Simulating the Effects of International Travel in a Virtual World to Provide Training and Reassurance

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Submitted in partial fulfilment of the requirements for the
Degree of BSc (Hons) Games Computing

Supervisor Marisé Galvez Trigo
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May 2023

Acknowledgements

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Abstract

In 2022 the worldwide coronavirus pandemic induced travel restrictions were lifted whilst the United Kingdom (UK) had also left the European Union (EU). Most people have not been able to travel on holiday abroad for a while now. This has created an unneeded level of anxiety.

This project aims to create a 'safe space' to teach the user on how the airport process works and allows them to experience the experience in a quicker, more digestible experience, by taking advantage of the developments in the 'Virtual Reality space' to create for an immersive experience for the participant.

In this dissertation, you will be able to travel throughout the researcher's process on making development choices through to the creation of the final project and to the validation and review process.

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Chapter 1

Introduction

From 2020 when the first COVID-19 lockdowns hit, international tourism has decreased by more than 80% (Luo and Lam, 2020). Luo and Lam, 2020 determined that the hypothetical worry or fear of catching the coronavirus or other ailment has a direct relationship with people having an increased level of travel anxiety and people wanting to travel less (decrease in the travel intention) (Reisinger and Mavondo, 2005). UNWTO, 2020 are concerned that this number could fall even further.

It has been proven in the past that providing a simulation of an experience beforehand can reduce levels of anxiety. This has been proven by Armitage and Reidy, 2012, and Ignacio et al., 2016, in a healthcare setting. They concluded that the anxiety, being reduced, allowed the patients to have a much better quicker and stressless experience.

This was further researched by Miller et al., 2020, for the context of air travel (but with autistic people) they found that it was successful at improving airport literacy/confidence. They noted that they found that the VR application running on a phone and Google Cardboard (a cardboard box that has a lens and folds to fit a phone to be a VR headset) worked well, but had limitations. This is because it didn't provide as much presence as a dedicated system with a PC.

The project is designed to target a Meta Quest 2 headset which combines affordability whilst providing a good experience, and can be run standalone. This will let the researcher take just the headset and the Microsoft Form (which they can complete on their own device or one provided) to the participant.

The project has been developed using the Unity Engine and the OpenXR tooling. It has been built as an APK (**A**ndroid **P**ac**k**age) to run directly on the headset.

The project was managed using a collection of cloud based tools and techniques such as GitLab.com, Toggl Track, Notion, and Gantt Charts.

The participant travels between multiple stages or scenes and completes a short set of interactions (which have been developed with a custom in-house system) which forces them to complete certain activities before they can continue with the simulation.

However, a project of this scope may present unforeseen dangers and risks such as motion sickness, cybersickness, data loss, equipment damage, and difficulty from researching with human participants. This has been considered for the project and appropriate safeguards have been implemented.

A number of different techniques have been used to ensure that the results from this study are valid; by using previously tested and validated questionnaires such as the GAD-7 and the Witmer and Singer, 1998 presence questionnaire. This ensures the results have a strong level of validity.

The participant will first answer a questionnaire about their previous experience and their anxiety levels when flying. And then they will enter the VR application and will experience the process of travelling. Then they will return to the questionnaire, and answer the same anxiety questions   this will then be compared to identify possible changes with the score.

This was then calculated, and determined that there was an insignificant amount of change to promote the use of the system, and there should be further development into different project destinations.

And to finish off this paper, potential improvements will be discussed.

Chapter 2

Literature Review

2.1 Previous Work

This project is building on previous works that have been completed by previous researchers. The work has been created to fill a gap within the research market, by developing a generic solution which can be used to help a multitude of people who are feeling anxious, specifically towards the airport experience.

2.1.1 Virtual Reality Air Travel Training For Autistic Individuals

One example of previous work has been completed by Miller et al., 2020 which aimed at allowing autistic adolescents and adults to simulate the process of the travelling internationally. They decided to do this because they wanted to remove barriers formed by services stopping support when folks turn 18.

Miller et al., 2020's work is flawed in two significant ways. The first matter being the number of test subjects. They only managed to obtain seven participants whereas Threlfall (2020, p.g. 21) managed to obtain twenty. This could be accounted to Miller et al., 2020's methodology of requiring a participant to possess a clinical diagnosis of *Autism Spectrum Disorder*. this was reported by Fusar-Poli et al. (2022, p.g. 190)'s study, which was able to identify an 11-year delay between first evaluation and diagnosis of ASD. Their study was consisted of 161 individuals within the range of ageing between 18 and 55 who got diagnosed later in life, and found that there was a median age at diagnosis of 23.

This is confirmed by Miller et al., 2020 as they state that there is a greater awareness of the diagnostic criteria and reduction in stigmatisation are causing a *rapid increase* in people seeking a diagnosis, and that at a later age. However, this comes with a risk that some participants are simply unable to access a diagnosis; meaning that a person who would significantly benefit from the application may be unable to access it.

2.1.2 Use Within Supporting Anxiety Conditions

Likewise, Maskey et al., 2019 states that fears, phobias, and general anxiety are common for people on the autistic spectrum, and there are multiple ways to reduce the symptoms of anxiety   this can be tackled by exposure in a safe and controlled manner (exposure therapy), this has been researched by Powers and Emmelkamp, 2008. Or by applying cognitive behavioural therapy (CBT) techniques (Springer, Levy and Tolin, 2018).

Through gradual exposure while being fully immersed; the levels of anxiety should be reduced, we can then use the research provided by Witmer and Singer, 1998 to measure the levels of presence (or immersion) within the virtual reality experience to read if this correlates accordingly. This is defined as 'VRET' by Powers and Emmelkamp, 2008 and they have investigated the impact of giving people a virtual counterpart to their anxiety invoking stimuli; this is similar to what we are trying to attempt. They found this method was *highly effective* at treating specific phobia that trigger anxiety. However, with Powers and Emmelkamp, 2008's work there is a significant risk that an application can be developed which prepares the user for the simulated environment but not the real world conditions, therefore creating a false and unreliable level of impact, which would not directly translate into the real world as expected. This is important to consider, as a system that only works on paper, doesn't really work.

As previously discussed a significant number of content has been developed on people with both anxiety and autism, and that is because it is twice as likely that an autistic person will have anxiety compared to their neurotypical[1] counterpart, leaving a reduced quantity of general content (Jeffrey-Wilensky, 2019; Rodgers et al., 2017).

On the contrary, Schoneveld, Lichtwarck-Aschoff and Granic, 2018 created a game that was designed to be used by a more general audience. They wanted to treat subclinical[2] levels of anxiety (specifically in children), allowing for treatment to occur naturally and before symptoms become out of reasonable control. Therefore, with our knowledge, we can assume that the there is a significant research deficit in the consultation of the overall effectiveness of the application. Because of this, the researcher will be aiming to be conducting the experiment by gathering a wide range of people.

But, there is still a flaw in both this and Schoneveld, Lichtwarck-Aschoff and Granic, 2018's research; the simulation will not be used outside clinical or structured settings, such as in a school. Therefore, it would be an interesting improvement to see how this technology could be adapted to working with a person all the time.

2.2 Technology Used

2.2.1 Google Cardboard vs Meta Quest 2

Previously discussed was Miller et al., 2020's methodology; A flaw within their methodology is that they were using an Apple iPhone X and a Google Cardboard device to create a five-minute experience.

[1] Person who does not have a developmental disorder/condition, such as Autism Spectrum Disorder (ASD) and therefore experiencing typical neurological development (Merriam-Webster, 2023a)

[2] "Not detectable or producing effects that are not detectable by the usual clinical tests" (Merriam-Webster, 2023b)

The first problem is that five minutes isn't the full experience of travelling, as Baker, 2022 discovered after interviewing a collection of airports, that a wait time to pass through security can range between seven and twenty-seven minutes, this is significantly more time than the five minutes that Miller et al., 2020 consumed for the whole experience. There is a point regarding the full twenty-seven minutes of waiting does not need to be implemented as this could make the participants lose interest and become bored, so this could be implemented so that the time was randomly determined or picked by the researcher. There is a valid reason why Miller et al., 2020 chose to reduce the experience's time span; there could be room to create a simulation which dynamically increases the durations of activities until the participant reaches a level which is a facsimile of real life.

The second problem is that they are using a Google Cardboard device, which Perla and Hebbalaguppe, 2017, p.g. 1 describes as a frugal solution to create an immersive VR experience at a minimal cost. This is a great solution if the device is being used by someone who already has a phone, and in situations such as a clinical setting it can be rather affordable, as when Yeolekar, Shinde and Qadri, 2019 conducted their research with vertigo they had the ability to purchase them for 'less than 10 dollars' which means that in a clinical setting these devices can be owned by a patient without the requirement of them being returned; which is especially important in a post pandemic world. And, a benefit of it being cardboard it can be modified easily to ensure that the patient has the best experience possible.

However, Perla and Hebbalaguppe, 2017, p.g. 5-11 notes several limitations are found with the headset including having a limited field of view which Versus.com, n.d. describes as being significantly worse than the `Meta Quest 2`, which also has improved interaction control and comfort. Even though it is more initial money the device is designed to last long and provide a significant experience, reducing things such as eye strain. Therefore, we will be using a Meta Quest 2 headset.

2.2.2 Unity vs Unreal Engine vs Godot

Since we have chosen to target the Meta Quest 2 headset, we need to pick a game engine to create the application within, and in the market of video game engines, there are three key options; Unity, Unreal Engine, and Godot. These all have the ability to create applications for the Quest device.

Godot

Godot is a free open-source video game engine which allows for the development of video games and 3d applications, including those for VR. When using Godot you have access to the single-purpose language 'GDScript' or the much more popular C#. It is funded solely by donations (Dealessandri, 2020).

And, the Godot team received an undisclosed grant from Meta Reality Labs (Takle, 2022), so they could improve further development, but this does not negate the fact they are the youngest popular game engine, being released in 2014.

This leads into the fact that currently, Meta does not recommend building VR applications with Godot on their 'getting started' tutorial pages of their documentation site. This will hopefully change in the future after more development has taken place with the project and after the funding has been utilised, because Meta are clearly seeing this as an opportunity to make strong use of this software, as they are including it on other parts of their website (Olij, 2019; Meta Platforms Inc., n.d.[b]).

Unreal Engine

Unreal is an engine developed by Epic Games[3], which has a proprietary licence with available source code to any developer which signs the non-disclosure agreement (NDA). It is used to create many traditional large and triple-A (AAA) video games, such as 'Fortnite: Battle Royale', 'PlayerUnknown's Battlegrounds (PUBG)', 'Gears of War (series)', 'Final Fantasy VII Remake', 'Valorant', and many more. (Bradshaw and Kruppa, 2020)

[3]Also known simply as 'Epic'

It can be used to develop applications for VR, and you can take advantage of ‘Blueprints’ or C++, with tutorials and documentation provided directly from Meta.

Epic has stated that they would like to be a key partner in developing ‘Metaverse Technologies’ and have been developing important toolsets for this use case. (Bradshaw and Kruppa, 2020)

Unity

Unity is an engine developed by Unity Technologies, who’s sole purpose is to develop the engine and provide support for it. The source code for the engine is available for enterprise customers, and has been used to develop a wide range of games, such as ‘Pokémon Go’, ‘Monument Valley’, ‘Call of Duty: Mobile’, ‘Beat Saber’ and ‘Cuphead’ (Bradshaw and Kruppa, 2020).

It can be used to develop applications for VR and uses the C# programming language, and like Unreal, has resources created by Meta (Meta Platforms Inc., n.d.[b]).

Compared to Unreal’s aims to be a key partner in the development of ‘Metaverse Technologies’ Bradshaw and Kruppa, 2020 state that Unity has an upper hand since it has a significant level of developers focusing on mobile applications which provides an upper hand to Unity; as the Meta Quest headsets run a customised version of the Android operating system.

Which Should I Use?

At the time of writing, the support issues currently from Godot causes it to be written off the table for any sustained long term development projects, due to the nature of the current releases. This however will hopefully change in the future due to the development currently taking place.

So it really comes down to a matter of personal choice, between Unreal Engine and Unity. Both engines are strongly supported by Meta, so there shouldn’t be any disadvantage between picking them.

There is a further choice to be made of using OpenXR or native Oculus[4] integrations. Both have their pros and cons, but the main difference is that OpenXR allows for multiple brands of headsets to be used, and not just ones developed by Meta. But, this leaves out specific development done directly by Meta for functionality unique to their headsets.

Regarding developer experience, Unity makes use of the C# programming language (which is a well known language by the researcher) compared to Unreal using C++ (less known by the researcher), even though there is the blueprint system it is important to be able to develop outside the artificial compounds as required. Therefore, out of personal preference it was chosen to use the Unity engine with the OpenXR tooling, as no specific Oculus functionality is required.

2.3 User Experience

It is important to consider the user experience throughout the project's development cycle. There are a couple of ways of approaching this, such as Hicks et al., 2019's Juicy methodology, which is his term for describing a type of visual embellishment within a video game. This can be useful for allowing a player to understand what they are aiming to complete. However, some levels of juiciness leave a lot less to be desired, especially in the context of a simulated experience, as it can become overwhelming to the player as it does things which are expected in a video game but do not happen in the real world. This could leave the player with the feeling of immersion broken Slater et al., 2009.

However, to follow on from his work, we can investigate into the aspects of the work of Hameed and Perkis, 2021; which focuses the same motive onto VR architectural walkthroughs. They investigated the difference between a 'passive walk' and a 'interactive walk', the difference between the two versions is that the interactive walk contains the ability to change the scene using affordances that replicated real life. Hameed and Perkis, 2021 discovered that it created a much better experience for the player to have the affordances, as it kept them engaged with the simulation.

[4] The original name of Meta Reality Labs is Oculus VR, which was changed to encompass the Meta brand, but some use of the 'Oculus Brand' remains in situ

Doing this implements what (Kilteni, Groten and Slater, 2012) describes as the sense of embodiment, which is the feeling that the player is in the virtual world.

There are a few different ways of implementing walking in a VR experience, the most effective type is the ones that make use of a treadmill such as the work being done by Jung and Yu, n.d.; Park et al., 2011, but this is not effective for this project's scope simply because the hardware to do this is inaccessible and cost prohibitive. Oppositely, Usoh et al., 1999 has researched other types of virtual reality movement. They discovered that real walking was the most natural feeling, and with the use of the `Meta Quest 2` headset, we are able to do this in a large space, however, the large space is not always available. So it can be useful to augment this with the ability to move your position around using joystick control, which may come with some the chance of increasing cybersickness. This can be alleviated by Wu and Rosenberg, 2022's research, which recommends the use of an adaptive field of view restriction. This tricks the player into feeling as if they are moving slower, so they are less likely to become cyber-sick, however this is not bulletproof for all people.

2.4 Aims & Objectives

To devise and develop a game which emulates the experience of travelling (internationally) from the UK, this will be providing training and reassurance to the player. This can be used to teach someone who has never been on holiday abroad or someone who hasn't been in a long time.

This will be tested by having them answer a set of questions rating their experience, anxiety, and presence before and or after using the system.

We will recruit users to partake in a study and, use the data collected to see if the players improve their anxiety after the training, and we will determine if the system is successful.

If it is successful, it has reduced the player's uncertainty as their anxiety result would have seen a reduction.

This is to be completed within the space of two academic semesters.

Chapter 3

Requirements Analysis

Strongly defining the requirements of the project is helpful to ensure that the project meets all the functional expectations to ensure that the stakeholders receive a completed delivery in the agreed timeframe.

In this chapter, we will discuss the three stages of the development process; designing, developing and evaluating. This ensures that the final project has a strong quality level before leaving to be used in a production environment.

3.1 Designing the Scenes

The project must consist of a wide range of airport experiences that a user may face in a real world equivalent situation. This also must be concise to ensure that the development process does not spend too much time on activities that aren't beneficial towards the project.

This involves creating a diagram (Figure 3.1) describing the relationship between each scene, and then removing the desired scenes if they provide little value over the time it would take for implementation. For example, it was decided to not implement the shuttle as the pre-made airport model didn't include significant detail to implement the desired size.

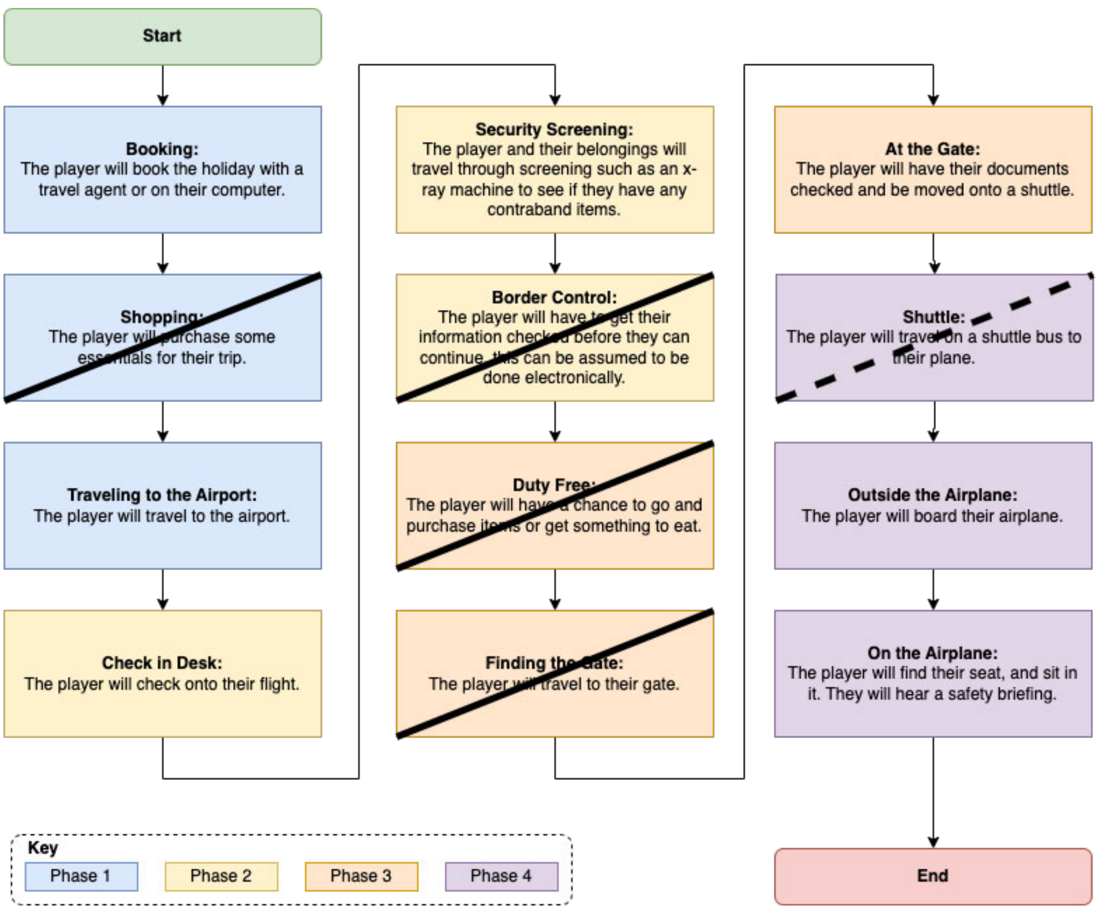

Figure 3.1: Flow Diagram Showing the Interconnection of Each Scene

3.2 Developing the System

The scenes must have their interactions and environments implemented within the game engine. Obtaining or creating the models requested in the previous requirement.

The system must be integrated with the VR headset to a significantly full extent; ensuring that the player is able to interact with the world as designed.

3.3 System Evaluation

Make use of relevant evaluation tools, including literary review and user feedback.

Literary review took place before the project commenced, and took place throughout development to ensure significant implementation took place. This involved reviewing every decision that was taken and identifying if there was a researched alternative of better quality or provide the user a better experience.

Primarily, research was conducted through the use of a questionnaire which makes use of known valid and measurable questionnaires (the GAD-7 and Witmer and Singer, 1998 Presence) which ensured the stability of the results.

Secondly, the researcher had to meet with the participants due to the use of a VR headset, and in some cases was offered unstructured feedback, such as the order of operations error which caused the experience to become stuck at an unfinishable state and requiring restarting, because the player has placed their bag in the tray, but the `InteractionManager` is unprepared for this to happen as dialogue is still being read out. (This was improved by adding the same waypoint material to all position based interactions).

Chapter 4

Design & Methodology

4.1 Software Methodology

The project made use of object-orientated programming, this is because it is the standard choice for the Unity Engine. However, this is choice is effective for this use case as it allows for all the components to operate individually. Functionality which needed to be added from the ground up made use of Gamma et al., 1994's principles, such as abstract factories and singletons. This allowed for the codebase to scale with relative ease.

The project was developed using a hybrid between waterfall and kanban task-list methodology, this is because the development tasks were all being completed by a solo-researcher, and using this allows the development and planning overheads to remain low, compared to something such as SCRUM. SCRUM typically involves three separate roles, the team, the owner, and the master and for this project it seems to be excessive (Stoica et al., 2016).

The project required the use of a waterfall methodology because of the requirement of some previous components being build upon. What happened was the overarching tasks were structured in a waterfall (and were managed by the Gantt chart), whereas the individual smaller tasks, which didn't have to be completed in a set order, were managed with an agile approach.

Doxygen was used to visualise the internal documentation and for creating diagrams of the class structure, such as the one in Figure 5.2.

4.2 Project Management

4.2.1 Git Version Control

Git was chosen to be used due to familiarity with the tool by the researcher, and the fact there wasn't any clear reason to use any other system, e.g. Plastic SCM.

Using Git allows for the use of project management tools such as 'Commits', 'Branches', 'Issues' and 'Pull/Merge Requests'. This allows for code to be developed as a part of a team which was not required in this instance, but the commit system was beneficial for allowing for easy rollbacks to happen if there was a mistake were to happen. Branches add onto this, allows for complicated, multistep changes to be worked on without breaking the 'main' (or release) version.

The code-base was hosted remotely on GitLab.com. This project could have been hosted on GitHub successfully, but it was chosen due to the more flexible usage quota on the platform and for the ability to experience another platform's developer experience. Nevertheless, since both platforms are using the Git protocol it is possible to connect to both platforms (and GitLab offers automatic code mirroring; which can be useful for a development team to create an internal repository for live changes, while using GitHub.com to host a public version.) Doing this allows for the code to be hosted in many places at once; reducing the risk of data loss.

Git also allows for the version control system to be run locally[1] meaning that changes are tracked and reverted without needing to make use of a hosted platform.

[1]On the computer being used

4.2.2 Gantt Chart

Multiple Gantt Charts were created throughout the project to showcase the big picture scheduling of the development process. This was used to create wide scope deadlines for the project.

The first (Figure 4.1) one was created during project initiation this created the first over-view of how long things would take.

The second one (Figure 4.2) was taken at the project interim; this gave an update during the middle of the project. This version was updated to include

Finally, a new version (Figure 4.3) has been created. This is so that the project actuals can be compared to the previous two records. This version is now including the problems accounted with the ethics process.

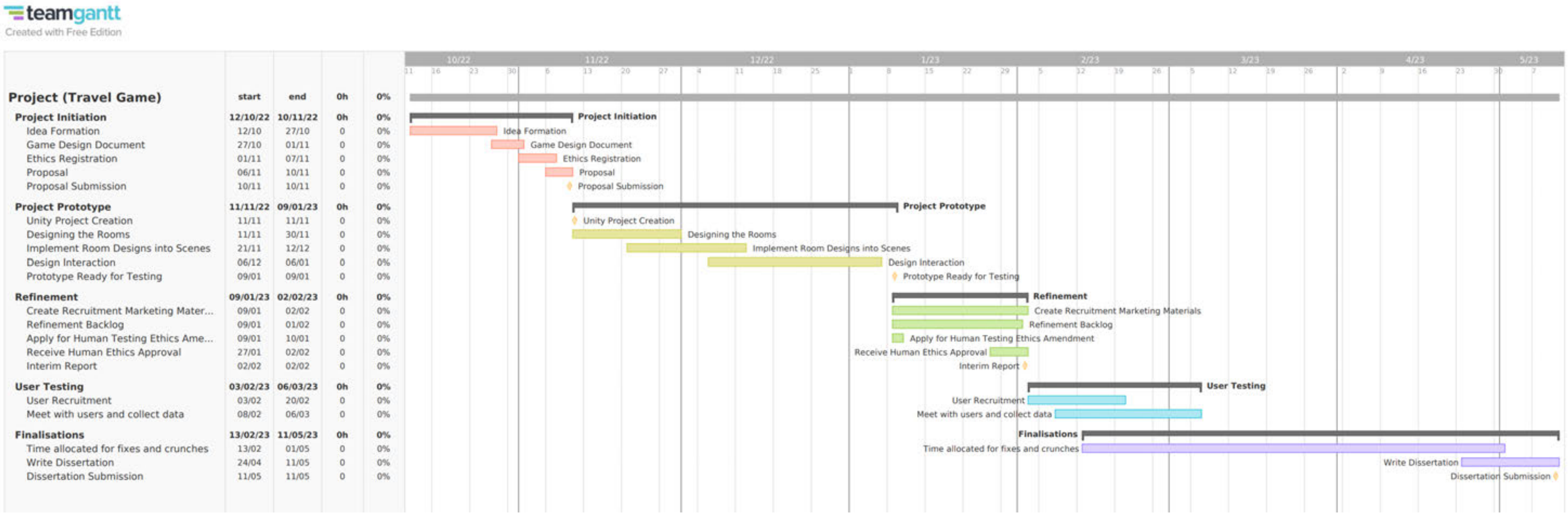

Figure 4.1: First Gantt Chart: Created at project initiation

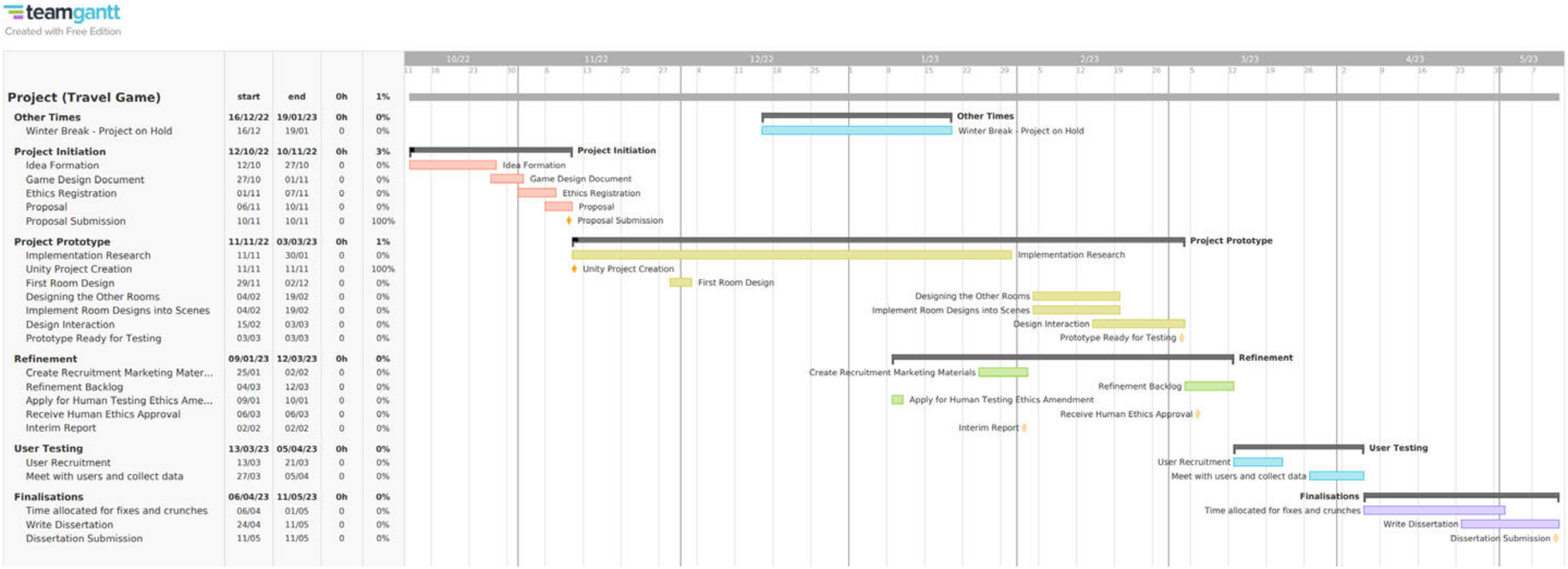

Figure 4.2: Second Gantt Chart: Updated during the project interim

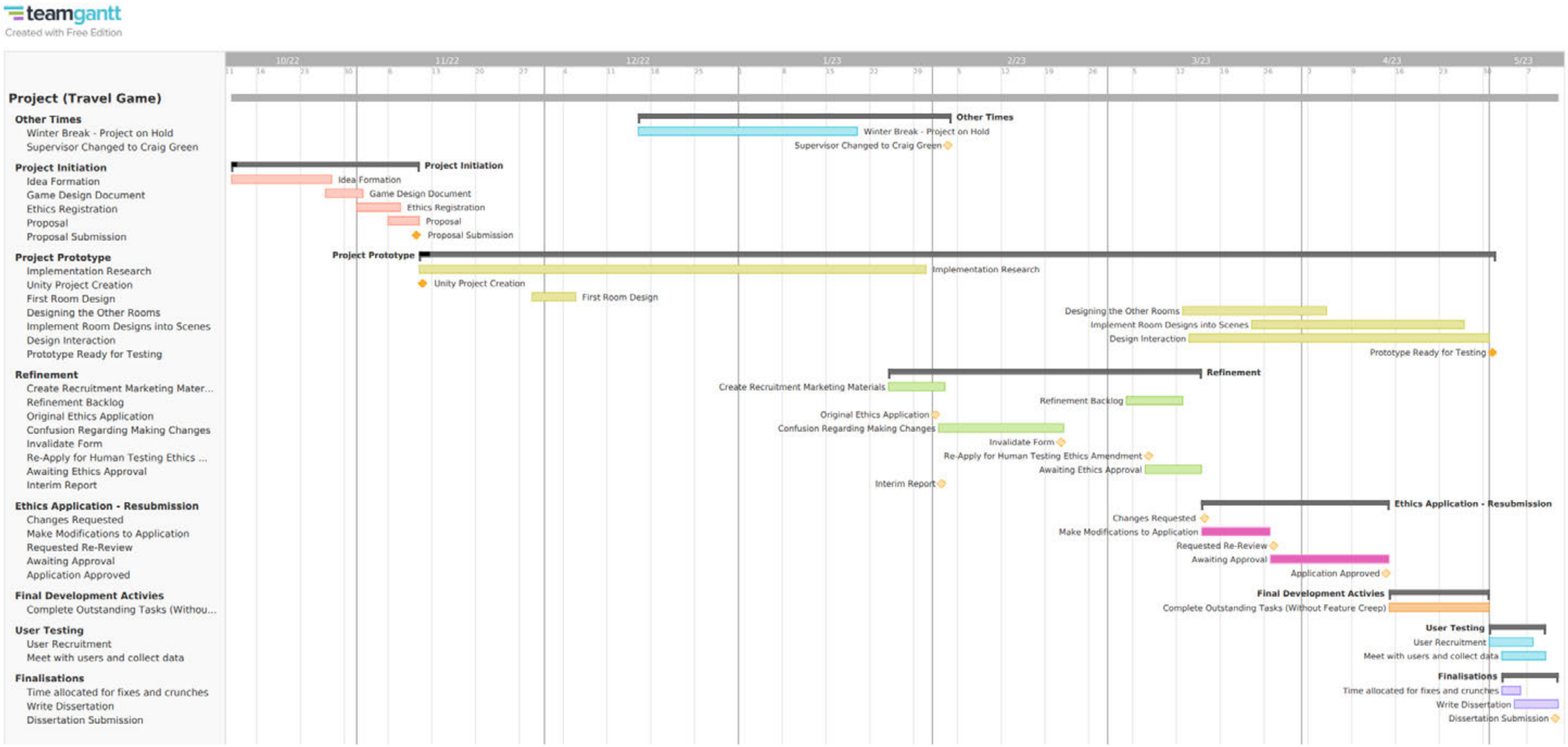

Figure 4.3: Final/Third Gantt Chart: Updated after project completion

4.2.3 Toggl Track

Toggl Track is a time tracking application and works similarly to a timesheet. This was used to monitor[2] the time spent developing the project and was used as a motivation tool for how much has been completed. This is useful for understanding the quantity of time spent on the project, so a proportional quantity of time on the project, and then other responsibilities including other modules.

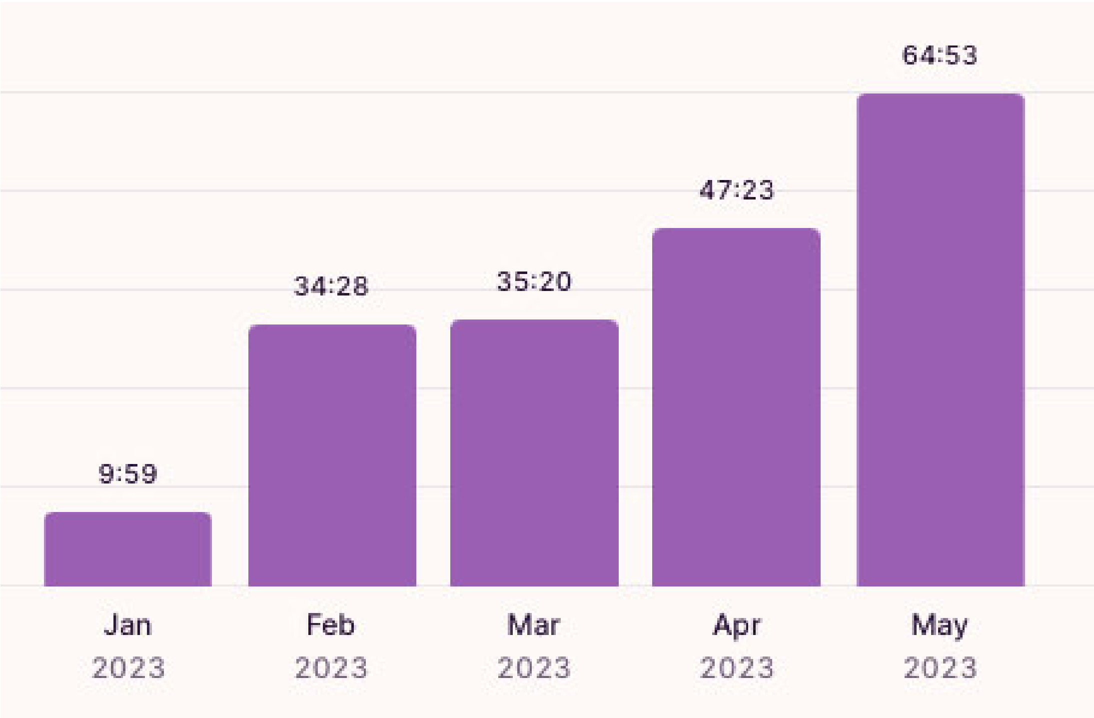

Figure 4.4: Report from Toggl Track of How Many Hours Spent Working On The Project Since January 1st 2023

4.2.4 Notion

Notion is a flexible document system allowing for notes to be systematically organised and edited quickly. Notion was utilised in two key areas, for game design and for minor management of time and tasks.

This was used alongside the Gantt Chart(s) to create day-to-day task lists, allowing for the project to be broken down into multiple steps. However, it is important to note that this was not used for appointment scheduling, and instead Outlook was used due to University data policies and the ability for greater levels of collaboration.

[2] Since January 1st 2023 (when data collection started to become reliable after committing to using the application)

4.2.5 Game Design

Notion was used to generate an initial game design document, this takes what has been decided from reviewing literature and developing onto it. The document was created to create a key point of reference to what the project should have implemented, and how it should feel to the user. The document was updated during the development process.

Context

This document is the game design document to record the ideas process for the game, created as the primary artefact of the Project Module.

Hardware and Tools

The game will be created using **Unity 2021.3** ***(LTS)*** and will be targeting a **Meta Quest** ***2*** - due to their cost to performance ratio.
Source code will be hosted and managed inside of **GitLab**.

Elevator Pitch

The game will be used to educate people on the rules and process of air travel. From the initial booking, through to security (having stuff removed if it's not allowed following UK rules), to boarding the plane, flying, and leaving (this will be the finish state).

Game Stages

Each stage will most likely be its own scene, and the screen should fade to black while transitioning to ensure that the user experience is smooth and to prevent sickness.

Booking

The user will visit a travel agent which will book their holiday for them.
This could be further expanded to allow them to simulate booking via a website.

Travelling to the Airport

The player will need to travel to the airport. There are a couple of ways of implementing this.
The simplest is to teleport the player to the location, they could also travel in a taxi (with the potential of implementing a second person driving mechanic, however this may induce sickness, and would need to be investigated further.)

Checking-In

The player will need to locate the check-in assistant's stand. And will need to travel to it, and when they are at the check-in desk, talk to the representative.

Security

There will be a point where the player needs to walk through a security checkpoint, this will involve them getting their bags checked. And, potentially, including a screening screen where they would have to pick out what's wrong to test their knowledge.

Boarding the Plane

The player will need to navigate towards their plane and then board it. This can be done in one of three ways; teleportation, stairs, or a tunnel.
Teleportation will be the easiest to implement and will provide the least risk of motion sickness.
The stairs will be the hardest to implement, as it will require a new mechanic not developed else where in the project.
And a tunnel will require the most art time and would run the risk of missing outside content.

Flying

They will sit in a seat, and the plane will appear as if it is moving.
There is a chance for playful experiences such as conflict (which could be a baby crying and the user has the ability to interact with them and change the environment). Or, they may have the ability to use an in plane entertainment screen. Or, they may get an in-flight meal.

Completion

The game should indicate that it has finished by either returning to the main menu or should provide a 'ta-da, enjoy your holiday. You survived travelling!' informational screen.

Extra Enhancements

- Allow for the user to make choices within the play through, allowing them to choose things such as where they are going to, what they have packed, affecting the game's outcome.
- Improved graphical fidelity.
- Unique input controls.

4.3 Risk Analysis

4.3.1 Loss of Data

During the development of the project, data is created. This can be classified as ‘high-risk personal data’ and ‘non-sensitive development data’.

High-Risk Personal Data

Due to the sensitive nature of this type of data, it has been collected securely using University Cloud Services provided from Microsoft 365.

This means that the data will not leave the University’s possession and will be deleted securely.

This data is managed and backed up by the University, so the risk of loosing it is low. But, if it was lost; the data is only identifiable by the randomly generated identifier created by the participant, so only they would only be able to identify their submission. And if the data was lost recruitment process would have to be restarted to obtain new unique participants.

Non-sensitive Development Data

Data such as the application source code is of a non-sensitive nature, this is due to it not containing personal data collected from participants.

The application source code may be released in the future under an open-source licence, so the risk of the code being exposed prematurely is low.

Task lists are ephemeral and if it were to be lost, a new one can be created without significant downtime.

Source code is kept in multiple locations, locally on the development computer and remotely on the GitLab.com server. This means that if the server went down the code would still be able to be worked upon locally, or if the computer was destroyed the code be ‘cloned’ back, allowing for development to continue.

4.3.2 Loss of Equipment

Loss of equipment used for developing and testing would cause significant issues to the project. This is because a replacement headset or development computer would incur a significant cost.

However, reducing this risk, the school provides multiple computers and VR headsets, which would allow for the development activity to continue in place of personal hardware or while awaiting repair or replacement.

Sunlight Damaging the Meta Quest

It is important to note that Meta Platforms Inc., n.d.(a) states that their headset must not be exposed to sunlight, as it has the ability to cause damage to the sensors and screen.

This has also been discussed by Poore, 2021 as the headset is 'essentially a blindfold' and small things such as a slight change in elevation or a temporary obstruction such as a neighbour's dog can cause significant risk of the participant tripping and causing injury to themselves.

Not only this, Poore, 2021 mentions how the sensors do not work well enough in direct sunlight or darkness, this is due to the device being built to be operated inside. This is because there isn't a clear enough image captured by 4 sensors/cameras, as they do not have an ND filter[3].

4.3.3 Access to Participants

At the time that the project would be at the point that it would be ready for testing is the busiest time of the academic year and, as previously discussed, the large majority of people who will be testing the project will be colleagues and will be busy. They would have to allocate a large amount of time to engage with the research, this would potentially be spent with little to no reward from being involved.

[3] Sunglasses for a Camera

4.3.4 Motion & Cyber Sickness

The participant may feel motion/cyber sick. This is due to the headset taking over their sense of vision, which can cause confusion as their other feelings don't match what they are seeing. This is a completely different feeling compared to general anxiety caused by the experience.

Before the participant is allowed inside the VR headset, they will be briefed, that if they become feeling sick or anxious that they should communicate this with the researcher verbally (or otherwise predetermined and preferred by the participant). They would then be removed from the situation.

With Cybersickness the symptoms can be; Eye strain, Headache, Pallor, Sweating, Dryness of mouth, Fullness of stomach, Disorientation, Vertigo, Ataxia, Nausea, and Vomiting (Laviola, 2000). The difference between cybersickness and motion sickness is the fact that a person doesn't have to be moving to feel cyber sick (Laviola, 2000; Davis, Nesbitt and Nalivaiko, 2014).

However, since Laviola, 2000 research, there has been developments in the space on how to reduce the effects of cyber sickness. One way of doing this was suggested by Farmani and Teather, 2018, and that's to implement view point snapping this will cause fast movements to snap into percentages of 22.5°.

Another way is to manipulate the users' field of view as a lower field of view makes it so movement and speed is perceived much slower. This mitigates the impacts of moving in VR space (Wu and Rosenberg, 2022).

If, after taking the necessary steps to reduce the risk of this occurring, the participant experiences the effects of cybersickness or anxiety. Access to water will be promoted and the contact information for the on-site first-aider, and other support organisations are provided on the Participant Information Sheet.

4.4 Research Involving Human Participants

4.4.1 Ethical Application

This project has been reviewed from University of Lincoln ethics board and has received the reference '2023_13535'.

For this to happen, an application form had to be completed and submitted; which was then reviewed by the project supervisor[4], and then sent onto the ethics board. They then requested some changes regarding the clarification of some matters. After this was completed,the board returned a favourable[5] opinion.

4.4.2 Participant Recruitment

Participants were informed of the project with a message which included information regarding why the project was being conducted, and what was being asked of them.

Participants were recruited from the researchers connections.

> I am conducting a study on the effects that simulating the process of travelling from the UK.
> As you may know things have changed since Brexit, so if you haven't travelled before or in a long time this might be overwhelming.
> The study will consist of you being exposed to a simulation in a virtual reality headset to allow you to practise the process before you go away. You will be asked to complete a questionnaire before and after you take part.
> This should take around an hour of your time, at your convenience, on the Brayford Pool campus in Lincoln or remotely if you have the necessary equipment.
> If you would like to get involved or would like more information, please contact me via my University email 25466645@students.lincoln.ac.uk to learn more.
> This project has been approved by the University of Lincoln ethics board, reference 13535 and is supervised by Craig Green.

[4] Craig Green
[5] Happy for the research to be conducted

4.4.3 Study Design & Statistical Testing

The participant would be given a link to a Microsoft Form, which would ask them to identify statistical information such as how often (and far) they have travelled, then each question would be rated based upon the five point Likert scale.

Travel Experience

The five positions and their score weightings are:

- I have never (1 point)
- I have more than 10 years ago (2 points)
- I have in the last 10 years (3 points)
- I have in the last 5 years (4 points)
- I have in the last year (5 points)

Then participants were asked to rate the following ten statements using the previous Likert scale options. This was then calculated by adding together the score of each question, which would create a score out of 50, with 50 being the highest possible travelled person.

- Travelled outside my home county (e.g. Lincolnshire or Nottinghamshire)
- Travelled outside my home country (e.g. England, Wales, Scotland, NI)
- Travelled outside the United Kingdom
- Travelled into the Schengen Area
- Travelled into the North America
- Travelled into South America
- Travelled into Africa
- Travelled into Asia
- Travelled into Oceania
- Travelled to a different planet

The purpose of measuring the quantity of travel experience that the participant has is so that the level of anxiety change for someone who hasn't travelled as much, can be accurately weighted compared to someone who travels more frequently.

Anxiety

When diagnosing mental health conditions, the PHQ[6] is currently used as a system to calculate the severity of a condition. Created by Kroenke, Spitzer and Williams, 2001 it is a three-page self-administered questionnaire which has diagnostic algorithms attached to it to calculate a wide range of mental health conditions. There have been many derivatives such as the PHQ-9 (targeting depression) and the GAD-7 (targetting anxiety) (Kroenke, Spitzer and Williams, 2001; Sapra et al., 2020).

To answer our research question, we are asking the participants questions relating to their anxiety. The anxiety questions used the GAD-7 structured questionnaire, which is used for the diagnosis of general anxiety conditions (Sapra et al., 2020; Kroenke, Spitzer and Williams, 2001).

Presence

The participant would then be given access to the simulation, and they would complete the full experience, and then complete the same Microsoft Form once again, but this time it used branching to still ask them questions regarding their anxiety, but don't ask them questions regarding their travel experience. And instead, it was decided to use Witmer and Singer, 1998's framework for asking questions about their VR Presence, to provide additional feedback metrics to see if there is a potential correlation between the effective change to the rate of personal anxiety with the amount of presence they felt (Schwind et al., 2019).

[6] Patient Health Questionnaire

Chapter 5

Implementation

5.1 Developer Tools

5.1.1 Unity

It was decided to make use of the Unity Engine and the C# programming language due to the lead researcher's comfort with the engine.

Visual Studio 2022

Multiple code editors were used during the development, but it was settled on to use "Visual Studio 2022" due to the strong integration with the Unity Engine without requiring additional subscriptions or tedious configuration.

5.1.2 Meta Quest 2

The Meta Quest 2 headset was used because it was accessible for development and the flexibility it provides by being able to be used standalone while also providing a good user experience, it is also an affordable headset, decreasing the risk to the project.

OpenXR

OpenXR is a toolkit which has been implemented inside the Unity Engine and the Meta Quest headset, which allows development time to be spent on the design of the application rather than integrating with the headset, which would have significantly increased development time.

Using OpenXR also allows for the ability to use another headset much more flexibly.

5.2 3D Models, Art, and Design

The project did not have sufficient budget to hire an art team to create custom assets for the experience, so online networks such as 'the Unity Asset Store', 'CG Trader' or 'Sketchfab' had to be relied upon.

Due to the budget requirements of the project, assets had to be free, or low cost. The project was implemented with assets built with the 'Pro Builder' tool inside the engine, or downloaded from the networks.

These models came already textured, which were taken advantage where appropriate, however in some instances this left the experience less than desirable. Therefore, it was necessary to 're-skin' the models, such as adding the University livery.

Blender was also used to alter and fix models that came with issue and incompatible with Unity.

5.3 User Interactions

The core system which allows for the implemented experience to progress for the player was by creating a User Interaction System. This is a system that generically controls the flow within the game. All the interaction code is stored inside the `Interaction` namespace, this is used to separate the interaction logic, proactively preventing code confusion[1].

[1] The term 'interaction' isn't unique enough to confidently use it without worrying about the Unity Engine getting confused with another class.

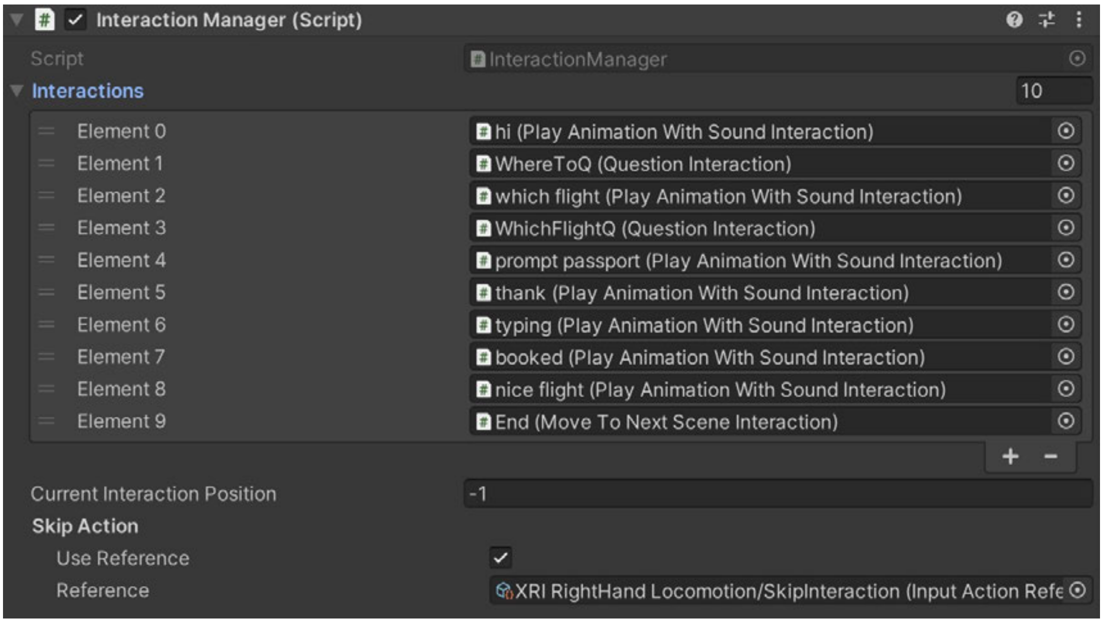

Figure 5.1: Interaction Manager Script

This is controlled by an over arching `InteractionManager` (Figure 5.1) which handles the state of the game. It works by creating a C# list which it iterates through, running each interaction and then once it has completed the current one; move onto the next one. This class is implemented as a 'singleton' which means that there is only allowed to be one instance of the class and that instance is available globally within the application (Gamma et al., 1994, p.g. 127). Meaning that when a method wants to be called from it, such as `RunNextInteraction()`, it can be done by using the instance property, e.g.

```
InteractionManager.instance.RunNextInteraction();
```

How this works is that it makes use of the abstract `Interaction` class which contains the definitions for the two method calls `Entrypoint()` and `Completion()`, which can then be reimplemented as required for each derived interaction.

The `Entrypoint()` function is called when the interaction is currently active within the `InteractionManager`. And, the `Completion()` method is called before `InteractionManager` has started to use the next interaction.

There are many interactions which have been created for a range of purposes and have been named in the format of `DescriptionOfActionInteraction`, a full list of all the interactions can be seen in the class diagram shown in Figure 5.2.

For example, the `Play Animation With Sound Interaction` is used to play an animation while also playing an audio file. This has been for the non-player characters to communicate with the player. This has been used inside the Travel Agent's scene to allow the agent to ask the player which flight they would like to board while configuring the Unity Animator to have them seated and talking. This allows for the animations to be inline with what action they are currently doing. The inspector window can be seen in Figure 5.3.

This interaction wouldn't typically be used on its own, and for this context, it was used with a `Question Interaction` which opens a UI canvas with two options. It will then wait until the user presses a button, picking their option (and in this case the result is discarded and makes no difference to the gameplay, but increases the player's connectivity to the game). And, then, it takes advantage of the `Completion()` method to hide the UI canvas once the player has completed the interaction.

However, a limitation of how this system works is that a player can often accidentally complete an in interaction in the incorrect order. This is a significant problem in the security checkpoint scene. This was discovered during internal testing as the player can move their suitcase to the tray, but not active the interaction for approaching the area. This was resolved in two ways, applying the translucent blue coloured waypoint material to the trigger collider and adding a button which would advance the interaction, preventing the need for it to be restarted if something were to go wrong.

On the note of the suitcase being moved; the conveyor belt originally worked by applying a force to the suitcase to move it to the other side. However, this was hard to interact with; as the suitcase would often go either too slow and not move, or go too fast and hit into the back wall. So, this was replaced to increase the user experience with an animated tray and a `Simple Socket`, which meant the player only had to wave the suitcase near the tray, and it would fit into it (providing a snapping effect).

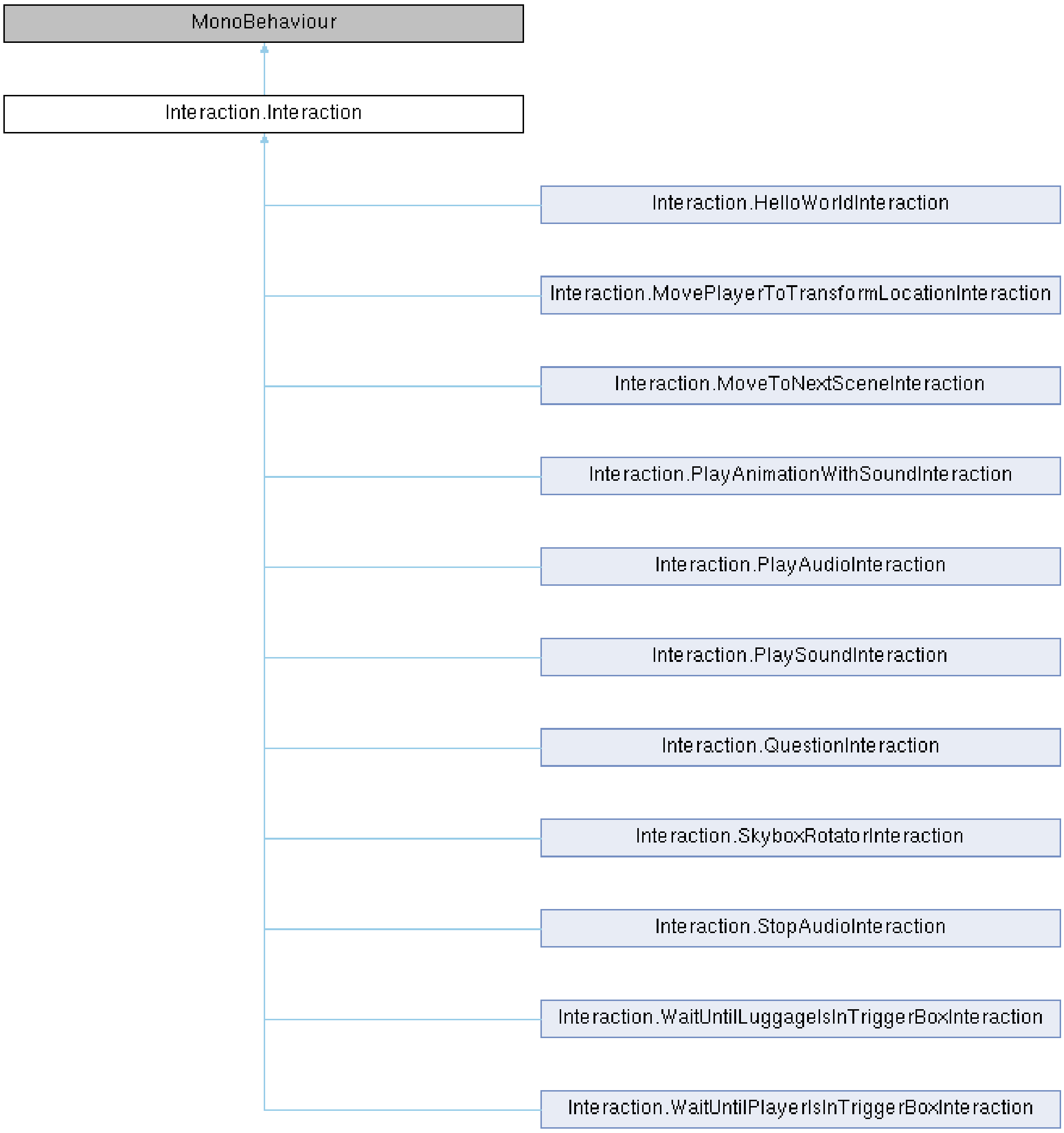

Figure 5.2: Class structure diagram of the 'Interaction' object

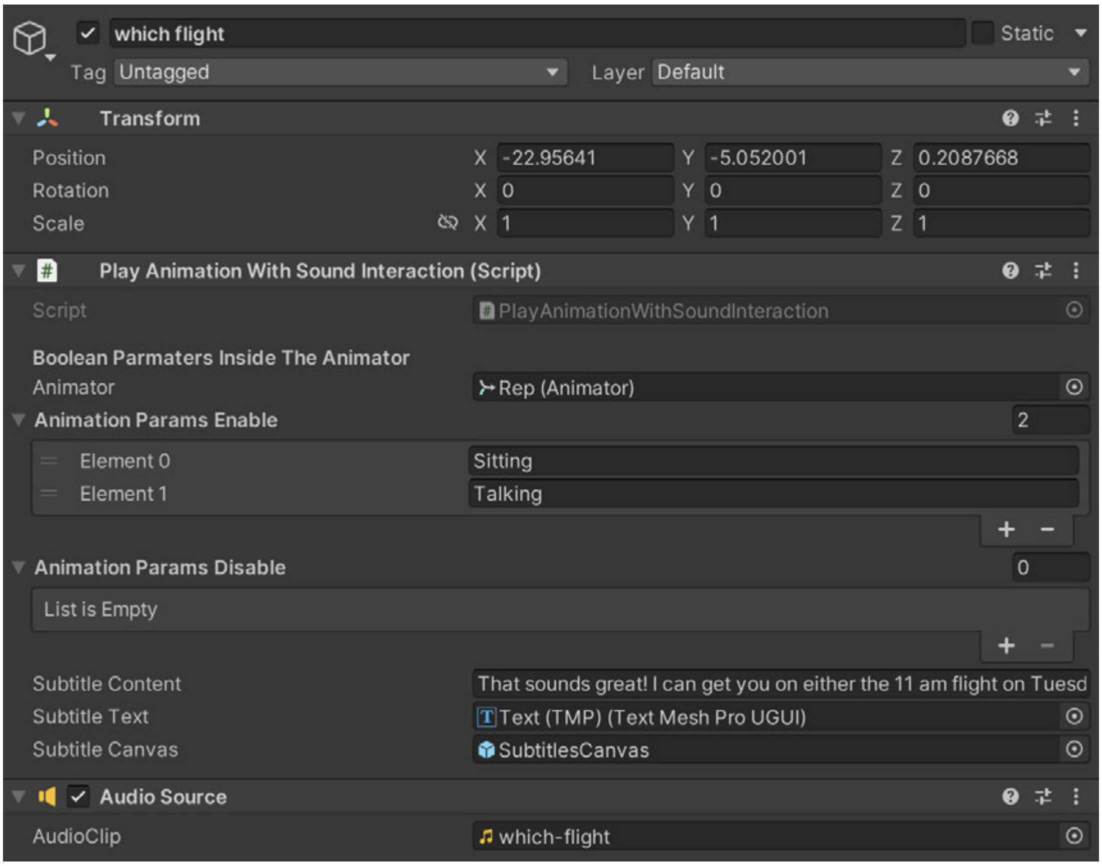

Figure 5.3: The Implemented Interaction for 'Which Flight?'

5.4 Final Product

The final product is a VR application that creates the perception of travelling internationally, between the UK and an international location, such as 'Paphos' and 'Ibiza'.

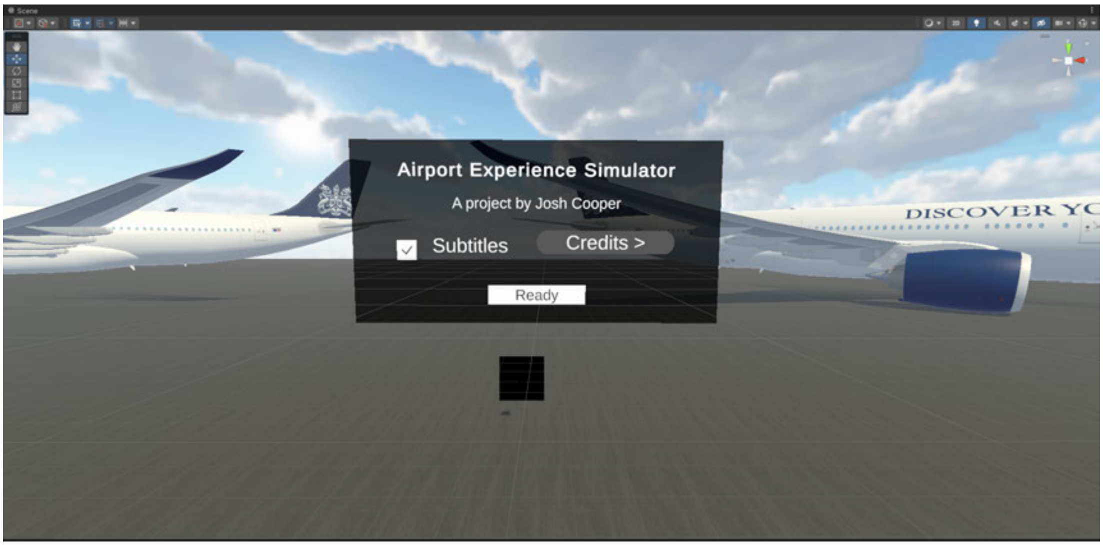

Figure 5.4: Final Product: Main Menu Scene

Figure 5.5: Final Product: Travel Agent's Scene

Figure 5.6: Final Product: Entrance to the Airport Scene

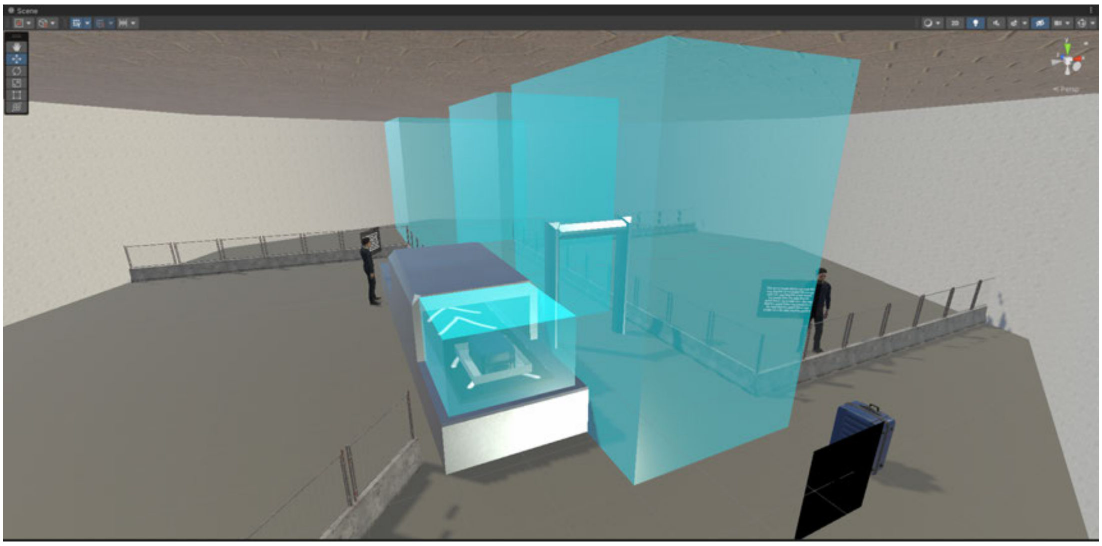

Figure 5.7: Final Product: Security Checkpoint Scene

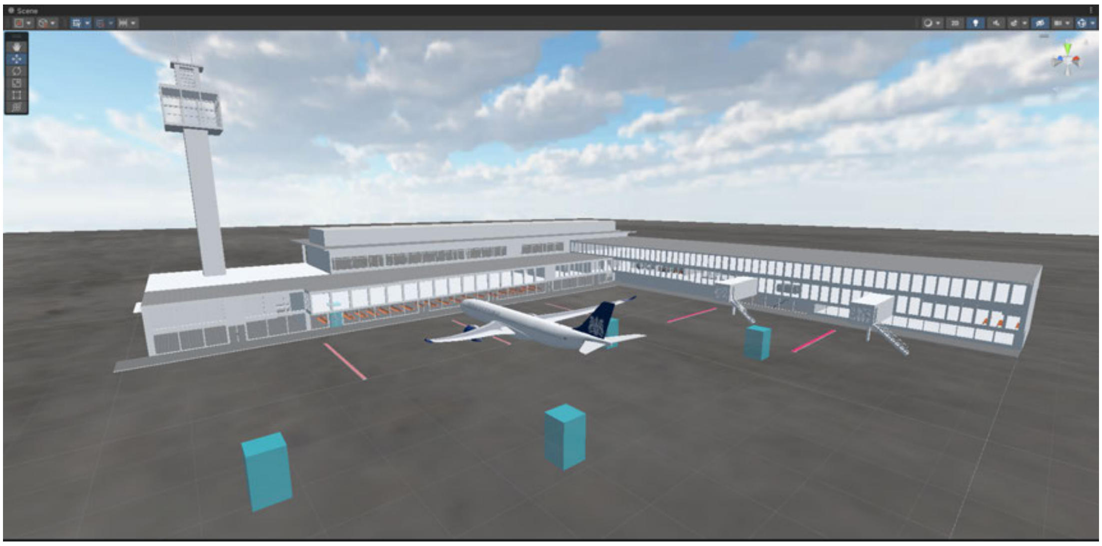

Figure 5.8: Final Product: Rear Airfield Scene

Figure 5.9: Final Product: Aeroplane Cabin Scene

Chapter 6

Results & Discussion

6.1 Calculations

This section discuses how the calculations took place and provides insight into what a score may mean.

Participants originally provided unique identifiers, but this has been converted into a letter system to ensure the analysis remains consise.

6.1.1 Presence Questionnaire

To keep calculations as simple as possible, Slater, 1999's methodology of calculating the presence questionnaire was used. As the users are rating based upon a number based scale, the simplest way of calculating this is to sum each question together. This has its limitations as it does not enable specific review, but for the purpose of this experiment it is more than enough analysis.

There are 23 questions which were used, this with the seven-point scale meant that there was a maximum value of $23 * 7 = 161$, meaning that 50% would be valued at 80.5, and 75% is at 120.75. The higher the level of presence, the more immersive the experience is.

6.1.2 Anxiety/GAD-7

The GAD-7 calculations work by collecting a sum based upon the value of the responses, in this case; Not at all adds 0 points, A little bit adds 1 point, Somewhat adds 2 points, and A lot adds 3 points to the total. This is then used to calculate the change in anxiety (Δ).

The Δ Anxiety has been calculated by subtracting the Post-Anxiety score from the Pre-Anxiety score. A score which is negative is a positive sign, a score of 0 indicates there has been no change with the person's rate of anxiety, and a positive score indicates that the participant feels more anxious.

6.1.3 Travel Experience

Understanding the experience of travelling, a participant has had, can be beneficial to determining how effective this system is at providing the necessary results. The score was calculated by adding points based on which answer they provide. The lowest score a user may receive is 10 and the highest is 50, providing a range of 40 points. An average score is expected to be 30 points.

The points were awarded based on the answer that the participant provides; 'I have never' (scores 1 point), 'I have more than 10 years ago' (scores 2 points), 'I have in the last 10 years' (scores 3 points), 'I have in the last 5 years' (scores for 4 points), and 'I have in the last year' (scores 5 points). This is then summed together to receive the final score.

6.2 Actual Results

Adding to the previous section, this section reviews the results of the experiment. The first thing to discuss is the recommendation factor, it is a split 50/50 reaction that the participant would recommend the solution to others, or that they are unsure about it.

6.2.1 User Presence

The range in presence is 31, this is approximately $\frac{1}{5}$ of the result space in difference. We can determine from the results shown in Table 6.1 that the participants mostly felt immersed into the environment, but there is an obvious headroom for significant improvements to be made, as the highest score is valued at 77%. But, the result is positive, as the presence scores are all above 57.7%.

6.2.2 Change in Anxiety

Using the methodology discussed, and the results collected in Table 6.1 and visualised in Figure 6.1 the change in anxiety levels for the participants. This tool had more of an effect on some participants compared to others. This could be indicative of further unrecorded data, such as if the participant is Autistic. This relates back to the literature and how there is a lot of use for Autistic people.

It can be seen that no participant's anxiety increased. But, half of the participants did not see any change in their rate of anxiety.

One participant (B) saw a one point decrease in their anxiety rate, this could be indicative of a margin of error and further research would have to be completed.

Participant D, saw a huge seven point loss of anxiety, there is a high significance that this was an anomaly within the data collection process, or the fact that the participant has had time to get adjusted to their surroundings and potentially external pressure such as using a VR headset for the first time could have affected how this made them feel.

Likewise, Participant C received a five-point loss, which could indicate the same thing happened as participant D, or that both answers are valid. And that the system only works in specific circumstances not recorded within the questionnaire.

6.2.3 Travel Experience

All participants had a score which was below a medium level of travel, with participant F being the closest to that point, at 29 points. This is an indication that the participants aren't too experienced with travelling.

As previously discussed, participant D has had a seven point reduction in their anxiety, but it aligns with the travel experience, they have the lowest score at only twenty-one points. This could add to the hypothesis that the system only succeeds in certain scenarios.

However, there is some flaw within this methodology and that's that it misses to account for travelling multiple times to a single destination, which would be expected to increase experience but with this current system wouldn't provide any differentiation between someone who goes to that location once.

Participant	Travel Experience)	Pre-Anxiety	Post-Anxiety	Δ Anxiety	Presence	Recommendation
A	26	5	5	0	112	Maybe/Unsure
B	25	9	8	-1	93	Maybe/Unsure
C	22	14	9	-5	97	Yes
D	21	7	0	-7	124	Yes
E	22	4	4	0	102	Maybe/Unsure
F	29	2	2	0	124	Yes

Table 6.1: Participation Data Collection Summary

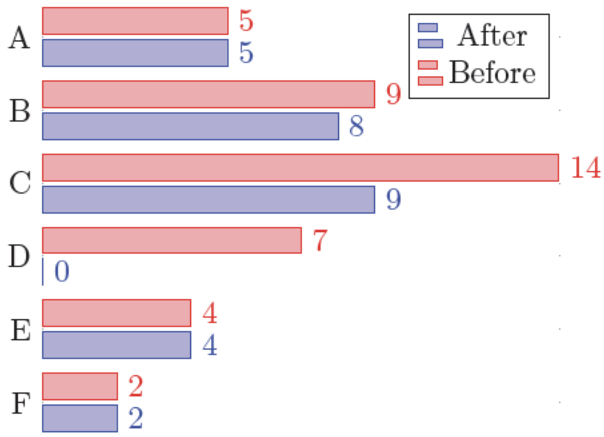

Figure 6.1: Calculated Anxiety Levels of the Participants Before and After Using the Simulation

6.3 Limitations

Sadly, the project's ethical application took a longer than naively expected amount of time for the review, which compounded with the issue of having changes requested pushed back the time that testing could commence. This has left the time for recruitment and testing to be less than desired, this has left it so that the period that testing took place was towards the end of the academic year, causing many potential participants to be unable to afford the time it would take to participate. This has caused the project to only have been tested fully by 6 people.

Chapter 7

Conclusion

The project was indeed mostly successful in meeting the development aims it set, but in the worst turn of events, the target it was aiming for wasn't the right one to go for. Despite the fact that there is a limited amount of participants; the methodology is flawed. There are many contributing factors to why this could be the case; such as the models not being accurate enough, some interactions bordering too close to simplicity, or maybe something else entirely. The results have started to indicate that there was not a significant difference with the rates of the anxiety a player feels.

To rectify some issues, it may have been necessary to gain the amount of people that worked on the project who have a wide range of skills, so one person could be focused purely onto the art direction. Or purchasing higher quality models rather than relying on freely available ones, which are of significantly lower quality.

Another thing to improve would be to incorporate some test into the simulation to identify if the player has learned things about the airport experience. Due to the fact that this was not explicitly tested, it is impossible to say for certain that this wouldn't have improved even though

The final reason, I feel that this project was given a larger scope that what was feasible during the available timespan, as it was assumed that the project would have ore available development time than actually available. This has caused multiple scenes and considered functionality to be removed to get to a finished project.

On a positive note, it was enjoyable to work on the project and to create the final artefact, despite the discussed issues.

7.1 Future Works

There is an interesting gap which could be filled by further work in this area.[1]

The easiest answer is to take this project, make the necessary improvements to the final polish to ensure it is more feature complete, and then provide it to a much wider population. This could also be compared with a screen-based learning system, such as a computer game or video. This comparison would help determine if an invasive virtual reality system was necessary or not. And, if it wasn't required it would allow for much greater access to the system, this is because participants could get involved from their home.

Or to create a system using Augmented Reality which would make use of 'iBeacons[2]' which are known more generically as Bluetooth Low Energy Beacons. They work by transmitting a unique identifier, which is used to calculate the proximity from the location (Ji et al., 2015). This can be used with or without other internal localisation techniques, to place the information over top a real airport. This could be provided via an application which would be used on a smart-phone or via smart-glasses. A possible benefit to using an augmented system is that the user would be experiencing a real situation and not a digital facsimile.

[1] If you create something derived from the work presented within this dissertation – please feel free to contact me.

[2] Small devices that emit a Bluetooth signal which can be used for internal localisation.

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Chapter 8
Appendix

Word Count: 8,494

Demonstration Video Link: https://youtu.be/k0OpUYfHLgQ

Source Code: [redacted]