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SCHOOL OF SCIENCE AND TECHNOLOGY

COMP40321 – Major Project

of

The Effects of Serious Games in Virtual Reality on Children with Learning Disabilities

by

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Project report in part fulfilment

of the requirements for the degree of

Master of Science with Honours

in

Computer Science

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Abstract

There are approximately 350,000 children who live in the United Kingdom that suffer from a learning disability. The purpose of this study is to help children with learning disabilities develop and foster personal skills that can be applied later in life in professional working environments. The application is a scenario based game, where the user will be faced with multiple scenarios and they must select the correct answer to gain points.

The research that has been conducted for this topic was done through literature reviews, and a dive into research into existing solutions within the same industry. Although this project had some challenges (as mentioned in 5.2 Challenges Encountered) leading to a minimal user testing, the aims and objectives were followed throughout the development of the project to create a successful project.

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List of Abbreviations

2D – Two-Dimension

3D – Three-Dimension

ASD – Autism Spectrum Disorder

BCS – British Computer Society

DPA – Data Protection Act

FPS – Frames Per Second

FR – Functional Requirements

GB – Gigabytes

LR – Literature Review

LTM – Long-Term Memory

MoSCoW – Must, Should, Could and Would

NFR – Non-Functional Requirements

NLT – National Literacy Trust

PC – Personal Computer

PEGI - Pan European Game Information

SG – Serious Games

SFX – Sound Effects

UD – Updated Literature Survey and Project Planning Document

UI – User Interface

VE – Virtual Environment

VET – Vocational Education and Training

VR – Virtual Reality

ZPD – Zone of Proximal Development

Chapter 1 – Introduction

1.1 Research Context

"A learning disability is a reduced intellectual ability and difficulty with everyday activities" – (Mencap, 2022)

The title of this project is "*A-Wear VR*", and the purpose of this study is to help children with learning disabilities develop and foster personal skills that can be applied later in life in professional working environments. There are approximately 350,000 children who live in the United Kingdom that suffer from a learning disability (Mencap, 2020) and struggle with everyday activities. Through creating an application within Virtual Reality ('VR') alongside Serious Games ('SG') will help these individuals challenge their weaknesses into strengths by exposing them to scenarios that will help them develop abilities such as autonomy, problem-solving and communication. These skills have been identified as key areas desired in professional working environments by the LEVEL 5 Validation System within the Vocational Education and Training ('VESVET') (VESVET, 2021).

Using constructivist theories of learning is an important aspect of A-Wear VR. Following Piaget's work on how children learn through constructivism (Piaget, 1971), his theories follow that children create more meaningful connections when they can relate information to personal experiences. VR allows the opportunity for children with learning difficulties to create their own world of learning through allowing individualised meaning from their experience in the game. Moreover, A-Wear VR will employ Vygotsky's theory on learning and development through the understanding of the Zone of Proximal Development (ZPD) to help avoid children experiencing cognitive overload (Vygotsky, 1978). The ZPD is the difference between what children can do alone and what they can do with assistance. A-Wear VR will act as assistance within children's ZPD to promote cognitive development.

Moreover, VR is used because the aspect of constructivism (Wimm, 1993) has been used in this project to allow users to make sure that they are physically learning different skills rather than passively, as studies show that active learning yields an "improved learning

experience" (Allcoat & von Mühlenen, 2018). In addition, SG would benefit from this project as its main aspects include an "increased emphasis on abstract knowledge [that] is reflected in educational goals" (Abt, 1987) and therefore can be used for an education project to enhance specific personal traits as listed in *2.4.1 LEVEL 5 Validation System*.

1.2 Aims and Objectives

1.2.1 Aims

The primary aim of this project is to create a VR application using SG to assist children aged 7 to 14 with learning disabilities in developing and fostering personal skills that will be useful in a professional working environment. Children will be able to develop these skills and apply them to real-life situations by playing scenario-based games.

1.2.2 Objectives

Objectives of this project include:

- Recognize information in the literature review that can be added to the project.
    1. How can the LEVEL 5 Validation System Help Children with Learning Disabilities?
    2. How can VE Help People with Learning Disabilities?
    3. How can Video Games be used in Education?
    4. How can VR be used in Education?
    5. What is the effect of SG on Children with Learning Disabilities?
    6. Advantages and Disadvantages of Education in Video Games?
    7. Unreal Engine vs Unity?
    8. How can Audio be used in Video Games?
    9. Score System and Positive Reinforcement?
- Understand how Virtual Environments (VE) can help people with learning disabilities.
- Develop a VR application that would use SG.
- Features that are implemented into the project will help develop children with their personal skills with the use of the LEVEL 5 Validation System.
- Test the VR application to search for bugs that need to be fixed.

1.3 Report Overview

Chapter 2 contains the literature review, exploring the existing solutions for the background of the project and identifying any gaps in the literature. *Chapter 3* focuses on the functionality of making the game. This includes how the game will be developed, any risks, and its requirements. *Chapter 4* will be bringing the research into the development phase. This chapter will discuss how the physical product will be created in order for it to be used and how it will be continuously developed. *Chapter 5* will look into the testing procedures needed to make sure that the product is fit for commercial use. This will include a study with participants to determine if the product is fit for use and what further developments could be made. Finally, *Chapter 6* will look at the product as a whole to determine if it has reached its aims and objectives that are stated in *1.2 Aims and Objectives.* This section will also explore the future for the product created, including potential additional features and how it could be improved for future use.

Chapter 2 – Context

2.1 Introduction

The purpose of the context section is to find out different factors of SG and how they can be used within VR. Dörner, Göbel, Effelsberg and Wiemeyer define SG as "a digital game created with the intention to entertain and to achieve at least one additional goal" (Dörner, et al., 2016). They go on to mention that these goals are labelled as "characterizing goals" and are used to enhance personal skills, such as learning. SG has the ability to provide key skills that can be acquired from all ages, allowing individuals to bolster their sets of skills through playing games. This document will detail how SG is linked with VR, focusing on the following question: '*how can SG be an aid for education within VR?'*.

2.2 Orientation and Background

Clark Abt coined the term 'Serious Games' to refer to an "increased emphasis on abstract knowledge [that] is reflected in educational goals, which continue to rise to meet the [educational] demands of the society" (Abt, 1987). SG has grown in popularity, providing a new format of education that can benefit all ages. This is what drove the project to focus on how SG can be further developed to meet the educational needs of students with learning disabilities, who cannot access education in the traditional or mainstream environment. The *SG* Initiative of Rejeski and Sawyer (2002) was established with one goal in mind, "to use games to engage the broader public in policy discourse" (Wilson Center, 2022). This goal is shared in this project, in order to broaden the educational sphere with a specific focus on children with learning disabilities.

2.3 Problem Statement

Giessen states that learning should be taught in a way that the part of the brain should be activated. He is referring to the hippocampus, as it is absorbing "knowledge and information which is connected with positive emotions" (Giessen, 2015), and not the Amygdala because it is known to be connected to stress and boredom. Siegel goes on to further explain the hippocampus is "the 'search engine' of memory retrieval" (Siegel & Bryson, 2011). Moreover, Tyng, Amin, Saad and Malik state that another factor of cognitive processing in

humans is influenced by emotions (Tyng, et al., 2017). They argue that the studies show that emotions either "enhances or impairs learning and long-term memory (LTM)", as activating the hippocampus can provide "successful learning and LTM retention" (ibid).

2.4 Research Questions

As outlined in the introduction, the question '*how can SG be an aid for education within VR?* is reviewed throughout the following questions:

1) How can the LEVEL 5 Validation System Help Children with Learning Disabilities?
2) How can VE Help People with Learning Disabilities?
3) How can Video Games be used in Education?
4) How can VR be used in Education?
5) What is the effect of SG on Children with Learning Disabilities?
6) Advantages and Disadvantages of Education in Video Games?
7) Unreal Engine vs Unity?
8) How can Audio be used in Video Games?
9) Score System and Positive Reinforcement?

2.4.1 LEVEL 5 Validation System

LEVEL 5 Validation System "is a unique system to validate competences and competence developments and to create learning environments and pathways in non-formal and informal learning contexts" (Wiemann, 2018). REVEAL adds that LEVEL 5

> *"a three-dimensional model which maps the development of:*
>
> - *Knowledge (-> cognitions)*
> - *Skills (-> actions) and*
> - *Attitudes (-> emotions and values)*
>
> *along five quality levels – from beginner to competent expert."*
>
> (REVEAL, 2020)

Research into LEVEL 5 Validation System indicates that within VESVET, there are ten sub-competences which include: autonomy, problem-solving, evaluating/reflecting, communication, teamworking, leadership, resource planning and management, flexibility/adaptability, and critical thinking (VESVET, 2021).

Furthermore, these sub-competences include what they call "soft skills" which are "the personal traits that make a person an excellent employee, employer and, in this case, entrepreneur." They also go on to explain "hard skills" that are "measurable and deal with the technical aspects of your role". VESVET notes that these skills are essential for navigating challenges, reaching individuals' potential, better work-life balance, and personal and professional growth. These entrepreneurial skills or sub-competencies would help provide guidance on what activities/scenarios will have to be within the VR application.

REVEAL looks into the approach of the LEVEL 5 learning system which has a three-step procedure which is 'Plan-Do-Check' (REVEAL, 2020). This is as follows:

Plan: *"The starting point of the planning is the so called "action field" in which the learner is located. It describes context, actions, resources and objectives of his/her activities"*.

The LEVEL 5 reference systems, which derive the competences required to face the actions and solve the tasks in the field, help to convert this action field into a learning field.

Do: *"The delivery of learning is highly dependent on the context. It can range from a rather informal, [self-guided] learning (e.g. in learning on the job or in mobility settings)".*

LEVEL 5 is generally in favour of blended, web-assisted learning. For these aims, the REVEAL community provides cutting-edge learning technologies as well as an open learning environment.

Check: *"The check-element refers to the validation within LEVEL 5. Dependent on the identified action and learning field it covers the identification, documentation, assessment and certification of competences".*

It is built on the LEVEL 5 reference systems, which allow for individual and contextual validation. LEVEL 5 certifications, including the dynamic LEVEL 5 cube, document the learning outcomes.

Throughout the development of this project, the main sub-competences that would be implemented are autonomy, problem-solving, and communication. This would thus develop their soft and hard skills. The Plan-Do-Check system can be implemented within an educational game for children who have learning disabilities. The initial stage of the procedure includes creating a test that the participant will be able to complete before and after playing the game. The purpose of this test is to locate where the individual can improve their sub-competencies. This will then lead to setting self-guided learning through various activities designed within the game. The final phase would be to produce an assessment, which would display how well the child has completed the activity.

2.4.2 How can VE Help People with Learning Disabilities

There are approximately 350,000 children who live within the United Kingdom that suffer from a learning disability, which is around 2.5% of children aged between 0 and 17 (Mencap, 2020). Hulusic and Pistoljevic wrote a document on the development of an SG for children who suffer from Autism Spectrum Disorder ('ASD'), and the abstract shows that these individuals that suffer from ASD can use SG to develop various skills so that they can learn with teachers and also in their spare time (Hulusic & Pistoljevic, 2017). The details of the document go on to mention that these skills can be taught in a "fun, informal and engaging way" (ibid). Furthermore, as mentioned in the problem statement, looking into activating the hippocampus can help unlock the key to providing a way for children with ASD and other learning disabilities to be interactive with an application that can help foster specific skills.

2.4.3 How can Video Games be used in Education

Janarthanan claims that every game that has been developed is made with the ability to "play, produce, teach, motivate, socialize, communicate and educate different cultures" (Janarthanan, 2021). In addition, Brown poses the notion that video games "challenge our

notions of identity, creativity, and moral value, and provide a powerful new avenue for teaching and learning" (Brown, 2014). This is relevant in education as the benefits of video games "include improved powers of concentration, creativity, memory, languages and teamwork" (Iberdrola, 2022). As the application that is being developed for this project is targeted for children who have learning disabilities, that is being created to be used on the Oculus Quest 2 and will incorporate the abilities and notions that are mentioned prior alongside SG.

2.4.4 How can VR be used in Education

A study was conducted in 2018 where 99 participants were averaged around 19 years old at the University of Warwick (Allcoat & von Mühlenen, 2018). The purpose of this study was to display if using VR would help with learning. The participants were then separated into different groups (textbook learning, VR, and Video) where they were given different learning methods. They were all given a test before the learning methods and after these learning methods. The results showed that the participants that learnt through textbooks had improved overall performance. This was also shown for people who learnt through VR, although they also displayed an enhanced display of memory than textbook learning or video. The final feedback from this study displayed that VR is an "improved learning experience when compared to traditional and video learning methods" (ibid).

Wimm elaborates on this understanding that educational application inside of VR would allow the learner to immerse themselves fully in the experience so that they would be able to have a 'first-hand' experience (Wimm, 1993). Wimm follows on by mentioning that when individuals complete a task in the first person it is known as constructivism, which is when "people actively construct or make their own knowledge, and that reality is determined by your experiences as a learner" (Western Governors University, 2020). Testing and learning by constructing this knowledge would allow would provide a successful way to understand whether the information taken in by the participants would have been successful.

2.4.5 How can VE Help People with Learning Difficulties

An investigation was taken at the University of East London, which discussed the effects that VE had on "vocational training of people with learning disabilities" (Rose, et al., 2000). The investigation inspected whether individuals who suffer from learning disabilities enjoy interacting with a VE and examined if "active learning" would be a more effective way to transfer skills to the "real world" than "passive observation". The scenario that was presented to the learners involved them being placed in a bungalow where they had to search to find a toy car, which was placed in one of the "four inter-connected rooms". The results retrieved for this investigation are shown in *Table 2 - Results of Active vs Passive Participation in a VE* (Rose, et al., 2000).

	Active Mean	SD	Passive Mean	SD
Spatial Recognition Test	11.07	2.66	8.13	2.53
Object Recognition Test	10.27	2.15	10.73	3.96

Table 1 – Results of Active vs Passive Participation in a VE

The results displayed in the table above show that the individuals that were actively participating in the VE led to an enhanced spatial and object recognition of the specific virtual environment that was provided, which was higher than the individuals that were passively participating (ibid).

2.4.6 Advantages and Disadvantages of Video Games

A study was carried out by the National Literacy Trust ('NLT'), to determine what effects video games had on children's literacy at schools. The survey pool consisted of 4,626 students who were aged between 11 and 16 (National Literacy Trust, 2020). The results provided from this study that several personal skills were fostered. One of these personal skills increased was confidence in reading. The results for this showed that 1 in 3 children (35.3%) had better reading due to playing video games (ibid). Another personal skill that was improved was an increased level of empathy as 65% of children that played these video games stated that it helped them imagine what it was like to be another person (ibid). Finally, one of the biggest issues faced in recent times was COVID-19 and specifically lockdown. Children who had to work from home struggled with their social lives, which led

to a decrease in children's general life satisfaction (Christner, et al., 2021). The study from the NLT showed that children struggle to deal with "stress" or "difficult emotions" and to rectify this, 59.6% of children who were playing video games during lockdown with friends and family showed an increase in mental health (National Literacy Trust, 2020).

Although there are many advantages to using video games in education, as mentioned in the sections prior, there are many disadvantages to take into consideration as well. One of the biggest issues in individuals playing video games, in general, is addiction. Addiction is defined as "not having control over doing, taking or using something to the point where it could be harmful" (NHS, 2021). This has been recognised as a problem that is rapidly increasing in individuals of all ages and the side effects can include "loss of interest in individual activities", "gaming to escape or relieve anxiety", and "loss of relationship, educational, or career opportunities" (Clement, 2021). A survey was conducted on 4,000 individuals in the United States displaying the "distribution of video gamers in the United States in 2021, by age group" (ibid).

As displayed in Appendix A – *Graph Displaying Age Percentage of Video Game Players*, 20% of participants of the survey aged 18 and younger can provide figures of "nearly one in 10 of the gamers (8.5 percent) to be pathological players" which is defined as "causing family, social, school or psychological damage because of their video game playing habits" (Iowa State University, 2009). To stop this, in future work A-Wear VR would use a feature to stop the user using the application after a certain timeframe.

2.4.7 Unreal vs Unity

The two main game engines are Unreal Engine and Unity. There are many benefits in using either of these game engines, such as they are both free to use and they can both develop applications on the Oculus Quest 2 (VR headset). Unreal Engine has been used by the developer of this project several times before, and therefore is familiar and comfortable with the user-interface ('UI') provided. The main advantages for developing within Unreal Engine include: the graphic quality of the engine is "amazing and workable", and the tools and options are continuously updated to stay competitive (EDUCBA, 2022). Furthermore,

the Epic Games assets store is linked to Unreal Engine and can be used for their assets to be put within the application for free. Unity on the other hand is predominantly used to develop 2D and 3D games, the graphics quality is excellent, and finally also has a straightforward design so that users can use the UI easily (Juegoadmin, 2022). As the developer has experience in developing a VR application within Unreal Engine, the Epic Games assets and also for use on the Oculus Quest 2, the developer has then decided to create the application within Unreal Engine.

2.4.8 How can Audio be used in Video Games

Whilst conducting a deep dive into what type of audio can be used in video games to help children who have ASD, the research found proved that the theme of nature can be a "healer for autistic children" (Barakat, et al., 2019). It also goes on to state that using audio from nature such as a waterfall can have a "calming effect for hyper reactive children with ASD" (ibid). By using the VR experience is this application, the user is spending time in nature. This has many cognitive advantages, one of which is the ability to reinforce collaborate skills (ibid). This will help primarily in developing the communication skills as outlined by VESVET (VESVET, 2021). Moreover, there are mental benefits for the nature setting of this application that is further reinforced by the audio of the waterfall. This audio will help fully encompass the users senses and therefore help reinforce positive feelings associated with being outdoors (Barakat, et al., 2019).

2.4.9 Score System and Positive Reinforcement

Score systems are an integral part of any video game as it provides the user with "an engaging experience as they serve as motivators for the player" (Holmberg & Modee, 2021). A good score system should also always have a "considerable influence on the satisfaction of players during gameplay" (Lee, et al., 2017). The reward mechanism for any educational video game should also be created in such a way that when the user gains any form of reward there is an "instant gratification, which in turn reinforces that neural circuit in the brain" (Vu, 2017).

2.5 Conclusion for Research Questions

In conclusion, through working alongside the guidelines and methodologies set in place within VESVET and REVEAL - including sub-competencies, hard and soft skills, and Plan-Do-Check - these will be combined to understand what is needed within the project to create a successful game and surpass expectations. The aim of developing an SG is to be effective for participants of young ages, in order to fulfil its objective of helping children with learning difficulties by activating the hippocampus in in order to help foster long-term memory retention to aid educational purposes.

Using VR in education has been proven to be an effective method to present the application of this project. To prove this, a test will be conducted following the same concept as used by Allcoat and von Mühlenen (2018). Moreover, focusing on the aspect of constructivism this will demonstrate how participants receive information through doing the exact task in order to obtain the knowledge. An experiment conducted at the University of East London showed that individuals who actively learning during the trail, through participating fully in the scenario, led to them having enhanced spatial and object recognition. The study also examined if active learning would be a more effective way to transfer skills into the 'real world' than passive observation. This has helped the development of the SG because the research demonstrates that in order to positively impact the learning retention of children with learning difficulties, a game must be created that encourages active learning through scenario-based activities.

In addition a dive into audio and how it can be used in video games provided important results. It focused on how children who suffer from learning disabilities when listening to nature sounds yielded as a "healer for autistic children" (Barakat, et al., 2019). This could then help with the development of the application as adding nature sounds could help with attention for these users. Furthermore, a score system must be made sure that it is made to be a positive reinforcement and not degrade the user who uses the application by reducing their total score.

The advantages of video games include increased reading, higher levels of empathy, and increased mental health during the COVID-19 lockdown. However, it should be noted that one serious disadvantage to video games is addiction. It is recorded that one in ten childred aged eighteen or younger are pathological players (Iowa State University, 2009). Nevertheless, this study concludes that the benefits outweigh the negatives in this situation, in order to best help children with learning difficulties foster the necessary skills outlined by REVEAL to be the most beneficial in professional working environemnts. Overall, based on the research provided SG would be an effective aid for education within VR.

2.6 Existing Solutions

Solution	Description	Key Features	Console
Job Simulator	Job simulator is a VR video game that is based in the future in 2050. The main premise of the application is that robots have taken over the jobs in the world, and the purpose is to step up and learn what it was like to work in a job. By experiencing this game the users can understand what is like to try different jobs such as work as a chef, in an office or even a convenience store (Owlchemy Labs, 2022).	Try working either professionally or unprofessionally in a multitude of jobs that range from: • Gourmet Chef • Office Worker • Convenience Clerk • Mechanic	1. HTC Vive 2. Oculus Touch 3. PlayStation VR 4. Oculus Quest 5. Valve Index
AltspaceVR	"AltspaceVR is the leading platform for the live virtual events, empowering artists, brands, and businesses to easily design meaningful experiences that foster community and connection" (AltspaceVR, 2022).	Within AltspaceVR provides the user with daily events that can be created by the public. These events can include: • Meetup • Show • Class or Lecture • Entertainment	1. HTC Vive 2. Oculus 3. Windows Mixed Reality 4. Desktop Mode
ClassVR	ClassVR is an educational tool that is used on both VR and AR and "is a groundbreaking new technology designed to help raise engagement and increase knowledge retention	The different age ranges include: • 4-7 • 7-11 • 11-14	N/A – Create their own devices.

	for students of all ages" (ClassVR, 2021). One of the main categories of ClassVR is the vocational courses for students that are 18+.	• 14-16 • 16-18+ The courses in the vocational courses for 18+ include: • Experiencing Workplace • Learning Skills • Situation Understanding	

Table 2 – Existing Solutions

2.7 Moving into *Chapter 3 – New Ideas*

Within *Chapter 2* there has been a deep dive into existing research the in the forms of a literature review that answers research questions that will be used to understand what is needed to be implemented within a Video Game or VR application, and additionally existing solutions that look into projects that are already in the market and accessible by the public. This research conducted will used in *Chapter 3* to help guide and create a planning document that will consist of the key features that will be used in the implementation phase of this project.

Chapter 3 – New Ideas

3.1 Introduction

Chapter 3 will detail the methodology followed; the task and deliverables that establish the key points of development and how it will be done; the time plan that will display the lifecycle of the development process in a Gantt chart design; the key risks that could occur and how to mitigate them; the key aims and objectives and when they need to be completed by; the project planning document which will display some ideas that could be used within the actual VR project shown through multiple figures; functional and non-functional requirements; user testing for feedback on what changes can make the key features surpass the current plans; and finally UML diagrams displaying the functionality of the application.

3.2 Project Methodology

For the purpose of this project, the methodology that is being followed throughout is the Waterfall methodology. The breakdown of this project is linear, meaning that the 'phases' will occur successively. One of the main purposes using this methodology for this project is that the structure focuses down the avenue of developmental side rather than financial. The benefit of using this methodology is that the requirements detailed are stated clearly and accurately, structuring the phases would lead to less issues arising and additionally, the product release date will be calculated before development (Lvivity, 2018).

These aforementioned phases include requirements, design, implementation, verification, and maintenance and is displayed in Appendix B – *Waterfall Methodology.* The requirement phase focuses on the defining the main ideas behind the project plan and includes setting the aims and objectives, the project risks and time plan (Gantt Chart). The next phase in the linear model is design which focuses on the planning overview of the project and what physical features will be implemented within the project. The subsequent phase will be implementation. This will focus on the development phase of the project, commonly known as the shortest phase as the research has already been collected After implementation, the product must be tested and verified to make sure that it is doing what it is meant to, whilst

making sure that it provides a good user experience. After these issues are located, they are fixed to the design specification. Once all of the prior steps are completed the product enters its next stage of its life cycle that is deployment and maintenance that means the product is deployed for the customers to access, whilst continuously being maintained to achieve updates and new versions of software.

3.3 Tasks and Deliverables

Task No.	Task Title	Task Explanation
1	Literature Review ('LR')	Submission of the initial LR that provided background research into the project field.
2	Updated Literature Survey and Project Planning Document ('UD')	Submission of UD provided the project plan of what is needed for the development of the application in terms of aims and objectives, tasks and deliverables, risks and mitigations, sources of information, professional issues, and a time plan.
3	Review Research	Reviewing the research that has been conducted and understanding what is needed to be implemented in the project to make it successful.
4	Developing Scenarios	The scenarios are the background story that is being told in the level and the path that the player will have to follow. This will consist of multiple options and therefore multiple scenarios need to be created.
5	Designing Storyboard for Scenario	The storyboard of the scenarios will show the physical design of the scenarios through a 2D drawing and a write up of each image explaining what will occur within this scenario.
6	Feedback on Scenario	A questionnaire will be created to receive feedback on the quality of the scenarios that have been drawn up. The feedback will help the developer understand where the scenarios need to be improved.
7	Create and Locate Assets Packs	The asset packs must be created manually using software such as Autodesk 3ds Max, or locating the assets using a variety of online stores.

8	Testing – Phase 1	Testing phase 1 includes user testing. This will include showing the users what type of audio is going to be used in the application and what the template layer looks like and what they would like in improve.
9	Create and Locate Audio Files	The audio files will be created by recording an individual's voice using a microphone connected to the developer's PC that will use a preinstalled recording application. Some other audio files will be located on the internet from free audio websites.
10	Set up Unreal Level Environment	The developer must set up an initial Unreal Level Environment where all the VR application development will occur.
11	Design Template of Level	A template level will be created that will consist of the scenario mechanics, sample assets and audio files to make sure that the background of the application is created for future development.
12	Testing Template Level	There will be continuous phases of testing throughout the development of this project to make sure that the risk of the application crashing is minimal and therefore the user satisfaction is increased.
13	Feedback on Level	The level will be tested by users and will again provide feedback through a questionnaire.
14	Testing – Phase 2	Testing phase 2 would include a second stage of user testing to see what needs to be changed after the first stage of development. Additionally, there is going to be functional and unit tests to make sure that all the functionality in the application is working the way it should do.
15	Writing Report	The report must be kept up to date throughout all phases of application development, to make sure that everything has been implemented correctly.
16	Submission of Project	The submission of the project is when the application and document must be handed in.

Table 3 – Tasks and Deliverables

3.4 Time Plan

The time plan is the structure that allocates a certain amount of time to a specific task so that the project schedule is completed on time and not overwhelming. As displayed in Appendix C – *Gantt Chart*, each red block as shown in Appendix D – *Key for Gantt Chart* shows whenever the developer has to hand in a specific piece of work. The milestones for this project are shown in Appendix E – *Project Milestones*.

3.5 Sources of Information and Resources Required

3.5.1 Sources of Information

Google Scholar: Reading published papers will be used to help create a background understanding of what will be needed to create a flourishing application.

Case Studies: Case studies can be used to understand the previous research that has taken place. This will include research into the background of the term SG and how it can be applied within the sphere of VR to create the optimum educational game. This will be looked at in greater detail throughout Section 2 *Literature Review*.

Focus Groups: A focus group is used to help establish if the application has been created effectively for its purpose. When using a focus group for this project, the questions will be designed to establish if children with learning difficulties have developed the personal skills originally outlined in the objectives of the games.

Interviews: Using one-to-one interviews will allow the developer to have a conversation with an individual who has used the game to get feedback on if the VR application being developed can be enhanced. There are multiple ways that this interview can be taken, but the approach within this project is a semi-structured interview. This will allow a set of generic questions to be pre-planned by the interviewer, designed to allow for open-ended conversation. These questions would be a variation between close-ended questions that would require a short answer and open-ended questions will encourage free-flowing conversation (Dennis, et al., 2014).

Questionnaires: Questionnaires are a very effective way of retrieving information to help increase the features within the VR application. Each question must be "tailor-made to fit [the] research project, including a series of questions that address the topic of interest" (McLafferty, 2003).

3.5.2 Resources Required

Unreal Engine 4: Unreal Engine 4 will be the main development platform that the application will be designed on.

Oculus Quest 2: Oculus Quest 2 is one of the most up-to-date models of VR devices. This VR device has been selected for this project as is extremely light and has a higher processor and can therefore provide a better overall display, leading to the application looking more realistic.

Desktop Personal Computer ('PC'): The developer will be using their PC to download different software's to develop the application on, such as Unreal Engine 4.

Microsoft Word and Excel: The documentation for this project will be created using Microsoft Word. The use of Microsoft Excel will be used to develop the Gantt chart which will display the layout and the time frame that each section of the project will be completed by.

Autodesk 3ds Max: 3ds Max will be used to create the assets that will be used within the VR application.

Bandicam: Bandicam will be used to record google translates text-to-speech feature for the scenarios for users to listen to.

3.6 Project Risks

The project risks will look at the issues that can occur whilst develop an application in VR. Each section will consist of a risk, the severity and how it can occur, the likelihood, the risk impact, and how this risk can be mitigated. The likelihood and risk impact will range between **1** and **10** (10 being the highest probability/impact respectively). The scale is

determined by the developer of the game and based upon opinion. The objective of the mitigation plan is to assess the risks and how best to overcome them.

3.6.1 Time Management

One of the biggest risks of any project is time management. This can occur when a project has no specific time plan. By outlining a time plan, specific tasks can be completed and improved, allowing for the game to be developed to the highest ability. Not having a time plan can delay tasks and cause the project to not be completed. The severity of this is extremely high, as this will cause tasks to need to be completed quicker and therefore create something of inferior quality.

- The likelihood of this occurrence is **9**.
- The risk impact of this occurrence is **9**.

A way to prevent time from being an issue in this project is to make sure that the Gantt chart created by "[visualizing] beginning dates, ending dates and the important duration parameters helping to track various projects over specific time periods" (Bednjanec & Filipović Tretinjak, 2013).

3.6.2 Data Loss or Corruption

Data loss or corruption can occur for a variety of reasons, some of which cannot be retrieved or fixed by the developer. The severity of this is extremely high as if the data is lost or corrupted it can lead to restarting a section from the beginning or restarting the whole project. 67 per cent of data loss or corruption occurs due to memory drives failing, 14 per cent is caused by human error, and 10 per cent is due to some sort of software error (Consolidated Technologies, Inc., 2021).

- The likelihood of this occurrence is **7**.
- The risk impact of this occurrence is **9**.

The main way to prevent data loss or corruption is by making sure that the data is continuously updated and stored on multiple storage devices to make sure that if data loss

or corruption occurs, the data can be retrieved from the last updated state rather than restarting the project.

3.6.3 Technology Error

Technology errors can put a strain on the development of a project, resulting in issues such as being unable to access specific applications that the developers are currently working on. The severity of this is medium because the developer is unable to continue developing the software due to this limitation.

- The likelihood of this occurrence is **6**.
- The risk impact of this occurrence is **6**.

Technology errors can be resolved by simply connecting to another computer on university campus that has the application installed. The data can be saved on a hard drive, which can then be uploaded onto that computer, allowing the developer to continue working on their project.

3.6.4 Large Project Scope

There is a concern that the project is too large and there is a lot to complete in a short time frame. However, the time plan has been implemented to avoid this, therefore the severity of this is medium. Failure to comply with the time plan can lead to delays and affect time management.

- The likelihood of this occurrence is **5**.
- The risk impact of this occurrence is **4**.

To stop this from occurring, there is a time plan and an order to complete the project in order of importance. An effective method for this is MoSCoW (Must, Should, Could and Would), using a clear set of requirements and ranking them from most to least essential (Haughey, 2021).

3.6.5 Force Majeure

Force majeure events are "defined as certain acts, events or circumstances beyond the control of the parties, for example, natural disasters or the outbreak of hostilities" (Practical

Law Commercial, 2022). The severity of this is extremely high and can lead to a multitude of issues that may be out of control for the developer, and an example of this is the recent COVID-19 pandemic.

- The likelihood of this occurrence is **3**.
- The risk impact of this occurrence is **9**.

There is no exact way to mitigate this risk as these events are unavoidable and therefore unpreparable.

3.6.6 Recruiting Participants

For this project, there is a need for continuous development and testing that is helped by the feedback received by individuals that are willing to test the project and to give a response on what they would recommend should be implemented to create a more efficient product.

- The likelihood of this occurrence is **5**.
- The risk impact of this occurrence is **5**.

Although educational facilities are closed, there are some individuals that are interested in giving feedback on this project. If feedback is not received although not vital, it would limit how efficient that project can reach as it will only include one individuals vision.

3.6.7 Cost

One of the biggest issues surrounding about a project is the overall cost. The cost for this project can range from anywhere from assets and animation creation, to creating good useable audio files that have to all be created using specific software, most of which are not free to use.

- The likelihood of this occurrence is **3**.
- The risk impact of this occurrence is **7**.

The main way that this risk will be mitigated is by making sacrifices in the overall aesthetics of the project by using pre-made free animations and basic audio files that may not be of the best quality, therefore producing a lowered design.

3.6.8 Psychological Factors

As A-Wear VR is targeted for children between the ages of 7-14 years old, studies have shown that video games can lead to a continuous hyperarousal. Hyperarousal can include "paying attention, managing emotions, controlling impulses following directions and tolerating frustration" (Luker, 2022).

- The likelihood of this occurrence is **5**.
- The risk impact of this occurrence is **7**.

To mitigate this risk, a feature will be added that quits the application if the user has been on it for over 30 minutes.

3.7 A-Wear VR Design Ideas

3.7.1 Game Overview

A-Wear VR is being created for the sole purpose to help children that have learning disabilities develop and foster personal skills. These skills have been carefully selected using VESVET's guidance on the main skills people need to thrive in a professional environment or even in their personal lives. One of A-Wear VR's key objectives is to implement the key skills or sub-competences (VESVET, 2021) that are being focused on within this project are autonomy, problem-solving and communication. A-Wear VR will consist of developing these aforementioned personal skills by using VR and SG as mentioned prior in *Chapter 2*.

VR has been chosen as it will provide an immersive environment, which will help the user transport into the situations and develop their skills more effectively. This is based on Vygotsky's work on the ZPD (Vygotsky, 1978), with the scenario-based levels helping the user progress in what they can do alone whilst also assisting with what they cannot do alone. Moreover, the use of VR will help employ a child-centred approach to learning, in

which the user creates their own learning environment and can therefore make better connections between the application, the skills, and the real world. Through emulating real-life scenarios, the user can learn at their own rate whilst also seeing how these skills can be applied outside the application.

These skills were decided after a deep dive into research papers resided in the literature review within *Chapter 2*. To summarise, VESVET (VESVET, 2021) defines these skills as essential for a better work life balance and personal and professional growth.

3.7.2 Core Objectives

Objective No.	Objectives	Goal	Estimated Deadline
1	Recognize information in the LR that can be added into the project.	Conduct a deep dive into different sections of research. This can be used within the project to understand gaps in the market that are not saturated, which can then help provide a service for children with learning disabilities.	9th May 2022
2	Understand how VE can help people with learning disabilities.	Within the research conducted in the LR, looking into how VE can be used within the project being developed and how the user (child) can interact with the VE and make sure that using these environments can be used as an effective form of obtaining information.	30th May 2022
3	Develop a VR application that would use SG.	Additionally, whilst conducting the literature review produced an understanding of what a SG is and what the key factors are that are implemented within vocational training. The goal for this is to make sure that the VR project follows the guidelines set in place to achieve a successful SG.	22nd July 2022

4	Features that are implemented into the project will help develop children with their personal skills with the use of the LEVEL 5 Validation System.	Focussing on the different personal skills mentioned within LEVEL 5 Validation System is an intricate part of this project as adding these specific sub-competences (autonomy, problem-solving and communication) need to be a consistent theme throughout the project and to make sure that are continuously related to.	22nd July 2022
5	Test the VR application to search for bugs that need to be fixed.	After the project has been developed, the VR application will go through many stages of testing to make sure that all the bugs are removed. This will mostly be completed both performance and user testing for the maximum feedback.	15th August

Table 4 – Project Objectives

3.7.3 Game Structure

A-Wear VR is structured as a scenario-based VR interactive game, where the user will be given a situation and they will be encouraged to create understanding of their surroundings. These levels will be based on the skills of autonomy, problem-solving and communication. Each scenario will focus on a specific skill. The user will then be given choices of which action they would like to take. There will be five different sections given within every scenario with each option providing four different decisions. After a certain scenario is completed, it will show the user how well they did by showing them their score. There will also be an explanation about why the right answer is correct. The goal is for the user to be able to self-reflect and realise why this is the right answer. By allowing the user to make these connections by themselves is a central part of the child-centred learning approach of the game, as outlined previously. If the user cannot make meaningful connections on their own, they will be limited in the development of the personal skills the application is aiming to develop. The user will make more meaningful connections the more they play and therefore develop their autonomy, problem-solving and communication skills.

3.7.4 Distinctive Features

A-Wear VR has multiple distinctive features. One of which is the option for the user to edit in application settings. This was created with the audio in mind. Background music has been added to the application because studies show that "music without lyrics is preferable because songs with lyrics are likely to reduce worker attention and performance" (Shih, et al., 2012). This will allow the user to be able to adjust the music volume to their personal liking. This was done because children with learning difficulties may find it easier or harder to concentrate with background music. Whilst one user might find the music to help their concentration, the next user might find it a distraction. This way the user can create a personalised environment that is conducive to their own learning preferences.

In terms of audio, the user can also adjust the volume on the water fall sounds. The waterfall sound is there to act as either white noise or a calming visual for the user. White noise is particularly beneficial to users of have attention deficits, who are easily distracted by any outside noise. The use of white noise can also act as a relaxation technique, which will help the user feel more comfortable when using the application. By allowing the user to adjust the water fall noise and the music separately, the application is more flexible for different users with different needs. Furthermore, waterfall sounds were used within the application as research showed that nature sounds had a "calming effect for hyper reactive children with ASD" (Barakat, et al., 2019).

Moreover, the user has an option to include a voice over in the game. This is to cater to users that may be visually impaired or have dyslexia and struggle to read. However, voice overs have another impact in VR games. Voice overs can help bring the application to life and give it a personality. By having a voice over, the user can have a friendly voice to relate too. By having the voice over be an option, this gives the application another adaptability to help cater to individual learning needs of the user.

3.7.5 Reward Mechanism

A-Wear VR's reward system will allocate points based on the 'most irrelevant' answer to the 'most correct answer. Once the user has picked their answer, they will be awarded points, one to four, based on this scale. The 'most irrelevant' answer would receive **one** point. The 'second ranked' answer would give the user **two** points. The 'less correct' answer would gain **three** points, and finally the 'most correct' answer would help the user obtain **four** points (the maximum amount). The summation of the results will be shown at the end of the scenario. This will allow the user to see how well they implemented the skill and if they need to revisit this later or if they are ready to move onto the next level. The more the user plays the game, they should see their score steadily increase. An increased in score will indicate to the user that they are developing and fostering autonomy, problem-solving and communication. This will give the user confidence and they will begin the implement these skills into their own lives.

3.7.6 Control Mechanism

A-Wear VR will be played on the VR device – Oculus Quest 2. The user will use the two controllers provided with the Oculus Quest 2. They will be able to move with the thumb sticks on both controllers. The left thumb stick will allow them to move forwards, backwards, left and right, whereas the right thumb stick will allow them to rotate their camera left and right. These features of the Oculus Quest 2 controllers are shown in Appendix F – *Oculus Quest 2 Controls*. Unfortunately, this application will not be able to be used by people who have certain physical impairments, mainly those who have dyspraxia and struggle to complete fine motor skills.

3.7.7 Interface Mechanism

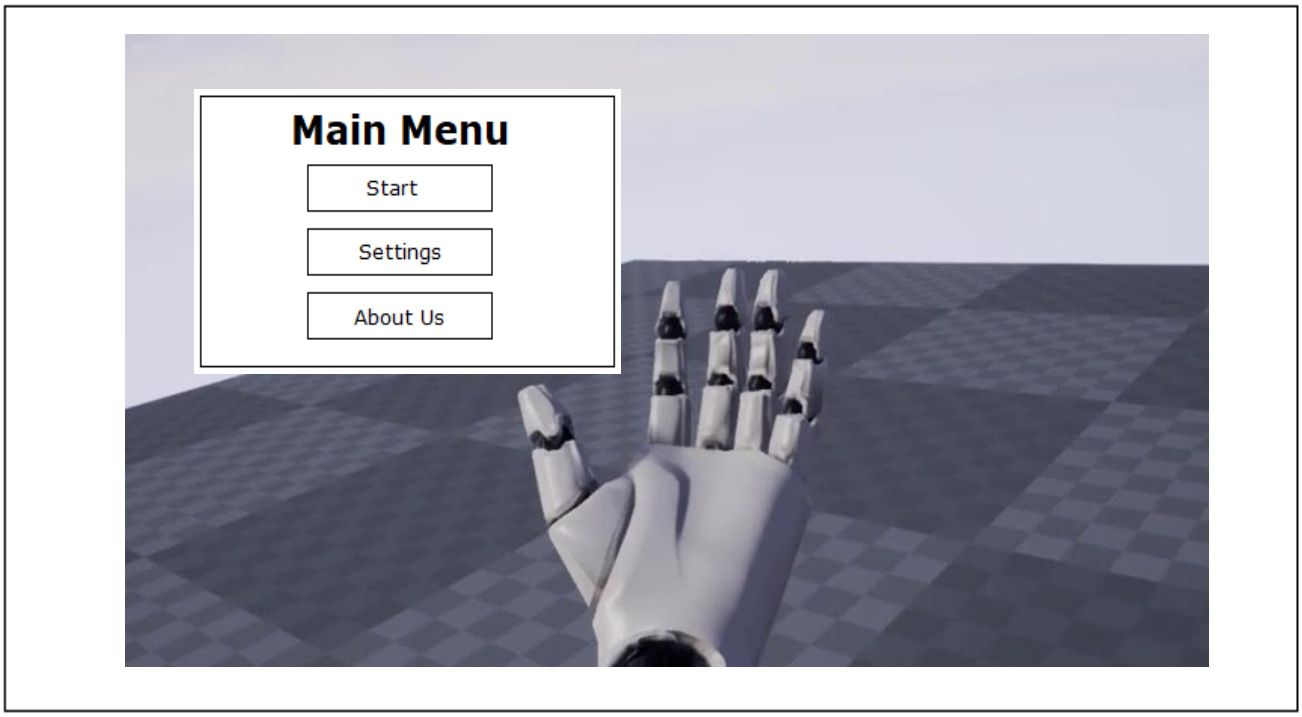

Figure 1 – Main Menu Interface Mechanism

In A-Wear VR the user will be displayed with a main menu that will direct them to the specific page they would like to enter. This could be settings or the different scenarios. The buttons will be clickable and functionable to allow for the user to easily manoeuvre between different functions. When the user enters the scenario, a piece of scene will be presented in front of them. After, the user will have to select an answer to then lead them onto the next part. Each scenario will have five parts within to answer.

The interface will also include visuals of a tropical island to help encourage relaxation and provide the user with a calming experience. This background will be present throughout the game as to not induce a sensory overload to the user by constantly changing their environment. A constant change in the background could result in a feeling of motion sickness. This is something the application aims to minimalize through having the consistent tropical island background. The audios are also linked to this background to help create a calming learning environment.

Displayed in Figure 2 – *Interface Mechanism of A-Wear VR* shows a basic image designed on Paint that displays how the main menu will be used by the user. The main menu will be

connected to the users' hand and can be opened and closed by a click of a button. This main menu would display the key features of the application which will be explained in *3.7.8 Storyboard*. The user will then click a button on the Oculus Quest 2 controller whilst pointing at one of these options.

3.7.8 Main Menu Functionality

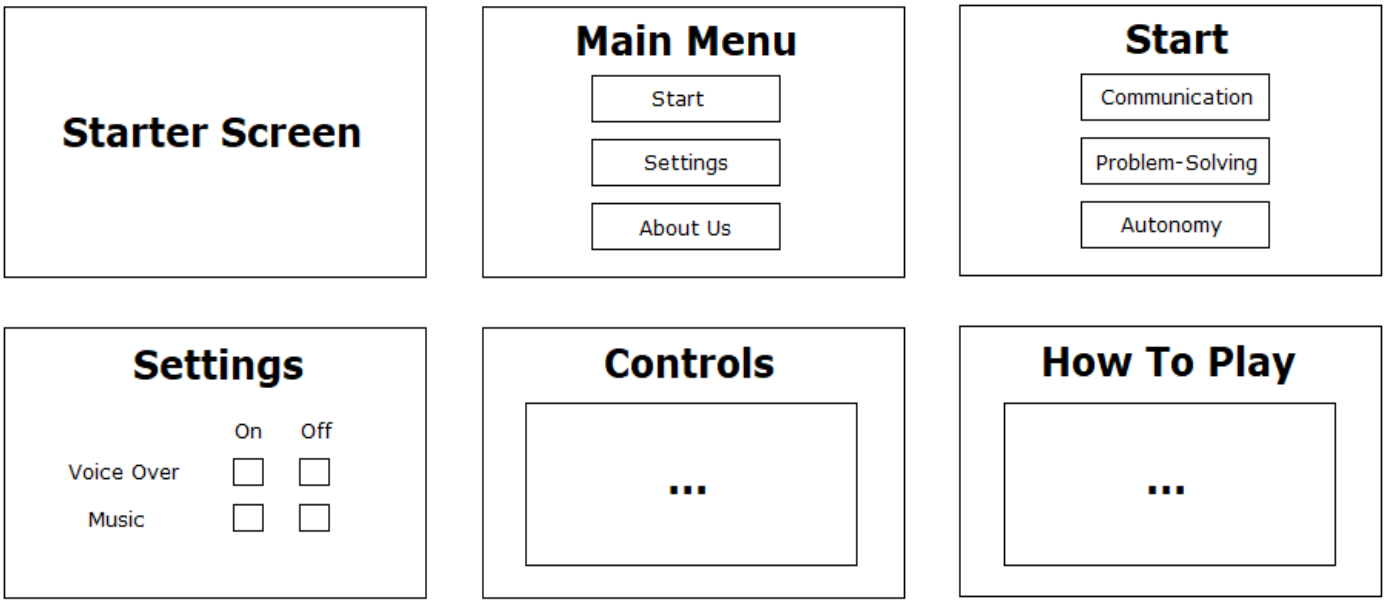

Figure 2 – Main Menu Functionality Layout

Figure 2 – *Main Menu Functionality Layout* is broken up into six separate sections and consist of the starter screen, main menu, start, settings, controls and how to play. The starter screen will be displayed when the user selects to open the main menu up by twisting their wrist (as displayed in shown in Figure 1 – *Main Menu Interface Mechanism of A-Wear VR*). After the starter screen is shown the user will have three options that they will be able to select.

The first option is the start button which would load up the 'start game' menu which would lead the user to have another selection which is the type of skill they would like to improve, and when one of the options is clicked, it would direct them to that specific game level. The second main menu option is settings which would direct the user to a page where they would be able to select whether the voice over's, SFX (Sound Effects) or music in the background is on. The final selection is that of the 'about us' section which would explain

why the project was created and what the purpose of the study is. When the main menu is being displayed to the user, there is a small section which is always on display that would help the user to understand what the controls are from the application and how to play the game (game structure).

3.7.9 Scenario Gameplay

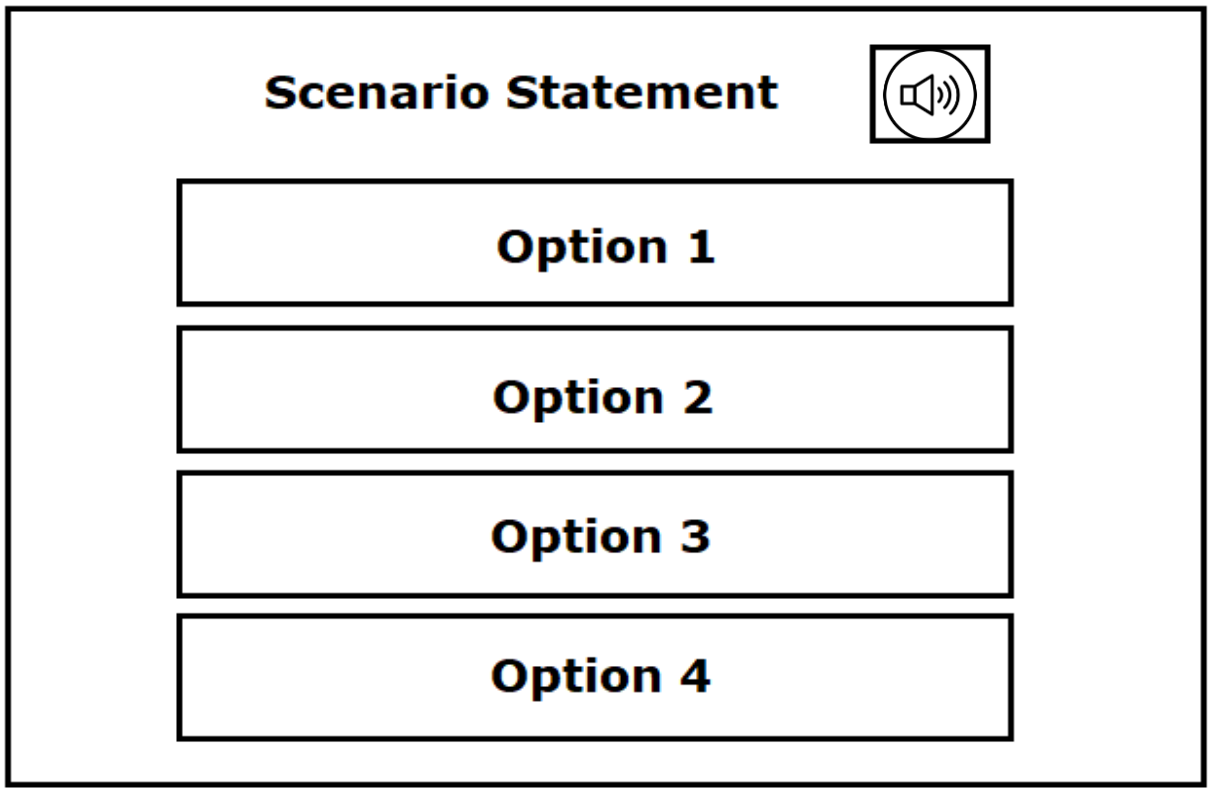

Figure 3 – Scenario Gameplay Layout

The scenario gameplay (as displayed in Figure 3 – Scenario Gameplay Layout) is simplistic in nature so that it does not provide a level of confusion on how to manoeuvre throughout. As shown on the top of the design, there is the scenario statement, which will display the scenario that the user will have to answer with one of the four options. Each option will give the user a certain score determining on which option is more responsible response. Furthermore the user will be able to interact with the button on the right of the scenario statement, and in doing so will play a voice over of what is written in the scenario statement.

3.8 Functional and Non-Functional Requirements

3.8.1 Functional Requirements (FR)

Main Menu:

FR1 – There is a guide to how to use the controls and manoeuvre through the application which will be displayed on the front of the main menu.

FR2 – There would be three buttons which included the start button, settings button and about us button as displayed in Figure 2 – *Main Menu Functionality Layout*.

FR3 – The main feature within settings is allowing the user to turn the volume within the game level down if they find it difficult to be around loud noises.

Gameplay:

FR4 – The user will be able to select one out of three buttons to choose what competency they would like to improve by clicking a that specific button.

FR5 – A text box and four buttons will be then displayed, and the user will select one of these options which they think is the best response to the scenario in the text box.

FR6 – Five different scenarios within this competency will be displayed.

Score and Results Screen:

FR7 – After the user selects a button, a certain number of points will be added to their score. The higher the better.

FR8 – A short text box will display whether the answer selected was good or bad and why that is the case.

FR9 – A text box at the end of the game will display the total score for that attempt.

Player:

FR10 – User movement is controlled by the Oculus Quest 2 controllers, which can move forwards, backwards, right and left. Furthermore can rotate left and right 45 degrees.

FR11 – The user can close the application by pressing the 'Quit' button.

Results:

FR12 – When the user selects an answer it will display it the answer is correct or incorrect.

FR13 – If the user selects the most reasonable answer, they will be given the most points.

3.8.2 Non-Functional Requirements (NFR)

Storage: As the project is designed for VR, the application is a large size of just under 3 Gigabytes ('GB'), so therefore the user must have at least a recommended space allocated to this application of around 5 – 7GB so that any future work that needs to be added or updated on the application can be downloaded in the allotted space.

Aesthetics: The aesthetics of the game level that is being developed would relate to the theme of nature and peacefulness. The colours and images that are going to be used are bright and colourful also to be appealing to the target audience of 7-14 years of age. These colours will not only be on the game level, but will be within the main menu which will help the user through the application by having the buttons coloured differently to the background of the main menu.

Performance: The most important aspect of any VR application is the Frames Per Second ('FPS'). For Oculus Quest 2 it is stated that it should be around 90fps (Bodleian Libraries, 2022). If the FPS is lower it can lead to multiple side effects on humans which include: "disorientation, nausea, and other negative user effects" (IRISVR, 2016).

3.9 User Testing (Phase One [New Ideas])

User 1 and User 2 personas are displayed in Appendix G – *User Personas*.

Question (What do you think of…)	User 1	User 2
Application Name	"I think it is a really smart name, as it sounds like awareness and when I hear that I think of learning and other forms of disabilities."	"I like it, very interesting."
Audio Ideas	"I really am excited to see how you incorporate audio into this application, both background sounds and voice overs."	"I really like nature sounds, like birds and waterfalls. That might be cool to add."
Main Menu Layout	"The main menu looks really easy to use which is perfect for your target audience."	"Looks easy to use. Some colours would be nice to add instead of just white and black."
Score System Ideas	"I find it very confusing; I think it would be easier just to have the score increase every time the answer is correct."	"Why are there so many numbers. If the answer is right, just add one."

Table 5 – User Testing (Phase One [New Ideas])

After looking at the user feedback for the Chapter 3 – New Ideas and the feedback showed from the users, some of the ideas being used for the implementation phase needed to be changed which does not include the name of the application. The users thought the name sounded interesting and had a smart meaning behind it. This means the name of the application does not have to change.

The main features that the users thought needed changing or adding are as follows. Firstly, the audio that can be included in the background needs to suit the theme of the application and study conducted shows that nature themes needed to be incorporated to create a peaceful environment. Second of all, the main menu could do with some colours just to be more appealing to the target audience of 7-14 years of age. Finally, the users found the score system quite confusing so it will be changed to plus one point for correct answers.

3.10 UML Diagrams

3.10.1 Flowchart Diagram

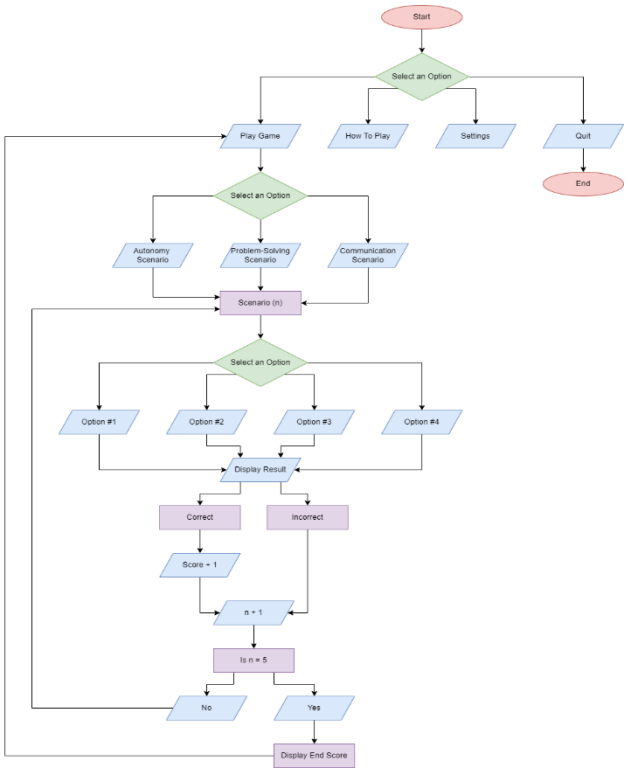

Figure 4 – Flowchart for A-Wear VR (Appendix N)

The flowchart (as displayed in Figure 4 – *Flowchart for A-Wear VR*) displays the functionality of what can be done within A-Wear VR. The application loads up and the user is presented with four options: play game, how to play, settings and quit. If play game is selected the user will then be shown with another decision where they would choose the type of scenario, they would like to compete which include autonomy, problem-solving, and communication scenarios. The application then checks how many sections of the scenarios the game has gone through by using the letter 'n' that is an integer for the number of loops. The user then has an option of what answer they would like to select out of four different variations of answers. The result will then be displayed and if it is correct, they will gain one point to the score, whereas if the answer is incorrect, they would not gain any points. The integer labelled as 'n' then increases by a value of one. After 'n' has increased, it is checked to see if it is equal to five, and if it is the game will end and the total score will be displayed but if not, the scenario will loop back to the question and go through the function again. When the user selects the quit option, the application will close.

3.10.2 Use Case Diagram

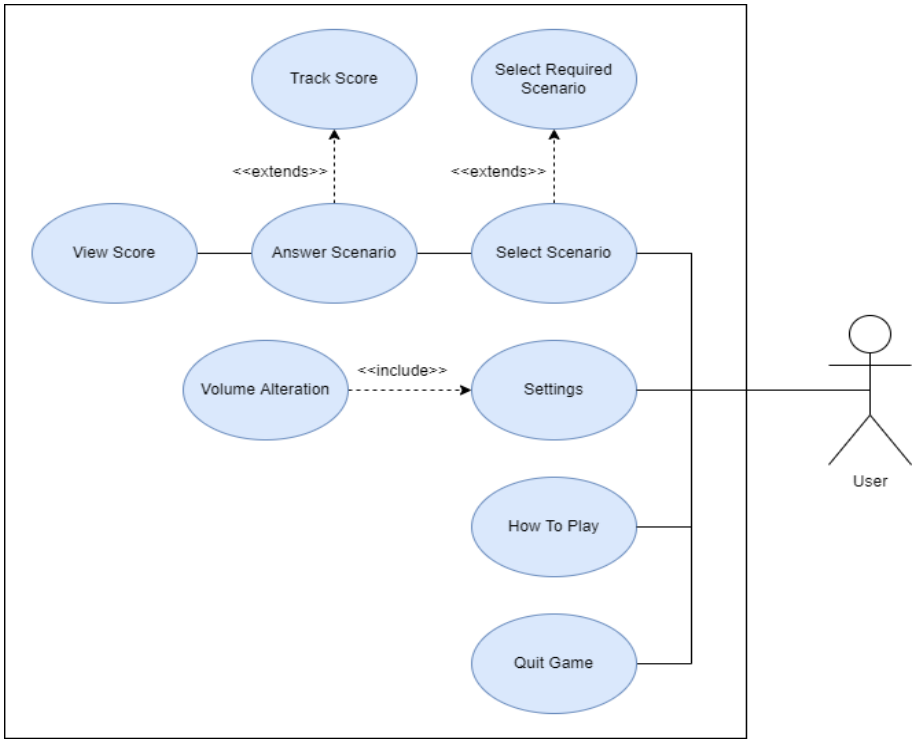

Figure 5 – Use Case Diagram for A-Wear VR (Appendix O)

The use case diagram (as displayed in Figure 5 – *Use Case Diagram for A-Wear VR*) displays how the user will interact with the system. The user has the option of selecting a scenario, where they must select a specific scenario. Whilst in the scenario they must answer a series of statements, in which they can also view how well they are doing by looking at the score. When the game is finished the total score is displayed on the screen. The user can also enter the settings page where they can alter the volume of the audio within the application. The user can also view how to play interacting with that button on the main menu. Finally, the user can close the application by clicking on the quit button.

3.11 Moving into *Chapter 4 – Design & Implementation*

Within *Chapter 3* the main ideas of the application have been decided and planned out to make sure that it can be developed within the duration of the Gantt chart (as displayed in Appendix H – *Gantt Chart*), whilst making sure of all the possible risks and how they can be occur/mitigated. Furthermore, to help with the implementation of the application, UML diagrams; flowchart and use case diagrams have been included to help organise how the functionality in the application will be structured.

Chapter 4 – Design & Implementation

4.1 Introduction

Chapter 4 will explain what key features have been implemented in the first stages of development; the user testing that has been completed to find ways to improve what has already been developed; the key features after the second user testing; and finally the test report that shows what features have been tested and corrected in the implementation of the A-Wear VR.

4.2 Key Features

No.	Key Features	What being it used for?
1	Main Menu	The main menu will be the main focal point of the application as this is where most of the application can be accessed from. This is explained further in 4.3.1 – Main Menu.
2	Scenario Buttons	Clicking one of these buttons will send you to the allocated competency scenario.
3	Scenario Scenes	From selecting an option from the scenario buttons, the competency scenarios will display that particular scenario.
4	Settings Button	The settings button allows the user to customers the settings within the application.
5	How to Play Button	The how to play button displays to the user how to play the game, and what is needed to be done to navigate through the application.

6	Quit Button	When the user presses the quit button, the application is closed.
7	Timer	A timer has been implemented at the end of each scenario section. This is explained further in 4.3.2 – Timer.
8	Audio	Audio has been implemented in the game level that will play continuously throughout the scene although the volume can be edited through the settings widgets. The audio files that have been implemented are: • *Waterfall sounds* • *Background music* • *Correct and Incorrect answers* • *Voice overs*.
9	Assets	The assets that have been implemented are: • *Low Poly Tropical Environment.*
10	Score System	The score system that has been implemented will give the user one point for each answer they get correct, and 0 points for the incorrect answers.
11	Movement	The movement feature that has been implemented allows the user to travel forwards, backwards, left and right. Furthermore the user has the ability to rotate left and right.

Table 6 – Key Features in A-Wear VR

4.3 User Testing (Phase Two [Implementation])

Question (What do you think of…)	User 1	User 2
Application Name	N/A	N/A
Font and Text Size	"I think the text size is way too small which makes it hard to see, and the font colour doesn't really complement the background of the main menu."	"I think it is ok if you move close to the main menu, although it could be bigger."
Level Layout	"I really like the special layout of the application as it is not too cluttered and therefore doesn't feel overbearing."	"It is very peaceful. I really like it."
Audio	"The audio that is in the background is a bit loud, and cannot be changed. I would say create something so that the user can alter the volume. Also I don't believe the music in the background suits the game aesthetic, so I recommend looking into that." "The voice over feature in the scenarios was a really smart addition."	"You listened to me; I really like the waterfall sound in the background."
Movement	"Moving around in the game is very basic and I have to actually turn around to see the rest of the application, maybe add a turn button."	"The instructions on how to move around is quite difficult."
Scenarios	"Very easy to understand."	"They are very easy to read. I also like the voice over feature, it really helps."
Main Menu Functionality	"Very simple to use."	"I like the colours you have added, the main menu looks like it is made out of water."
Score System	"Much more simplistic which is better."	"I really like it."

Table 7 – User Testing (Phase Two [Implementation])

Phase Two' user testing was conducted after the development of the following: basic level layout, audio files implemented, character movement, scenarios main menu, and score system. After the 'Phase One' of the user testing conducted for Chapter 3 – New Ideas, the feedback provided helped mould the application to create a more user friendly project by understanding what the User 1 and User 2 would have like to be changed or implemented at future dates. These included an amended score system and adding a peaceful soundtrack as the background music.

Although the 'Phase Two' of the user testing conducted for Chapter 4 – Implementation exhibited that the user were happy about the changes or additions, there were some features that needed to be changed. The highlighted issues brought up included:

- The text size was too small for both users so a main menu on the wrist was incorporated to help people look at the main menu with less strain on their eyes.
- An issue with was the audio. Feedback showed that the audio was way too loud at the start when the application was loaded, so the audio levels were reduced to accommodate this issue.
- The movement of the character in the application was very restricting so therefore added a feature where the user can rotate with the right thumb stick.

4.4 Key Features

4.4.1 Movement

A main part of A-Wear VR is the user having the ability to move the character within the application around. This has been developed to allow the user to move forwards, backwards, left, right and rotate 45 degrees either in the left or right direction.

When the user interacts with the left controllers thumb stick, the user can move in that direction. If the thumb stick has not been touched a branch function will calculate whether it has been touched or not. When the user presses the thumb stick down in any direction the axis value (float) will increase, and will then be multiplied by the move speed (float) set to '2.0' (as displayed in *Figure 6* – A-Wear VR Movement). The character will then be moved in that direction, and the further the thumb stick is pushed the faster the character will move. The only difference with the forwards or backwards and left or right blueprint is that one movement is designed for the X-axis (forwards and backwards), and the other is for the Y-axis (left and right). This is changed by instead of the forwards and backwards function getting the forward vector for movement, the left and right function uses get right vector.

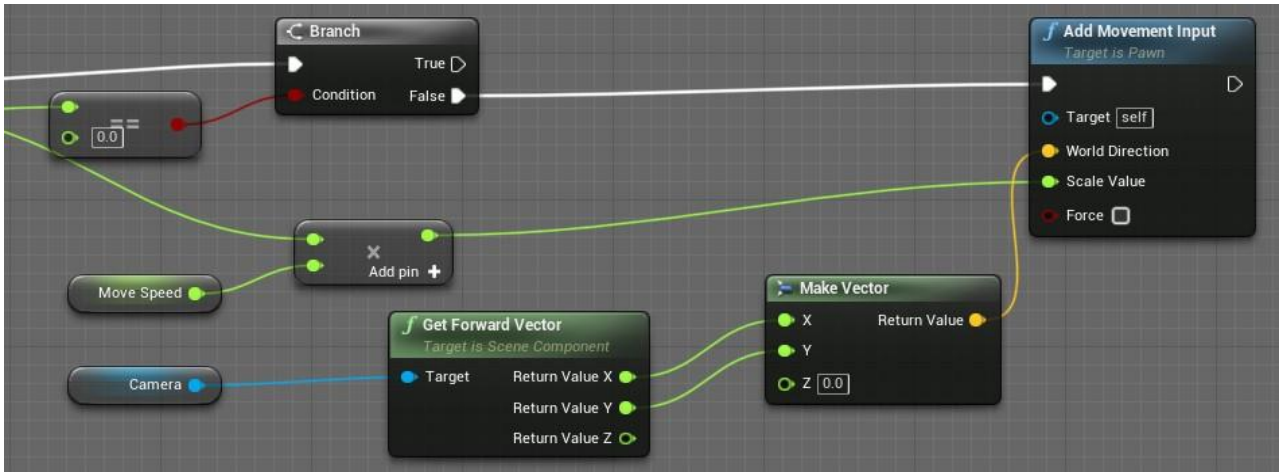

Figure 6 – A-Wear VR Movement

Rotation has been created by movement of the right thumb stick. When the user pushes the thumb stick all the way in one direction, the character will move in that direction. As prior, if the right thumb stick is not touched the character will not rotate. If it is pushed right the character will rotate 45 degrees in the right direction whereas if it is pushed left,

the character will rotate left 45 degrees in the other direction (as displayed in *Figure 7* – A-Wear VR Rotation). The feature will only happen once, and this is done by a do once flow control feature. This is so that the character will spin out of control and lead to the user becoming nauseous.

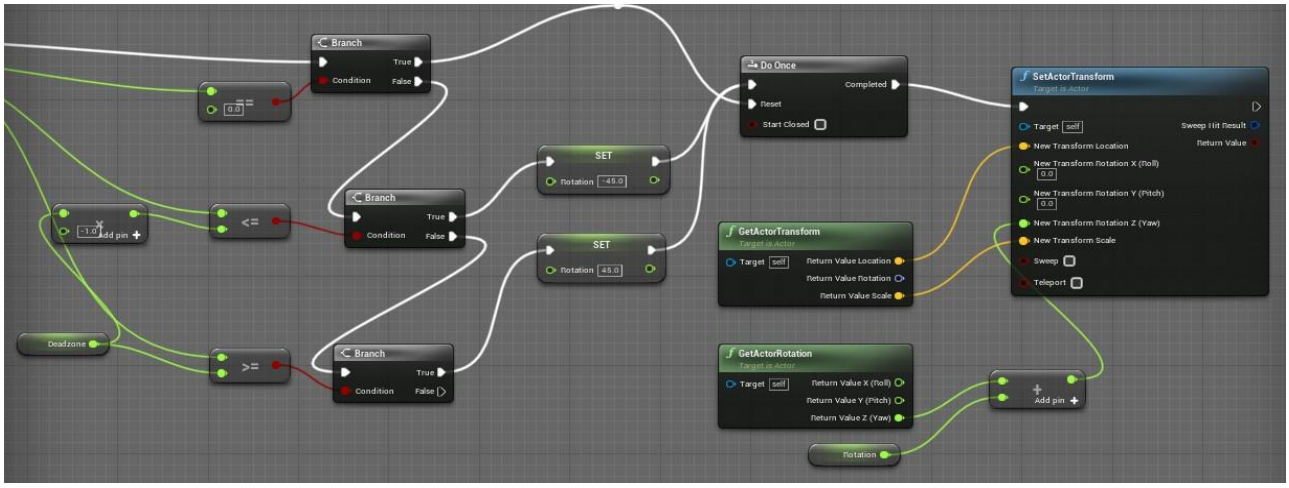

Figure 7 – A-Wear VR Rotation

4.4.2 Scenarios

A data table has been created where different rows are setup, this includes; rows number; the question; the answers; and the correct option (as displayed in *Figure 8* – Data Table for Autonomy).

	R	Questions	Answers	Correct
1	0	It's your best friends birthday party but you have an test the next day. Wh	("1. Don't go, the test is more important","2. Go to the party but leave early	3
2	1	The teacher asks you a question. You think you know the answer but you	("1. Refuse to answer the question","2. Start yelling at the teacher for pick	2
3	2	Your parents or carers think your best friend is a bad influence. Do you...	("1. Yell at your parents","2. Listen to them and keep a close eye on your b	1
4	3	You notice that the dishes in the dishwasher are clean. Do you...	("1. Put the clean dishes away","2. Walk away","3. Put dirty dishes in the d	0
5	4	Your parents or carers sign you up for a sports team. You go but don't lik	("1. Throw a tantrum everytime you go","2. Run away from your house","3.	2

Figure 8 – Data Table for Autonomy

The scenario blueprint first gets all the information from specific rows from the table (in the example [row = 0] as displayed in *Figure 9* – Get Information from Data Table). The columns are then broken apart as 'question', 'answers' and the 'correct' answer. The information is then set as particular text blocks. Which displays the information in the scenario layout (as shown in 5.3.3 Scenario Quiz).

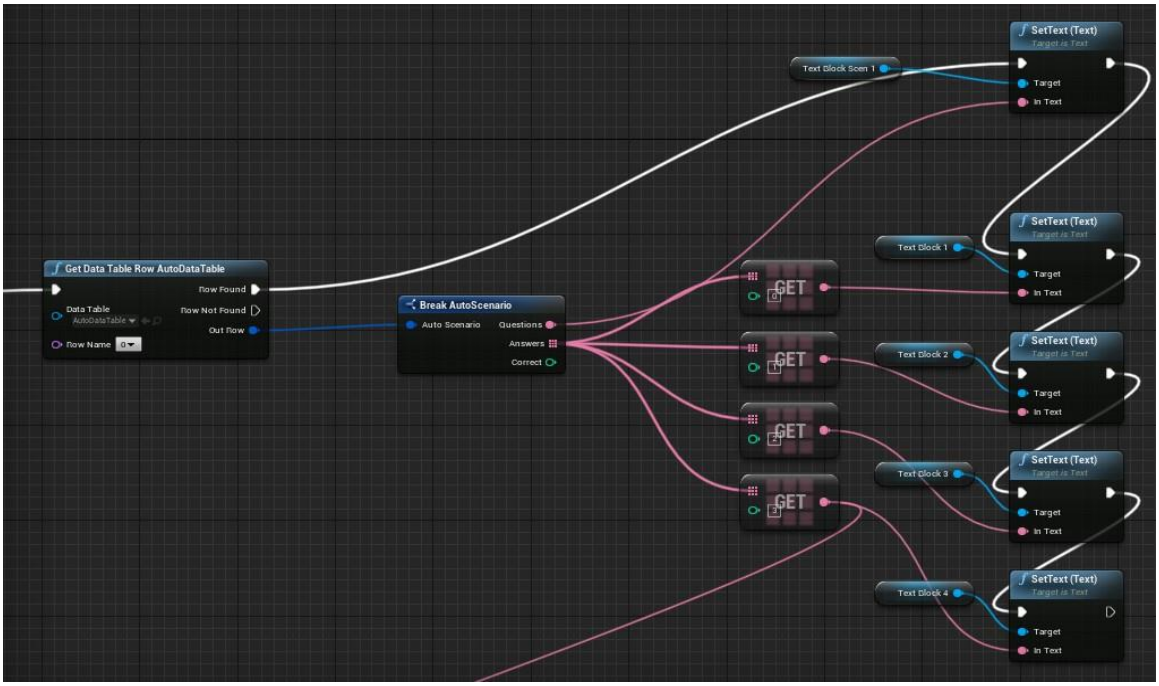

Figure 9 – Get Information from Data Table

4.4.3 Audio

Settings Audio: The waterfall and background music can be altered via a slider located in the settings page. The slider provides an audio in-application change feature so that the user can lower or raise the volume. The values are ranged between zero and one. When the application opens the audio starts on the highest volume but when the slider is moved towards the left the lower the volume (as displayed in *Figure 10* – A-Wear VR Settings Audio). These audio files were created by using the 'Sound Cue' asset within Unreal Engine that allows the developer to connect the audio to the application.

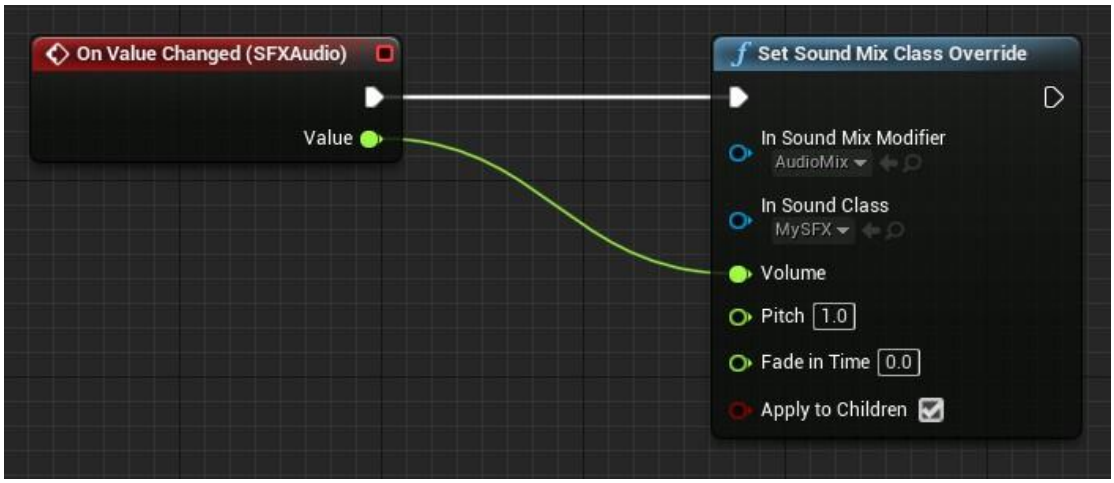

Figure 10 – A-Wear VR Settings Audio

Voice Overs Audio: When the user presses the button in the scenario, an audio file will be played in the background that will read out the scenario sentence that the user must answer. This audio will only be played once, but if the user would like to hear it again, they can press the button another time. the voice overs have been created by using google translates text-to-speech feature, whilst using Bandicam to record this audio. This produces a '.wav' file that can be implemented within the application.

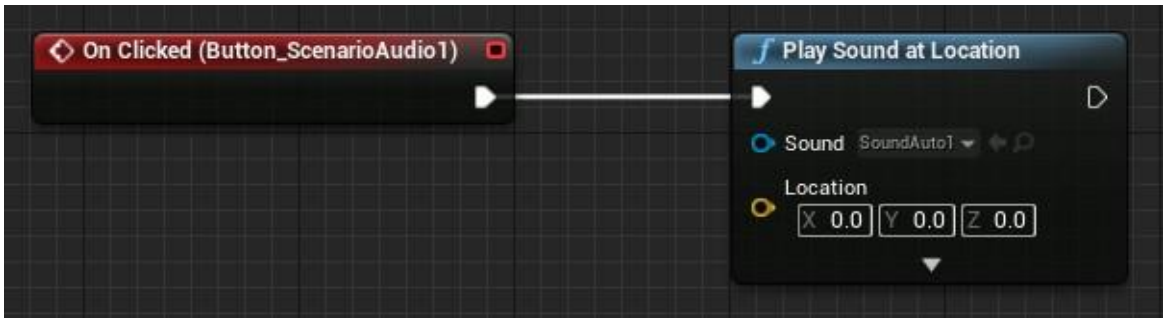

Figure 11 – A-Wear VR Voice Over

Correct or Incorrect Answer Audio: When the user selects the correct or incorrect answer, audio will play in the background that will resemble whether the answer is correct or incorrect (as displayed in *Figure 12* – Correct or Incorrect Answer Audio). This is explained more in 5.3.4 Results.

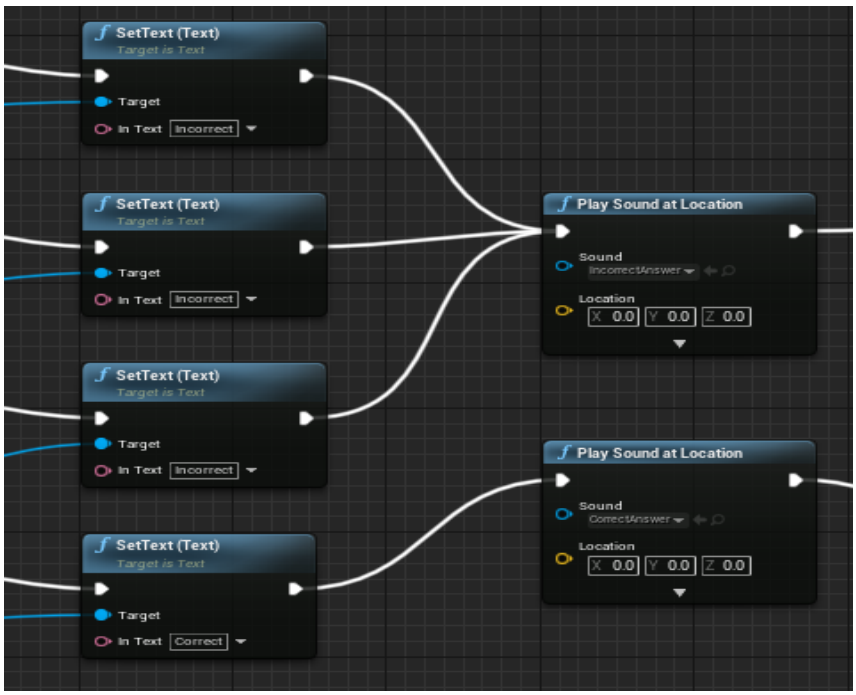

Figure 12 – Correct or Incorrect Answer Audio

4.4.4 Score System

The integer 'Score' starts by being set to zero. Whenever the user selects the correct score, the 'Score' will be increased by one, by connecting to a math integer function, set to 'Score' plus one. This new integer is set as 'Score', and displayed for the user to view in the score widget called 'Score WG' (as displayed in *Figure 13* – Score System). This is displayed in the scenario and at the end of the scenario quiz. Whenever the answer selected is incorrect the user score will not be affected.

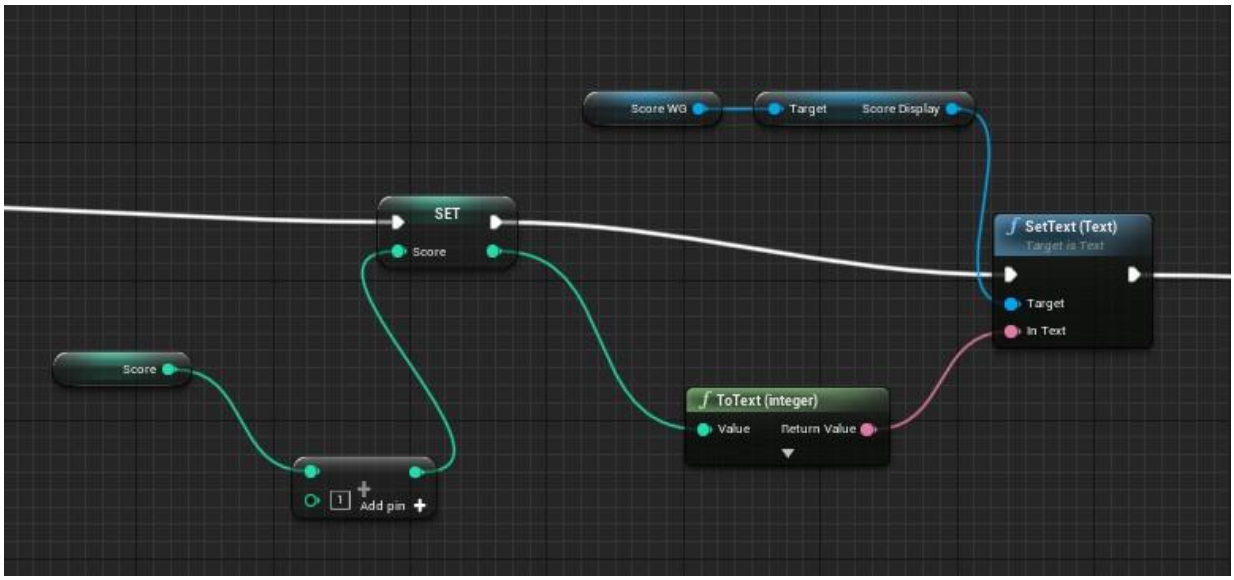

Figure 13 – Score System

4.4.5 Timer

The timer feature was created by adding a delay function that works by when a button is clicked it takes the delay of the float you enter within the 'Duration' text box. If the answer to the scenario is correct the delay will take five seconds. On the other hand if the answer is correct it will delay by ten seconds.

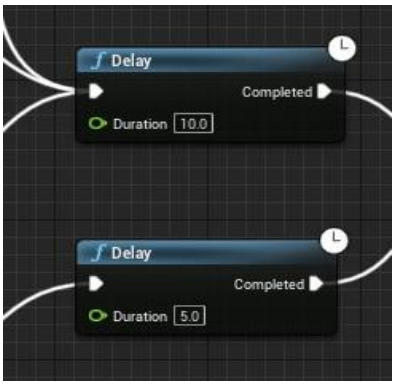

Figure 14 – A-Wear VR Timer

4.4.6 Widget Switchers

Widget switchers are a very important aspect of the main menu functionality it is the way the user can alter the main menu screen that they are on. The main example of this is shown in *Figure 15* – Switching Widget Function. This function is activated when the user clicks a specific button on the main menu. The way this works is by inputting all the widgets within the widget switcher (as displayed in *Figure 16* – Widget Switcher), and changing the 'index' value within the set active widget index to that certain number starting from option zero (item one in the list).

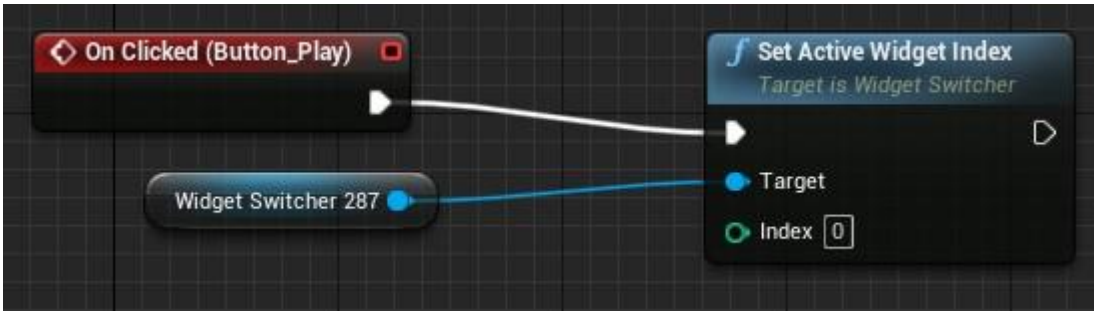

Figure 15 – Switching Widget Function

Figure 16 – Widget Switcher

4.5 Moving into *Chapter 5 – Results & Discussion*

Chapter 4 shows the key features that are being used within A-Wear VR. These key features include; main menu; scenario buttons; scenario scenes; variety of buttons; timer; audio and assets; score system; and movement. After which user testing was conducted that help add elements onto the key features that were not thought of. This included the lowering of audio within the application and making more ways that the user can move the character within the application.

Chapter 5 – Results & Discussion

5.1 Introduction

Chapter 5 will detail the following; the challenges that were encountered throughout the design and implementation phase; the results of the A-Wear VR; and finally the legal, social, ethical and professional issues of this project.

5.2 Challenges Encountered

One of the main challenges encountered throughout this project was that the author of the document and project contracted COVID-19 only a couple days before being able to attend Oakfield School in Nottingham. The aim of this data collection visit was to present the teachers at this school with a particular questionnaire which consisted of different sets of scenarios that would navigate through these quiz-like tasks. The ultimate aim of this was to receive feedback on whether the scenarios were achieving the aim of the project. Unfortunately, due to the researcher having to isolate, this feedback could not be obtained. Instead of gathering data in this format, user testing was used to focus on the particular gameplay within A-Wear VR.

5.3 Results of A-Wear VR

5.3.1 Game Level

The game level develop has been created in response to the research conducted within *Chapter 2*. The user has the ability to walk around the level to view the surrounding environment where they can hear waterfalls and background music included to create a peaceful environment that can be used by children ages between 7 – 14 years old to get away from their day-to-day life. The game level has been shown in *Figure 17* – A-Wear VR (Game Level 1) and *Figure 18* – A-Wear VR (Game Level 2).

Figure 17 – A-Wear VR (Game Level 1)

Figure 18 – A-Wear VR (Game Level 2)

5.3.2 Main Menu

The main menu purpose is to direct the users throughout the application through a general hub. The main menu can be accessed by two different points. The main menu is displayed both in the middle of the game level, and can be shown on the users wrist. The widget will then pop up and then can be interacted with. The wrist main menu can be put on view by the user pressing the 'Y' button on the Oculus Quest 2 controller. The main reason for this is that some people struggle to see from distance and therefore the user can look close up at the menu and put it right in front of themselves. There main functionalities of the main menu are allowing the user to select what scenarios they would like to try, changing the audio settings within the game level, displays how to play the game, and finally allows the user to quit the game and close the application. The main menu can be controlled by pressing the left trigger, and when the debug laser is aimed at a widget, it changes colour and then the user can interact with the buttons.

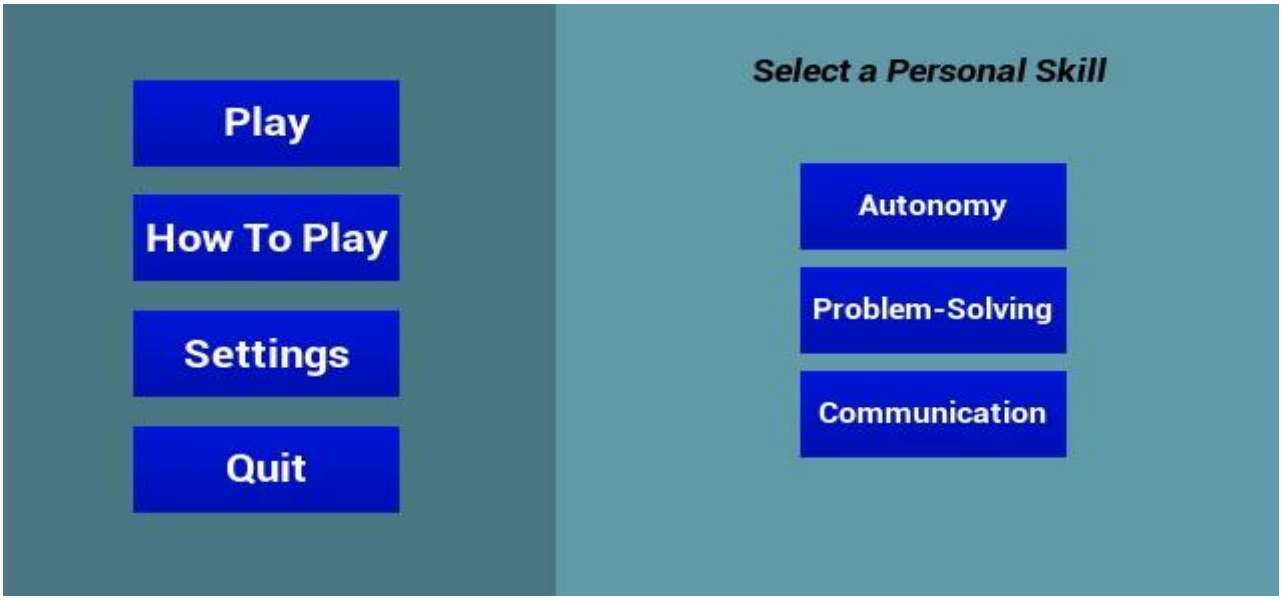

Figure 19 – A-Wear VR Main Menu Page

5.3.3 Scenario Quiz

When the user selects a personal skill within the play button option in the main menu, they are sent to that personal skills scenarios that they need to answer where a phrase is displayed (as displayed in Figure 20 – A-Wear VR Scenario Quiz Page), and the user will have to decide which option out of the four is the correct answer. If the user selects the correct answer, they will receive one point to their total score (mentioned prior in 4.5.4 Score System). Furthermore, if the user struggles to read they have the option to press the button on the top left of the options page, and it will read out the scenario in full.

Figure 20 – A-Wear VR Scenario Quiz Page

5.3.4 Results

At the end of the scenario quizzes the score is displayed in front of them in three different ways. When the answer that is selected is correct there is uplifting music played to display that they got the answer correct called 'Completion of a level' (Mixkit, 2022), whereas if the answer is incorrect, it will play an incorrect answer sound called 'Buzzer or Wrong Answer' (Pixabay, 2022). When the answer selected is incorrect the screen will show the correct answer to help the user out next time, they complete these set of scenarios. These are displayed in Appendix I – *Correct Answer Response* and Appendix J – *Incorrect Answer Response*. In addition, the results page (as displayed in Appendix K – *Results Page*) will show the total score the user gained throughout the set of scenarios.

5.3.5 Settings

The settings page has been created to help the users to lower down the volume of the game level. As some individuals with learning disabilities are hypersensitive to audio, this is an option so that if the music or background music is too loud, it can be reduced with the sliders displayed in *Figure 21* – A-Wear VR Settings Page. There were two audio assets that included the 'Big Waterfall Loop' audio asset (Mixkit, 2022) and the 'Journey's End' audio asset (Cat, 2021). In addition, another asset that was used for the development of this project was The 'Low Poly Style Deluxe 2: Tropical Environment' asset pack (WolfDigitalLLC, 2020). These assets combined to create a peaceful environment of nature that would help be a "healer for autistic children" (Barakat, et al., 2019).

Figure 21 – A-Wear VR Settings Page

5.3.6 Timer

The timer feature will help enable the user to use the application at a steady rate and also encourage quicker thinking in order to help the development of the skills. The timer will start once the user has selected an option within the scenario. If the user is correct, the text box will read correct and after a 5 second timer the next scenario will appear on the screen. If the user in incorrect, the text box will read incorrect and display why it is wrong and what the correct answer is and why. The timer for this instance will last 10 seconds and then the next scenario will appear on the screen. The reasoning behind the 10 second time gap is so that it gives the user enough time to read the description and then move onto the next scenario with pace.

4.3 User Testing (Phase Three [Results])

Question (What do you think of…)	User 1	User 2
Game Level Layout	"I think the game level is absolutely gorgeous, I think it is also great that the main menu is hidden until the user wants to go through the scenarios. The user such as I can enjoy the peacefulness and stunning area."	"It's extremely pretty."
Main Menu Functionality	"The main menu is extremely easy to use, and can be hidden so it doesn't clutter up the screen."	"I really like how easy it is to use."
Scenario Quiz	"The scenarios levels are extremely easy to understand and are very relevant to the personal skills they aim to develop."	"I feel like these questions really relate to me."
Results of Scenarios	"The score system is perfect for a game like this, as it is made for children, it does not take points away from them. It uses positive reinforcements which I really appreciate. Although if the user gets the answer wrong the buzzer sound is a bit off putting."	"I like the scoring, as I can't lose point which makes me happy."
Settings Options	"Very easy to use and very effective allowing the users to lower the volume of the music and audio of the waterfall."	"I love the audio, but I like that I can turn it down"
Timer	"I love that the time is added so that the user can see where they went wrong in a certain time frame, but I would have liked to see how long I have so I don't have to rush reading the responses to the answers given."	"I think it is really cool."

Table 8 – User Testing (Phase Three [Results])

5.4 Legal, Social, Ethical and Professional Issues

5.4.1 Legal Issues

Legal issues "is something that happens that has legal implications and may need the help of a lawyer to sort out" (Solicitors Regulation Authority, 2021). The Data Protection Act (DPA) of 2018 was passed by the government to protect the personal information that has been collected and/or stored. It ensures that no data is used without an individual's consent (UK Government, 2018). As this project will be collecting information during the project, the user must be able to choose whether the information provided can be used at a wider scale if the project would be commercialised in future work. The results that will be displayed at the end of the scenario within the application being developed for the game would be sent to the email of the teacher or the student to show how well they have done in a certain scenario against other scenarios they have done in the past. This data is valuable and therefore must be protected in the right way by the DPA.

As the project's target audience ranges from 7 to 14, the application that is being created must be allocated a Pan European Game Information (PEGI) age rating to display what it is going to include. As the application "will not contain any inappropriate content but can sometimes be too difficult to master for younger children" (Pan European Game Information, 2003), it will be deemed an age rating of 3.

5.4.2 Social Issues

Social issues are matters that have an effect on society. These can occur in multiple places such as the home, educational places, or workplace. As this project is targeted toward children between the ages of 7 to 14, certain games developed can lead to "[desensitizing] youths by numbing them emotionally, cause nightmares and sleep problems, impair school performance, and lead to aggressive behaviour and bullying" (Harvard Health Publishing, 2010). Therefore, this project must focus on making sure that there will not be an effect on the children in any form that would negatively impact them whilst using this application.

5.4.3 Ethical Issues

Ethical issues focus more on the moral side of the project. One of the main ethical issues in developing a VR application for children who suffer from learning disabilities is consent. As the application is targeted at individuals between the ages of 7 to 14, the parents or guardians of the participants must be asked for consent. The reason for this is that a child must be 16 before they can give consent to be a part of a study. Until then the parents will be able to make the decision whether they participate or not. Additionally, children can only participate in the research for the VR application if "the circumstances in which the research is conducted provide for the physical, emotional and psychological safety of the child" (UCL Research Ethics Committee, 2019). Furthermore, another ethical issue is communicating to the participants what the nature of the study is that is being conducted is extremely important. When a user will engage with the VR application, they must be aware in what they are taking part of to make sure that they are comfortable to participate.

5.4.4 Professional Issues

Professional issues focus on the understanding that everything that a project does is in the interest of the public. The British Computer Society ('BCS') states that an application that is targeted at children should regard for "public health, privacy, security and the wellbeing of others and the environment" (BCS, 2018). In addition, there must be professional activities conducted without any type of discrimination that occurs linking to "sex, sexual orientation, marital status, nationality, colour, race, ethnic origin, religion, age or disability, or any other condition" (ibid). As this project is being developed for individuals that suffer for learning disabilities, then the professional activities have to take into consideration that it is being targeted towards people with disabilities so that there is no discrimination.

5.5 Test Reports

ID	1	**Description:**	Movement (Forwards)
Test Type	Functional Test	**Success criteria:**	Character moves forwards.
Number of Attempts	1	**Comments:**	N/A
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	When user presses the left thumb stick forward (as displayed in Appendix F – *Oculus 2 Controls)*, the users character would move that direction.		
Failure correction procedure:	N/A		
Individual results:	Pass		
Test Date:	19/07/22	**Result:**	Successful

Table 9 – Test Report 1

The rest of test report tables are displayed in Appendix H – *Tests Report*.

Chapter 6 – Conclusions & Future Work

6.1 Conclusions

A-Wear VR has shown that helping children between the ages of 7-14 years old with learning disabilities develop and foster personal skills that can be applied later in life in professional working environments can be done in a relaxation environment. Although this project had some challenges (as mentioned in 5.2 Challenges Encountered) leading to a minimal user testing, the aims and objectives were followed throughout the development of the project to create a successful project.

6.2 Future Work

If the project were to be developed further, there are numerous features that the developer would add to help increase the application's accessibility, desirability, and learning outcome. These features are as follows:

Physically Impaired Individuals: As this application is targeted at users who have mild and moderate learning disabilities, individuals who have certain physical impairments cannot use this application due to being having restricted movement. This could be addressed by developing a two-dimensional or three-dimensional application that would require less physical movement and therefore be more accessible to this demographic.

Develop More Scenarios: Upon completion of this application there is only one scenario per sub-competency. If the application were to be developed further, the developer would like to add a minimum of four sets of scenarios for each sub-competency that is randomly selected from the data table within the Unreal Engine. This would ensure that the user would not always select the same answer and therefore allow for further educational benefits. The developer would also like to incorporate more sub-competencies to allow the user to further foster and develop additional desirable skills for future employers and work environments.

Bonus Level: A feature that would provide a more exciting trait to A-Wear VR would be designing a bonus level that can only be reached by users that receive five out of five on a scenario quiz. This would provide a statement and the user would have to decide and answer which competency it would relate to.

Peaceful Game Level: Users of such a young age can be highly hypersensitive to sound, therefore a level could be implemented where the user could hide the main menu and the background music, and instead just have the sound of the waterfall in the background to provide a relaxation area, where they can get away from their day-to-day lives.

Timer for User: Although there is a timer already in the application, the developer would like to the timer as a more prominent feature. This would be developed so the user will have an allocated amount of time - a maximum of thirty seconds - for each scenario. This is to keep the application at a swift pace and encourage the user to think quickly, therefore allowing the user to mimic the fast-paces decision making that is necessary in a working environment.

Database: The developer believes that it would be beneficial for the user is if they, their parents, or their teachers could view their scores and monitor progress. This would then help the user see which sub-competences require improvement. To allow for this to happen, a database consisting of their results would need to be saved and displayed on their own device. This would be a local database on their VR device.

Translation: As VESVET (VESVET, 2021) is partnered with educational institutions in Lithuania, Latvia, Portugal, and Turkey, the application could be developed to translate into the spoken language in each country. This would allow the application to expand its outreach and help more children learn and develop skills they need to take into professional working environments.

Safety Feature: If the users have an addictive personality and can't get off the application, there will be a safety check that would force the user to quit the application when they spend too much time on the application.

6.3 Project Limitations

Some limitations that are faced over the duration of the project are as follows:

Financial limitations: As the developer is a student, they do not have the financial capability to download software to create their own assets. If there were no financial limitations applications such as 3ds Max would be used to develop the best assets to best suit the application.

School Closures: Schools are closed as of middle/late July and return late August/early September. This leads to not being able to have a large sample size of the right age group being able to test the application and give feedback.

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Appendix

Appendix A – Graph Displaying Age Percentage of Video Gamer Players

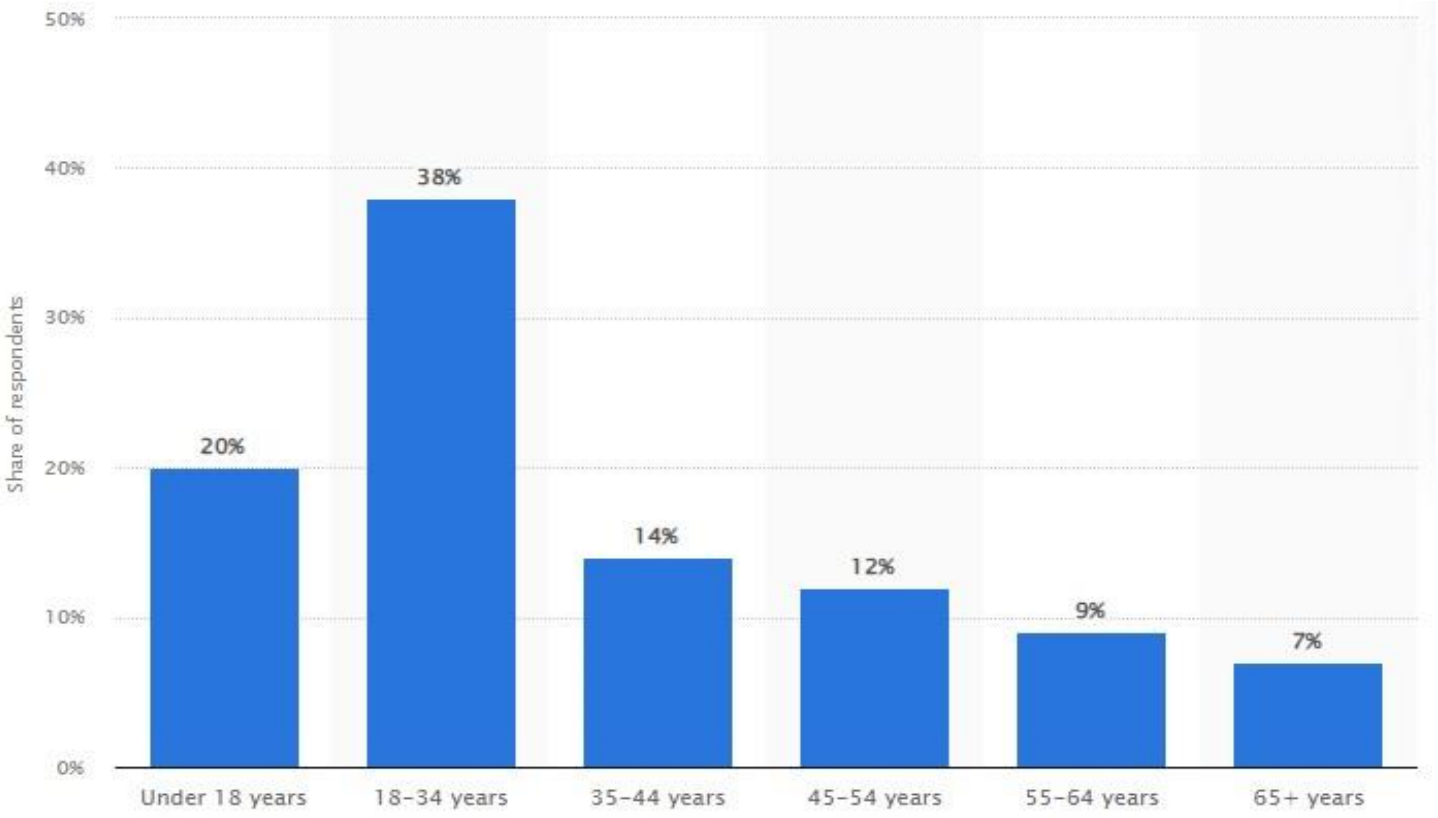


Figure 22 – Age Percentage of Video Gamer Players

Appendix B – Waterfall Methodology

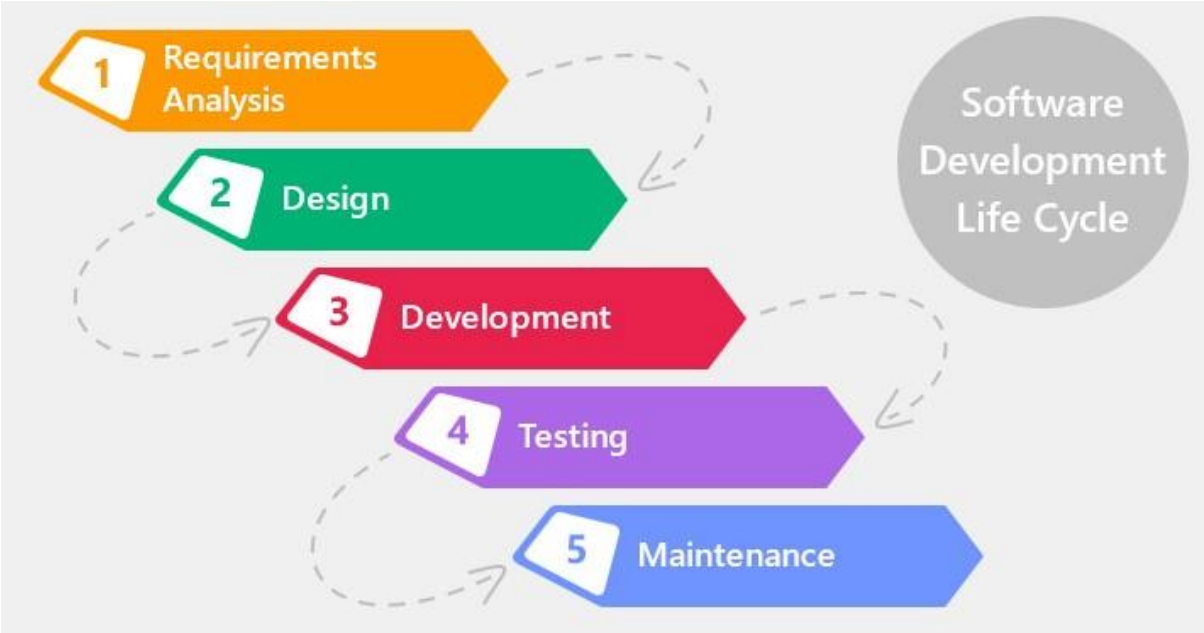


Figure 23 – Waterfall Methodology

Appendix C – Gantt Chart

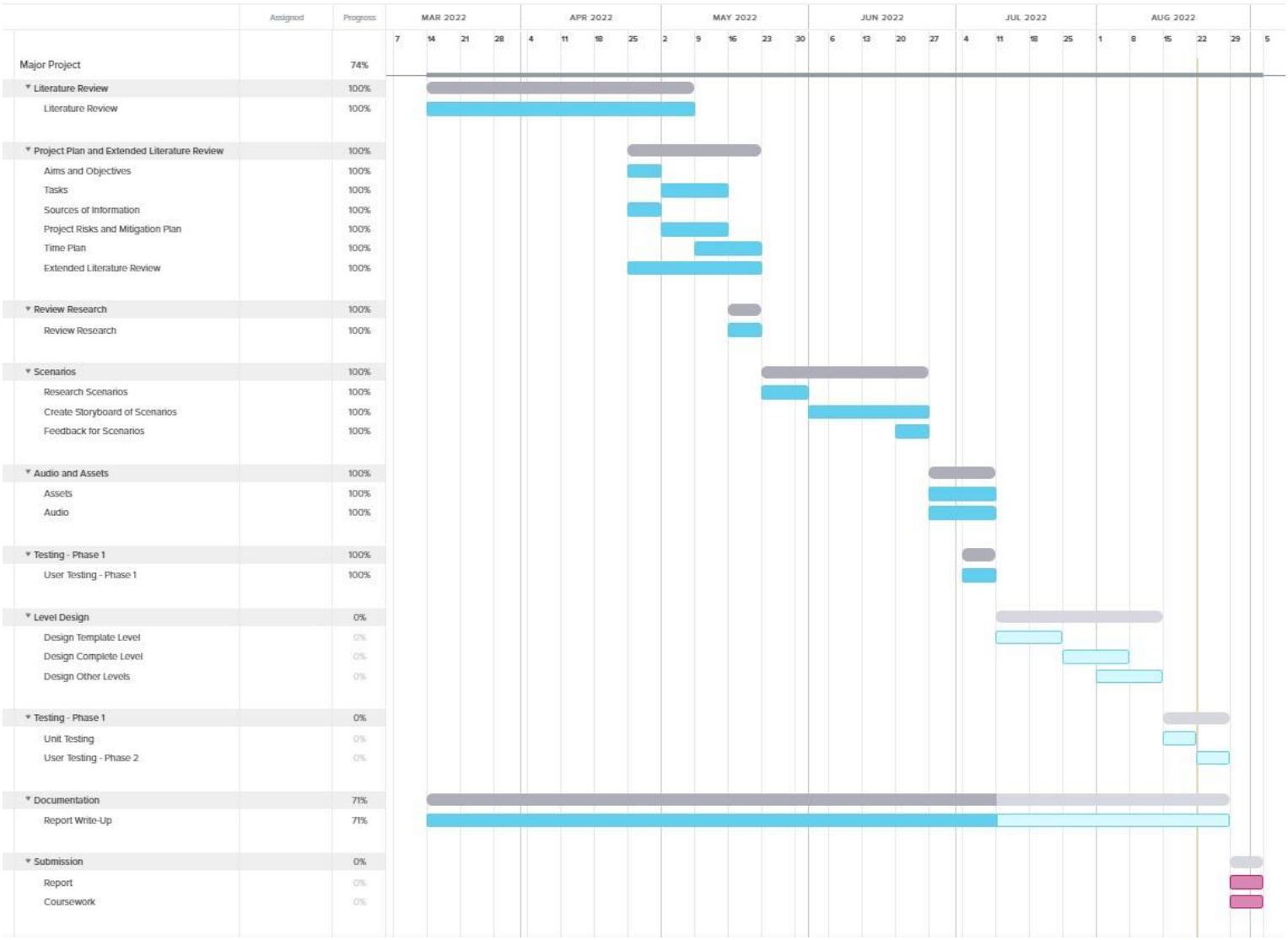


Figure 24 – Gantt Chart

Appendix D – Key for Gantt Chart

Figure 25 - Incomplete Milestone

Figure 26 - Completed Milestone

Figure 27 – Submission Milestone

Appendix E – Project Milestones

Milestones	Date Finished	Week
Project Start Date	15th March	1
Literature Review	9th May	9
Updated Literature Survey and Project Planning Document	30th May	11
Feedback on Scenario	21st June	15
Feedback on Level	23rd August	24
Project Submission Date	2nd September	25

Table 10 – Project Milestones

Appendix F – Project Risks and Mitigation Plan

Risk #	Risk Description	Probability	Impact	Rating	Risk Category
1	Time Management	9	9	81%	Jeopardy
2	Data Loss or Corruption	7	9	63%	High
3	Technology Error	6	6	36%	Medium
4	Large Project Scope	5	4	20%	Low
5	Force Majeure	3	9	27%	Low
6	Recruiting Participants	5	5	25%	Low
7	Cost	3	7	21%	Low
8	Psychological Error	5	7	35%	Medium

Table 11 – Project Risks and Mitigation Plan

Table 1 – Project Risks and Mitigation Plan is broken up into six columns that display a certain section of the project risk or mitigation.

***Risk Description*:** The risk description is the risk that is being assessed in that column to see how drastically it can affect the project.

***Probability*:** The probability is the likelihood that the risk would occur throughout the duration of the project.

***Impact*:** The impact is regarding how the risk would affect the performance or validity of the project.

***Rating*:** The rating is an indicator that is represented in a percentage and is calculated by the probability multiplied by the impact, to give an estimate of how severe the risk is to the project.

***Risk Category*:** This is a word that defines the percentage given in rating as displayed in Appendix F – *Project Risks and Mitigation Plan.*

***Mitigation Plan*:** The mitigation plan is the steps to avoid the risk from occurring.

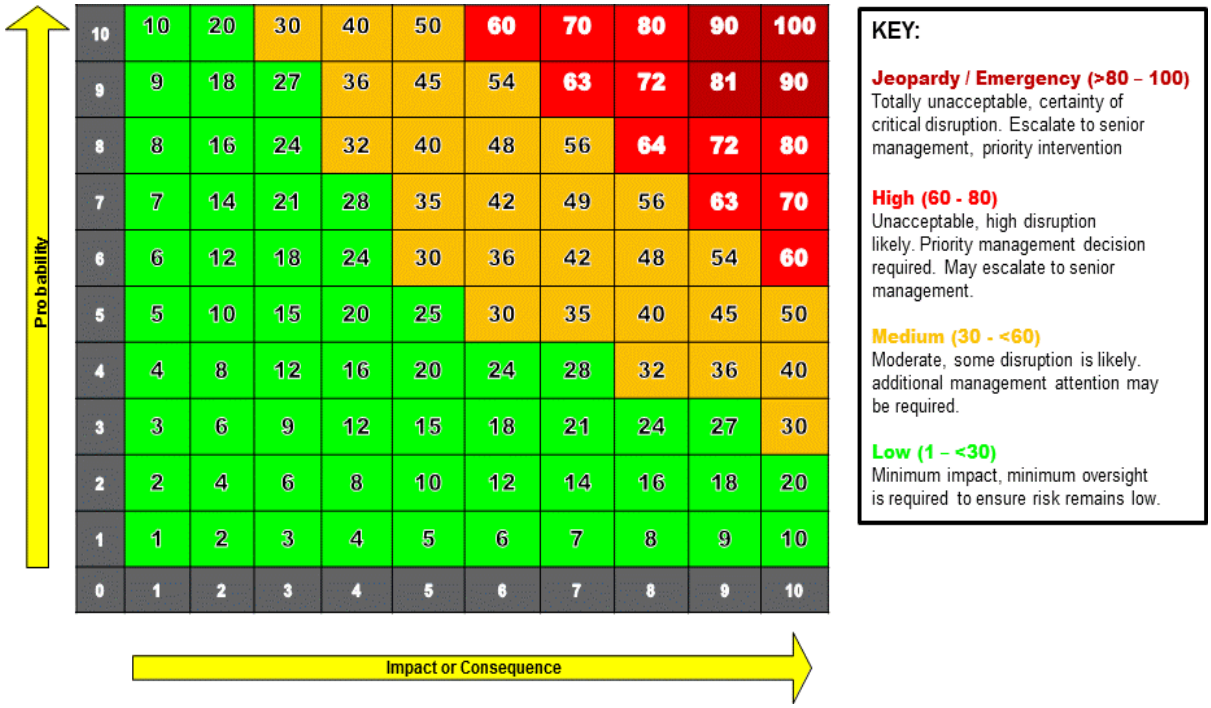


Figure 28 – Key for Risk Rating

Appendix G – User Personas

User	1
Name	Mark
Personal Information	• Age: 56 • Gender: Male • Job: Dentist • Location: London
Issues	• Struggles with deciding • Struggles to read • Gets distracted easily
Solution	N/A – Not Target Group

Table 12 – User Persona (User 1)

User	2
Name	Alexandra
Personal Information	• Age: 12 • Gender: Female • School Grade: Year 8 • Location: Essex
Issues	• Struggles with being independent • Struggles to complete tasks on their own
Solution	• Create a problem-solving scenario • Allow them to make the music quieter or turn it off

Table 13 – User Persona (User 2)

Appendix F – Oculus Quest 2 Controls

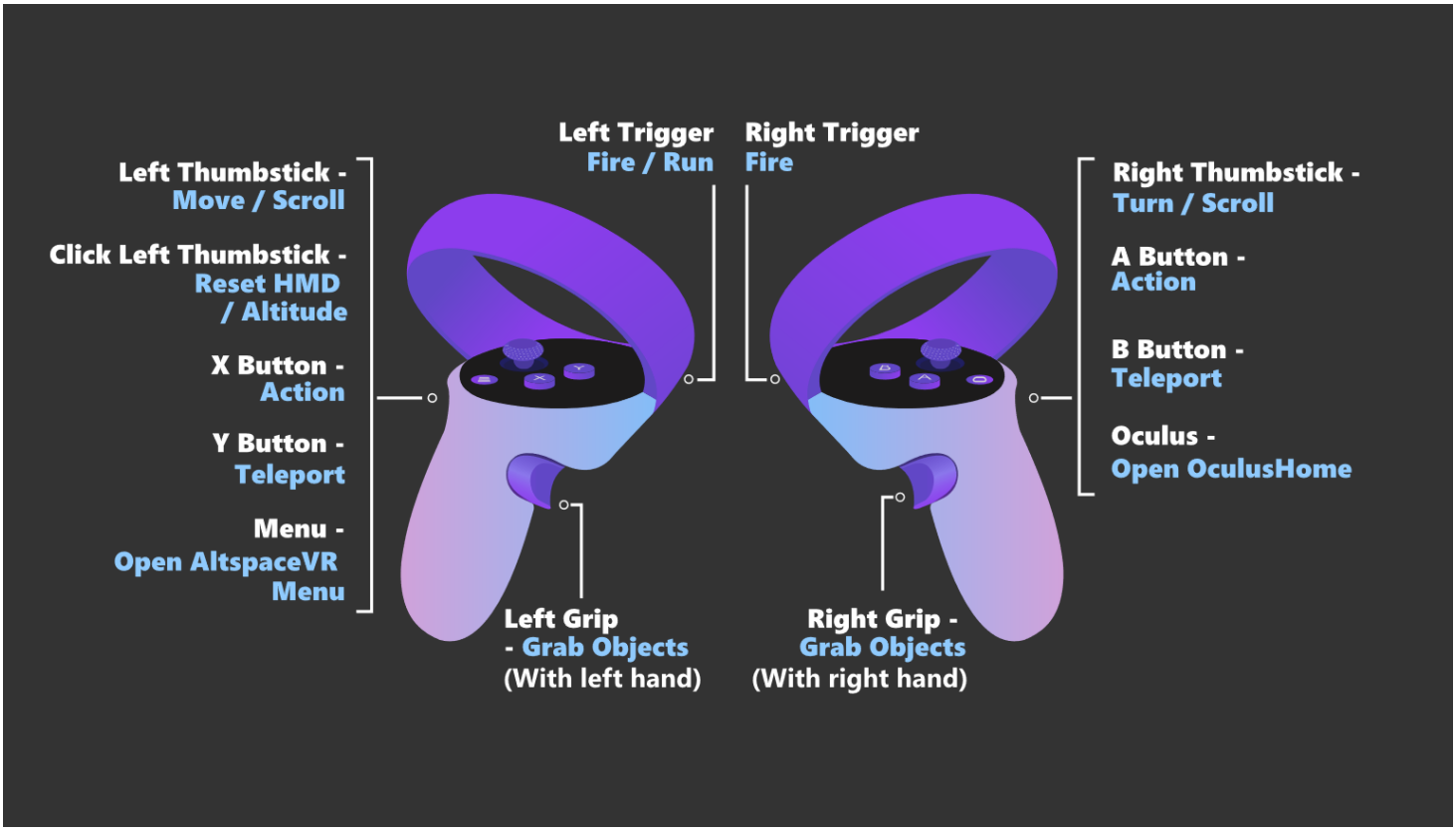


Figure 29 – Oculus Quest 2 Controls

Appendix H – Test Reports

ID	2	Description:	Movement (Backwards)
Test Type	Functional Test	Success criteria:	Character moves backwards.
Number of Attempts	1	Comments:	N/A
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	When user presses the left thumb stick backwards (as displayed in Appendix F – *Oculus 2 Controls)*, the users character would move that direction.		
Failure correction procedure:	N/A		
Individual results:	Pass		
Test Date:	19/07/22	Result:	Successful

Table 14 – Test Report 2

ID	3	Description:	Movement (Left)
Test Type	Functional Test	Success criteria:	Character moves left.
Number of Attempts	1	Comments:	N/A
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	When user presses the left thumb stick left (as displayed in Appendix F – *Oculus 2 Controls)*, the users character would move that direction.		
Failure correction procedure:	N/A		
Individual results:	Pass		
Test Date:	19/07/22	Result:	Successful

Table 15 – Test Report 3

ID	4	Description:	Movement (Right)
Test Type	Functional Test	Success criteria:	Character moves right.
Number of Attempts	1	Comments:	N/A
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	When user presses the left thumb stick right (as displayed in Appendix F – *Oculus 2 Controls)*, the users character would move that direction.		

Failure correction procedure:	N/A		
Individual results:	Pass		
Test Date:	19/07/22	**Result:**	Successful

Table 16 – Test Report 4

ID	5	**Description:**	Rotation (45 Degrees Left)
Test Type	Functional Test	**Success criteria:**	Character rotates left in that same position.
Number of Attempts	1	**Comments:**	N/A
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	When user presses the right thumb stick left (as displayed in Appendix F – *Oculus 2 Controls)*, the users character would rotate 45 degrees in that direction.		
Failure correction procedure:	N/A		
Individual results:	Pass		
Test Date:	20/07/22	**Result:**	Successful

Table 17 – Test Report 5

ID	6	**Description:**	Rotation (45 Degrees Right)
Test Type	Functional Test	**Success criteria:**	Character rotates right in that same position.
Number of Attempts	1	**Comments:**	N/A
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	When user presses the right thumb stick right (as displayed in Appendix F – *Oculus 2 Controls)*, the users character would rotate 45 degrees in that direction.		
Failure correction procedure:	N/A		
Individual results:	Pass		
Test Date:	20/07/22	**Result:**	Successful

Table 18 – Test Report 6

ID	7.1	**Description:**	Collision Detector
Test Type	Functional Test	**Success criteria:**	User does not fall through floor or go through walls when walking around.

Number of Attempts	2	**Comments:**	N/A
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	The user would stay on top of the plain used as the floor and no entering through the mountains around the level.		
Failure correction procedure:	The collision boxes have not been implemented properly so that the users character falls through the floor.		
Individual results:	Fail – Understanding how to implement collision boxes correctly.		
Test Date:	22/07/22	**Result:**	Unsuccessful

Table 19 – Test Report 7

ID	7.2	**Description:**	Collision Detector
Test Type	Functional Test	**Success criteria:**	User does not fall through floor or go through walls when walking around.
Number of Attempts	2	**Comments:**	The collisions are now working.
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	The user does not go through collision boxes now, and can walk on the island and cannot travel through physical objects.		
Failure correction procedure:	N/A		
Individual results:	Pass		
Test Date:	22/07/22	**Result:**	Successful

Table 20 – Test Report 8

ID	8	**Description:**	Play Button
Test Type	Functional Test	**Success criteria:**	Main menu loads up the different scenario buttons.
Number of Attempts	1	**Comments:**	N/A
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	When the user interacts with the play button and the widget switcher will display the different scenarios that the user can select which include Autonomy, Problem-Solving and Communication.		
Failure correction procedure:	N/A		

Individual results:	Pass		
Test Date:	24/07/22	**Result:**	Successful

Table 21 – Test Report 9

ID	9	**Description:**	How to Play Button
Test Type	Functional Test	**Success criteria:**	The screen displays to the user how to play the game.
Number of Attempts	1	**Comments:**	N/A
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	When the user interacts with the how to play button and the widget switcher will display to the users all the controllers for the application, so they are not confused.		
Failure correction procedure:	N/A		
Individual results:	Pass		
Test Date:	24/07/22	**Result:**	Successful

Table 22 – Test Report 10

ID	10	**Description:**	Settings Button
Test Type	Functional Test	**Success criteria:**	User should be displayed with the settings page.
Number of Attempts	1	**Comments:**	N/A
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	When the user interacts with the settings button and the widget switcher will display to the users the slide widget that allows the user to adjust the volume within the game to their preferred volume.		
Failure correction procedure:	N/A		
Individual results:	Pass		
Test Date:	24/07/22	**Result:**	Successful

Table 23 – Test Report 11

ID	11	**Description:**	Settings Widgets
Test Type	Functional Test	**Success criteria:**	User should be able with to adjust widgets.

Number of Attempts	1	**Comments:**	N/A
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	The users can adjust the slide widget to make the audio settings within the game to their preferred volume.		
Failure correction procedure:	N/A		
Individual results:	Pass		
Test Date:	27/07/22	**Result:**	Successful

Table 24 – Test Report 12

ID	12.1	**Description:**	Audio
Test Type	Functional Test	**Success criteria:**	Audio should be heard within the game.
Number of Attempts	2	**Comments:**	N/A
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	Audio implemented in game level cannot be heard whilst Oculus Quest headset is on.		
Failure correction procedure:	The sound que was not included within the game level, as a result nothing was heard.		
Individual results:	Fail – Understanding how to implement audio correctly.		
Test Date:	28/07/22	**Result:**	Unsuccessful

Table 25 – Test Report 13

ID	12.2	**Description:**	Audio
Test Type	Functional Test	**Success criteria:**	Audio should be heard within the game.
Number of Attempts	2	**Comments:**	The audio is now working.
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	The audio was meant to be in the game so that the user could hear all the SFX features, and voice-overs included.		
Failure correction procedure:	N/A		
Individual results:	Pass		
Test Date:	28/07/22	**Result:**	Successful

Table 26 – Test Report 14

ID	13	Description:	Quit Button
Test Type	Functional Test	Success criteria:	The application should terminate.
Number of Attempts	1	Comments:	N/A
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	If the user is to press the quit button, the application will be closed.		
Failure correction procedure:	N/A		
Individual results:	Pass		
Test Date:	24/07/22	Result:	Successful

Table 27 – Test Report 15

ID	14	Description:	Personal Skills Scenario Buttons (Autonomy)
Test Type	Functional Test	Success criteria:	Sends the user to the Autonomy scenario.
Number of Attempts	1	Comments:	N/A
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	The user will be displayed with 5 different sections, to do with autonomy within the scenario, depicting a specific story that the user must navigate through.		
Failure correction procedure:	N/A		
Individual results:	Pass		
Test Date:	25/07/22	Result:	Successful

Table 28 – Test Report 16

ID	15	Description:	Personal Skills Scenario Buttons (Problem-Solving)
Test Type	Functional Test	Success criteria:	Sends the user to the Problem-Solving scenario.
Number of Attempts	1	Comments:	N/A
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	The user will be displayed with 5 different sections, to do with problem-solving within the scenario, depicting a specific story that the user must navigate through.		
Failure correction procedure:	N/A		

Individual results:	Pass		
Test Date:	25/07/22	**Result:**	Successful

Table 29 – Test Report 17

ID	16	**Description:**	Personal Skills Scenario Buttons (Communication)
Test Type	Functional Test	**Success criteria:**	Sends the user to the Communication scenario.
Number of Attempts	1	**Comments:**	N/A
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	The user will be displayed with 5 different sections, to do with communication within the scenario, depicting a specific story that the user must navigate through.		
Failure correction procedure:	N/A		
Individual results:	Pass		
Test Date:	25/07/22	**Result:**	Successful

Table 30 – Test Report 18

ID	17.1	**Description:**	Option Buttons in Scenarios and Score System
Test Type	Functional Test	**Success criteria:**	N/A
Number of Attempts	2	**Comments:**	N/A
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	Clicking the correct option button increases the score by one, but the user can click the option as many times as they want which continuously increases the score by one.		
Failure correction procedure:	Create a widget that automatically displays when the user selects an option.		
Individual results:	Fail – Understanding how to create a score system.		
Test Date:	25/07/22	**Result:**	Unsuccessful

Table 31 – Test Report 19

ID	17.2	**Description:**	Option Buttons in Scenarios and Score System
Test Type	Functional Test	**Success criteria:**	N/A

Number of Attempts	2	**Comments:**	Score system works successfully.
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	The score system works, and the user cannot gain more than one point each section.		
Failure correction procedure:	N/A		
Individual results:	Pass		
Test Date:	25/07/22	**Result:**	Successful

Table 32 – Test Report 20

ID	18	**Description:**	Voice Over Button
Test Type	Functional Test	**Success criteria:**	N/A
Number of Attempts	1	**Comments:**	N/A
List of Equipment / Requirements:	Oculus Quest 2 Controllers and Unreal Engine		
Setup Instructions:	The sound que is connected to a button and when it is pressed that scenario sections phrase is read aloud for the users to hear.		
Failure correction procedure:	N/A		
Individual results:	Pass		
Test Date:	25/07/22	**Result:**	Successful

Table 33 – Test Report 21

Appendix I – Correct Answer Response

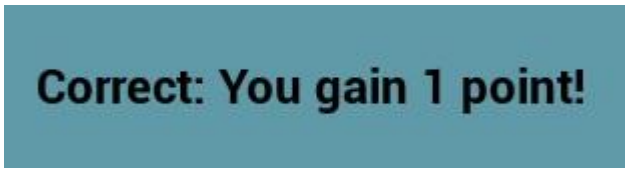


Figure 30 – Correct Answer Response

Appendix J – Incorrect Answer Response

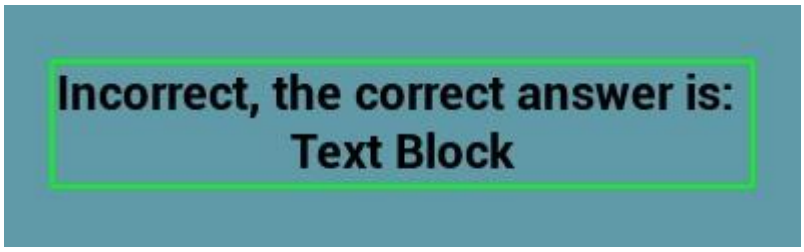


Figure 31 – Incorrect Answer Response

Appendix K – Results Page

Figure 32 – Results Page

Appendix L – Computing & Technology Ethical Issues Declaration Form

All project students are required to consider potential ethical issues that may arise over the course of their project work. A discussion regarding ethics relating to your project must be held with your supervisor and any potential ethical issues identified.

In order to allow effective monitoring and record keeping, this ethical declaration must be completed for every project and signed by both the student and supervisor, whether or not ethical issues were considered to be involved. No student can commence work unless this form has been completed.

Ethical Approval

Project work using human volunteers as subjects requires ethical approval, examples might include: monitoring subjects physiological and biomechanical responses to stimulus, undergoing psychological tests, examining the impact of applications on human behaviour, conducting any work with participants classed as vulnerable (e.g. minors), utilising any data collection methods that seek personal or confidential information.

If your project produces any ethical issues as described above an application for ethical approval must be made to the Colleges Non-Invasive Ethical Committee.

If the work appears to be of a more sensitive nature, approval may be required through the Universities Ethical Review Committee; discuss with your supervisor or module leader if in doubt.

Student Name: *William Becker* **Student Number:** *N073245*

Course: *Computer Science MSc*

Project Title: *The Effects of Serious Games in Virtual Reality on Children with Learning Difficulties*

Name of Supervisor: Matthew Harris

I have read the above text and discussed this with my supervisor?	☒ Yes ☐ No
This project requires:	
Approval from the Non-Invasive Ethical Committee	☒ Yes ☐ No
Approval from the Universities Ethical Review Committee	☐ Yes ☒ No
Disclosure and Barring Service (DBS) approval	☐ Yes ☒ No
A Health and Safety Risk assessment	☒ Yes ☐ No

Please give details below

Presenting teachers of Oakfield with a questionnaire and also a set of scenarios that they will have to navigate through to display what the application for this project would look like.

Signature of student: 

Signature of Supervisor: 

Appendix M – Participant Consent Form

I, Mark Becker provide my daughters and my own full written informed consent to take part in the investigation regarding the reliance of spatial ability to successfully complete manual assembly.

I understand the procedures which will take place and agree to complete tests to the best of my ability. I have had the opportunity to ask any questions or communicate and discuss any additional concerns and queries associated with the study. I understand my participation is voluntary and I have the right to withdraw or discontinue participation at any time with no obligation to provide reasons behind the decision. I am assured that during the study all data will be stored as password protected electronic files. Also, I understand that I can withdraw my data after I have completed the tests up to two weeks from signing the Statement of Informed Consent.

Finally, I am assured that all information which I have provided and any that is obtained during the study will be treated as private and confidential and only communicated to others with my identity concealed, and that all research data will be kept in an anonymised form for up to 5 years in the case of possible publication but will otherwise be destroyed after graduation.

☒ Please tick or highlight this box to confirm that you understand that you may withdraw from participation in the usability trial at any stage.

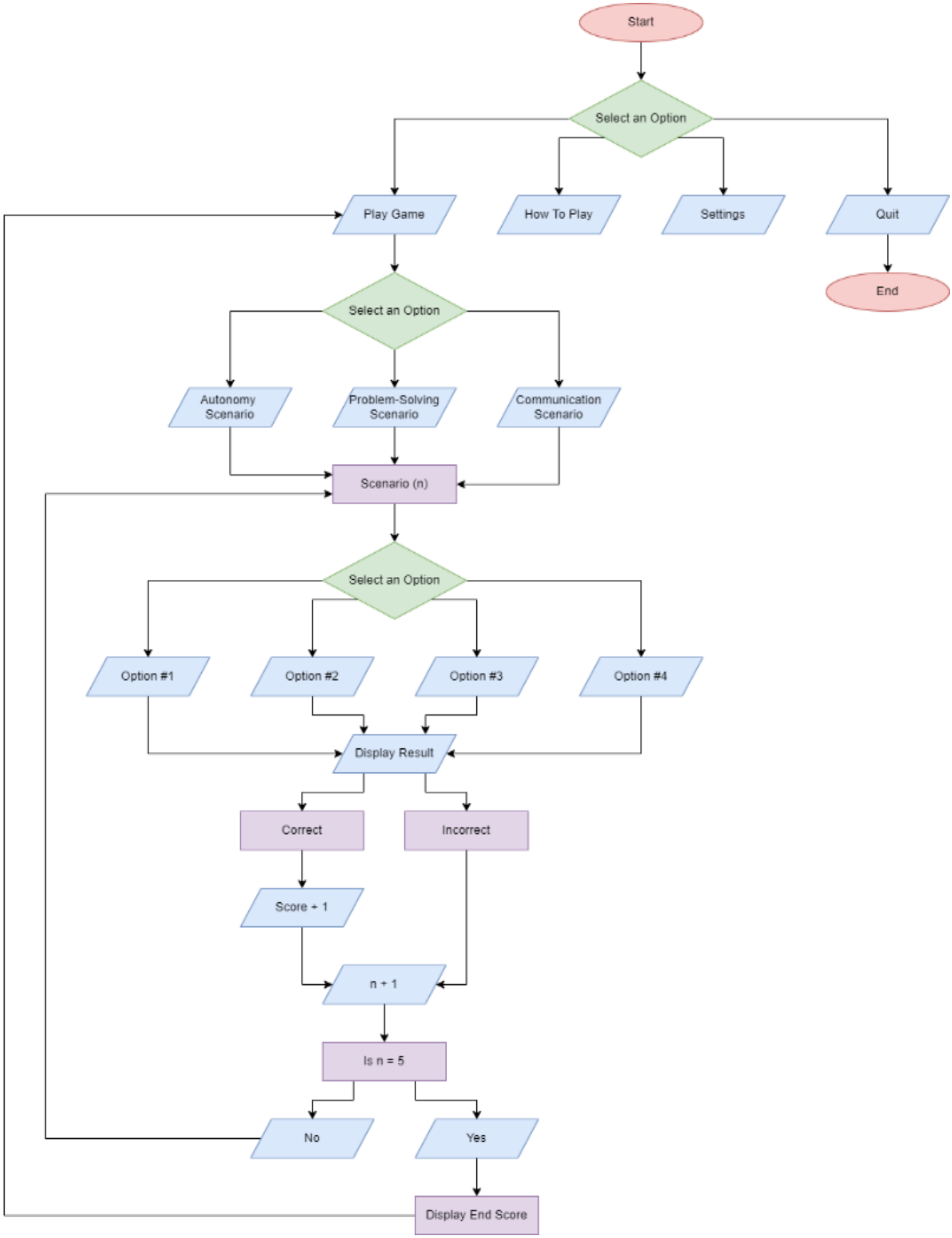
☒ Please tick or highlight this box to confirm that you understand that after participating in the usability trial, you may withdraw your data two weeks from signing the Statement of Informed Consent by contacting the researcher and quoting your unique identification number (where applicable).

Participant's Signature: 

Date: *9th August 2022*

Should you have any questions or desire further information please contact me on N0732425@my.ntu.ac.uk or my project supervisor at matthew.harris@ntu.ac.uk at Nottingham Trent University.

Appendix N – Flowchart for A-Wear VR



Appendix O – Use Case for A-Wear VR