

Computer Games Development

Project Report

Year IV

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**Contents**

[Acknowledgements 2](#_Toc133346649)

[Project Abstract 2](#_Toc133346650)

[Project Introduction and Research Question 2](#_Toc133346651)

[Literature Review 3](#_Toc133346652)

[Virtual Reality 3](#_Toc133346653)

[Level Editors 3](#_Toc133346654)

[Steering Behaviours 4](#_Toc133346655)

[Evaluation and Discussion 5](#_Toc133346656)

[Testing 6](#_Toc133346657)

[Project Milestones 10](#_Toc133346658)

[Major Technical Achievements 14](#_Toc133346659)

[Project Review 14](#_Toc133346660)

[Conclusions 15](#_Toc133346661)

[Future Work 15](#_Toc133346662)

[References 15](#_Toc133346663)

[Appendices 16](#_Toc133346664)

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# Project Abstract

This project showcases a 3D Virtual world that incorporates elements of farming, animal care, commerce and NPC behaviour. The game features an inventory system, planting, watering and harvesting mechanics, and a day and night cycle. NPCs have two distinct behaviours, wandering and path following. The path following NPCs have an option to loiter at certain locations and enter NPC shops. The traffic system includes NPCs driving cars, stopping at traffic lights, and honking at pedestrians. A map editor allows players to add, move and rotate objects, create custom NPC paths, and save them to a database. This project explores the technical challenges of implementing a complex game world with multiple interactive systems. The project also discusses future directions for the game, and what areas need more forethought.

Playtesting has proven to be quite useful in determining the weak and strong aspects of the project, not only concerning player comfort, but player experience as a whole. “To better understand just what players think of your ideas, be it an entire art concept or even just your latest game icon, a survey is the way to go.” (Barratt , J. (2023). Playtest Surveys: What They Can Do and How To Use Them. PlaytestCloud.). A questionnaire was created for chosen testers. According to the ratings given by the participants, the game has received generally positive feedback. A third of the participants rated the game with five stars, suggesting that some players find certain aspects of the game highly appealing. Furthermore, most participants gave the game a four-star rating, indicating that the game is enjoyable and engaging with only a few minor areas for improvement. The responses suggest that there is room for improvement to meet the desires of some players. These recommendations provide guidance for future development. The farming mechanics are well-designed and engaging, and are a key factor in player satisfaction with the game. The positive feedback on the art style indicates that it is well-suited for the game and should continue to be used. The majority of players found the inventory positioning to be well-optimized, which is a positive sign for game design. All 15 responses for the ease of understanding question were positive, indicating that the inventory system is well-designed and intuitive. More research on inventory systems is recommended for anyone attempting a similar mechanic.

The speed of rotation was increased, the colour of the grass and other objects' was dimmed, and the vehicle movement code was refactored to avoid the pileup issue. The addition of labels around the buttons of the level editor was necessary as it indicated that the controls of the Level Editor are not as intuitive as they should be. A tutorial system or help screen would have been useful to implement into the game. For any person wanting to implement a similar Level Editor, research must be conducted on a tutorial system. The delay between spawning a vehicle has been increased, and the font size of the text on the watch has also been increased. More object options have been added, and player movement and rotation have been limited.

# Project Introduction and Research Question

Virtual reality is the use of computer technology to produce an artificial 3D world which allows users to engage in a virtual world in a way that simulates reality. It does so by influencing the human senses, specifically sight and hearing, in order to immerse the user in the simulated world. VR has become an increasingly popular game environment, “VR market size 2022 - 12bn USD”(Alsop, A. (2020). Consumer and enterprise virtual reality (VR) market revenue worldwide from 2021 to 2026. Statista),it is vital to explore just how using a player engagement tactic like Level Editors in VR games could improve the overall experience of the game. A Level Editor is a tool which allows the user to edit the virtual world around them that provides an outlet for the user’s creativity. It gives the user control over the overall look of the world, as well as let the user influence the steering behaviours of the non-player characters (NPCs).

Steering behaviours are artificial intelligence algorithms which influence how the NPC navigates around their environment in a way which would simulate the real-life movement of a person. In terms of improving user experience, aesthetically pleasing world design helps the user fully immerse themself in the virtual world and the storyline of the game.

In this thesis, we aim to investigate the impact level editors, steering behaviours and world design have on the player experience in VR games. We will analyse the important factors to take into consideration when creating a comfortable to use level editor. We will also look into which steering behaviours best simulate real-world movements without causing negative impact to the performance of the game. Additionally, we will explore how the placement of objects in the world and the used colours can alter the player experience.

To achieve these objectives, I will create a playable game with farming mechanisms and conduct playtesting with willing participants to collect data on the comfortability of the controls. The data collected from this will take into account the orientation of the level editor, whether the user would be more comfortable looking up, down or straight ahead when editing a level, the placement of the buttons and choices on the level editor, and the physical wellbeing of the participant, in order to avoid nausea and headaches. I will also conduct a series of tests of the reliability of different steering behaviours to examine which suits the game and which would best react to change in the environment without slowing the game down or causing lag

The results of this thesis will add to the knowledge already available on VR game design and offer new perspectives on how level editors, and steering behaviours can be used to improve player experience.

**“Is it possible to create an immersive, smooth level editor by using VR without causing discomfort?”**

# Literature Review

## Virtual Reality

VR games have gradually been gaining popularity since the creation of the first VR machine, the Sensorama (patented in 1962). “It combined multiple technologies to stimulate all of the senses: there was a combined full colour 3D video, audio, vibrations, smell and atmospheric effects, such as wind.” (Barnard, D. (2022).History of VR - Timeline of Events and Tech Development. Virtualspeech.*).*

As of 2022, the Oculus Quest 2 has become the most popular VR headset among the gaming community. With the constantly improving software, the Oculus Quest 2 provides the user with a multitude of features which has gained them a majority of positive reviews. “It can get phone notifications, pair with keyboards and connect with virtual meeting apps, do basic fitness tracking and wirelessly stream from PCs. It's still the best self-contained VR headset right now, and the most affordable for its features.” (Stein S.(2022). The Quest 2 Is More Expensive, But It's Still the Best VR Headset For Now. CNET.).

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## Level Editors

To my knowledge, due to how recent the launch of this headset is, there are no academic works focusing specifically on Level Editors in the Quest 2. There are, however, some works which have researched Level Editors on other headsets. LevelEd VR, for instance, created by Lee Beever, Serban Pop, and Nigel W. John, is a system which allows users to create levels during the VR game. “The initial focus was on improving or assisting the level creation process for virtual reality games by allowing designers to prototype levels in VR.” (Beever, L. (2021). LevelEd VR. leebeever.).

User Generated Content (UGC) in games has become a very popular tactic to increase player engagement and increase game replayability. UCG refers to any content that has been created by users as opposed to content created by the game developers. “User generated content, or UGC, is content that has been created and posted by a user on any type of online platform, from social media and streaming platforms to video games.” (Hubert, E. (2022). The weight of UGC in the gaming industry. DigitalMediaKnowledge.).

A popular form of UGC in games are Level Editors, a mechanic which allows users to create levels or maps for a specific game. For instance, Super Mario Maker 2, a side-scrolling platform game published by Nintendo in 2019. The game includes a Story Mode in which the player controls Mario as he avoids obstacles, defeats enemies and collects pickups each level in order to get to the castle and rescue Princess Peach from the antagonist, Bowser. Super Mario Maker 2 also allows the users to create, play and share their custom-made levels worldwide.

As for Level Editors in VR, however, there are numerous important factors to take into consideration when designing one. One factor to consider is the effect of the added weight of the VR headset. As it stands, the Valve Index headset is the heaviest one, weighing 809 grams (Alsop, T. (2022). Comparison of VR headsets worldwide 2022, by weight**.** statista). The lightest being the HP Reverb G2, weighing at 498 grams. The added weight causes leaning down for long periods of time which in-turn causes discomfort and also raises the risk of the headset getting damaged due to it slipping off.

According to the questionnaire given to the play-testers ([**Appendices**](#_Appendices)), another factor to consider is the colourisation. Testers have stated to receive headaches from the too bright colours, particularly the grass.

## Steering Behaviours

While Steering Behaviours have been frequently used in Game Development, other uses of it can be seen in robotics and animation. “Steering behaviours are simple techniques for controlling goal-directed motion of simulated characters around their world, with applications in games, animation and robotics.” (Duggan, B. (2013). Introduction to Steering behaviours for Autonomous Agents. slideshare)*.* Whether it is an NPC or a robot, the agent must be able to realistically navigate its environment and avoid obstacles and sharp turns. Research into steering behaviours is on-going, however the most well-known work belongs to Craig Reynolds’ 1987 work, commonly referred to as ‘Boids’. The purpose of this work was to simulate bird flocking behaviours. “The basic flocking model consists of three simple steering behaviors which describe how an individual boid maneuvers based on the positions and velocities its nearby flockmates”(Reynolds, C. (1995). Steering Behaviors For Autonomous Characters. red3d). He has done this by creating three steering behaviours: Separation (steering to avoid crowding), Alignment(steering towards the average heading), and Cohesion (steering to move towards the average position).

In Reynolds’ 1999 paper, “Steering Behaviors For Autonomous Characters”, Reynolds proceeds to describe other such steering behaviours. Three of those behaviours are particularly useful in simple NPCs. Those being Wander, Path Following and Obstacle Avoidance. To create a Wander behaviour, the NPC must “retain steering direction state and make small random displacements to it each frame”(Reynolds, C. 1999)*.* One such implementation of this is adding a randomly generated small angle value to the rotation of the character. As for Path Following, this behaviour receives a set of points and will head to each point in that list. “The goal of the path following steering behavior is to move a character along the path while staying within the specified radius of the spine. If the character is initially far away from the path, it must first approach, then follow the path.”(Reynolds, C. 1999)*..* This implementation differs slightly from other such implementations by adding a smoothing factor to the turns, which contributes to the realistic aspect of the movements. Finally, Obstacle Avoidance is a behaviour which can be paired with the other behaviours to realistically and smoothly avoid any objects which stand in the middle of their path. “Obstacle avoidance behavior gives a character the ability to maneuver in a cluttered environment by dodging around obstacles.”(Reynolds, C. 1999)*.* This behaviour considers each object as a sphere, it calculates the distance from the origin of the current object and the object ahead and compares it to the sum of the radius of the current object and the obstacle. If the distance is less than the sum, it adds a steering force away from the obstacle, allowing the NPC to avoid it.

Unrelated to Craig Reynolds’ work, there also exists a path-searching algorithm called A\*. A\* can be used by splitting the world into a grid and finding the shortest, most cost-effective path to a chosen goal. “To approximate the shortest path in real-life situations, like- in maps, games where there can be many hindrances.” (Belwariar, R. (2023). A\* Search Algorithm. geeksforgeeks).While it succeeds in providing us with the most realistic, effective path, it does require many calculations to check each cell and its’ neighbours.

# Evaluation and Discussion

Due to its capacity to completely immerse the player in the game environment, VR technology has grown in popularity in recent years. There are always risks when using a VR headset, however these risks can be minimised by simple playtesting. Taking into account the weight of the VR headset, and the strain of keeping your head in an unnatural position , the optimal placing for an in-game level editor would be at eye-level.

The VR headset allows the user to be fully immersed into the game world, which is the reason why it is vital to take into consideration the aesthetics of the game. The game's color scheme and lighting settings are essential factors in this regard. After receiving feedback from the play-testers ([**Appendices**](#_Appendices)), the shade of the grass in the Level Editor as well as in the game world, has been dimmed.

As for Steering Behaviours, the three Craig Reynolds’ implementations, as opposed to complex behaviours such as A\*, succeed in realistically moving the NPCs without causing strain to the game.

As such, with a VR game, which is already cost-effective, with many NPC characters, each calculating their own paths, the game would be too laggy to provide an enjoyable experience. Taking this into consideration, and how easily Craig Reynolds’ implementation succeeds in its goals, the three steering behaviours mentioned suit the game better than A\*.

# Testing

In order to further study the comfort levels of the player, testing was conducted through the use of a questionnaire. This questionnaire ([**Appendices**](#_Appendices)) was designed to obtain information about not only the comfort levels, but also each important aspect of the game, such as the world layout, player’s understanding of the mechanics, and overall enjoyability, among others. The chosen participants come from different sectors and possess different levels of expertise when it comes to both game development and programming in general. The pool of participants include classmates, herbologists, people working in computing sectors and students from unrelated courses. Each participant was given access to an early version of the game, as well as videos of the game showcasing features, and was sent a link to a questionnaire containing 18 questions. The questionnaire received 15 responses. In the following sections, answers to each question will be discussed and the changes made will be explained.

Chart, bar chart

Description automatically generated

(Fig 1.1)

The first question of the questionnaire was aimed towards finding the overall rating of the game in order to gain insight into the average enjoyment levels of the testers ([Fig 1.1](#Rate)). A third of the chosen participants have awarded the game with a full 5-star rating, while the vast majority of of the participants have opted to rate it 4-stars, and a single participant has rated it a 3. Based on the ratings provided by the participants, it appears that the game has generally been well-received. The fact that a third of the participants awarded the game a full 5-star rating suggests that there are aspects of the game that are highly appealing to some players. Additionally, the fact that the vast majority of participants opted to rate the game 4-stars indicates that most players found the game to be enjoyable and engaging, with only a few minor areas for improvement.

The following two questions were aimed towards understanding how the game could be improved. Participants were asked about actions they wish could have been possible ([Appendices](#MoreActions)) and what area of the game was the most enjoyable ([Appendices](#EnjoyedArea)). 6 out of the 15 responses have mentioned wishing for more interactions with the NPCs. Some in particular have requested “Friendship/Romancing of the NPCs” as well as hiring NPCs as farmhands, “Hired NPC to help do some of the farming.”. Other responses have recommended adding new activities such as fishing, mining, upgrading tools and fighting. 3 participants have recommended no changes. Overall, the responses suggest that there is some room for improvement in the game to meet the desires of some players. These recommendations outline what further directions can be taken in the future. As for the most enjoyable area of the game, 7 out of 15 responses have stated that the farming aspect of the game was the most enjoyable. 3 participants have enjoyed the exploration factor of the game and another 3 have praised the aesthetics of the game. Other praised areas included the map/level editing and customisation. Based on the responses, it appears that the farming mechanics are well-designed and engaging, and are a key factor in player satisfaction with the game.

The participants were then asked their opinion on the layout of the game world and the UI. All received responses came back positive, with a select view offering recommendations for improvement. Such recommendations included, a smaller inventory UI, inventory system moved further away from player, a bigger watch on the player’s hand, and less traffic as it “conflicted with that aesthetic” and “made it feel urbanised at times” which took away from the country life aesthetic. As a result, the delay between spawning a vehicle has been increased and the font size of the text on the watch have also been increased.

Chart, pie chart

Description automatically generated

(Fig 1.2)

The next question regarded the enjoyment of the particular art style ([Fig 1.2](#Art)). When creating the game, a low-poly cartoon style was chosen for the gameworld to offer a cute, innocent aesthetic to the game. Out of 15 participants, 14 stated that they enjoyed the art style, with only one indicating indifference. The positive feedback on the art style is a strong indicator that the art style is well-suited for the game and should continue to be utilized.

Chart, pie chart

Description automatically generated

(Fig 1.3)

**Chart, bubble chart

Description automatically generated**

(Fig 1.4)

The following three questions concerned the inventory system. In particular, the inventory placement, easy of understanding and areas of improvement, were questioned. As for the positioning ([Fig 1.3](#InvPosition)), the response has received conflicting results, however the vast majority of the participants have stated that the location was just right, with 9 out of 15 responses. 5 participants stated that it was positioned too close to the eyes and 1 participant stated that it was too far. These responses, however, indicate that the inventory positioning was well-optimized for the majority of players, which is a positive indication for the game design.

All 15 responses have come back positive for the question regarding ease of understanding, which is a good indication that the inventory system is effective in communicating the necessary information to players and is well-designed and intuitive ([Fig 1.4](#InvEase)).

Some of the changes suggested for the inventory system included, adding titles of objects in the inventory slots, clearer and bigger images of the items, and also some responses have described a bug with the inventory system in which occasionally some items taken out of the inventory get stuck and do not work as expected. While fixes have been applied to remove this bug, in rare occurrences the bug persists. Further research on inventory systems should be taken in the future to any person attempting a similar mechanic.

Chart, pie chart

Description automatically generated

(Fig 1.5)

The participants were then asked about the movement system ([Fig 1.5](#Movement)). Out of 14 responses, 13 stated that the movement and rotation were comfortable, with only 1 participant stating otherwise. This is a positive indication that the controls for movement and rotation are well-implemented and intuitive for players. As for the suggested improvements, 9 responses stated that no changes were necessary, however 2 participants have expressed that the rotation speed was too slow. Subsequently, the speed of rotation was increased.

Chart, pie chart

Description automatically generated

(Fig 1.6)

When asked about the audio system, the responses came back predominantly positive, with 14 responses stating that it feels natural ([Fig 1.6](#Audio)). When followed up by a question regarding the issues encountered with the audio, some note-worthy recommendations were, increasing the volume, adding a volume controller that can be controlled by the player, adding more audio, and one participant in particular has expressed an issue with the direction in which the audio was coming from. The issue was, however, unable to be replicated and thus no fix has been implemented.

Chart, pie chart

Description automatically generated

(Fig 1.7)

Chart, pie chart

Description automatically generated

(Fig 1.8)

The three following questions are on the topic of player comfort. 6 out of 15 participants have voiced their discomfort while playing the game, with the majority, 9 out of 15, experiencing no discomfort ([Fig 1.7](#Discomfort)). When prompted as to which point caused them discomfort, the participants revealed that, the colourisation of some objects, particularly the grass, was too bright, and a vehicle pile up issue caused lag when the player was moving or rotating. As a result, the colour of the grass and other select objects has been dimmed and the vehicle movement code has been refactored to help avoid the pileup issue. 14 out of 15 participants have experiences no discomfort due to the lighting ([Fig 1.8](#Lighting)). The 1 participant which expressed discomfort has not described the issue in any other answer box and so a fix was unable to be created.

Chart, bar chart, histogram

Description automatically generated

(Fig 1.9)

When asked about the Level Editor, the majority of the participants experienced mild difficulties. Only a third, 5 out of 15, responses rated the difficulty level as a mild 1, with 6 responses rating it a 2, 3 responses rating it a 3, and a single participant rating it a full 5. This is a clear indication that the controls of the Level Editor are not as intuitive as they should be. As a result, labels were added around the buttons of the level editor to better explain their purpose. However, a tutorial system or a help screen would have been a good feature to implement to the game. For any person wanting to implement a similar Level Editor, research must be conducted on a tutorial system for the Level Editor. Three noteworthy recommendations for changes suggested by the testers have been, adding more placeable objects, publishing levels online and downloading levels, and limiting player movements when inside the Level Editor. As a result, more object options have been added and player movement and rotation have been limited.

Finally, at the end of the questionnaire, the participants were asked for any other issues they encountered or changes they would like to see happen. 4 responses have suggested adding more objects, such as more animals, more plants and more decorations. One participant, in particular, would like to see a character customization option, and another suggested adding a settings page to change the field of view, HUD distance, motion sensitivity, brightness and graphics settings (shadows, anti-aliasing, bloom).

# Project Milestones

|  |  |  |
| --- | --- | --- |
| **Features** | **Milestone Date** | **Completed Date** |
| Project Setup and Player Movement | November 10th 2022 | November 5th 2022 |
| Land Tilling and Inventory System | November 10th 2022 | November 5th 2022 |
| Basic World Design and Seed Planting | November 10th 2022 | November 9th 2022 |
| Day/Night Cycle, Plant Growth Stages | November 17th 2022 | November 16th 2022 |
| Plant Watering | November 24th 2022 | November 23rd 2022 |
| New Plant types and New Textures | December 1st 2022 | November 29th 2022 |
| NPC model and Environment Testing | December 1st 2022 | November 29th 2022 |
| Shop Mechanic and Currency | December 1st 2022 | November 30th 2022 |
| Farming Mechanic Testing and Bug Fix | December 1st 2022 | November 30th 2022 |
| Final Harvestable Growth Stage and Produce Selling | December 8th 2022 | December 5th 2022 |
| Sleeping Mechanic and Simple Animations | December 8th 2022 | December 6th 2022 |
| New NPC Shop model and NPC house | December 8th 2022 | December 8th 2022 |
| Shop Closing and Opening Hours | December 8th 2022 | December 8th 2022 |
| Environment Design and Boundary Creation | January 12th 2023 | January 11th 2023 |
| Level Editor Layout and Model | January 19th 2023 | January 18th 2023 |
| Level Editor – Object Placing | January 19th 2023 | January 18th 2023 |
| More Objects for Level Editor Object Placing | January 19th 2023 | January 18th 2023 |
| Level Editor – Object Rearranging | January 26th 2023 | January 25th 2023 |
| Level Editor – Object Rotation | January 26th 2023 | January 25th 2023 |
| Capsule to enter Level Editing | February 2nd 2023 | February 1st 2023 |
| NPC Wander Behaviour | February 9th 2023 | February 9th 2023 |
| Rotation Gizmos on World Objects | February 9th 2023 | February 9th 2023 |
| Update Wander Behaviour | March 2nd 2023 | March 2nd 2023 |
| NPC Path Following | March 2nd 2023 | March 2nd 2023 |
| Level Editor – NPC Placing | March 2nd 2023 | March 2nd 2023 |
| River Object Creation | March 9th 2023 | March 7th 2023 |
| NPC Loitering | March 9th 2023 | March 8th 2023 |
| Level Editor - Update NPC Placing | March 9th 2023 | March 8th 2023 |
| Level Editor – Assigning paths to path following NPCs | March 9th 2023 | March 8th 2023 |
| NPC Object Avoidance | March 9th 2023 | March 8th 2023 |
| Custom Path Saving | March 9th 2023 | March 8th 2023 |
| NPC heads to closest path position | March 16th 2023 | March 13th 2023 |
| Level Editor – Custom Path Deletion | March 16th 2023 | March 13th 2023 |
| Level Editor – Custom Path Loading | March 16th 2023 | March 14th 2023 |
| Level Editor – NPC Hover Animation | March 16th 2023 | March 14th 2023 |
| Level Editor – Custom Path Editing | March 16th 2023 | March 14th 2023 |
| Level Editor – Option to Leave Editor | March 23rd 2023 | March 22nd 2023 |
| Level Editor – Testing and Bug Fixing | March 23rd 2023 | March 22nd 2023 |
| Level Editor – Progression Pause while Editing | March 23rd 2023 | March 22nd 2023 |
| Level Editor – Custom Loiter Amount | March 23rd 2023 | March 22nd 2023 |
| Update Object Avoidance | March 30th 2023 | March 30th 2023 |
| Basic Database Saving for Custom Paths | March 30th 2023 | March 30th 2023 |
| Environment Redesign | March 30th 2023 | March 30th 2023 |
| Vehicle Model and Vehicle Movement | March 30th 2023 | March 30th 2023 |
| Town Décor | April 14th 2023 | April 8th 2023 |
| Traffic Light System | April 14th 2023 | April 8th 2023 |
| Update Vehicle Paths | April 14th 2023 | April 10th 2023 |
| Traffic Light Colour Change | April 14th 2023 | April 10th 2023 |
| NPC Wakeup Hours | April 14th 2023 | April 11th 2023 |
| Shopkeeper Schedule | April 14th 2023 | April 11th 2023 |
| NPCs Enter NPC Shops | April 14th 2023 | April 11th 2023 |
| Vehicle Parking | April 14th 2023 | April 12th 2023 |
| NPC Interaction | April 14th 2023 | April 12th 2023 |
| NPC Visitors | April 14th 2023 | April 12th 2023 |
| Grass Generation | April 14th 2023 | April 12th 2023 |
| NPC Sleep Hours | April 14th 2023 | April 13th 2023 |
| Vehicle Testing and Bug Fixing | April 14th 2023 | April 13th 2023 |
| Animal Shop | April 14th 2023 | April 13th 2023 |
| Animal Housing Models | April 14th 2023 | April 13th 2023 |
| Object Scaling Testing | April 14th 2023 | April 14th 2023 |
| Tree Chopping | April 14th 2023 | April 14th 2023 |
| Testing after World Redesign | April 14th 2023 | April 14th 2023 |
| Teleportation Option on Tiles | April 14th 2023 | April 14th 2023 |

# Major Technical Achievements

* Developing an interactive 3D environment with realistic physics and collision detection algorithms that enable players to pick up and interact with objects in the game world.
* Implementing an inventory system that allows players to store and manage items they collect in the game.
* Developing a planting and growth system that attempts to simulate sped-up real-world farming practices, including watering and harvesting.
* Implementing a day and night cycle that dynamically changes the environment and NPCs' behaviours.
* Developing AI algorithms for NPCs with wander and path following behaviours that simulate realistic human behaviours and interact with the environment and other NPCs.
* Implementing a traffic system with traffic lights, car parking, and realistic car and pedestrian interactions.
* Developing a map editor that enables players to modify the game environment and create custom paths for NPCs.
* Utilizing the C# programming language and the Unity game engine to develop an interactive game.
* Creating a database to store custom path information for NPCs, enabling the game to remember and use this information for future gameplay sessions.

# Project Review

The decision to dim the colours and keep the Level Editor at eye-level has proven to be the best decision, as proven by the questionnaire filled out by the play-testers ([**Appendices**](#_Appendices)). However, people looking to further research this kind of project, should take time to consider creating a Level Editor which allows for editing the world while walking around it, as opposed to this solution of editing a map of the world. While not breaking the player out of the immersion, editing a world map freezer the player to one position which can hinder the enjoyment of the game.

The steering behaviours chosen were the best choice for this particular environment. They don’t require many run-time calculations and so allow for the addition of numerous NPCs without causing lag and discomfort. However, one such behaviour that has not lived up to expectations is the Obstacle Avoidance behaviour. While this behaviour does avoid small obstacles accurately, it struggles with bigger objects such as houses, which causes the NPC to walk into the wall multiple times before managing to walk around it. This takes away from the realism of the game and as such, better options should be investigated by any person willing to attempt a similar project in the future.

# Conclusions

In conclusion, research into Level Editors in VR should continue to expand as more headsets are being developed now as the years progress. Each implementation of Level Editors provides a different level of immersion and should be carefully researched before choosing.

Steering behaviours are an essential part of adding realism to NPC movements. Research on steering behaviours will likely continue to expand as the development and understand of AI continues to broaden. As for now, there are numerous available options for AI programmers, but each method should be tested in the wanted environment to help determine whether to focus on efficiency or cost-effectiveness.

# Future Work

It would be beneficial to further research the best steering behaviour for NPCs in Virtual Reality in particular. Virtual Reality allows the user to see much more of the world than a 3D game might, and so attention to detail must be greater.

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# Appendices

The following are the results of the questionnaire given to the Testers. Responses have been minorly edited to fix spelling errors and to censor inappropriate responses. Form has been split up into three separate tables to aid with readability.

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| --- | --- | --- | --- | --- | --- |
| **Game Rating**  ([Fig 1.1](#Rate)) | **Was there anything you wanted to do that the game wouldn't let you do?** | **What element of the game did you enjoy the most? (Farming, Exploring, Aesthetics etc). Explain your answer** | **How do you feel about the layout of the world and UI?** | **Did you enjoy the art style?**  ([Fig 1.2](#Art)) | **Was the UI (inventory) an appropriate distance away from your eyes?**  ([Fig 1.3](#InvPosition)) |
| 4 |  | Farming is so fun and the map is vivid and interesting, loved the way you can drag and drop a tree down and move the house | I like the layout, the UI clock on the wrist should be bigger so it's easier to see | Yes | Too Close |
| 4 | Destroy the terrain/ environment | Customisation | Easy to understand and navigate | Yes | Just right |
| 5 | No, the game performed perfectly and did exactly what I wanted. | Exploring! I felt like I was in my own little world discovering new things in every corner I looked. | The layout was simple and pleasing to the eye! | Yes | Just right |
| 5 | More activities in the gameplay loop, like mining or fighting bad guys | Aesthetics | Clear and easy to read | Yes | Just right |
| 4 | I would like to see more interactions. Interacting with the environment around you Interacting with people other than the shop keep | I enjoyed the farming, as a Horticulturist the farming aspect was very realistic in the game world. I enjoyed the small detail of the gun to shoot away birds which is a common issue amongst Horticulturist | It's simple, and effective. You're able to find everything and everything isn't too far apart where the player would loose time | Yes | Too Close |
| 4 | Hired NPC to help do some of the farming | Exploration , the exploration was the most fun part for me as the more I explore , the more I learned about the game | The game world is pretty good and fit the theme | Yes | Just right |
| 5 | Not Particularly, seems quite extensive and the editor is very good. | Map editing and how easy and seamless it is | Very good, one note about UI, I feel like inventory should be a bit smaller as it takes up a lot of space on screen and can be very overwhelming in terms of its size. I feel a slightly smaller sized inventory would be a little bit better. Other UI elements work very well . | Yes | Too Close |
| 4 | Have more animals | Farming because its fun to grow carrots | Good | Indifferent | Just right |
| 4 | Shoot NPCs | Farming | Very nice, pretty easy to follow and understand | Yes | Too Close |
| 3 | Friendship/Romancing of the NPCs | Acquisition of capital | Suitable readability | Yes | Just right |
| 5 | Fishing! | Farming | The world was easy to traverse | Yes | Too far |
| 4 | Fishing | Aesthetics, everything felt very cohesive and pleasing to look | UI felt natural and easy to use, made the layout and overall game a much more enjoyable experience than some VR games I've played with poor, clunky UI that got in the way of what could of been a fun game underneath | Yes | Just right |
| 4 | I wish we had the ability to interact with the NPCs. | I mostly enjoyed sitting back and watching the NPCs and the vehicles move around. | I like it. Everything is close by. | Yes | Just right |
| 5 | I would have liked to been able to upgrade my equipment , watering one plant at a time took a lot of time | Farming , I enjoyed selling my plants and also growing the different types of produce I could while planning out where everything is going to go | Very straightforward and intuitive , the inventory could be laid out further away from my face though | Yes | Too Close |
| 4 | Go inside buildings and have conversations with the people wandering around town. | Farming and exploring. I think the farming mechanic is really well implemented with plenty of room for growth. I really enjoyed exploring the areas of the game as the cell shaded low poly graphics really appeal to me. The layout of the town is really well designed and it left me wanting more. | I think the world layout was designed really well. The mountains that surround the playable area give it a sense of scale and really make it feel like you're tucked away in this small mountainside community. I do think there was too much traffic that kind of conflicted with that aesthetic so it kind of made it feel urbanised at times which took away from that country life vibes I expect with a farming sim. Having less traffic on the roads would have helped with my immersion. The UI worked as I expected it to. It was simple and responsive and tracked well with the view from the headset. | Yes | Just right |

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| --- | --- | --- | --- | --- | --- |
| **Was the inventory system easy to understand?**  **(**[**Fig 1.4**](#InvEase)**)** | **What, if anything, would you change about the inventory system?** | **Does the movement and rotation feel comfortable?**  ([Fig 1.5](#Movement)) | **What would you change about the movement system?** | **Does the audio feel natural?**  ([Fig 1.6](#Audio)) | **Explain any issues you have encountered with the audio** |
| Yes | Maybe titles of objects in your inventory slots | Yes | I like the way it moves, maybe slight wobbles sensitive | Yes |  |
| Yes | No | Yes | No | Yes | No issues |
| Yes | Absolutely nothing! | Yes | The movement system was perfect for me | Yes | I had no issues! |
| Yes | Clearer images for items in inventory | No | Rotation of view is too slow | Yes | No volume control, but otherwise easy to listen to |
| Yes | I'd make the inventory steady. If you bobble your head the inventory bobbles along with your head so in my personal opinion make the inventory display still |  | The movement was smooth no issues here | Yes | No issues |
| Yes | I faced a bug where the items got stuck when it was taken out | Yes | The teleportation was a good bonus on top of the movement system | Yes | I have no issue with the audio |
| Yes | As I mentioned above make it slightly smaller. The inventory slots as it is very easy to place items in them but they are very large on screen, | Yes | Not much | Yes | None, I believe |
| Yes | Carrying a chicken around would be nice | Yes | Not much | No | I didn’t hear |
| Yes | Maybe move it slightly further away | Yes | Nothing really | Yes | No issues found |
| Yes | No feet to carry things? | Yes | I can't see my feet | Yes | Can't hear my footsteps |
| Yes | Bigger images for the items | Yes | Change height of camera and FOV | Yes | Too quiet |
| Yes | Cosmetic customisation, like choosing border colour, light/dark mode etc | Yes | While movement and rotation was comfortable most of the time, at one point all the cars seemed to glitch and come to a complete stop after too many spawned. Turning to look at my now overcrowded Tesco parking area was very uncomfortable due to the lag spikes. | Yes | In rare cases, some sounds that should clearly be heard in my left ear would play into my right ear, but other than that I had no issues with audio |
| Yes | There is a glitch where sometimes an item when taken out, still disappears with the inventory. | Yes | The rotation is way too slow. | Yes | None |
| Yes | Maybe add more slots , even add that as an option I could spend my earned money on | Yes | Sometimes I felt there was a bit too much of a tilt when I was leaning sideward | Yes | No issues |
| Yes | I think it worked pretty well. Maybe have more slots and numbers indicating how many uses an item has left or how many of that item you have. It would also be cool to see the sale prices of items in the ui. | Yes | I think it worked pretty well. It was snappy and responsive. I never felt like i was drifting in a direction i didn’t intend on going to. I feel like having an indictor on the ground when youre using tools and planting seeds would help fine tune aiming though. | Yes | I enjoyed the audio that was present in the game. Although I do think having more audio and sound bites to create atmosphere and ambiance would really help with the immersion you get with vr. Things like crickets chirping at night, leaves rustling in the wind, hearing background conversations when near two npcs that are interacting etc. |

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| **Have you experienced any dizziness or nausea while playing the game?**  ([Fig 1.7](#Discomfort)) | **If yes, at which point did you feel discomfort?** | **Was the lightning comfortable to your eyes?**  ([Fig 1.8](#Lighting)) | **Was there anything missing from the Level Editor that you wish was allowed?** | **Rate how difficult it was to use the Level Editor** | **Any other issues or changes you would like to see happen?** |
| Yes | The green color of the grass is very intense so can make your eyes hurt slightly | Yes | Bushes and flowers | 5 | Maybe some grass hills you can drop in the level editor to give it some height |
| No |  | Yes | Change colour of objects | 1 | No |
| No |  | Yes | Nope! | 2 | No issues and no changes! |
| No | An FOV slider would be a good addition | No | I'd like to be able to rearrange the ground structure and environment (placement of buildings) | 1 | Having settings to change audio volume, FOV, HUD distance, motion sensitivity, brightness and graphics settings (shadows, anti-aliasing, bloom) |
| No |  | Yes | I'd like to rotate things without having to move in the direction to move things | 3 | No changes |
| No | I did not feel nausea or dizziness while playing the game | Yes | nope | 3 | The ability to skip time , watching the farm can be relaxing but i do want to see my product quickly sometime. |
| Yes | Inventory system taking up a large portion of screen. | Yes | Maybe a bit more variety to the items I can place, even random items like barrels | 1 | Just more variety to level editor to just have some extra fun. |
| No | No point | Yes |  | 2 | We need capybaras |
| No |  | Yes |  | 2 | Lemme shoot NPCs |
| No | N/A | Yes | More things to place (rocks, benches, flowers, etc.) | 1 | I wish I could see myself and dress my character up |
| Yes |  | Yes | I wish there was a survival horror aspect to it | 1 | Would love the option for background music. |
| Yes | Rotating to look at an area overloaded with entities caused some lag spikes which made rotating feel slower than normal, stuttery and jarring | Yes | Publishing my custom levels and downloading other players custom levels | 2 | Shooting birds was incredibly fun, would love to see a hunting update with more weapons, huntable animals etc |
| Yes | Sometimes the cars glitch and pile up, which causes a lot of lag when I rotate. | Yes | More object options. | 2 | More plants to grow. |
| Yes | While trying to water the plants , sometimes I had to shake the watering can in an uncomfortable position to make it work | Yes | Maybe a bit more flora options to give my world some more texture | 2 | Apart from everything I already mentioned , it was great |
| No | I didn't really feel dizzy during my playthrough. I feel like the smooth low poly graphics help reduce eye strain for me personally. Some of the green colours were too bright which kind of made my eyes feel dry at times if that makes sense. Not sore just like I have to blink. I think the brighter colours should be reserved for smaller surfaces or at least broken up with darker toned objects when used on large areas like landscapes. | Yes | I think having seasons and dialogue would really make the game feel more immersive. Being able to talk to NPCs would be pretty neat to check in on them from day to day. Also watching the town and surrounding area change with the seasons would be pretty neat. | 3 | I think the level editor would be easy to use if it was mapped to your view like the ui and you could zoom 8n and out on areas. Even having a grid for more specific object placement would be cool. But I’m not sure if the editor being tied to the users view would be good or bad. Just an idea |