GOING OUT OF BOUNDS

Expanding Physical Space and Movement in Virtual Reality

J A M E S W I L B U R N

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Abstract

This research explores the potential of utilising physical space and physical movement, in the creation of a virtual experience centered around the autoethnographic narrative of my own childhood memories.

Presently, VR experiences are developed to fit within the confines of 'Roomscale VR', which limits physical space and movement to a single room. After researching play-areas, game mechanics and physical movement, it was found that higher levels of immersion can be achieved through better consideration of how these elements are integrated into the virtual experience. By expanding access to greater amounts of physical space and representing physical obstacles within a virtual environment, we can empower the user to trust the world within the VR headset. This freedom results in more immersive experiences.

Employing the cyclical methodology of iterative design and the reflective methodology of autoethnography, the artefact created to support this thesis is the result of numerous prototypes and reflections. The artefact places the VR user on a virtual re-creation of a farm paddock located in Puketitiri, Hawkes Bay, with a narrative 'child-guide'. This guide demonstrates the interactive potential of the virtual environment, through movement that evokes the childhood feelings of whimsy and freedom found in strolling through hayfields, jumping for leaves and skimming stones across a pond. By utilising the new play-space model, the artefact demonstrates that there is immersive potential to be realised through feeling freer, safer to roam and extending physical interactions with a virtual environment.

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The videos referenced in the research have been supplied as both live links to youtube, and as files included with the project.

Chapter Four: Critical Commentary

Attestation of Authorship

"I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning."

Signed: Date: 06/06/23

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Throughout the project I was reminded time and time again, that I was very lucky to be born into my family. You have all helped foster the moments that I looked back on and made reflecting on these moments a happy process. This thesis is dedicated to all of you.

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CHAPTER ONE

Introduction to the Research

I open my eyes. Before me lies a landscape of rolling hills and grass that dances to the song of the wind. In the distance a tree sends a palette of vibrant reds, oranges and browns into the air; bursts of colour waiting for me to dive in. A veritable smorgasbord of the digital lies in wait, visually and sonically delectable. The potential of re-lived spaces, sights and adventures call to me, tempting me with promises of excitement and possibilities…

"Hey!"

A small ginger-haired child stands in front of me, freckles darting across his cheeks, bowl cut bristling in the wind, a mischievous smile spread widely across his face.

"Wanna see something cool?"

Before even waiting for an answer, he disappears into the grass and heads towards an ancient oak tree shedding its leaves in the distance.

Something isn't right though. I see the space before me, but I know it is a lie. Its existence is impossible and fraudulent. It is illusory trickery, designed to cause a divorce of the mind and body. My legs tell me to move, but my mind silences their ambition. It knows not to place its trust within the virtual.

Still…

My legs want to walk.

My arms want to reach.

I want to 'be there' . . .

My childhood memories serve as vivid and impactful snapshots of my past. This exegesis documents the practice based research undertaken towards exploring and sharing these memories with an audience, providing an avenue for them to experience some of the feelings I felt in Puketapu, 1995. This will be achieved through Virtual Reality (VR).

This research begins by examining the appropriateness of using VR head mounted displays (HMD), comparing their capabilities to the requirements of re-living childhood experiences and highlighting current shortfalls, as well as considering conceptual solutions. The research produces a VR application that responds to the issues identified in the written work and presents a visual, sonic and kinaesthetic interpretation of how I might re-live and share my childhood memories.

Immersion of the VR user is often limited by small play-spaces and lack of consideration for the potentials of natural movement, stifling the user's ability to subjectively interpret the virtual environments presented to them. The research approaches this problem statement by highlighting how these issues are symptomatic within VR and promotes solutions that can be found within a more holistic consideration of the physical capabilities of the body and the physical spaces they occupy.

The aim of this project is to add to the critical discourses surrounding 'play-space' potential and considerations of presence and immersive possibilities within VR.

Thus the question of this exegesis asks:

How can expanding the role of physical spaces, body movement and interactivity in VR be utilised to create an immersive autoethnographic experience?

CHAPTER TWO

Contextual Review

Keywords

These definitions will be explored in more depth in the Contextual review.

Virtual Reality (VR): VR refers to a simulated environment that can be accessed, explored and interacted with through the use of technology like Head Mounted Displays (HMDs) (Bardi, 2019).

Play-space: A play-space is the real world space that a user can freely physically move around in (Ovation VR, N.A).

Presence: The sensation and the degree to which a person is convinced that they exist within an environment. This can also be thought of as the feeling of physically existing within a space, without actually having to physically exist there (2010, pg. 40).

Immersion: Immersion can be described from both a technological and subjective context. Slater and Wilbur (1997) consider 'immersion' to be the degree to which a system creates an "inclusive, extensive, surrounding and vivid illusion of reality" (Slater and Wilbur, 1997, pg 3). Witmer and & Singer (1998) consider 'immersion' as the subjective experience and the psychological state where one connects and generates experiences from an environment (1998, pg. 8).

The Physical: This research considers the 'Physical' as relating to both the body movement of the user and the physical world around them. Body movement includes feedback generated by kinaesthetic and proprioceptive sensors. In this research, the physical world is considered to be the immediate environment that exists outside of a virtual environment.

Kinaesthesia/Proprioception: This research considers these to be synonymous terms that refer to the sensations felt as a result of movement in one's limbs, the effort required to move them (Burke, 2007, pg 890) and our awareness of where they are in space (Sherrington in Han et al., 2016, pg 81).

Technical Definitions

Roomscale VR: Roomscale VR refers to a process where a VR user can scale their 'play-space' to the size of the room that they occupy (Gepp, 2017) .

Positional tracking: Positional tracking refers to a hardware system that communicates the location of a user within a 'play-space' to a device, like a computer, or the headset itself. This hardware typically consists of sensors that are set up in an 'Outside-in' or 'Inside-out' configuration (Karlsson, 2020, pg 5) .

Outside-In/Inside-Out Tracking: Outside-in tracking is a configuration of external sensors that tracks the position and orientation of the VR headset and the user. These sensors emit signals, such as infrared, which are picked up by the headset's sensors to determine the user's position in the virtual space (Gepp, 2017).

Inside-out tracking is a sensor configuration that is physically located within the HMD. This means that the headset is able to track the user's movement from the perspective of the user, without the need for any external sensors or devices (Karlsson, 2020, pg 6). The sensors identify consistent features of a physical space and compare their form from different angles, using a built-in accelerometer and gyroscope (Karlsson, 2020, pg 7)

Contextual Review Introduction

This contextual review aims to explore the roles of the physical within Virtual Reality, and the potential for immersivity through a combination of VR technology and movement. It will provide information that will contribute towards developing an in depth understanding of the research question and inform the development of a playable artefact.

Realisation of the Virtual Through Technology

My childhood memories are incredibly special and vivid to me. The experiences on the family farm have shaped who I am today and linger in my conscious memory. The aim of my project is to revisit those memories and share them with other people. As a VR practitioner, I tend to favour Virtual Reality as a medium as VR has an immense power to immerse those who use it (Bowman & McMahan, 2007, pg 36).

VR, in the form of HMD's, began in 1968 with the development of 'The Sword of Damocles' (Morelo, 2022). The original prototype, developed by Ivan Sutherland in (Morelo, 2022), was a bulky headset that lay suspended from the ceiling and was capable of 'tracking' the user's head and eyes. Through this headset the user was able to view a rudimentary three dimensional wireframe representation of a shape. The Sword of Damocles required the user to stand still, limiting 'play' to head position and rotation tracking (Morelo, 2022). If this concept was applied to my artefact, it would be the equivalent of miniaturising the farm and looking from the outside in. We can see the farm from a holistic point of view, but are ultimately prohibited from jumping in.

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Fig. 2.1.1: "The Sword of Damocles" (Morelo, 2022)

Recently, there has been a move away from cable connections with the development of 'self-contained' headsets that can 'adapt' to available physical areas (Roomscale VR) and process all information required for VR experiences by themselves (Wohlgenannt and Simons, 2020). The introduction of new hardware has led to new definitions for Virtual Reality. My research has observed that current definitions do not focus on 'what it is', but rather 'what it does'.

Bergen and Delueze formalised original perceptions around 'the virtual'. Bergen considered that 'the virtual' lived within an individual person's consciousness, shaped and formed by subjective experience (Ansell-Pearson, 2005, pg 1113), whereas Delueze believed 'the virtual' to be a dimensional life-force, living as its own entity (Ansell-Pearson, 2005, pg 1120).

Within the context of 'The Sword of Damocles', the user was able to recognise an object that existed outside the physical dimension which could be enhanced by the user's subjective perspective. Would all users view this box in the same way or would those who have never used the device react differently? When considering Delueze's view that virtuality exists as an independent dimensional life-force, it can be argued that the wireframe box existed within an external dimension, accessible only through the lens of the original HMD. It appears that both Bergen and Delueze's theories can co-exist. This co-existence becomes more apparent when considering the form and ability of more modern technology.

There has been considerable discourse in an attempt to determine the commonly agreed upon characteristics of Virtual Reality. Generally, these characteristics take the form of some iteration of presence; typically defined as the 'feeling of being there' (Walsh and Pawlowski 2002, pg. 299), immersion and interactivity; the ability to influence and manipulate an environment (Steuer 1993, pg. 10 - 11). Wohlgenannt and Simons (2020) believe the difficulty in defining Virtual Reality is centered around the definitions of immersion and presence. This lack of agreement means "..it is difficult to draw sharp lines between the concepts of presence, interactivity, and immersion."(2020). However, they both cite Steffan et al.'s definition:

"VR leverages immersive technologies to simulate interactive virtual environments or virtual worlds with which users become subjectively involved and in which they feel physically present." (Steffan et al. in Wohlgennant and Simons, 2020)

This research acknowledges that VR should be defined by function, and observes three key areas of investigation: immersion, presence and interactivity. In the context of exploring my memories, I will therefore ask: 'How do I create opportunities for interactivity in my memories?', 'How do I create opportunities for immersion in my memories?" and 'How do I create opportunities for presence in my memories?'

Movement within Virtual Reality

A key focus of Virtual Reality is interactivity within the virtual environment. We should consider the thoughts of Makransky and Peterson (2021) who believed that "Interactivity refers to the amount of freedom the user is given to control the learning experience, often through handheld controllers and a virtual body" (2021, pg 179). A large part of my memories were experienced through the body (walking, reaching, throwing etc). When we consider the position that we are trying to immerse ourselves within the virtual, to create the feelings associated with 'being there', it would be pertinent therefore, to consider the potentials of body movement and position as key aspects of interactivity.

The first consideration is how people move through virtual environments within 'Roomscale VR' play-spaces. Moving through the setting of Half-Life Alyx's "City 17" (Valve Corporation, 2020) requires the user to teleport between locations, using a point and click mechanic with the VR controllers. This is an effective method of movement within the limited physical space generally available in a home, but can feel unnatural.

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Fig. 2.2.1: "Teleportation in Half-Life: Alyx " (Valve, 2020)

I find myself incredibly aware, when exploring "City-17", that my physical location lies outside of the headset; I am not 'there'. Nilsson et al. (2010) discuss the importance of a person using their legs and the immersive potentials of 'Free Roaming VR'. They conclude that current locomotive techniques like teleporting, proxy gestures and omnidirectional treadmills can be effective in virtually relocating a player but do not cut the perceptual mustard when compared to the idea of a person walking freely (2010, pg 13).

However, the areas requiring consideration do not just relate to movement and spaces. Potential for interaction is severely limited by the heavy focus on arm movement. Games like Beatsaber (Beat-Games, 2019) require quite extensive movement of the arms in order to wave batons around and hit flying boxes. But what about our hands, fingers and legs?

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Fig. 2.2.2: "Beatsaber" (Beat-Games, 2019)

In Beatsaber, the user only occasionally utilises their knees to contort their body in an effort to avoid hitting boxes with their face. Could I not poke flying boxes with my fingers? What about kicking them? This is not a critique of the game itself, but rather a yearning for more extensive consideration of the limbs and how they can be simulated.

On top of considering where our limbs are, we should also consider the feelings invoked when we move them. This sensation is known as kinaesthesia. First coined by Henry Charlton Bastion (1887), kinaesthesia refers to the sensations caused by movement itself based on muscle impressions in the form of "muscular sense"and "sense of force" (1887, pg 5). He believed these impressions provide "unconscious guidance in the performance of movement generally"(1887, pg 6). Similarly, Margaret H'Doubler advocated for integration of movement into the classroom, deeming dance to be "the medium through which we receive impressions from the external world and by which we express our meanings" (H'Doubler, 1932, pg 17). These physical movements play an important role throughout our lives as we develop the relationships between our body to itself, to others, and to the spaces around us. Madan and Singal (2012) focus on how movement can directly affect our memories and ability to remember. Their research discusses 'the enactment effect' which refers to the phenomenon where actively performing or re-enacting physical movement leads to better memory retention and recall of information, than if a person were to 'passively observe' it (i.e. reading). From these observations, this research determines that movement played a core part in forming my childhood perceptions of the world. Analysing these movements can contribute to communicating the meanings behind these perceptions to an audience.

When we relate the importance of movement based learning to the problem statement established in the research question, we can see justification for concern with the lack of physicality within VR and how it may limit the potential heights of user interaction, immersion and presence. When considering the importance that Makransky and Peterson's (2021) placed on freedom of movement within interaction, we can see that research on movement restrictions within VR is critical; *how can a user understand the freedom of walking through a field of grass if they can't actually experience moving through a field of grass?*

Within the context of virtually representing my childhood activities on the family farm, these problems could have a significant negative impact on my ability to produce the artefact. The research will have to experiment with technical solutions for these problems, as well as effective practice to maximise the potential for movement as a tool for the audience to engage with my virtualised memories. To find these solutions it is necessary to consider the role of immersion and presence within Virtual Reality.

Immersion and Presence within Virtual Technology

The term ‘immersion’ is used across multiple fields, including virtual environment (VE) research, video game studies and film studies. This makes it confusing and difficult to define (Nilsson et. al, 2016, pg 109).

To understand the effective usage of immersion, the non-technological interpretation of Janet Murray (1997) should be considered. Murray (1997) compares the feeling of being immersed to the feeling of being submerged in water; fully surrounded in an environment different to what is normally experienced (air) (1997, pg 98). Since then, researchers (noted by Nilsson et. al, 2016, pg 110) have reached a consensus for an abstract definition, agreeing that immersion involves being or the feeling of being surrounded by something (Nilsson et. al, 2016, pg 110). This definition is not very specific, but justifiable when considering that it can be interpreted within both technological and subjective contexts.

Similarly, presence is the sense of being in a mediated environment. (Steuer 1992, pg. 5; Draper et al., 1998, pg. 356). Sheridan (1992) and Slater and Wilbur (1997) suggest that examples of a ‘mediated environment’ could include computer generated worlds such as those found in VR (1992, pg 1; 1997, pg 2). Weibel and Wissmath (2011) define presence by focusing on what the sense itself could be described as, suggesting a feeling of being spatially present at remote locations displayed through interfaces like HMD’s (2011, pg. 2). It has also been described within other mediums like film, with Bracken and Skalski (2010) describing presence as a feeling of ‘being there’ (2010, pg. 40).

Immersion and presence, while being two separate terms, both relate to this research. ‘Being there’, the defining element of presence, considers both subjective and perceptual elements in more depth and describes the level of involvement (attention) and perceived reality within a virtual environment. Immersion can contribute to the overall sense of presence, but presence considers the subjective experience of the user to a higher degree.

When I consider how vivid my memories of the farm are, I understand the roles that both immersion and presence play within them. If I drift away in a mnemonic state, while sitting outside on a cold morning, I can feel the crisp autumn Puketitiri air surrounding me. At this moment, I am not sitting on a deckchair in suburban Auckland, but standing in a wide open field in rural Hawke’s Bay.

Slater et. al. (2009) present a technological interpretation of immersion, by highlighting considerations such as: the extent to which reality is excluded, the range of sensory modalities addressed, the field of view, the quality and fidelity of the displays and the extent to which physical body movement matches what is displayed in the HMD (2009, pg. 195). A subjective interpretation promotes consideration of how a person feels when they solve complex problems, when narrative structures unfold, when they receive feedback on physical movement and what they feel when performing ‘extensive’ manoeuvers (Björk and Holopainen in Wohlgenannt, 2020). The ultimate difference between these two interpretations of immersion is that the technological regards immersion as a property of media (Virtual Reality hardware/software), while the subjective relates to the user’s experiences created by the media (Nilsson, et. al., 2016, pg 112 - 113).

This research views elements of both perspectives to be valid when conveying personal experiences in Virtual Reality. The technological perspective acknowledges an aim to objectively define and highlight the important hardware/software factors, however overlooks the importance of subjective experiences outside of muscle memory. The subjective perspective considers the feelings of the user, but shies away from important factors like quality of imagery.

Immersion and presence have been known to draw on memories within digital media. PC games such as “What remains of Edith Finch?” (Giant Sparrow, 2017) encourage the player to vicariously explore the memories of the protagonist and her family; learning about their pasts and determining their fate.

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Fig. 2.3.1 & 2.3.2: “What Remains of Edith Finch” (Giant Sparrow, 2017)

As I play this game, I am captivated by the world, its objects and the stories of each family member. It is their world and their memories and yet through the way that memory is represented by objects, environments and actions, I feel present; vicariously experiencing memory and learning more about them with each discovery.

One of the moments that immersed me the most was the wedding sequence, where the player embodies a child guest. While this wedding is happening, a melancholy poem that dwells on the writer’s abusive past is being recited by the protagonist. The focus on play is not on the wedding however; it lies with a kite that the player flies around, collecting the words of the poem as they appear in the sky above. The poem being read is sombre and foreboding, yet as I played this sequence I realised that there was a whimsical mask over the event.

Swinging the kite around and jumbling the words of the poem, rendered the depressive nature of the narrative mute; replacing it instead, with a focus on a single source of vibrant colour in the scene. As someone who connects through physical actions, this kite was the gateway for immersing myself in what would otherwise be, a world that I would not wish to partake in.

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Fig. 2.3.3: "What Remains of Edith Finch - Kite" (Giant Sparrow, 2017)

If the purpose of contemporary Virtual Reality is to place a user within a virtual world and have them interact with it (Bowman and McMahan, 2007, p. 36), then it is clear why immersion is a key characteristic of the medium. This research believes that Slater et al. are well positioned in their view that "The more that a system delivers sensory modalities and tracking that preserves fidelity in relation to their equivalent real-world modalities, the more that it is 'immersive'" (2003, pg 1 -2). This interpretation places importance on harmony between the sensors and VR hardware, while stating the relationship between real world sensory modalities and requests from the virtual environment.

When considering that developments such as high resolution screens, surround sound and 'Roomscale' in VR have increased our ability to be present, it is important to consider the views of researchers who argue that presence can entail elements of agency (Steuer in Hartmann et al., 2015, pg. 120) and believe that the sensation of presence is contingent on both the feeling of 'being there' and the feeling of 'doing there', which begets the feeling of being able to interact with a virtual environment.

As with Virtual Reality, this research is less concerned with 'what immersion and presence are', than with 'how they can be achieved' and 'what they do to a user'. This research interprets immersion as a reminder of the potential of technology to 'submerge' the user within a Virtual Reality and presence as a way to connect a user to an experience, by having them feel 'there'.

So, how do I create opportunities for immersion and presence in my virtual memories?'

Visually, I recall the farm as being painted in bold, autumn coloured grass and leaves and formed by strong geometric patterns of fence lines. Sonically, I remember the chirping of birds and the whooshing of the wind. Movement-wise, I remember muscle tension in my legs when walking and my arms when throwing. Creating a virtual environment that engulfs my visual and auditory senses, while engaging my muscles in pursuits that match the activities prominent in my memories is the key to better immersion within my VR experience.

How can expanding the role of physical spaces, body movement and interactivity in VR be utilised to create an immersive autoethnographic experience?

This research validates the significance of movement and interactivity when creating an autoethnographic environment. Consideration of VR play-spaces and the impact of specific movements, could help inform design decisions that elicit feelings of presence and immersion within the users and enable the sharing of my childhood memories.

The research has highlighted the importance of movement within immersion and presence. As a Virtual Reality based project, we can therefore see the importance of expanding our potential for physical movement; a key aspect of my childhood experiences. Activities like chasing falling leaves, wading through waist high grass, skimming stones and bending grass with my fingertips are movements embedded in my memories.

As a consequence of encouraging more physical movement, the project needs to consider the physical spaces that this movement will occur in. Nilsson et al., (2018) discuss the importance of natural walking within VR, while stating that "techniques involving physical movement are particularly problematic because the user's ability to travel virtually will be constrained by the size of the tracked space" (Nilsson et. al., 2018, pg 14). A smaller physical space will result in less ability for the player to move their limbs and in turn deprives them of opportunities to connect with the virtual world. The importance placed on physicality in expression and remembering, (Margaret H'Doubler, 1932)(Madan and Singa, 2021) determines that more physical space for play means that creating and remembering memories is easier and more vivid.

Virtual Reality has also previously been used to convey autoethnographic narratives. The experience "Notes on Blindness" (ARTE, 2017) documents the sensory and psychological experiences of John Hull as his eyesight steadily deteriorates. Using clusters of dots to represent people and environments, a comprehensive virtual world unfolds around the player, giving insight into blindness and the emotions of those who suffer from it.

The visual style of this experience is stunning and the increased usage of negative spacing highlights the ability of our minds to 'connect the dots' and draw conclusions based on minimal visual information. The movements within the virtual environment make it feel alive, despite the abstract visual representations. However, the most significant element is the autoethnographic context. Through the VR adaptation of 'Notes on Blindness', we can immerse ourselves within an experience that we would normally only be able to understand through the loss of sight. The narrative focus of autoethnography pairs well with the ability of VR to immerse.

Utilising this combination will lead to lines of questioning around the immersive potential within my own experiences and how the technological focus of VR can help make these a (virtual) reality.

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Fig. 2.4.1: "Notes on Blindness" - (ARTE, 2017)

Furthermore, framing the project in a subject that is familiar to me will provide focus points and help establish development objectives. Through auto-ethnographic analysis, this project aims to explore the possibilities of representing the physicality of memory within Virtual Reality and to share selected memories through physical expression, rather than just visual and auditory modalities. Through the lens of my childhood, I will position the VR user in a life-sized vignette of rural Puketiri circa 1995, creating possibilities for them to find familiarity in another person's past, and new outlooks on disparate cultural upbringings.

CHAPTER THREE

Methodology and Methods

Introduction

The aim of this research is to explore the possibilities of the physical space we can move through, the physical movements we can make, the interactive potentials of Virtual Reality and the possible outcomes of increasing these potentials. Developing this knowledge requires a practice-based research approach, as the artefact being made forms the foundation of my contribution to this knowledge, by researching and learning by doing, and creating new understanding through experiential activity (Gray and Malins, 2004).

Autoethnography & Iterative Design

The methodology employed by the project is a synthesis of two methodological concepts. The first is autoethnography. Autoethnography is defined as: "a research method that uses personal experience ("auto") to describe and interpret ("graphy") cultural texts, experiences, beliefs, and practices ("ethno")" (Adams, Ellis, & Holman Jones, 2017, pg. 1).

Authoethnographic researchers seek to better understand cultural events or phenomena through reflective consideration of personal experiences. Through the narrative of the researcher's past, the potential for understanding and empathy can be established with the reader and thus, we can see the use of framing research in such a way.

This methodology also allows complex ideas and emotions to be communicated in a way that may be otherwise difficult to achieve within a written context. Ellis and Bochner (2000) highlight the value of moving away from the structures of academic writing explaining that some phenomena cannot simply be measured by quantitative means (Epstein, 2021). They also believe that communicating a narrative to the audience can be more evocative than positioning them in a purely observational role (Ellis and Bochner in Epstein, 2021, pg 35).

To reflect on their work, autoethnographers engage in a process called reflexivity with the intention of producing critically reflective realisations. True to the descriptive nature of the term, reflexivity involves the process of 'bending back' or 'looking inward and outward' (Ellis, 2004, p. 37) in an effort to gain a holistic perspective of the meanings generated by producing personal experiences and how they impact understanding of culture and the world (Kout, 2019).

Reflexivity is an important concept in the context of iterative design as it shares a commonality through reflective analysis of practice. Tynan Sylvester (2013) highlights the importance of iterative design, by stating that "We can't not plan at all, but nor can we plan every detail to the end of the project. We need a middle ground. We need to iterate" (Tynan Sylvester, 2013, pg 283). Initially, I did not consider this project to be 'game play orientated', however upon further thought, I determined that activities like "jumping for leaves" and "skimming stones" remove themselves from a 'purely sensory experience' box because as a child, I considered them to be games. It is for this reason that I believe game design techniques like iterative design will be useful in the development of this project.

The iterative design process is a methodology that works well with a practice based research approach in that the investigations are "partly by means of practice and the outcomes of that practice" (Candy, 2018, pg 63). It is a "cycle of conceptualization, prototyping, testing and evaluation" (Macklin and Sharp, 2016, pg 153)(Fig. 3.1.1). Macklin and Sharp describe this process as 'adaptive', promoting a fluid transition between idea conception, prototype creation, playtesting and critical analysis.

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Fig 3.1.1 - "Second order design diagram nested in an iterative design diagram."
(Macklin and Sharp, 2016, pg 153)

This project consists of a number of interactive elements that need to be identified, strategised and evaluated on a case-to-case basis to determine if they fall in line with the original line of questioning of the research, the effectiveness of the representation of my memories and the meanings communicated through their implementation. Using iterative design I will be able to isolate elements, prototype, question them, then build new iterations based on my findings.

When considering my own work, these concepts of personal narrative and reflection of meaning fit perfectly within my intent to provoke greater movement and spatial considerations. This is because memories themselves invoke, in me, feelings of freedom, curiosity and desire to move. These concepts will also hold me accountable in considering how communicating these memories to an audience will create thoughts, feelings and understandings that may or may not have been intended.

Conceptualisation

As a VR practitioner, I develop experiences that are conceptualised by clients. Flowcharts are a key method I implement when undertaking a project. Within this context, flowcharts are created in tandem with the client to ensure a consensus of expected outcomes.

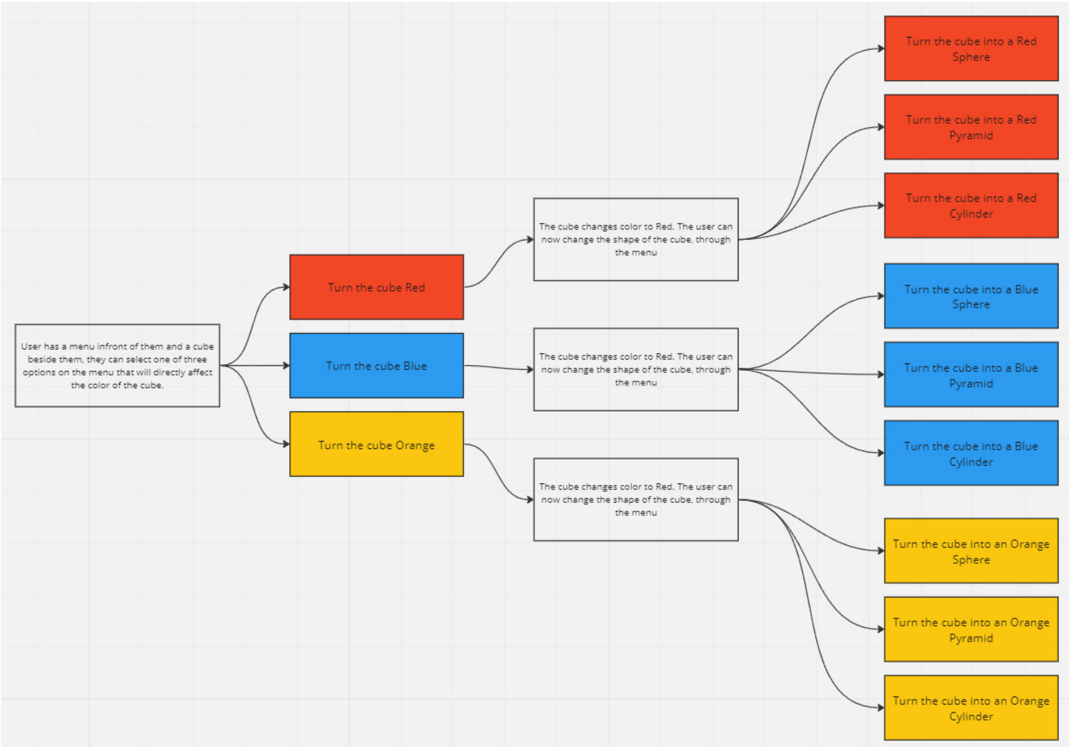

Fig 3.1.2 - "Changing a Cube" - Flowchart example.

A flowchart is a chart (Fig, 3.1.2) where a person can model the flow of events in a system. They are made up of processing steps, with conditional branching nodes and arrows connecting them

(Malacaria & Hankin, 1998). It is the holistic nature of a flowchart that can be seen as beneficial for developers as it allows for an overview and the establishment of possible interactions and their desired outcomes. From a programming point of view, this is useful as it allows me to create a system based around my specific needs. I also employ moodboarding as part of my conceptualisation process.

Deploying mood boards is a way of gathering and displaying a range of imagery with the overall aim of establishing meaning of specific areas of focus (Rutter & Bryce, 2006, pg 81). The collation

Fig. 3.1.3 - "The Farm Palette" - A Moodboard used within this Project.

of imagery gives insight towards associated colours, moods and intentionality behind specific elements (Fig. 3.1.3).
Smith et al. (1995) acknowledges the importance of visual notes, sketches, pictures and image gathering, believing that their usage has a crucial role in the creative thinking of designers. They also believe that many studies converge on the fact that nonverbal processing, including visualization, often enhances creative insight.

In the context of this project, significant visual meaning can be drawn from my memories that reinforces the important and visceral qualities of movement within a VR experience. As a child, I had so much fun performing these activities, and exploring them visually will provide insight into the factors that played a part in making them so special. Similar to flowcharts, establishing a series of mood boards will provide a holistic overview of the project, its time frame, scope and justification for key design decisions.

Playtesting & Prototyping

"The purpose of playtesting is not to find technical problems or marketing data, it is to understand how the game works when put into action" (Tynan Sylvester, 2013, pg 295).

Playtesting is one of the key processes that will be involved in this project. Playtesting forces designers to consider the experience of the play, and its effect on players. Fullerton et al. believe that "playtesting is the single most important activity a designer engages in" (Fullerton et al, 2004, p. 277).

Playtesting can be undertaken internally by the developer, or externally by an outside player (Macklin and Sharp, 2016, p. 160). Self-testing a project does not require any ethical consideration as I am the sole contributor of feedback, ideas and innovation; ".. just watching the game systems in motion brings a tremendous amount of understanding. It reveals many problems in flow, pacing, and balance. And, of course, technical bugs are best found in self-tests. The earliest loops of an iterative process should conclude with self-tests" (Sylvester, 2013, pg 296).

Given this emphasis on testing at early stages of the project, I will consider what prototyping is and how it can contribute to the project I am building. Prototyping comes in many forms; within the digital, prototypes can showcase roles, aesthetics and mechanical concepts.

In the context of developing my project, it is useful to utilise prototyping to quickly test ways of incorporating each activity aesthetically, mechanically and kinaesthetically. Exploring these possibilities will ensure accurate representation and communication of mnemonic aspects. When we consider the idea of memory exploration and the capabilities of VR, we should acknowledge how these physical activities are affected by the constraints imposed by play-spaces and the visual and sonic segregation from the outside world.

The prototypes that contribute towards this project will be rapidly performed and self-reflective. Therefore, the changes incurred will be minor and typically in response to the variations in methods or design decisions. These methods will ensure that the project explores a range of solutions towards evoking immersion, and potentially answering my research question.

Critical Reflection

Critical reflection is a process of identifying the ways in which we might unwittingly affirm discourses that work against us and the people we are working with, through examining our implicit assumptions (Morley in Liamputtong & Rumbold, 2008, pg 270). Morley uses critical reflection as a way to analyse practice, by combining constructivist and experimental approaches to research and applying the narratives around their own agency. This was achieved by deconstructing and reconstructing internal discourse that occurs during the research process. In the context of VR experience development, this would mean reflecting on the results of data received from the frameworks used, and on the processes and the framework as a whole.

Deconstruction begins by identifying and questioning commonly accepted conclusions around a subject and continues by seeking alternative perspectives, highlighting how these perspectives support popular thought (Morley in Liamputtong & Rumbold, 2008, pg 270). Within interactive experiences, internal discourse can be seen in the biases of the designer, their expectations and how these may influence or restrict their design decisions (Morley in Liamputtong & Rumbold, 2008, pg 270). Reconstruction is the process of taking these deconstructed reflections and creating interpretations (Morley in Liamputtong & Rumbold, 2008, pg 271). The conclusions that arise from this process become guidance for future actions, appreciations and understandings by helping us to gain a wider overview of the research.

Another practitioner, Linda Candy, discusses how "reflection [in creative practice] plays a vital role and enables the practitioner to learn from the process and its outcomes" (Candy, 2020, pg.71). In the context of this project, engaging in critical reflection will not only assist by providing a better understanding of subjective design choices, but will also garner opportunities for reflexivity, resulting in more balanced approaches and conclusions. It will also help me understand the elements of my memories, my own tacit knowledge as a designer and assist in furthering my understanding of why I make design decisions.

CHAPTER FOUR

Positioning Design Decisions

Introduction

I open my eyes. The sounds of a gently imposing autumn wind blow throw the grass. A maze of wooden stake fences extend into the distance and the promise of adventure beckons just over the horizon.

"Hey!"

The small ginger-haired child stands in front of me, freckles darting across his cheeks, bowl cut bristling in the wind, a mischievous smile spread widely across his face.

"Wanna see something cool?"

Before even waiting for an answer, he disappears into the grass, and heads towards an ancient oak tree, shedding its leaves in the distance.

I begin to follow…

The Farm and Opportunities for Movement

My journey began with contemplation. Looking through albums of childhood photos, memories began flooding back to me. Wide open spaces framed with wooden stakes and galvanised metal gates, overflowing with explorative potential. These visuals evoked feelings of freedom. Freedom of decision, freedom of journey, freedom of space.

The research around movement within VR, highlighted its importance within immersion. It also identified the limitations imposed by the play-space. These limitations needed to be solved if I was going to be able to evoke the feelings of freedom and movement associated with farm life.

As a practitioner, I find that approaching planning from a holistic overview allows me to see all of the elements of a project and how they may interact with each other. I knew before beginning the project that I wanted to include limb movements outside of the usual head and arm movements, but I did not know which ones. This required investigation into potential limb movements (fig. 4.1.1). This brainstorm chart outlined the limbs that I could explore (under the heading 'The Allowances') and the physical constraints (under the heading 'The Home'), then centralised these around the problematic element: 'The Play-space'

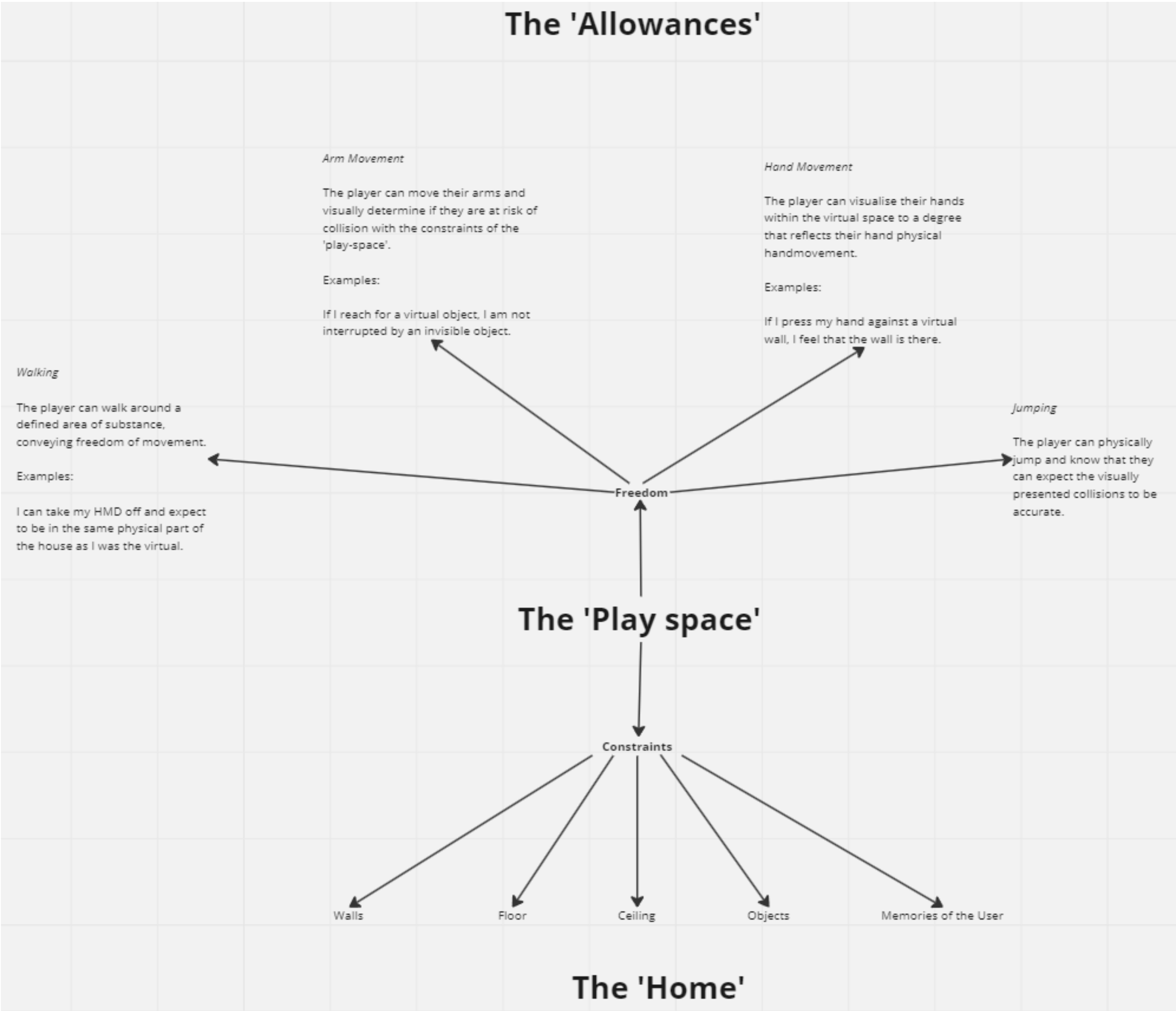

Fig. 4.1.1: "The Allowances: Establishing Avenues for Exploration".

Exploration of the farm as a child required a lot of walking; strolling through fields of grass guided by the fences that determined our property lines. The concept of this walking was, to me, the foundation for my childhood freedom. The sensation of being able to walk freely is what I wanted to achieve within my artefact. The user needed to feel as though they were walking across a substantial area, which presented a problem when considering the current form of play-spaces.

The limitations of 'Roomscale VR' lie in its ability to only delineate one room for play. Nissan et al. (2016) highlight that this lack of space can prohibit movement; if I wanted to create an expansive field to walk across, this technology would not suit my needs.

'Homescale VR' on the surface, sounded more appealing as it utilises all space available on a single story of a home, rather than just a room. It would definitely provide more, explorable area. For example, my own home contains one hundred and ten square metres of potential explorable area that could be used as a play-space. The problem with this notion, was that at the time of beginning this research, it did not exist.

I translated this concept into a flowchart that provided a holistic overview of how this could be constructed (fig. 4.1.2)

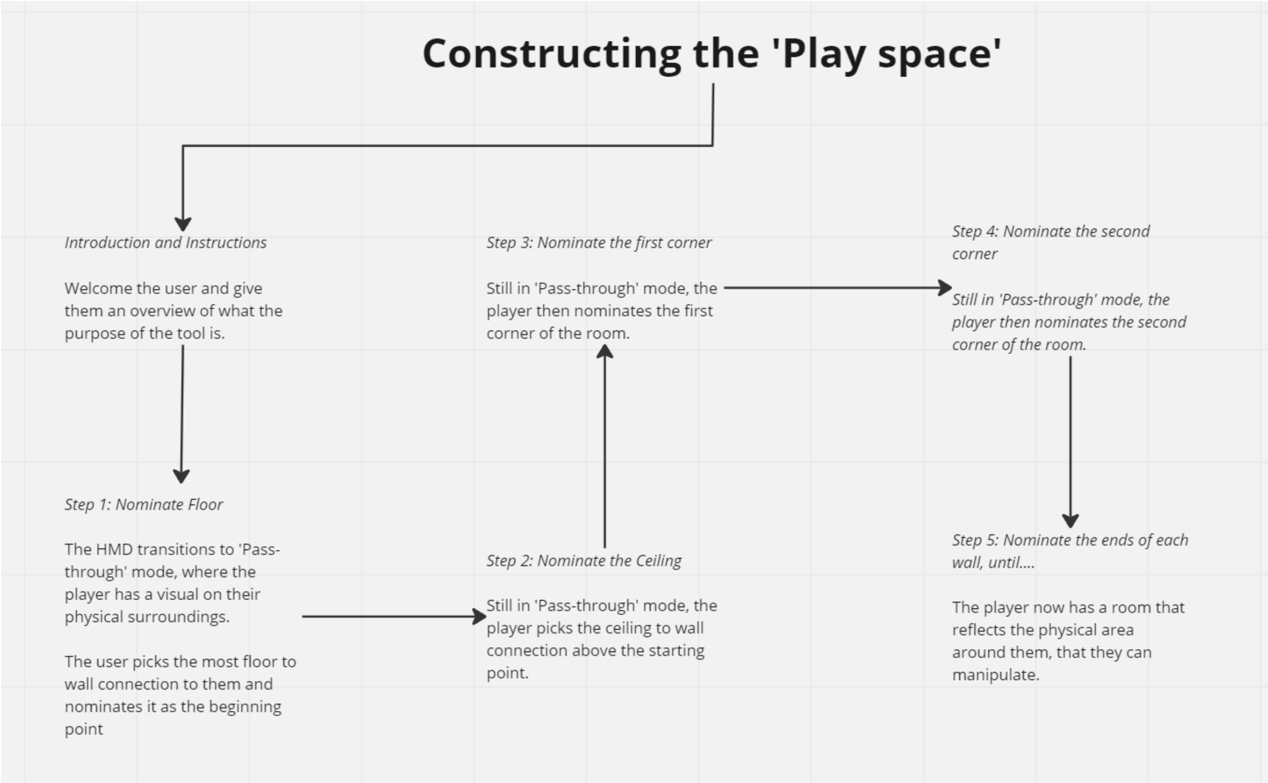

Fig. 4.1.2: "The Allowances: Establishing Avenues for Exploration".

Based on the processes employed by Meta's boundary setup system, this system aims to outline all of the parameters needed to establish physical space availability. Identifying the floor height allows the ground position of the virtual environment to align with what would be physically expected. The research highlighted the ability for us to understand the position of our limbs, without having to see them and thus not aligning the physical floor with the virtual ground would result in unexpected collisions and breaks in immersion. Determining the positions of the walls allows for possibilities for the play-space to be represented in the virtual environment and to also avoid immersion and presence breaking collisions with the physical world. I considered not representing the ceiling height within the play-space as the mnemonic world that I wanted to virtualise was vertically wide open, however, I found upon playtesting that the inclusion of a ceiling resulted in more accurate and easier to determine walls when creating the playspace (fig. 4.1.3).

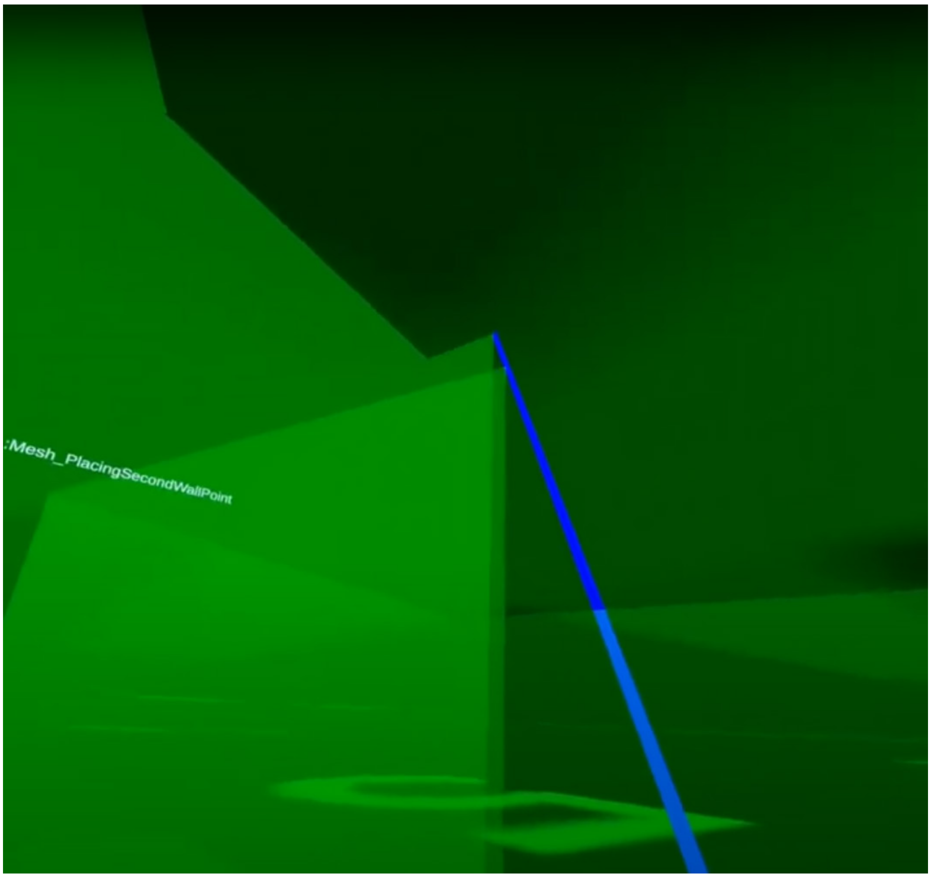

Fig. 4.1.3: "Floors, Wallings and Ceilings: The Home as a Play-space; First iteration". (Video)

For the sake of brevity, this research will omit the reasoning behind using Unity (the game engine chosen to develop the artefact in) and processes required in setting up a project for VR development as they were a necessity, rather than a design choice.

Playtesting the artefact initially caused a steady amount of anxiety, due to my paranoia of colliding with physical walls and objects. My non-visual senses kicked into overdrive, in fear of the unknown. The pitter patter of my dog Evie, reached my ears as she wandered around me, confused at the sight of her owner shuffling around in a zombie-like state. However, within minutes I became used to the newfound freedom of being unleashed from my office and my confidence in the virtual environment began to grow. This abstract green form of my home did not aesthetically resemble it in any form, but I knew that the walls were physically there; the contact between my feet and the floor was expected and accepted. At this moment I started to believe that this virtual world was reliable and began to appreciate the writings of Nilsson et. al. (2016) and their consideration of how important movement is within the virtual experience.

My legs could finally walk.

After reflecting and noting down my thoughts on this prototype, I put the HMD back on and entered the virtual environment again. However this time was different. The walls were not where I expected them to be. I took one step forward... and collided with the office wall. Could I have just taken the HMD off and compared the position visually? Sure, but I didn't want to be paranoid and suspicious of the virtual. I wanted to trust it and believe in its physical tangibility. I wanted to be immersed in it and free up my consciousness to feelings of 'being there', in the moment.

The need for me to build my own playspace had resulted in not being able to use some of the built-in features provided by the HMD software. One example of this was the spatial anchoring that positioned the virtual playspace in a consistent physical position. This code was deeply embedded within the HMD's software and so I was not going to be able to use it. I set about exploring alternatives that could ensure that my playspace was synchronised with the physical environment.

'Spatial Anchors' presented themselves as a potential solution. They operate by taking a camera snapshot of an area and, much like the HMD 'playspace', compare this with camera data to determine the position of the play-space within the room. However, as this solution required the use of the HMD's built in 'playspace', which I had previously established to be unsuitable for my purposes, I was forced to employ a different technique.

After reflecting upon the concept of 'anchoring' to a position in the world, I realised that the problem could be solved through determining a constant point in physical space that could be relied upon to be the same from play-through to play-through. Something as simple as placing a controller in a specific position and rotation would provide future reference for the HMD, to then position the new play-space (fig. 4.1.4) and thus the virtual environment in a way that is conducive with the actual world. This process was added to the flowchart (fig. 4.1.5), and a cycle of prototyping and playtesting began.

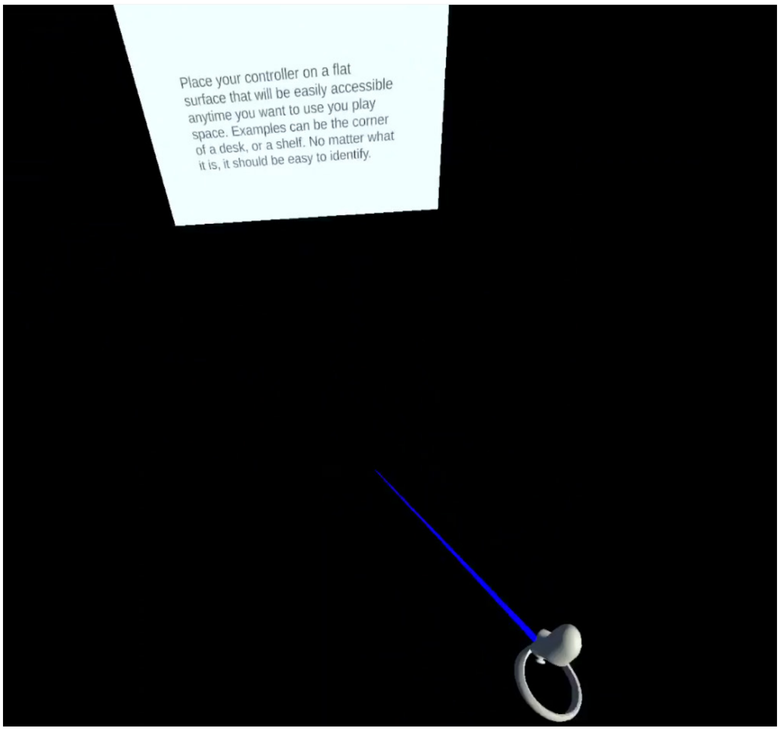

Fig. 4.1.4: "Controller Calibration: Positioning the Virtual Environment within the Physical World" (Video).

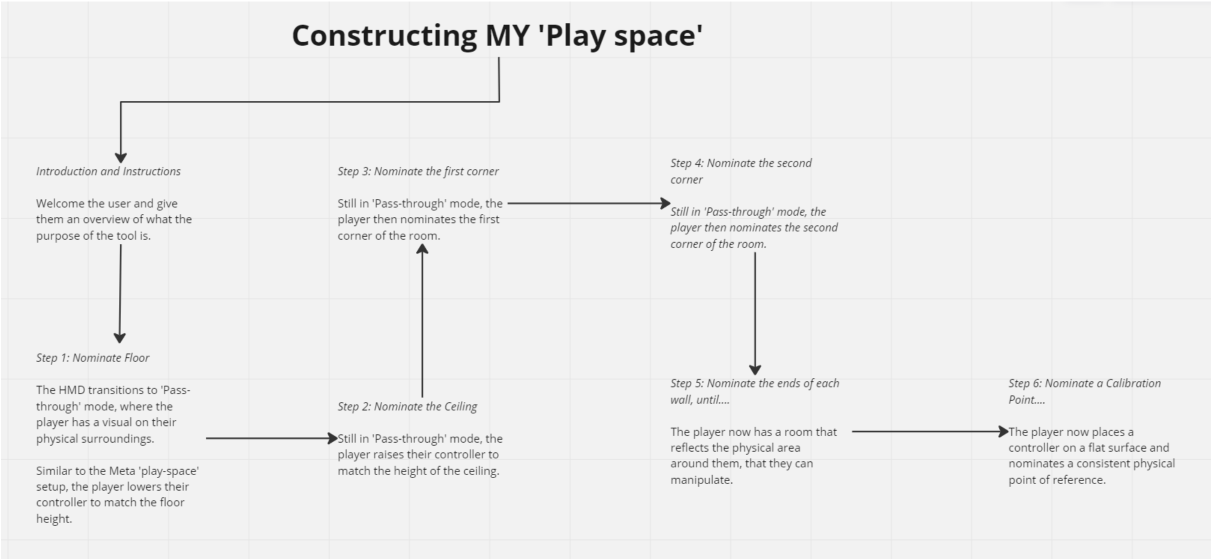

Fig. 4.1.5: "Constructing the Play-space: Second Draft".

I found that introducing this calibration technique grounded the virtual experience in the physical and reduced my doubts of whether or not the walls were located where I expected them to be. It was a significant step towards achieving the freedom of walking that I wanted, but I was still aware that unseen obstacles existed. Tables, chairs, couches, all objects that lay in the dark, ready to defend themselves in the event that I made physical contact. To free up this awareness of the invisible, I decided to make them visible. I implemented a rapid prototype of a 'Tracing' function that encourages the user to draw a three dimensional cube over the top of any obstacle that would interfere with movement. Although a simple solution, it was effective as it provided a buffer zone between the VR user and any object that could cause physical harm/loss of immersion. (Fig. 4.1.6).

Fig. 4.1.6: "Constructing the Play-space: Final Draft".

This pairing of the physical world with the virtual, revealed an insight into the symbiotic relationship that exists between the two dimensions. Within the 'Roomscale VR' model, we can see a reliance of the virtual on the physical to immerse the user; without the physical world, the virtual environment has no grounding or practicality and without the virtual, the physical world is robbed of explorative possibility. The problematic nature of a single room play-space can be seen in the hesitation and suspicion that I had when playtesting the prototype. Playtesting this new model now reignited my excitement for the project as I was able to put my faith within the virtual and walk around my home, immersing myself in a visually basic, virtual representation of my physical world.

However, there were still problems with this model. The visual positioning of the boundaries within this style of playspace are static and pre-determined. In the case of my confused dog, Evie, she will remain unseen and thus need to be considered, as well as any other changes made to furniture location and changes in room structure. The calibration was not perfect; deviations in position or rotation from the original establishment resulted in walls and obstacles not being exactly positioned. To counter this, I made a stand that kept the controller close to consistent, but this was still not a 'perfect' solution.

After going through a full cycle of iterative design and reflecting on the experiences I had while playtesting and prototyping, I felt positive that the hardware reflected the required capabilities for expansion of the playspace. In regards to opening up physical spaces for virtual considerations, this prototype was effective and ready to be aesthetically developed.

Exploring the Farm

The focus of this research is on physical aspects that can potentially be expanded upon, in the pursuit of immersive outcomes. However, it would be remiss to ignore the power of the visual and audiological within the virtual world. Development in this area was directed towards virtualizing my family farm in Puketitiri, Hawkes Bay. I am very fortunate in that my father was an avid documentor of my childhood, more likely found behind the lens of a Pentax camera than in front of it. It was these snapshots of history that provided a visual and audiological provocation of my memories.

To establish an aesthetic overview of life on the farm, I embarked on a journey through photo albums and created a visual landscape through moodboarding (Fig. 4.1.7).

Fig. 4.1.7: "Visualisation through Moodboarding: Childhood Moments".

This moodboard provided a holistic establishment of the farm's visual elements that could be included in the pursuit of immersion.

The grass in the hay paddock, when left alone, often grew to rival my childhood stature. It bowed and swayed in the wind, producing ripples of movement. Its blades were wispy and fragile alone, but thick and formidable in numbers. Extending across the entire farm, it dominated the eyes and accentuated the ebbs and flows of the land.

When implementing this first element in the project, I set about looking for models, as creating my own would be pointless if I was able to outsource. I found a suitable asset that came modelled and textured (fig. 4.1.8). It provided similar variations of types of grass found on the farm and satisfied the colour palette (green and gold), as well as the 'thick and formidable' clumps that I remembered. In my mind, I could see the grass swaying, the wind rippling through it and how accurately it could imitate the movement in my memories. Supporting this visual asset with the sounds of wind whistling through the paddock, would help to bring life and meaning to the virtual environment. I wanted a realistic aesthetic, but this could lead to performance issues and the HMD struggling to render everything in. I tested this initial thought and found it to be true (fig. 4.1.8). The drops in smoothness made the experience jarring and hard to witness, let alone to immerse myself in. One alternative to this was to consider 'stylised aesthetics' that utilised more hardware friendly methods to employ simpler renditions of modes (fig 4.1.9).

Fig. 4.1.8: "Asset justification: Realistic Grass Problems" (Video).

Fig. 4.1.9: "Asset justification: Stylised Grass" (Video).

By utilising 'stylised' grass I was able to bring in the golds and greens that were identified in the photos and it performed really well. The downside was that it felt cartoonish and presented as a very basic attempt at what I was trying to achieve. If I was to virtualise that connection with the memories induced by the photographs, I would need to find a way to make realistic aesthetics work. After utilising a process called 'LOD' (Level of Detail), I was able to change the complexity of the grass, based on the distance it was located from the player. When considering that we perceive detail less in objects that are located further away from us, this process made sense and more importantly, fixed the performance issues in the headset (fig. 4.1.10). As I reflected on the prototype in front of me however, I still felt that something was wrong. This element, although scaled correctly and visually accurate, did not feel 'alive'. In my memories, the grass swayed and bowed in the wind. I added a wind generator to passively sway the grass. What I learnt from this prototype was that visuals play a significant part in representing the world, but also, movement is incredibly important too. It adds 'life' to the visual fidelity. Taking these key observations, I moved on, adding more into the virtual farm.

Fig. 4.1.10: "Asset justification: Realistic Grass" (Video).

Embedded within these grass features were boundaries made of pine and number eight wire. These fence lines formed hard geometric patterns that sliced the land into explorable and unexplorable areas (fig. 4.1.11). They were subtle in their construct, overshadowed in visual impact by the endless land that extended beyond them. When choosing suitable three dimensional representations of the fences, I focused less on form (using simple cuboids) and more on selecting an aesthetically consistent wooden texture and utilising Unity's line renderer to create wiring between the posts (fig. 4.1.12). The final models visually represented their importance by subtly outlining their function. My initial iterations of the fence were too tall and through a process of height iteration, I was able to find a height that was dominant enough to establish the wall boundaries, but subtle enough to not leave me feeling caged in (fig 4.1.13).

Fig. 4.1.11: "Photo: Fenceposts"

Fig. 4.1.12: "Asset justification: Wires".

Fig. 4.1.13: "Asset justification: Just Right".

The visualisation of the farm triggered physical sensations that reminded me of the activities I would perform as a child. One of the strongest visual cues was that of a deciduous oak tree (fig. 4.1.14). Ancient in form and dominant in its construct, this tree provided significant feelings of joy and body sensation by allowing me to dance in the leaves it would release during the autumn months. This positioned it as an important source of physical movement and a source of visual fidelity with reds, golds and browns prevalent (Fig. 4.1.15).

Fig. 4.1.14: "Asset justification: Oak Tree".

Fig. 4.1.15: "Asset justification: Oak Tree In-Game" (Screen Shot)".

Much like the grass, this key element lacked life and after applying the wind generation used previously, the oak tree became a living resident of the virtual farm.

One final problem remained; the falling leaves. Utilising my pre-existing knowledge of Unity's 'particle' system functions, I iterated and playtested various leaf densities until I no longer felt overwhelmed by the mass of leaves falling upon me, but excited to jump around in them (fig 4.1.16).

Fig. 4.1.16: "Asset justification: Leaf Paradise" (Video)

This iterative process felt very similar to that undertaken during my exploration of grass, with one difference; I was very happy with the prototype at this point as the visual fidelity was starting to align with my initial intention. I decided to move on to another key aspect that would add to the aesthetics and play a key role in the functionality of the system; the pond.

I skimmed through the photo album and stopped at a picture of a pond littered with weeds (fig. 4.1.17). To anybody else, this pond could be conceived as a byproduct of its location within a valley. To me, this was the visual provocateur of a physical memory. It was these visuals and the provocation that they stimulated, that made the pond itself important to me. At this point, I had solidified my understanding of the importance of the relationship between movement and the visuals of the environment. This element should be aesthetically real and visually connect to the wind system that directed the grass and tree.

Fig. 4.1.17: "Photo: The Pond".

Prototyping the pond was interesting in that the actual model resembled nothing more than a simple, semi transparent plane with a focus on bringing the bottom of the pond to the top. Yet, the photos I used for guidance depicted a muddy, dark puddle, devoid of movement. Outside of the visual elements, trying to implement aesthetics based on the photos did not yield a desirable result, as I felt that the visuals of the pond would act as a deterrent, rather than an invitation to play (fig 4.1.18).

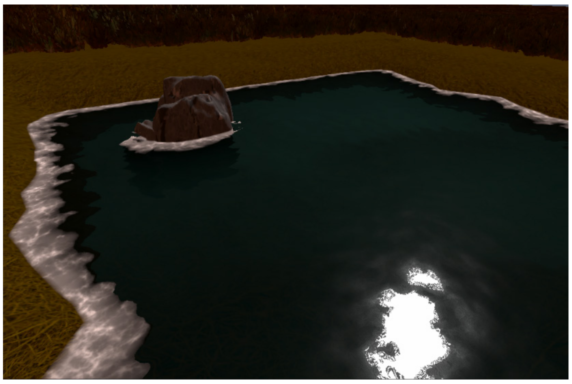

Fig. 4.1.18: "Asset justification: Murky Pond" (Image).

As I reflected on this observation and added clarity to the pond and to the iterative dance performed with the grass, fencelines and oak tree, I played with elements of identity. Too many weeds felt suffocating, and not enough felt strangely empty. Too much clarity in the water felt unrealistic, and not enough made the pond feel lifeless.

The final iteration of the pond brimmed with the possibility of life (fig 4.1.19); its surface and flora rippled with the wind. The relationship between aesthetics and environmental movement was balanced and, although inaccurate, still provoked the feelings I had when seeing it as a child. Could it be that my childhood naivety caused a rose-tinted idealistic perspective of a pond that in actuality was 'pretty gross'? Or was it that as the center of physical stimulation, its murky exterior was not important? I concluded at this point that the most important characteristics of the pond were its relationship with the environment and the idealism that I placed upon it, based on its possibilities for activity-based adventure.

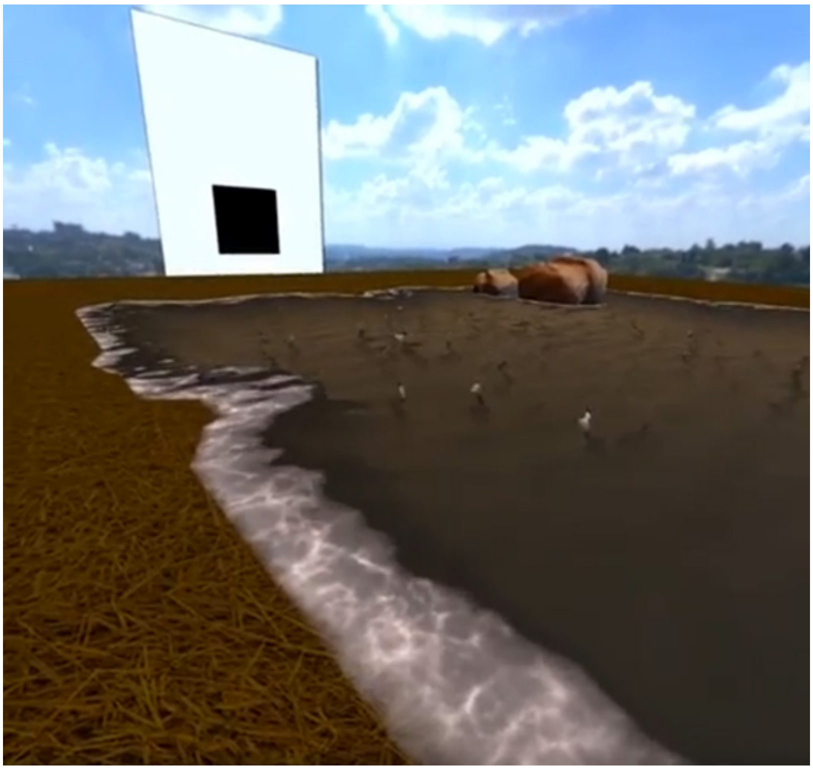

Fig. 4.1.19: "Asset justification: Just right." (Video)

The idea of skimming stones required deep consideration of the stones themselves. There is a deep complexity to achieving the ultimate 'skim' and the right stone is important. The process of searching for the perfect stone was interesting as I found myself being very selective and ultimately rejecting any outsourced offering in favour of modelling and texturing a variety of them myself. The perfect stone is a smooth, organic, natural construct, shaped through time and the raw abrasion of mother nature herself. Each dip, chip and double back in the curve forms its identity through imperfection. This individuality is important and so modelling multiple stones of various shapes, sizes and imperfections was required with the six below making the cut (fig 4.1.20).

Fig. 4.1.20: "Asset justification: Stones".

I considered the sonic elements of skimming stones too, selecting two samples that could imitate the sound of a stone bumping off the pond's surface and the 'plonk' of its inevitable sinking to the bottom.

This trip down a photographic memory lane, provided a significant amount of objects that could have been considered for inclusion, but a variety of factors including time, HMD processing power and desired communications shaped my decision making; resulting in the chosen elements. The sonic considerations were minimal. They still needed inclusion however; audio is an expected consequence of interaction and without it there would be a break in immersion.

As I reflected on the prototype, I witnessed a beautiful ecosystem full of nature that both did and did not reflect accurate representations of my childhood memories. Initially, I believed that visual accuracy was significant in positioning these elements as foundations for user movement. However, as I proceeded with the iterative cycles, I recognised the importance of movement within the environment itself. These memories are living snapshots of my past, accessed through still photography. With the possibilities of interactive media, I could experience these memories outside of my consciousness and in a more tangible capacity. This virtual ecosystem recognised the lifeforce found within the farm and established the environmental factors that contributed towards my physical memory.

Opportunities for Activity

The contextual research was focused on highlighting the importance of physical movement within Virtual Reality and the current prototype had developed ways to access this movement. The current iteration of the project allowed the user to include a wider range of physical boundaries and established the importance of environmental movement. However, I still wanted to consider H'Doubler's (1932) views on expressionism through movement. I needed to consider the movements themselves that were invoked by memories. I hadn't explicitly chosen these movements; as I integrated these environmental factors, I started to develop an understanding as to what these motions and actions could be.

I playtested the prototype and reflected on the lack of impact that I had within the environment. As a child, I remember pushing my way through and completely immersing myself within the hayfield. Much like the wind, the grass bowed as I 'trampled' through it and I remembered the resistance in my legs. I attempted to replicate this feeling by tying a 'resistance band', commonly used in body training, around my calves and walking through the virtual fields that way. Immediately, I felt endangered by this action and feelings of self-preservation prevented me from comfortably engaging with this method of muscle stimulation. I also wanted to see if Virtual Reality was able to stimulate sensations of resistance, without physical aid.

The initial setup focused around utilising shaders to determine the position of the user in relation to the grass and changing the form depending on that location. My original intentions were to use trackers that could be strapped to the users feet (Fig. 4.1.21), to relay the location of each foot, estimate a body form and use that for collisions.

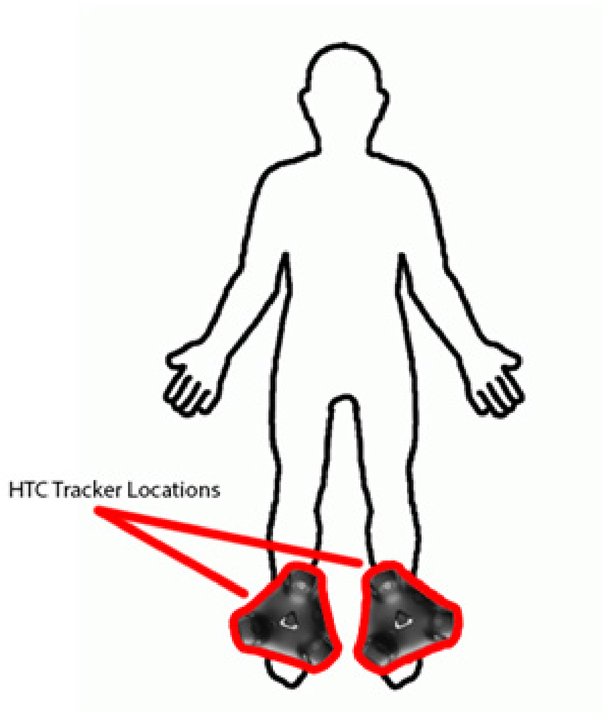

Fig. 4.1.21: "Tracker justification: The Plan".

Trackers, although accurate, have downsides. Individualising movement tracking provides more accurate locational data, however it can get complex and cause difficulties within the HMD due to the amount of elements it needs to keep track of. These problems can then lead to bugs in the experience and breaking of immersion. I decided to implement a single 'capsule' shaped collider that would be the sole influence on the grass and then I could decide if this had the desired effect, or if I needed to explore further.

Playtesting, as highlighted by Tynan Sylvester, helps us "understand how the game works when put into action" (Sylvester, 2013, pg. 295). After playtesting this, I realised that my thoughts on a complex solution may have potentially led me down a path of investigation that did not need to be followed. This 'simpler' iteration of trampling was an effective way of communicating the action (Fig. 4.1.22), despite not being the 'most accurate' solution. I could see the grass moving out of the way of me and knew that it was not an obstacle. This solution did require more development however. The footprint of the user was significantly larger than it should have been and felt very destructive on the environment. The iterative cycles of this element involved changing the area of impact that a user could have on the virtual environment. This aimed to be suggestive of presence, but not too destructive.

Fig. 4.1.22: "Grass Trample Justification: Too Much Destruction" (Video)

The final iteration of this prototype produced a working mechanic (Fig. 4.1.23). While the reaction of the grass could be considered too large for a child to make, it was suggestive enough of the action, without feeling too destructive. Upon further playtesting and reflecting, I found significance in my feelings of ambivalence surrounding the mechanic. I realised the irony of taking so much care in developing a living ecosystem and then handing the user the ability to destroy it, but the world also felt so much more alive when the grass acknowledged my movements. The research around presence focused on a sensation of 'being there', and through the inclusion of trampling, the environment would acknowledge my existence within it, creating this feeling through instantaneous and consequential feedback.

Fig. 4.1.23: "Grass Trample Justification: Final" (Video).

Another aspect I wished to integrate was that of being engulfed in falling autumn leaves. As a child, the ancient oak tree and its leaves provided opportunities for activity through jumping and swatting. Compared to the trampling of grass, this activity seemed far less destructive and far more worthy of childhood glee.

Within my commentary on 'Beatsaber', I justified potential explorations of finger movement as a possibility for a more immersive experience. Within this project, this involved implementing hand gestures; a function that built on hand tracking by recognising the position of individual fingers and the gestures they could form (thumbs-up, high-five, index-pointing etc). If a hand collides with an object we can condition a pickup on whether or not the user is performing a required gesture, for example: making a fist = grabbing. Prototyping this resulted in failure (Fig. 4.1.24) as grabbing the leaf resulted in it 'clipping' through the user's hand.

Fig. 4.1.24: "Leaf Grabbing: Clipping" (Image).

I set about fixing this, but stopped when I considered the activity I was actually trying to represent. I remembered that as a child, I was not as fixated with catching the leaves as I was at swatting at them. This aspect of the project should not be focusing on the idea of capturing these floating things, but rather, being one with them.

Implementing this swatting function had already been achieved through the requirement of collision detection in gestures. While playtesting, I jumped around, batting at the leaves (Fig 4.1.25) and for the first time during this project, I felt truly free. My legs were able to move without worry, my knees were able to join in and my arms and fingers flailed around, without a care in the world.

The iterative cycles undergone in the pursuit of this particular mechanic, had taught me to deeply consider the activities and what the desired outcomes were. Creating a complex and simple solution allowed me to realise the core of their functionalities. In the field of Game Design, this is referred to as a 'core mechanic' (Fullerton, 2014, pg. 210) and given the centralised nature of it within my memories of the farm, it felt like an appropriate description. The current state of this prototype gave me insight into the holistic potentials of moving within a virtual environment, as well as highlighting a 'core' element to the experience.

My arms could finally reach.

Fig. 4.1.25: "Leaf Grabbing Justification: Flailing" (Video).

The final activity that I wanted to include was skimming stones. Within the art of skimming, there was an inherent feeling of mastery over the pond and competition with my brother and cousins. Hours upon hours were spent perfecting the ultimate throw. When approaching the inclusion of this within the project, these feelings were the primary source of motivation.

Previously, when I had built the leaf mechanic, I learnt that employing a simplistic approach through prototyping effectively established the requirements of the interaction and so I began the 'skimming stones' mechanic by attaching the stone to the hand, when the user 'touches' it (Fig 4.1.26).

The process of having a stone 'snap' into place without any provocation other than 'touching' it, was jarring; my fingers felt neglected and my hand confused. What was this round thing that had latched on to my palm? Furthermore, I realised that I had not considered how this would detach itself when I threw it. Rather than continue this development further, I opted for using gestures (Fig 4.1.27).

When playtesting, I noticed that as I attempted to throw and release, the stone would 'flop' out of my hand, with no momentum inherited from my arms. This was very unsatisfying, but easily fixed. Calculating the position of the user's wrist over a short period of time allowed me to determine the velocity and angle that should be transferred to the stone upon release (Fig 4.1.28).

Fig. 4.1.26: "Stone Grabbing Justification: Touch" (Video).

Fig. 4.1.27: "Stone Grabbing Justification: Gestures" (Video).

Fig. 4.1.28: "Stone Throwing Justification: Great Success!" (Video).

During testing, I found each throw of a stone resulted in different speeds and trajectories consistent with my memories. A strange feeling of visualising myself as a child performing the same activity came over me and upon reflection, I realised that in that moment I had entered a triple layer of existence. At the bottom was reality, in the middle was Virtual Reality and on top was a mnemonic layer; all three together creating a phenomena of virtually stimulated reminiscence. Adding the ability for the pond to bounce the stones, created an environmental reaction that further increased immersion and presence. Similar to the trampling effect, I felt the environment reacting to my actions.

The prototype had achieved what I set out to create. The activities and visuals felt genuine. The world acknowledged my presence. But something was still missing. After reflecting upon my memories, I realised that this virtual world was missing an inhabitant; a small ginger-haired guide who would show me the way to experience the joys of the farm again.

The Mnemonic Guide

The concept of memory is strange to me. I had never realised that the subjective experience of remembering extends to the viewpoint from which we perceive it. Historically, I have always vicariously experienced my memories; as an outside observer, rather than as the person directly involved in the memory. Unbeknownst to me, at the time of researching, Sigmund Freud noted instances of a person describing childhood memories, from a third person perspective, "as an observer from outside the scene would see him" (Freud in Bergouignan et al., 2022).

I thought about my position as storyteller, describing and experiencing memory from a third-person perspective. I believe that my way of remembering places me somewhere in between that of a person reminiscing through a first person perspective and someone who had not experienced the memory at all. Both myself and the audience stand in the same place, but I have prior knowledge of the memory and thus, a more informed position of its significance.

As I rifle through the snapshots of my childhood, I observe the small ginger-haired child standing for a family portrait, smitten by the massive mushroom in his hands, bright red jumper keeping him warm (Fig. 4.1.29).

Fig. 4.1.29: "Grandpa, Grandma, The Ginger-Haired Child and a Giant Mushroom"

This is the boy that guides me through my memories, reminding me of the fun and adventure to be had in the simple actions of chasing leaves, skimming stones and marching through fields. He is the perfect narrator to my autoethnographic story, as he is the protagonist of the story itself. I set about considering how he could guide me through the virtual farm.

To visually represent him, I decided that a moodboard (Fig 4.1.30) would help me consider my childhood self and the position 'the child' held visually within the landscape, as well as distinctive colours and features that could be used to represent him.

Fig. 4.1.30: "Ginger Bowlcuts, Red Jumpers, Blue pants and Black Gumboots"

This moodboard caused an episodic reminiscence, flashing imagery of ginger bowlcuts, red jumpers, blue pants and black gumboots. This child was comfortable on the farm, at one with the land, yet standing out from a distance. I set about considering how to implement him into the experience.

Visually, I had my key characteristics and due to the importance of the narrator, I decided to model him myself. As a construct he was a shrimpy lad, born of Viking and Scottish heritage. With no perceivable arm strength, he relied on technique and muscle memory to elevate his abilities as a professional stone skimmer; with determination and enough practice, he could conquer the world, no matter who or what stood in his way.

The iterative process of modelling a child, especially one that represents yourself is a contradictory process. I considered how important the visuals of representation were when I clearly cared more about it as an adult, than I did as a child. I began by trying to model him myself and the results were not desirable (Fig 4.1.31). Shifting to Character Creator, I found quick ways that yielded better results. I learnt that using a childhood photo to texture the model was possible. Too stocky or skinny would leave the boy foreign to me and his guidance muted. Too tanned would show too much time spent in the sun, whereas too fair would leave him fragile and unnerving.

The clothing of the child was not as much of a consideration, as I felt that a simplistic approach could be justified by questioning what the purpose of the clothing was. I reflected upon this and felt that the strongest visual identifier could be found in the colouring of the bright red jumper that contrasted heavily against the golds and greens of the hayfield. This highly visible element was key to identifying the location of the guide and more significantly the direction that he was headed in. Reflecting on this element led me to conclude that this needed no real iteration as its importance was strong enough, due to its level of contrast to the land (Fig 4.1.32).

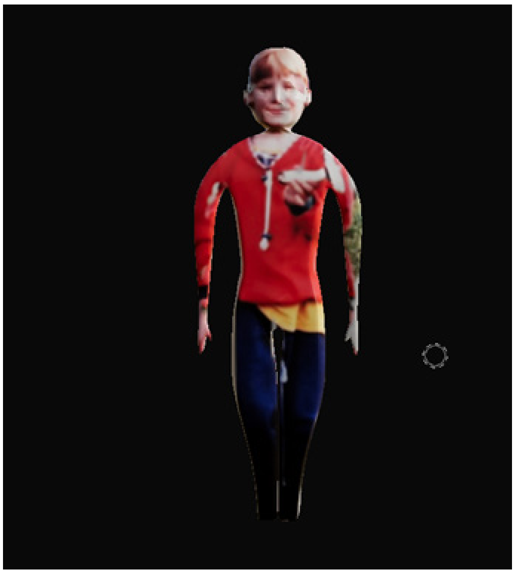

Fig. 4.1.31: "Modelling the Child: Failure" (Image).

Previously, I established that reflection on the initial prototypes had made me realise the 'child' was the solution to my feelings of 'being lost' within previous playtests. At this point, the model was static; I needed to consider how he could walk through grass, dance with the leaves and skim stones on the pond.

He needed to move.

Fig. 4.1.32: "Modelling the Child: Red Jumper" (Image).

Using 'Character Creator' meant that the model was already prepared for animation. The purpose of the 'child's movement was to guide the user around the farm. I constructed a diagram of what the 'child' would need to do to achieve this (Fig. 4.1.33).

Fig. 4.1.33: "Child Purpose: First Iteration"

As I reflected upon the first flow-diagram, I considered that a person engaged in this experience may not know to follow the 'child', and so I thought about ways to increase this awareness. I developed a second iteration of the flow-diagram (Fig. 4.1.34) that had the 'child' walk towards the activities and begin doing them. I also considered having the 'child' remind the user to follow them, but felt that this would be a form of harassment. This project was aimed at adding 'freedom' to virtual reality and pressuring the user to experience the farm in a specific way would be self-defeating.

Using flowcharts was beneficial to developing the prototype. Through visualisation of potential actions, I was able to determine the action'

Using flowcharts was beneficial to developing the prototype. Through visualisation of potential actions, I was able to consider the implications that interactions with the 'child' may have on a user and strategise ways that this guide could promote participation and freedom, without having the user feel coerced. Even though the 'child' had not yet been implemented in the prototype, I could see that this co-communicative relationship would add to my feeling of 'being there'. It was time to give the 'child' life, by animating him.

Fig. 4.1.34: "Child Purpose: Second Iteration"

I considered the animations that I wanted to employ in response to the activities I wanted to communicate. This child would show the user how to have fun with these different elements and so the animations would need to reflect that.

This iterative cycle had emphasised the importance in taking time to reflect upon results and consider how they could better represent the intent of their communication. I applied this knowledge to three activities (walking (Fig. 4.1.35), jumping at leaves (Fig. 4.1.36) and skimming stones (Fig 4.1.37)).

Fig. 4.1.35: "The Child Guide Walking Animation: Final Iteration" (Video).

Fig. 4.1.36: "The Child Guide Jumping Animation: Final Iteration" (Video).

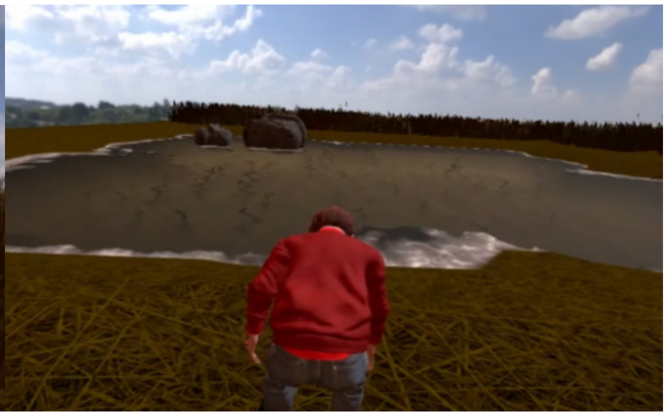

Fig. 4.1.37: "The Child Guide Skimming Animation: Final Iteration" (Video).

To prevent the ethereal nature of the child becoming lost in his constant visual occupancy of the viewport, I implemented a system that had the guide fade out in between engagements with the user. His role was to show the joys of participation, not control where the user went. Having him constantly present made the experience feel controlled and focused around the user. Fading him out between encounters felt less controlling and more communicative of the nature of memory; of moments in time (Fig. 4.1.38).

Fig. 4.1.38: "The Child Guide Fading Animation: Final Iteration" (Video).

With the prototype complete, I reflected on the journey undertaken. This final iteration represented more than the initial research. Within this prototype, I could engage in a virtual episodic experience that represented a part of who I was, and that has contributed to who I am now. The focus on play area had allowed me to expand the virtual play-space to a larger physical area resulting in more opportunity for movement and to explore more possibilities to feel 'free' in a virtual environment. The trust that I now had in the relationship between the physical world and the virtual environment meant that I could navigate without fear of interference; resulting in a much more immersive experience than what I was used to.

The visual manifestation of the farm had created an environment that I wanted to explore, utilising this new found sense of freedom and delivering it in a satisfying way. The actions that were able to be performed, also utilised this freedom and gave meaning to both elements by merging physical movement with virtual reactions.

The 'child' guide was eager to share, but refrained from controlling. Through him we could witness the joy of performing these actions and participate in the activities to discover if they resonated with us.

I was finally 'there'.

Every element within the project was justified regardless of whether or not it succeeded in its original intent. The combination of iterative design with prototyping and critical thinking had provided the grounds for effective design, consideration and development. I had discovered priorities of communication and learnt to approach development on a more holistic level. The user's mind and body was now free to trust the HMD and explore greater potentials for movement within both physical and virtual environments.

CHAPTER FIVE

Discussion & Conclusion

Physical Spaces for Virtual Places

This research has seen my perspective changed in many areas, over its duration. I began this journey by questioning the physical boundaries of Virtual Reality hardware and conceptualising ways to expand upon them. The prototype achieved this, meaning that users can now utilise more available space, engage in more physical activity and in my opinion, immerse themselves within the virtual farm to a higher degree than under previous models.

This is not to say that the experience was perfect. The calibration aspect is fairly crude in its application and further development could lead to better alternatives such as utilising 'trackers' as permanent fixtures or, utilising the Meta API that allows the developer to snapshot different parts of the room and use them as a constant. Developments in hardware that have occurred since the beginning of this project may render this model of play-space redundant. The new Meta Quest Pro can utilise lidar to find positions for walls, floors and ceilings as the user moves through the space, as well as providing more accurate detection of obstacles, both static and moving. This project was ambitious for the hardware used and so a frame-perfect virtual experience was never going to be feasible due to the higher processing requirements needed. Although I am critical of the outcome, I believe that the importance of it still remains and can be seen in the discoveries made throughout the development.

It would also be remiss not to mention the accessibility oversight of this project. Being able to use one's legs is not a luxury that all share, therefore immersion and presence may be manifested differently. However, I suggest that the autoethnographic nature of this research frames it within my subjective interpretation of growing up on a farm.

I came into playtesting the 'play area tool' with some apprehension regarding the invisible physical. Informally, I called this 'beaten dog' syndrome as it centered around the preconceptions formed by previous VR experiences. There was an inherent freedom presented to me by opening up my home as a play-space, but with it came feelings that an invisible entity could strike me at any time. As I playtested more and implemented the obstacle nomination within the playspace, I was able to focus on this freedom and immerse myself within future virtual iterations without having to worry about physical recourse.

When we consider that virtual experiences are judged by their levels of immersion, we can observe that this freedom is a strong path to helping us achieve this aim. Future explorations of this freedom could build on this research and explore concepts of how virtual environments can 'mask' the physical world; freeing up the user to be immersed with what they see and hear.

The research focused on physical spaces and physical actions and how they could enhance immersive experiences, however, I found a lot of substance when considering their relationship to memory. Skimming stones, jumping for leaves and strolling through fields had me reactivate muscle sensations that I had not felt for decades. I felt free from the inherent day-to-day grind associated with being an adult. For myself, there was a re-connection to who I was and an appreciation for who I am now, formed by re-visiting these feelings. Future research could examine how Virtual Reality can assist with mental health through invoking freedom and childish glee.

Virtual Reality hardware is ever changing; each iteration building off its predecessors. I believe this research can be positioned as a contributor to what could be achieved with better hardware and the reasons for wanting to achieve that. Furthermore, I believe that this research offers a contribution towards achieving higher levels of immersion and presence, through highlighting the importance of feeling free and feeling safe to roam physically within virtual worlds.

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DOCUMENTATION

Exhibition and Showcasing

Fig X.1 - "Going out of Bounds" was in the exhibition room to the right of this wall.

"Going Out of Bounds" was exhibitioned on the AUT Campus, at the St. Paul Street Gallery, between the dates of 29th June - 1st July, 2023 (fig X.1).

The exhibition consisted of a podium with the headset and one controller placed on top. I chose to keep this part of the exhibit minimal as the experience itself lies within the headset and I had determined that the marks of success for this project was for the VR users to look beyond the physical spaces and constraints and focus purely on the experience.

The gallery room was a wide open space that was approximately 20 x 40m, which unfortunately did not work well with my intention of opening up play spaces within the home. I ended up creating 'artificial walls' as I wanted to keep the experience as authentic to the originally available playspace which included hallways and tighter areas (fig. X.2).

The gallery had a concrete polished floor and featureless white walls. This raised a few challenges for the tracking abilities within the headset. Strategic positioning of coloured placemats and tea towels helped to provide some stability for the tracking system (fig. X.3). I later found that applying tape into various shapes on the ground provided enough detail to stabilise the tracking and was tidier. This problem was unforeseen as the original intention was to expand the playspace to match the layout of the home, not a purpose built exhibition area.

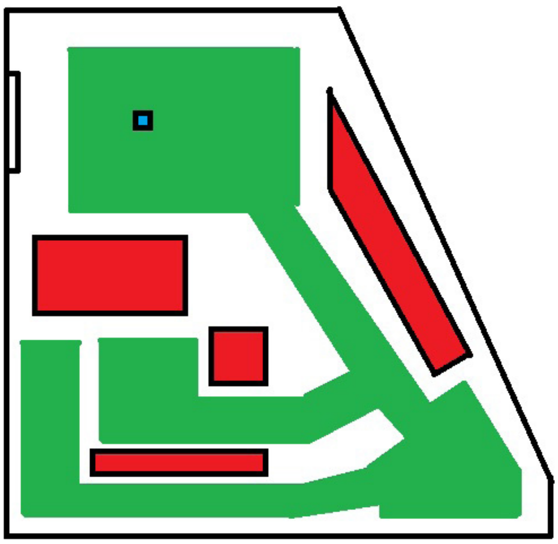

Fig X.2 - "Home Exhibition" - A quick overview of the playarea (green), obstacles (red), starting podium (blue) and the room itself (black)

To prevent any form of harm I walked alongside each user, intervening in the event that something unexpected happened.

I did find the need to intervene at times, when the gallery was full of audience members observing other artworks on display. This wasn't too problematic however, as the VR users generally didn't feel the need to explore with pace and I found I could ask people in the way to move slightly and avoid any collisions with the VR users. This also garnered more interest in my exhibit.

User feedback revealed that the supervision provided comfort to those who were less familiar with VR experiences. I did find that I had to engage with these less familiar users a little more than intended (assuring them that they were not in danger), but after the experience I also found that they still clearly understood the main concepts behind the work.

Overall I was happy with the discourse provoked by the experience. It appeared that the majority of people understood the intended focus of freeing the VR user from physical constraints and how this allowed them to immerse themselves within my childhood memories, to a higher degree than if they were confined to a smaller space.

Other than a need to charge the headset and clean it between users, the up-time of the event was high and I was able to show all interested parties through the experience.

Fig X.3 - Tea towels and Place mats as points of reference