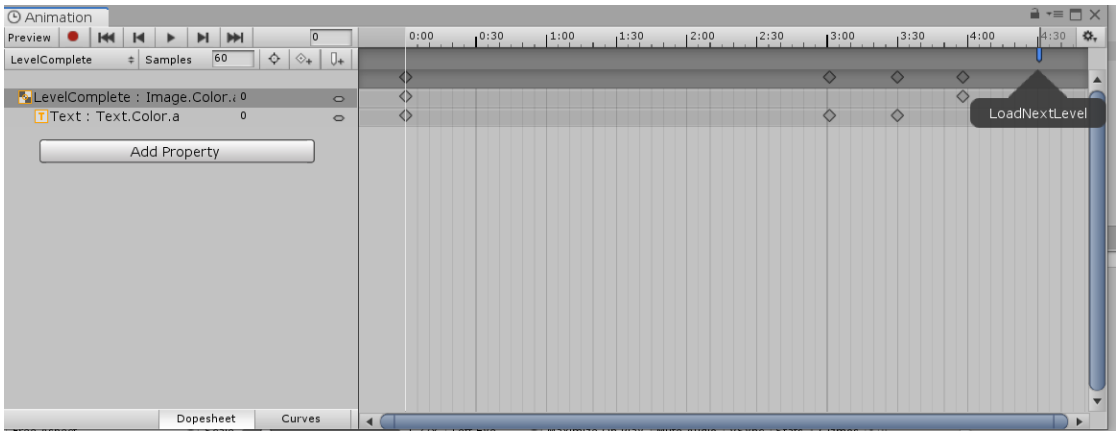


Figure 29 Level complete animation implementation

5.5 Implementing UI elements

Implementation of user interface elements utilises the functionality provided by Unity's canvas system. The UI elements include text and buttons which allows the user to read the tasks and select answers about themselves (see: Figure 30)

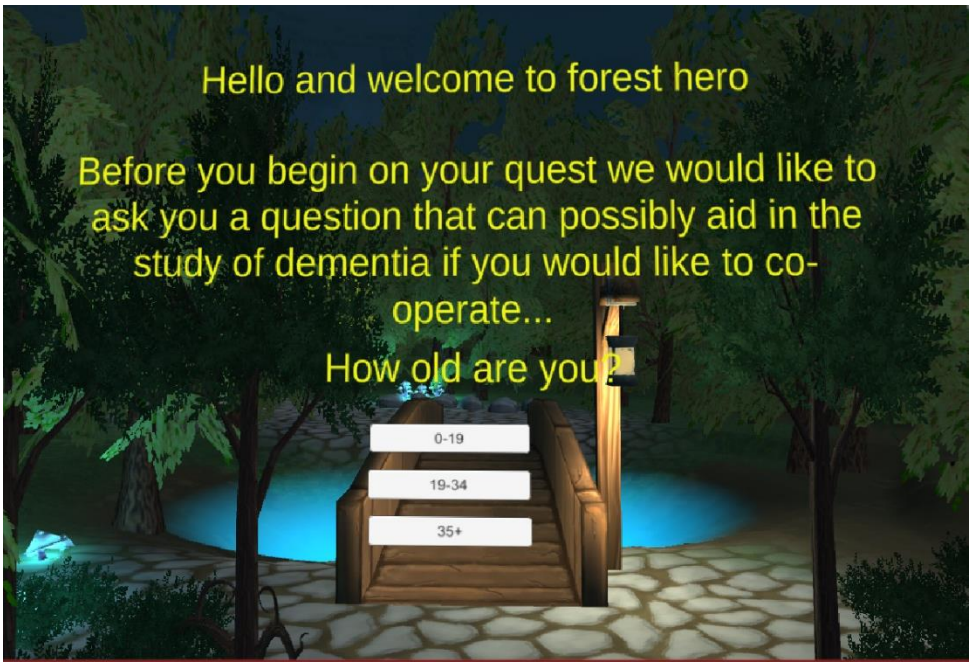


Figure 30 User Interface Implementation

The canvas system in Unity allows the implementation of user interface to be developed in world space, this meant that the elements of UI could be positioned around the environment as opposed to appearing on the screen. The way that this is used was aimed for the player to not be interrupted by any text flashing on the screen and to keep the immersive experience flowing.

It was important for the developer to follow the design of the UI (section 4.2.4) as one of the essential features was to create UI elements that are simple, clear to see and have larger font. To implement these features the text colour was changed to yellow, this is a strategic use of colour to direct attention to the text. Together with the increased font size, the text becomes more user friendly as it is bright and stands out to the player.

5.5.1 Creating Story

Implementation of this feature was not essential to the development but with this included, provided a better understanding of the game and the tasks to complete. The story explains to the user what they must do and why, based on a fantasy world it made sense for the developer to implement a story that is also suited to the game. The player is able to read the story from the UI elements that are implemented in the world space and acts as a guide to aid the player.

5.5.2 Collection of data for potential research on dementia

As explained in section 5.1.5 the user interface elements utilise the functionality provided by Unity's canvas system. Whilst implementing this feature it was important for the developer to create a feedback system that would keep the player immersed; With experience playing games, it is known that players can become impatient with several pop ups that interrupt the playthrough of a game. This was created by implementing the UI elements in world space.

From the discussion of different studies in the literature review (section 2.2) the research provided findings that proved spatial navigational abilities began to decline from the age of 19+ and that men performed better than women, so that decided what data was to be collected from the user as it showed the most relevance to research.

With the buttons implemented it was also important to consider the usability of the UI, discussed in the design of UI (section 4.2.4). Basic buttons would have not been suitable for this, as they show no indication of a button been selected or pressed. To improve the buttons usability, certain interactions changed colours to indicate the actions happening. Figure 31 shows how this was implemented and an example of the feature displayed in the game; Changing the colours of the interactions will enable the player to visibly notify what selection has been highlighted with the aim of increasing the ease of use.

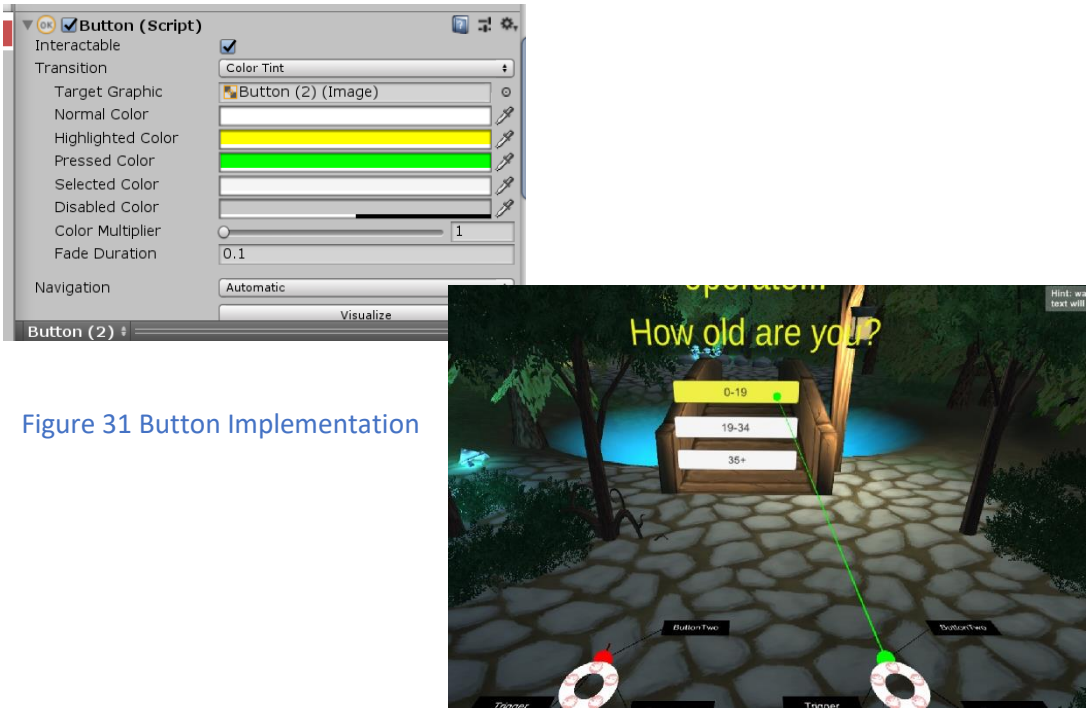


Figure 31 Button Implementation

When selected, the data is stored in a variable located in the UI script, with the potential of analysing this data in further development. It is important to mention, that the data collected in this game is not used to provide any kind of analysis but is implemented to show the capabilities and to provide a basis for the future if developed further.

6 Testing

6.1 Function Test Table

One of the forms of testing in this project is function testing. This form of testing focuses on the main tasks and actions that are performed in the game. These functions are required criteria for the project to be a success and should perform as designed and intended. The functionality in the game can be broken down into smaller functions that will be tested to determine whether they are working. As well as functionality, there are also tests to ensure the environment is displaying correctly. To perform these tests the developer is required to playthrough the game as a user would, performing all the actions slowly and efficiently to confirm that the functions work as desired. As stated in section 3.3, access to VR had been revoked as the university had shutdown because of the recent COVID-19 outbreak, this meant that the game had to be developed for use without VR so the tests below represent the game not using virtual reality.

ID	Name	Functionality	Notes
1	**Player Functionality**		
1.1	Collection of artifacts	Working	Altered after user testing
1.2	Player Movement	Working	Altered after user testing
1.3	Laser pointer	Working	
2	**User Interface**		
2.1	Button Controls	Working	
2.2	Text	Working	
2.3	Leaderboard	Working	
3	**Functionality**		
3.1	Proceed to next level	Working	
3.2	Timer	Working	Altered after user testing
3.3	Animations	Working	
4	**Environment**		
4.1	Graphics display correctly	Working	
4.2	Light display correctly	Working	
4.3	Boundaries	Working	
5	**Data Storage**		
5.1	Timer data	Working	
5.2	Player data	Working	

6.1.1 Detecting problems

When testing the game for any potential issues, it is essential to behave similarly to a new user thereby finding same situations the user would find themselves in. It is also important

to consider the different learning skills of the users as some may struggle coming to terms with how the game is to be played. Although these things are taken into consideration when testing, the developer still does not share the same representation of someone who has never seen the game before. However, many problems are usually detected in this stage and can be fixed to prevent any issues from arising.

This stage of testing was performed by playing through the game fast and very slowly several times. This gives chance for any major issues to be detected as the game would not perform how it is designed to.

One half of testing was prioritised to test the functionality of all the actions in the test table (section 5.2.1) and the other half was to detect any bugs that would interrupt the gameplay.

6.2 User Testing

To test the usability of the software, it is important for someone other than the developer to review and reflect on it. User testing is a great way of discovering problems and improving the software as it takes the view of somebody that is not familiar with the product. The main points of focus when user testing was to determine:

-They understand how the game works

-Can they complete the game

-Encountering issues

-User Experience

The users were tasked to complete the game and to reflect on their experience by answering a short questionnaire which consists of sections of the software to be rated from 1 to 5, with each section there is extra space for additional comments which should be used to provide any problems or areas of improvement for the developer. (see Appendix D for test sheets).

6.2.1 Results

All test sheets were collected, each was assigned a number as all feedback was entered into a table to analyse the results easier, the result data can be found in Appendix E. For each question, the average rating was calculated as this gives a better analysis of the results collectively, this helps to identify successful features and where areas can be improved upon. The users testing the product are kept completely anonymous and only the test sheet numbers are used, data such as their names is not required and is unnecessary.

To provide a better insight to the testing results, the data is placed into a graph for presentation purposes. The graph (figure 31) presents an average score for each section of the questions answered.

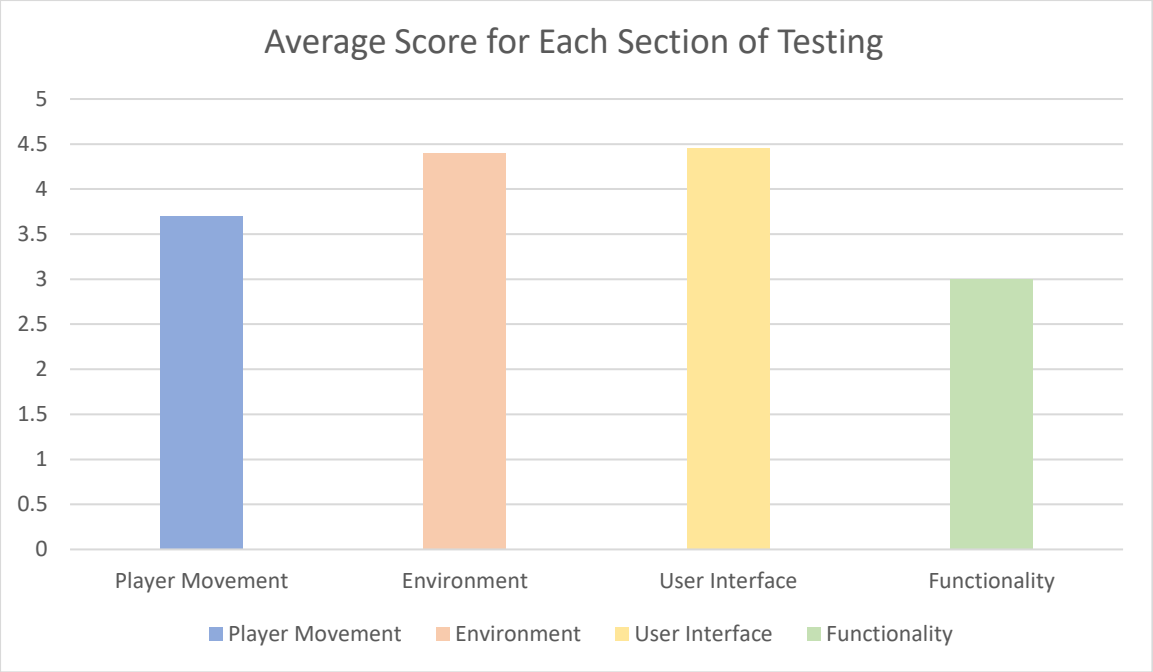


Figure 32 User Testing Results

The graph indicates the features that have succeeded and those that are an area for improvement. Functionality has the lowest average rating of 3 which expresses the users unsatisfactory experience with that feature. Looking at the feature more closely it is clear to see what the users were unhappy with. The developer had prepared for any issues to arise and time was reserved to alter any features to improve the users experience. The highest average rating is the user interface with 4.46. In particular, the clearness of UI was rated the highest, this can be credited to the features that were decided such as the colour scheme in the UI design (section 4.2.4).

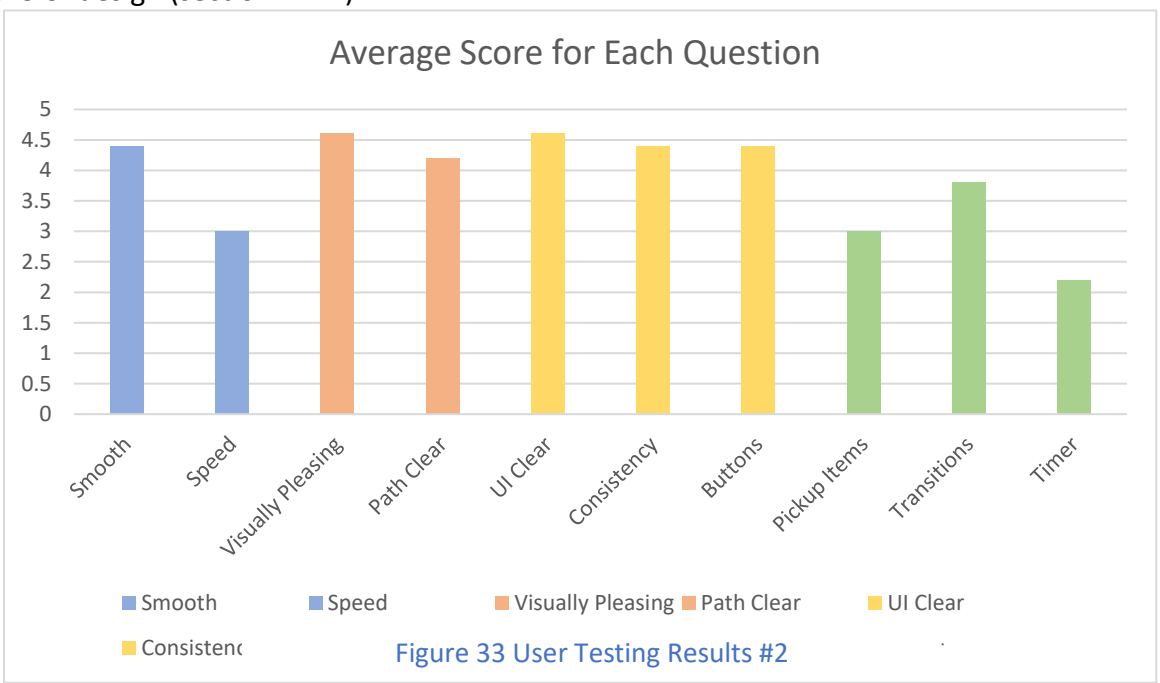


Figure 33 User Testing Results #2

7 Evaluation

The aim of this project was to create a 3D forest environment in which the player will be required use their navigation and spatial memory to collect items in different locations and return, to proceed to the next level. As all primary and some of the secondary objectives have been achieved, the project can be deemed as a success.

To evaluate the Forest Hero Quest project as a whole, the objectives in section 1.2 will be reviewed and described how each has been satisfied.

7.1 Review of Objectives

Objective 1- Create 3D environments

The aim of this objective was to create several 3D forest environments covered with trees and other scenery. Additionally, a path to help the player navigate through the forest should be clear to maintain visibility. Feedback from the user testing results, suggest this aim was achieved, this could be credited to the design process as the trees surrounding the player create a sense of closure, as a forest environment would be imagined. Glowing mushrooms are particularly interesting features of the world as they provide a lot of variety to the colour scheme to help the environment stand out to the user and is visually appealing; The dark setting of the scene also added to the effectiveness of the objects in the scene allowing them to glow brighter.

Objective 2-Create player movement

The aim of this objective was to allow the player to move freely in the game with the camera acting as the players eyes. The objective was met by implementing a tool that allowed the user to move the player freely around the environment in VR and without. As stated in the objectives section 1.2, the variables were analysed to set the speed if an issue arises. The user testing results signified to the developer the speed of movement was an issue as some users stated they was moving too fast within the game, this was altered to become more slow moving to suit the needs of the user. It is believed after this alteration the experience was improved.

Objective 3-Level Progression

The aim of this objective was to create a function that would allow the player to complete the level and proceed to the next environment when a condition had been met. This objective was achieved by implementing a task that the player is required to complete. This task is to ‘pick up’ artifacts in the world, when all artifacts in the scene have been collected the condition will be met and will allow the player to proceed to the next level. This was developed further by created a transitioning animation to create a smoother process, so the user felt comfortable.

Secondary Objectives

Objective 4-Story Creation

The aim of this objective was to create a basic story to follow and understand to create a sense of purpose. This objective was met by implementing text that would provide a short simple story that gives the user a task to complete. The text was implemented following the same design as the other UI elements in the scene to make it easy to read and clear enough for someone with visual decline.

Objective 5-UI to collect data

The aim of this objective was to collect data from the player such as gender and age by using simple UI buttons for the user to select, the data provided by the player could be used for research if further developed. This aim was met by implementing UI elements which the player could select using the laser pointer. The decision to implement these UI elements in world space was an effective one as it is believed that the immersive experience was not affected, as opposed to screen overlay buttons that are generally used and interrupt that experience of the immersive world.

7.1.1 Summary

All the objectives were fully met and achieved. Functional testing and user testing suggested that the objectives were satisfied but some could be improved on, small alterations were implemented to fix this and to improve the user experience.

7.2 User feedback review

The aim of user testing was to gain an insight of the experiences each user had, highlighting the best features and revealing issues to be improved on. Figure 31 & 32 display the testing results in which the users provided feedback on the game.

It was decided by the developer that if the average rating of a feature was rated 3 or below, then alterations would be made to provide a better experience. As seen in the graph above (figure 32), these features included the speed of the player, pickup items, and the timer. Some of the additional comments helped provide improvement ideas as they highlighted the problem that had occurred. Here is a breakdown of each section and the feedback provided which can be reviewed.

Player Movement

The player movement was scored 3.7/5 which signifies that the users were just satisfied with the feature.

- Smoothness

The average rating of the smoothness of movement was scored at 4.4/5, this indicated that the users were happy with this aspect of the feature, the gathered feedback suggested that the player could move freely in the game and was consistent.

- Speed of player

The average rating of the player speed was scored at 3/5 which indicated to the developer this could be improved upon. One user provided feedback that said, “moving too fast through the woods, do not have time to take in surroundings”. This provided the developer with the idea to slow the movement down, this was achieved by changing just one variable that affected the speed at which the player moved.

Environment

The average rating of environment testing was scored at 4.4/5 which suggested that the users were extremely happy with this feature.

- Visually pleasing

The average rating of the environment been visually pleasing was scored at 4.6/5, this indicates to the developer that the design and implementation of the forest environment was a success. The gathered feedback suggested that the users really enjoyed the colour scheme of the areas, including the glowing mushrooms that were bright and vibrant. The users also stated that the surrounding trees really give them the sense of closure of been in a real forest which suggests to the developer that the users felt immersed in the world because of the design that was implemented.

- Clear path to follow

The average rating of the path been clear to follow was 4.2/5, this shows that the users were happy with the display of path, the gathered feedback suggested that the path was always wide enough to keep track of and the grey texture made the path stand out from the green grassy areas so that it was always visible.

UI

The average rating of UI testing was scored at 4.46/5 which suggested that the users were extremely satisfied with this feature. The UI elements in the game were important to implement and was important to gather feedback on this as implementations were made to increase the usability of the features.

- Consistent

The average rating of the consistency of UI was scored at 4.4/5, this indicates that throughout the game the users found that the UI elements were consistent with each other. The gathered feedback suggests that specifically the users were happy with the colour of the text as it was easy to spot straight away.

- Clear

The average rating of the clearness of UI was scored at 4.6/5, this implies that the users found the UI to be easy to read and clear enough for everyone. The gathered feedback indicates that the users had a good experience with this feature as they said they found the

text large enough to read from the distance they were stood at and the colour of the text stood out.

- Buttons

The average rating of the buttons in the UI was scored at 4.4/5, this indicates that the users found the buttons easy to use. The feedback gathered suggested that the users were happy with the size and shape of the buttons, they also found the buttons easy to use as they were indicated of when the laser pointer was highlighting a selection.

Functionality

The average rating of the functionality in the game was scored at 3/5. This section had the lowest average rating which needed to be improved upon.

- Transitions

The average rating of the transition feature was scored at 3.8/5. The feedback gathered from the users suggested that they were happy with the feature, specifically when the scene faded out before proceeding to the next one, as they felt comfortable teleporting to the next environment.

- Pickup Items

The average rating of the pickup items feature was scored at 3/5 which indicated to the developer this could be improved upon. A user commented saying “the range at which the item is picked up is very small”. The alteration made to improve this feature was to increase the size of the collider attached to the artifacts which allowed the user to ‘pick up’ the item at a further range.

- Timer Usage

The average rating of the timer feature was scored at 2.2/5 which indicated to the developer this could be improved upon. A user stated that “the timer put me off as it was constantly reminding me how long I was taking” which indicated to the developer that this feature should be not presented to the user as it made several of them uncomfortable.

7.2.1 User feedback review summary

The user testing was a success as it highlighted the best features and revealed issues that users had which was improved on to help provide a better experience. The rating system was very helpful at providing an analysis of the user experience as the data could be calculated to present an average score. This score was then looked at and alterations were made based off the additional comments given by the users. To conclude, user testing provided a detailed insight of how well the features performed which is usually overlooked by the developer as they see no issue with the functionality as it suits them.

8 Conclusion

At the beginning of the project the aim was stated:

The aim of this project is to create a 3D forest environment in which the player will be required use their navigation and spatial memory to collect items in different locations and return, to proceed to the next level. Other factors including story creation and data collection will also be considered.

The project presents a game in which the player navigates through a 3D forest environment, utilising their navigation and spatial awareness to venture through the path to collect the items in different locations, for this reason it is believed the project aim has been met. This project has the potential to contribute to dementia research which would be very beneficial, inspired by 'sea hero quest' this game offers an enhancement in the field by providing an alternate environment for the player to indulge in.

Many skills were practised and learnt by the end of the project. Having never developing in virtual reality it was an interesting topic to get into and learn more about, the challenge of developing a VR game was very exciting and rewarding for the developer. Committing to a project of this size and length has given a much better understanding of development and how to plan and deliver the work needed. Before development began, the large amount of work was an intimidating thought but with a lot of thought in the planning stage this made the work-load easier to manage. There are many things to be taken away from this project, but one thing is it has prepared the developer with the courage to take on projects in the future, whatever they may be.

Because of the recent COVID-19 outbreak, the use of the VR technology was unavailable because of the university closing following the government's guidelines, which meant the last third of development was affected and the developer could not continue to develop and test in VR, this also meant that the game had to adapt and alter to the situation, this required the game to perform without the use of VR. The effect of this situation was that the VR features in the game may not be working correctly as there was no possible way of testing the functions as the technology was no longer available. With this to consider, the game still performs how it should and, in the future, can be developed and tested for the use of VR when the technology is made available again.

The project as a whole has been a success, Forest Hero Quest is a VR supported game that immerses the player into a forest world, enabling the player to venture and explore the colourful fantasy environments whilst providing clear and simple UI elements for the player to read and interact with.

8.1 Management Review

The management of the project was carefully considered throughout, following the time plan to ensure that all of the objectives were developed and achieved whilst allowing enough time to test the software and implement any changes that needed to be made. See the time plan (Appendix C) for a closer look at the revised time to develop the project.

Development on the project was completed a little earlier than expected which allowed more time for testing and collecting feedback from the users, which was important because it gave the developer slightly more time to alter the features that the users were not as satisfied with.

Implementing each objective at a time was an effective way to develop the project as it gave the developer one task to complete at a time, in comparison to juggling many tasks and under developing a feature due to prioritizing the others. Perhaps it would have been wiser to perform user testing midway including the main functionality of the game so that changes could've been made and tested again to see if the alterations had made a difference in the user experience.

8.2 Further Work

This project is just a small game with a lot of potential to be improved and extended, with extra development there are still a lot of features that could be implemented that would achieve this.

8.2.1 Positional tracking

To further develop the games data collection, positional tracking could be implemented into the game, this would mean that the players navigation would be recorded to display where they had navigated; The data the positional tracking would collect from the player would determine if they had struggled or performed well when navigating through the forest. The benefit of including this feature would be that it could provide an in-depth analysis of the players navigation and spatial awareness which potentially can be used to contribute to dementia research.

Together with a map of each level, the positional tracking would display the route the player has taken to complete the tasks. On the map, the tracking of the user could either be presented as a heat map that would identify where the user spent the most of their time which could signify they was struggling or as a simple line which would follow the users tracks and would identify exactly where the user has been moving and the direction.

8.2.2 Level Expansion

Expanding on the current environments could provide the player with more areas to explore. With further development extra environments could be created to give the player more levels to complete. These worlds would follow the same theme but can be larger and more complex to allow the play to explore deeper into this forest world. The benefit of this would be that there is extra content that a user can enjoy and provide a richer experience, also this would mean that there is extra data to be collected which would be useful for possible contribution towards research for dementia. The extra levels could include more animals to interact with which were a popular feature in the user testing results feedback.

8.2.3 Extended VR development

As stated several times throughout the report, development on VR was unavailable because of the recent COVID-19 outbreak which had stopped the developer from accessing the VR technology at the university. When the technology can be accessed again, development and testing could proceed as planned, allowing development of the features to be implemented and tested to extend this project further and to its intended use.

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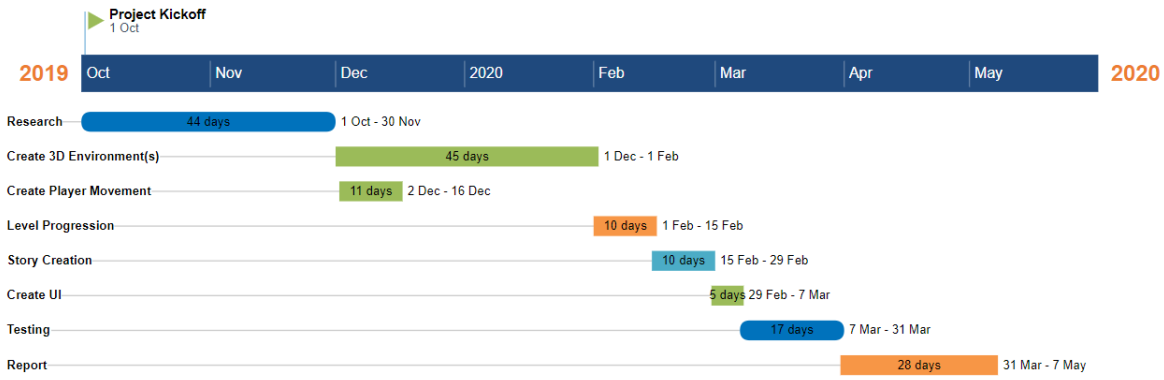
Appendix A – Task List

#	Task Name	Description
1	Create 3D Virtual Environments	Virtual environments are to be created for the game to take place.
1.1	Create Layout of Path	Layout of path to be created to guide the user to navigate.
1.2	Create Scenery	Scenery to be created to create forest, including trees, rocks and terrain.
2	Create Player Movement	Player Movement to be created to allow the user to move around the virtual environment.
2.1	Research on Movement in game	Research will provide an insight on how to create player movement.
3	UI Collect data	User interface to be created to allow the user to answer prompted questions.
3.1	Research ways to implement UI buttons	Research will provide an insight of how to create buttons that the player will interact with.
3.2	Keep data saved	Create variables to allow the data to be saved in the script.
4	Level Progression	The game will include level progression, meaning more than one of environment will be created and will be proceeding onto when the player completes each level.
5	Story Creation	To provide a story that the user will read and understand.
6	Report	
6.1	Initial	First report outlining objectives
6.2	Final	Final report to be submitted detailing the project as a whole
7	Testing	Testing the game throughout the entirety of the project

Appendix B – Risk Analysis

Risk	**Severity**	**Prevention**
Dizziness and nausea	mildly severe	Make sure the user is taking frequent breaks and introduce experiences gradually.
Not aware of surroundings/bumping into things	Mildly severe	This can be avoided because games provided can be used whilst sitting down and is recommended to do so. Ensuring there are no immediate obstructions surrounding the user before they put the headset on can also prevent the risk of injury and is important to do this for every user.
Eye Strain	Mildly severe	Limiting the amount of time using the headset.
Motion sickness	Low	Monitor the user's reaction whilst using the headset. Introduce experience gradually.
Risk of seizure	Highly severe	As with any computer or TV screen there is a risk. Be clear to the user about the risks and if they have had a history of seizures and discuss whether it would be suitable for the user to participate. Close monitoring.

Appendix C – Time Plan



Appendix D – User Testing Sheet

Forest Hero Quest: Questionnaire

Please answer the following questions regarding forest hero quest.

Please rate the features from 1 to 5, 1 representing the lowest score and 5 the highest.

Additional room is left underneath each section to provide any feedback.

Player Movement	1	2	3	4	5
Was it Smooth?					
How was the Speed?					

Additional Comments:

Environment	1	2	3	4	5
Visually pleasing					
Was the path easy to follow?					

Additional Comments:

User Interface	1	2	3	4	5
Was it clear and easy to see?					
Consistency					
Were the buttons easy to use?					

Additional Comments:

Functionality	1	2	3	4	5
Easy to ‘pick up’ the artifacts?					
Transition to next level					
Timer Usage					

Additional Comments:

Appendix E – User Testing Results

Player Movement	Environment	User Interface	Functionality							
User	Smooth	Speed	Visually Pleasing	Path clear to follow	Clear, easy to see?	Consistency	Buttons	Pickup items	Transitions	Timer
1	5	3	5	4	4	4	4	3	4	2
2	4	3	5	4	5	4	4	2	3	2
3	4	3	4	4	5	5	4	3	4	3
4	5	4	5	4	4	5	5	3	4	2
5	4	2	4	5	5	4	5	4	4	2
Average Rating	4.4	3	4.6	4.2	4.6	4.4	4.4	3	3.8	2.2
Section Average	3.7		4.4		4.46			3		