Exploring the use of meaningful VR experiences for those living with Dementia

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Abstract

This thesis explores the potential of immersive technology as a tool for people living with dementia, focusing on designing and optimising immersive experiences to align with their unique needs and preferences. The research is structured around three interrelated studies, each exploring different insights into immersive interventions for dementia care.

The first study investigates the feasibility and usability of a VR prototype application for dementia care through the development and evaluation of a VR video player application. This application enables individuals living with dementia to watch VR videos tailored to their interests and cognitive abilities. The study reveals both the potential of VR to enhance engagement and relaxation and the challenges posed by communication difficulties to understand the preferences of the participants.

Building on these findings, the second study adopts a participatory forward-thinking approach, allowing people living with dementia to create physical model boxes comprising of items and environments that are meaningful to them. These physical models are then transformed into personalised digital VR environments. This study highlights the creative potential of people living with dementia and the importance of co-design in building emotional connection and meaningful engagement, while also identifying continued barriers in verbal communication.

The third study pivots to the development of innovative design directions for immersive interventions. These directions are informed by findings from the first two studies and are structured around key features such as memory recall, physical interaction and creative expression. This study proposes concepts for immersive experiences that address the unique challenges faced by those living with dementia. Each design aims to provide opportunities for meaningful and recreational engagement.

Together, these studies present a comprehensive investigation into the design, evaluation, and innovation of immersive technologies for people living with dementia. The findings inform practical recommendations for creating immersive experiences that are engaging, accessible, and personalised, with significant implications for enhancing quality of life in dementia care.

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COVID Statement

This thesis represents a journey of research conducted during a global pandemic. The COVID-19 crisis shaped the research process for good and for bad, presenting significant challenges but also opportunities for resilience, adaptability, and innovation. Despite these obstacles, the work presented here demonstrates the capacity to persevere and produce meaningful contributions to the field of Human-Computer Interaction (HCI) and dementia care.

The research began with a strong foundation of **literature review** and **iterative design work** in collaboration with St. Andrew's Healthcare (Mental health charity and psychiatric hospital), where the focus was on **designing a prototype system** capable of delivering immersive and personalised VR experiences for individuals living with dementia. This initial phase was planned to be done directly with participants, and MAPPA (Management of Actual or Potential Aggression) training was necessary to provide ethical and appropriate preparations for research in dementia care within this specialised environment.

However, the COVID-19 pandemic disrupted common research practices, requiring a shift to remote working and data collection. While the initial plan was to continue working with the hospital for further studies and conduct larger-scale data collection, ongoing disruptions regarding social distancing meant that this was no longer feasible. Even after lockdown was lifted, St. Andrew's Healthcare continued to face restrictions, limiting the support available for external research. As a result, alternative methods had to be explored to ensure the study could progress. Despite these challenges, the iterative design process continued to produce valuable feedback, demonstrating the feasibility and adaptability of the VR system even in the face of significant disruptions.

The constraints such as social distancing and nationwide lockdowns pivoted the research focus, looking beyond from just working in clinical environments to collaborations with specialised arts organisations such as *Bright Shadow*. This collaboration introduced the concept of **model boxes**, which allowed participants to co-create meaningful spaces that were translated into immersive environments. For the first time, hands-on data collection resumed, gaining rich qualitative insights into the potential of participatory design and activities beyond reminiscence. The findings from this phase not only excelled the research but also gained acceptance into ACM Designing Interactive Systems conference 2024 (DIS), where the work was exhibited and brought to the spotlight to the HCI community.

The pandemic's long-lasting impact made it difficult to pursue other planned research activities, such as in-person studies. This limitation prompted a change to remote methods and collaborations with UCL, I spent two years focusing on assessing engagement from participants living with severe dementia, containing physiological signals and EEG data, through machine learning techniques. While promising, this approach yielded mixed results, and I was unable to gather quality data to present in this thesis.

These experiences led to a shift in perspective, steering the research towards **design directions** as a means of exploring the broader implications of immersive technology to be used in dementia care. This phase reflected a deeper engagement with the creative and human aspects of HCI, inspired by the success and learnings from the previous studies. The focus on speculative design allowed for a more innovative and forward-looking approach, showcasing how technology can create meaningful and impactful experiences for individuals living with dementia.

In summary, the pandemic highlighted the resilience of both people living with dementia and the research process itself. Despite disruptions to daily routines and care, individuals living with dementia continued to find ways to adapt and connect with others. At the same time, this research navigated unexpected challenges, but by adjusting research methods and finding creative solutions, myself along with my collaborators were able to keep the work moving forward. This thesis reflects both aspects of resilience, showing how determination and flexibility can drive meaningful progress even in difficult circumstances.

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Chapter 1: Introduction

Dementia is an umbrella term for conditions that reduce brain function, affecting memory, speech, and reasoning as a result of abnormal changes in the brain. It affects millions of people worldwide, with an estimated 55 million currently living with this syndrome [2]. As individuals grow older, the likelihood of a dementia diagnosis rises: from 65 years of age, 1 in 14 people is diagnosed with dementia, increasing to 1 in 6 after the age of 80 [171]. Thanks to advances in healthcare, life expectancy has increased, and consequently, the number of people living with dementia is predicted to reach 78 million in 2030 and 153 million by 2050 [196, 2]. Although there is no cure, it is vital to develop interventions that enhance quality of life for those with the condition.

Studies suggest that immersive environments, such as those provided through Virtual Reality (VR), can bring benefits like cognitive stimulation and relaxation for people living with dementia [144]. VR can transport users to different or even imaginary places, encouraging a sense of immersion [241, 10]. Yet, many existing studies have mainly focused on the functions and outcomes of the technology itself [250, 239, 217], rather than exploring how VR can support meaningful experiences rooted in each person's background, values and daily realities. Current research, while valuable at showcasing that indeed immersive experiences enabled by technologies like VR have potential, tends to be technology-driven, meaning it looks at VR's hardware and software effects rather than focusing on how well the system fits into the lives and personalities of individuals living with dementia.

In this context, supporting personhood is critical because it recognises each individual's history, preferences, and identity, which may otherwise be overshadowed by dementia

[269, 268]. By valuing personhood, it is possible to design interventions that help maintain a sense of self and respect personal choices. Unfortunately, many studies have not considered how VR might fit into daily routines, whether in care facilities or private homes. Nor have they explored how people living with dementia and their caregivers can contribute to decisions about how VR is designed and used. Most research also measures the performance of VR systems rather than examining how people living with dementia interact with them and how those interactions could be improved. These gaps make it difficult to create VR experiences that are truly beneficial and genuinely valued by those who use them.

"***. . . the real power of VR is to go beyond what is real, it is more than simulation, it is also creation, allowing us to step out of the bounds of reality and experience paradigms that are otherwise impossible.***" [241]

This thesis responds to these gaps by adopting the theme "**Meaningful Spaces, Meaningful Places**" [45], asking how immersive experiences can be shaped into experiences that support personhood, spark emotional connections, and allow people to engage with significant memories [228, 227, 54]. The work goes beyond simply presenting VR content, instead examining how personalised elements can encourage active participation rather than passive consumption [112]. Similar to how a house becomes a home through personal touches and emotional meaning, this research investigates ways to turn ordinary virtual spaces into experiences that resonate with each individual. By involving people living with dementia and their caregivers throughout the process, it aims to make immersive experiences part of a person-centred approach, ensuring that the technology remains a tool that serves real needs, upholds identity, and promotes everyday well-being.

1.1 Research motivation

Many individuals living with dementia face difficulties in their daily activities, often requiring support from family members or professional caregivers. They might be unable to venture outdoors alone or participate in social events they once enjoyed, resulting in limited independence and a higher risk of feeling isolated. This isolation can lead to depression, which is sometimes observed in the early and mid-stages of dementia [69]. Once depression sets in, it can become a repeating cycle that is hard to break, accelerating cognitive decline and further reducing daily engagement.

Although there is no definitive cure for dementia, non-pharmacological interventions – such as cognitive rehabilitation, reminiscence therapy, and creative activities – have proved valuable in addressing emotional needs and lessening symptoms [162, 147]. Compared to medication-based treatments, these approaches often provide lasting benefits, helping preserve personal identity and emotional well-being. Therapies like Cognitive Behavioural Therapy (CBT) and Virtual Reality Exposure Therapy (VRET) show comparable effectiveness for symptom relief, and VRET adds possibilities through immersive technology [205, 256].

In this context, immersive tools, such as VR, offers a way to create meaningful experiences for people living with dementia, allowing them to revisit memories, explore new surroundings at a relaxed pace, and take part in creative or social activities. However, most research on immersive technology in dementia care has focused on outcomes like reduced stress or improved cognitive performance [144], rather than examining how immersive experiences can be customised to reflect each person's background and emotional needs. Existing VR programmes often rely on generic content [125], which may not fully engage participants.

Beyond personalisation, it is equally important to consider the social context in which immersive technology is used, including the roles of caregivers and how they manage or introduce immersive interventions. In addition, involving people living with dementia in the design process — despite possible communication barriers — can offer valuable insights into their preferences and experiences. By exploring both personal and social factors, VR interventions can move beyond one-size-fits-all solutions to become a tool that enhances well-being, supports day-to-day life, and respects the viewpoints of those living with dementia.

1.2 Research questions and contribution

This thesis explores how immersive technology can offer meaningful, engaging, and supportive experiences to people living with dementia. It looks at whether immersive technology is practical, how to design experiences that feel personally significant, and what challenges might arise along the way. Below are the key research questions that shape the direction of this work:

- **RQ1**: *How feasible and acceptable is VR technology in delivering immersive and engaging experiences to individuals living with dementia?*

  So first of all, **why** is VR worth exploring for dementia care? By investigating feasibility and acceptability, we can answer whether VR is a viable tool to enhance the lives of individuals living with dementia. It addresses whether the technology itself is practical and beneficial, setting the stage for the more in depth exploration in **RQ2** and **RQ3**.

- **RQ2**: *How can immersive experiences for individuals living with dementia be designed to transform generic spaces into meaningful places?*

  Then onto the core purpose and theme of the thesis, **what** are we trying to achieve with immersive technology for people living with dementia? I explore the concept of creating "meaningful places" and identify the elements that make immersive experiences emotionally resonant and impactful for the users. By focusing on the transformation of space into place, this question examines the outcomes of good design in immersive experiences.

- **RQ3**: *What are the key design considerations and challenges in creating personalised immersive environments for individuals living with dementia?*

  This thesis then focuses on the practical application, **how** do we actually create these meaningful immersive experiences? I investigate the technical and design challenges, such as scalability, personalisation, and user-centred approaches. A more operational and technical approach compared to **RQ2**, asking how the ideas and concepts identified can be implemented effectively.

Overall, these questions provide a structure for understanding the potential of immersive technology in dementia care, the ways to make experiences meaningful, and the challenges of putting such ideas into real-world use.

Research outcomes and contribution:

Below, I present the main contributions that have emerged from examining the feasibility of VR, the practical design challenges, and the development of innovative design directions solutions. Each contribution relates directly to the research questions, providing clear evidence of how this work advances knowledge in dementia care through immersive and interactive technologies. These findings include both theoretical insights and practical guidance for creating dementia-friendly immersive experiences, laying a foundation for future projects in this area.

- **Understanding engagement in VR for dementia care**

  I have found that VR can spark emotional and cognitive responses in individuals living with dementia, especially when content is tailored to personal interests. This work expands our understanding of user engagement and emotional well-being in VR by exploring how environments and guided interactions can put users at ease.

  Relevance to RQ1 and RQ3: This contribution shows how VR can be both feasible and engaging by using customised, emotionally resonant content (RQ1). It also offers key insights for developing meaningful immersive designs (RQ3), focusing on factors that encourage user involvement.

- **Framework for personalised VR design**

  I have proposed a framework that connects crucial features, such as memory recall, life stories, and multisensory stimulation, to meaningful engagement. This framework guides future research by outlining specific design elements that can enrich the user experience.

  Relevance to RQ2 and RQ3: The framework acts as a guide to convert generic immersive spaces into emotionally significant places (RQ2), while also providing a basis for creating customised solutions tailored to the needs of people living with dementia (RQ3).

- **Feasibility of VR technology in dementia care (Chapter 3)**

  Through practical demonstrations, I show that VR can be acceptable for people living with dementia, provided caregiver support is incorporated. I address the practical and technical concerns that can affect uptake, drawing attention to strategies such as real-time caregiver assistance.

  Relevance to RQ1: These findings confirm that VR can be used in dementia care by tackling challenges like caregiver guidance and suitable interface design, making it feasible and acceptable for everyday use.

- **Role of creative expression in immersive design (Chapter 4)**

  By involving participants in activities like model-box building, I discovered ways to allow people living with dementia to shape their own virtual environments. This sense of agency makes immersive experiences more than a passive medium and helps users feel actively involved in their care.

  Relevance to RQ2: This contribution shows how user input can transform standard immersive experiences into personalised ones, thus building meaningful spaces that resonate with each person's identity and preferences.

- **Innovative design directions using morphological analysis (Chapter 5)**

  I present design concepts developed using morphological analysis, a structured and creative approach to generate ideas in dementia care. This method allowed me to creatively generate innovative combinations of 12 design features from my initial studies, to concepts that address emotional comfort, memory recall, and social interaction. These ideas and guidelines can help developers and caregivers create immersive experiences that go beyond traditional VR reminiscence or entertainment, giving individuals new ways to connect with, and create new memories.

  Relevance to RQ3: By focusing on specific user needs, these concepts provide practical steps for producing engaging immersive environments for people living with dementia.

- **Creative framework for design direction generation**

  I propose a method that generates user-centred concepts based on design features found during my research. This approach supports the development of varied and relevant design ideas that suit the complex needs of those living with dementia.

  Relevance to RQ2: This process-based approach addresses the design challenges associated with user-centred, personalised immersive technology. By incorporating collaboration and feedback loops, it becomes more likely that the final experience will be meaningful and beneficial for people living with dementia.

Overall, these contributions provide both theoretical perspectives and practical tools for developing immersive experiences in dementia care. They demonstrate how to move from feasibility to actual implementation, covering emotional engagement, personalisation strategies, and collaborative design methods. The work, therefore, advances both the academic understanding and real-world practice of using immersive technology to support people living with dementia

1.3 Research approach

To explore the potential of immersive technology as a meaningful tool for individuals living with dementia and to investigate methods for optimising immersive experiences based on individual preferences and engagement levels, this research is structured around three main studies, each focusing on a distinct aspect of immersive technologies in dementia care.

Study 1: Design and development of a VR prototype system. The first study in this research journey focused on designing and developing a prototype VR system tailored for individuals living with dementia. This initial phase aimed to create and evaluate the feasibility and acceptability of using an iterative designed VR technology to deliver engaging and immersive experiences to participants. The study involved the creation of a user-friendly VR platform that allowed participants to watch VR videos with help from their carers, providing insights into the potential benefits and challenges of using VR technology in dementia care settings.

Study 2: Personalisation of VR environments. Building on the findings from the first study, the second study aimed to enhance the immersive experience by introducing personalised environments. Participants were invited to physically design a model box and meaningful soundscape through co-creative workshops, which were then digitally recreated and assembled in VR to create personalised and meaningful experiences. This study aimed to demonstrate the potential of customised VR environments in enhancing engagement and satisfaction among individuals living with dementia, paving the way for more personalised and effective immersive interventions.

Study 3: Design directions for meaningful immersive experiences. The third study shifts focus to proposing innovative design directions aimed at creating meaningful and engaging experiences for individuals living with dementia in immersive environments. This study emerged from recognising the challenges of assessing engagement and personalisation in previous work. By compiling insights from earlier studies and employing a framework of key design features, this phase proposes actionable concepts for future immersive experiences. These designs aim to offer pathways for developing personalised and effective dementia care interventions.

Together, these three studies provide a comprehensive exploration of the potential of immersive technology as a supportive tool for individuals living with dementia, offering valuable insights into the design, customisation, and evaluation of immersive interventions tailored to the unique needs and preferences of this population.

1.4 Overview of thesis

This chapter (**Chapter 1**) presents the reader with the current situation at hand, and what this thesis is all about; from the problems to the gaps in this field. I would like to take this section to guide the reader in how the next chapters of my thesis will follow.

Chapter 2 introduces the reader to the core concepts surrounding dementia and the potential of immersive technology as a tool for care. The chapter defines dementia as an umbrella term for conditions causing a decline in brain function, affecting memory, speech, and reasoning due to abnormal changes in the brain. The chapter then transitions to exploring technology's role in dementia care, how technology can aid through interventions and rehabilitation. The chapter also introduces the concept of immersive technologies that simulate environments to immerse users in interactive experiences, with a focus of Virtual Reality (VR). There are many definitions among different disciplines, but for this thesis, VR is understood as a multisensory human-computer interface that places the user in environments that can be interacted with. Typically involving various senses such as visual, auditory and sometimes tactical feedback. Although they often simulate three-dimensional spaces, a three-dimensional environment is not strictly needed. The key distinction of immersive environments is that the user participates within the environment rather than just simply observing from the outside. This sense of immersion differentiates immersive technology from other forms of computer interaction. Furthermore, the chapter highlights immersive technology's potential in healthcare, thought while immersive technology can be beneficial, some environments may cause negative memories and distress. This chapter also delves into the concept of personhood in dementia care. It discusses the importance of personhood and how Human-Computer Interaction (HCI) approaches this concept. The chapter further explores immersive technologies in detail. This includes a discussion of VR for healthcare in general and specifically VR for dementia care. The chapter also considers the use of virtual reality to encourage art engagement. Furthermore, this chapter examines the concepts of *Space* and *Place* and how to make immersive experiences meaningful. It highlights the importance of connection and personalisation in creating effective interventions. The chapter concludes with a summary of the role of immersive technologies in dementia care and identifies key gaps in existing research, setting the foundation for the research questions addressed in the thesis. It notes that much of the current work has prioritised technological feasibility over meaningful, person-centred experiences that support identity and long-term emotional well-being.

Chapter 3 details the development of a prototype VR system designed for individuals living with dementia. It describes the iterative design process used, which included feedback from staff at the psychiatric hospital. The initial prototype focused on user-friendliness and remote accessibility for caregivers. The chapter also discusses the challenges of using VR with people living with dementia, and the importance of remote access for caregivers to select and control videos for users. It also describes the system's ability to deliver personalised content. The chapter further explores how personal photographs can be integrated into VR environments, discussing the technical challenges and limitations that arose. It also emphasises a move towards a more user-preference-driven approach to content selection, where participants' interests and personal lives are considered. A feasibility study was conducted with five participants, including those with Huntington's disease and other degenerative diseases. The chapter also examines the use of various videos, from generic nature scenes to personalised content based on user preferences and requests. It also highlights how the system evolved through testing, including improvements to video quality and remote streaming, and understanding the importance of personalised content in comparison to just the fascination of VR itself.

Chapter 4 explores the creation of personalised virtual environments through co-design with people living with dementia. It highlights the importance of moving away from a deficit-based model of technology design. The chapter details a study involving 44 participants who created physical model boxes that were then transformed into digital VR environments for participants to re-explore and experience their art in first person. This process underscores the importance of participatory methods where older adults are co-creators of technology. The chapter emphasises co-creation, abstraction, and different design implications for future research. The chapter discusses the immersive co-creation journey, which involved six workshop sessions. These included creating collages, model boxes, and soundscapes, which were later integrated into immersive VR experiences. Data collection and analysis are discussed, with the use of reflexive thematic analysis and vignettes to capture participant experiences. This chapter further highlights the emotional and social aspects of the co-creation process, with importance of creating meaningful experiences through art.

Chapter 5 presents various design directions for immersive experiences based on the insights from previous chapters. It focuses on creating concepts that are meaningful and enjoyable while providing supportive benefits. The proposed design directions include: *MemoryScape*, which uses personal photos to recreate past moments; *ImagineScape*, a creative tool where users build virtual worlds; and *Cultural Touchstones*, which allows users to explore cultural experiences. The chapter also explores the *Comfort Guide*, which uses virtual companions to create comforting and personalised interactions; and *Waypoints AR*, an augmented reality system that integrates user's past and future, into the present. The chapter also details the methodology for developing design directions, highlighting key features like memory recall, physical interaction, and cultural significance. It covers the creative processes involved, including feature identification, framework development, and iterative idea generation. The chapter also notes the potential opportunities and pitfalls of each proposed design, with suggestions for ways to mitigate these risks, whilst also identifying its relevance to dementia care.

Finally in **Chapter 6**, the implications of the research are discussed, addressing the main research questions about the feasibility, design, and impact of immersive experiences for dementia care. It reflects on the research's impact, future directions, and the transformative potential of immersive experiences. It addresses the feasibility and acceptability of immersive technology, and how it can transform generic spaces into meaningful places. The chapter emphasises the importance of co-creation and personalisation in creating effective immersive experiences. It also explores the role of immersive technology in enhancing social connections and building community. Furthermore, it discusses the practical implications for caregivers and clinicians, noting how this technology can reduce caregiver burden while improving care quality. It examines key design considerations and challenges in creating personalised immersive environments, including the balance between cognitive stimulation and preventing overload. The chapter also acknowledges the limitations of the research, such as small sample sizes and the need for more diverse cultural representation. Finally, the chapter provides future directions based on these limitations, especially the need for further research into long-term engagement with immersive technology and the potential assessing engagement for those living with dementia.

1.5 Relevant publications

- **WORKSHOP PAPER** – Ethan Cheung, Chee Siang Ang, Panote Siriaraya, Sophia Ppali, Kieran Breen, Sarrah Fatima. 2022. VRPassport: Travel the world in Virtual Reality for people with Dementia. Presented at the CHI 2022 workshop: The Future of Emotion in Human-Computer Interaction (EMOCHI '22)

- **WORK IN PROGRESS** – Ethan Cheung, Sophia Ppali, Anna Xygkou, Alexandra Covaci, Hiba H Jawharieh, Clare L Thomas, and Chee Siang Ang. 2023. Meaningful Spaces, Meaningful Places: Co-creating VR Experiences with People Living with Dementia. In Companion Publication of the 2023 ACM Designing Interactive Systems Conference (DIS '23 Companion). Association for Computing Machinery, New York, NY, USA, 217–221. https://doi.org/10.1145/3563703.3596624

- **ART EXHIBITION** – Ethan Cheung, Sophia Ppali, Boris Otkhmezuri, Clare L Thomas, and Alexandra Covaci. 2023. Co-creating Meaningful Spaces: Stepping into Virtual Worlds Crafted by People Living with Dementia. In Companion Publication of the 2023 ACM Designing Interactive Systems Conference (DIS '23 Companion). Association for Computing Machinery, New York, NY, USA, 81–85. https://doi.org/10.1145/3563703.3596645

- **FULL PAPER** – Hiba H Jawharieh, Luma Tabbaa, Chee Siang Ang, Ethan Cheung, Alexandra Covaci. 2024. Care Beyond Borders: Investigating Virtual Reality Deployment Opportunities & Challenges Through the Lens of Dementia Care (International Journal of Human-Computer Interaction) pp. 1–19, Sep. 2024, doi: 10.1080/10447318.2024.2400400.

- **FULL PAPER** – Sophia Ppali, Ethan Cheung, Alexandra Covaci, Wan-Jou She, and Chee Siang Ang. 2025. Creating with Care: Co-Designing Immersive Experiences through Art-Making with People Living with Dementia. In Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems (CHI '25). Association for Computing Machinery, New York, NY, USA, Article 673, 1–18. https://doi.org/10.1145/3706598.3714101.

Chapter 2: Related work

Immersive technologies such as VR [125, 62, 194, 92, 144], augmented reality (AR) [273, 116], multi-sensory environments (MSEs) [54] have gained increasing attention in dementia care, offering potential benefits such as maintaining cognitive status [179] and reminiscence therapy [172]. Studies have demonstrated that VR can provide individuals living with dementia an opportunity to experience environments beyond their physical limitations, whether by revisiting familiar places [52], engaging in nature-based experiences [139], or participating in meaningful activities [10]. However, while much research has been conducted on the general effectiveness of VR in dementia care, less attention has been given to how these experiences should be designed to be personally meaningful and engaging.

Existing immersive interventions in dementia care often involve pre-recorded content that is largely generic, designed to stimulate engagement [10] but not necessarily to evoke deep emotional connections or reflect individual life experiences. While these interventions can provide benefits, they often overlook the personal history, identity, and preferences of the user. This raises important questions about how immersive experiences can be tailored to better align with the needs and preferences of individuals living with dementia.

Another critical challenge in VR-based dementia interventions is how engagement is assessed [10]. While many studies focus on measuring outcomes such as cognitive function [278], there is limited research on what makes an immersive experience personally meaningful and beneficial on an emotional level. Theories of personhood and self-identity in dementia care suggest that interventions are most effective when they reinforce an individual's sense of self [124], yet there remains a lack of research exploring how immersive technology can be designed to achieve this goal.

This chapter reviews the existing literature on dementia care, personhood, and immersive technologies. It begins by providing an overview of dementia and its impact on cognition, memory, and engagement, before introducing the concept of personhood and self-identity in dementia care. It then explores how immersive technologies such as VR have been applied in dementia interventions, examining both their benefits and limitations. Finally, the chapter identifies key gaps in knowledge, setting the foundation for the research questions that will be addressed in this study.

2.1 Dementia

2.1.1 Overview of dementia & cognitive decline

Dementia covers a large group of cognitive decline diseases, including vascular dementia, Lewy body dementia, frontotemporal dementia, and Alzheimer's disease – the most prevalent, accounting for approximately 60-70% of dementia cases [68]. In some cases, people may develop more than one type, a condition known as mixed dementia. Although each form of dementia has different characteristics that define each one, there are common symptoms experienced across most types, such as memory loss, difficulty with concentration, communication challenges, emotion regulation, and disorientation.

Due to the rapid advance in technology and medicine, the overall population can live longer than those in the past, by 2050, the global population above 60 years old is expected to be 2 billion, which is a 900 million increase compared to 2015 [4], though as more people live a longer life, there will be an increase in those developing dementia, as ageing is a large risk factor for the disease, but does not exclusively just affect older people as there also exists young onset dementia (based on the appearance of symptoms before 65 years old). Alongside this, women are also disproportionately affected, partly due to longer life expectancy [185, 23]. Beyond these non-modifiable factors, lifestyle and environmental influences play a crucial role, with cardiovascular health, physical inactivity, social isolation, and cognitive engagement being key determinants of dementia risk [199], as it is estimated that 1 in 14 people over 65 years old can develop this disease whilst the rate increases at 80 years old to be a 1 in 6 people. [171]

Dementia is typically classified into three main stages — early, middle, and late — which help to monitor progression and tailor interventions accordingly. In the early stage, symptoms are often subtle and may include mild language difficulties [19] or challenges in organising tasks, although people can still manage daily activities and maintain independence [80]. As the disease progresses to the middle stage, assistance with daily tasks becomes necessary. Memory loss worsens, behaviour changes may occur, and communication becomes increasingly difficult. Mood swings and emotional instability, such as anxiety or irritability, are also common [254]. In the late stage, the effects of dementia are severe, and individuals can no longer live independently. They experience significant communication difficulties, severe disorientation, and little to no recognition of familiar people or surroundings. Distress from confusion, fear, or depression is common and requires extensive care [253].

Early diagnosis and staging of dementia are crucial for timely interventions, with tools such as the Global Deterioration Scale (GDS) [117], Clinical Dementia Rating (CDR) [27], and Mini-Mental State Examination (MMSE) [11] commonly used to assess cognitive and functional decline. This allows individuals to benefit from treatments that can slow progression and improve quality of life. Staging systems are used to categorise the severity of dementia and guide appropriate interventions. While these frameworks are essential for clinical practice, they primarily focus on deficits rather than the lived experiences of individuals.

As dementia progresses into its later stages, individuals often experience a significant decline in cognitive and physical abilities, making independent living difficult. Many require continuous care, often in residential or specialised psychiatric hospital settings, where care is continuously provided and tailored to their needs. While such environments provide professional support, they also present challenges for them and their caregivers.

One major issue is the impact of the care environment on well-being and behaviour. People living with advanced dementia can become agitated, manifesting into aggressive behaviour [41] towards staff or other residents causing caregiver burden and depression [88]. These responses may be heightened by factors such as unfamiliar surroundings [115], lack of personalised care [5], or sensory overload [24]. In secure psychiatric care, additional complexities arise due to legal and safety restrictions, particularly for individuals under the Mental Health Act or those with forensic histories.

Addressing these challenges requires rethinking how care environments are designed and experienced. Research suggests that modifying physical and sensory surroundings can significantly influence mood and behaviour [260], reducing agitation and enhancing emotional well-being. Approaches such as personalised immersive interventions, therapeutic VR experiences, and adaptive environments may provide alternative ways to encourage engagement and emotional stability. These interventions have the potential to improve the quality of life for individuals living with dementia while also supporting staff in managing challenging behaviours more effectively.

2.1.2 Traditional methods for cognitive stimulation & engagement

With pharmacological treatments for dementia being limited and potentially causing adverse effects [132], a common practice in modern intervention is to administer non-pharmacological approaches. Some examples of non-pharmacological approaches are functional analysis-based interventions [191], psychological therapy [200], reminiscence therapy [274] or art-based procedures [70], which are used to awaken memories, stimulate mental activity, and provide the ability to re-experience past emotions or generate new ones. As pointed out by Basting [21], present-focused activities are crucial for this population and should be emphasised to avoid the past overshadowing their current and future experiences. This is traditionally accomplished through talking therapy or the use of visuals, drawing activities, music, or physical objects [102]. Past work demonstrates that the benefits of therapy increase when more senses are engaged [133]. Since the surrounding environments directly influence emotions, providing environmental stimuli that stimulate multiple senses could enhance emotional, cognitive, and behavioural responses of people living with dementia [232]. Moreover, emotions are often expressed, regulated and interpreted in social settings [261]. Therefore, incorporating social interactions in non-pharmacological interventions has the potential to elicit stronger emotional engagement.

2.1.3 Technology for dementia-care

With new technology constantly improving such as AI, smart home systems and immersive technology such as VR, these types of technology are becoming more accepted in the public eye. Alongside these improvements [14], the need of technology to treat or diagnose diseases in easier or new ways is becoming increasingly popular [93, 101, 67], one of which being dementia. Different types of technologies are used to help with a range of aspects that affect the life of someone living with dementia, such as reminiscence [158], maintaining cognitive abilities [104] and social interactions [26] or the potential to detect early signs of cognitive impairment [169].

2.1.3.1 Screening and early detection of dementia

A diagnosis of someone's cognitive impairment can be found using different types of technology, from image analysis of the brain using single-photon emission tomography (SPET) and positron emission tomography (PET) [71] or a combination of magnetic resonance imaging (MRIs) and PETs [136] to diagnose different variations of dementia using medical images, to identifying what stage of dementia they are currently experiencing [276, 47].

Eye tracking. Diagnosing the level of cognitive decline, is helpful for early detection of dementia, to allow time to prevent further deterioration of more serious cognitive impairment. Such examples are using eye-tracking devices [201], through a series of task movies that participants watch, each task tests a different cognitive skill such as memory retention, eye tracking, deductive reasoning etc. The tracking of the eye will be observed to measure the duration of time the user looks at a certain area of the screen – region of interest. The results from these tasks are matched with a control group, mild cognitive impairment or dementia diagnosis. This information can then be correlated with patients doing traditional 'pen and paper' tests to see what level of cognitive impairment they have. The scores from the eye tracking test had a correlation with the dementia diagnosis and concluded that the eye-tracking, along with other studies [60, 190], was an effective way in determining the level of cognitive decline a person has.

Mobile games. With mobile phones being easily accessible, they too can be used as a convenient device for detecting signs of cognitive impairment [134] such as using popular mainstream games like Candy Crush, Tetris and Fruit Ninja. To analyse user gameplay can show signs of cognitive decline. The experiment did find significant and consistent patterns between gameplay and the cognitive assessment results. This technology has been explored through several studies [252] to allow early detection of cognitive decline and shows that it can be used for diagnosis for medical cases.

Non intrusive sensoring. Instrumentation can also be used unobtrusively such as implementing in the interior of a car to detect driving behaviours of early-stage dementia, comparing it with data from drivers without cognitive impairment [81]. Analysing that both groups can drive equally as safe but have differences in driving space and that the dementia group were more likely to get lost. This information can be used to differentiate and detect if a driver may have cognitive impairment traits. Some have used motion sensors to analyse gait patterns of people living alone and have detected differences between people diagnosed with and without cognitive impairment [75]. Rather than focusing on a single piece of technology, Malinowsky [174] examined how individuals living with varying levels of cognitive impairment interact with technologies of differing complexity. The study found that cognitive ability significantly influenced how these technologies were used.

Through these studies, it can be shown that data collected can differentiate those with differing cognitive abilities in both indirect and direct methods. However many have shown that it is difficult to make a general conclusion due to the small sample sizes [81, 75] and that as dementia is a progressive disease, it would be best to carry out tests for a longer time as cognitive ability declines for greater results [75] however must be balanced in the case of safety [81]. Some studies recruit participants in an advertisement method, this doesn't allow a representative variety of people to fully test the hypothesis in question, as the reason the majority of people may not participate may be the feature that is affected in the study [174].

2.1.3.2 Management for dementia care - reminiscence therapy

Other common ways to use technology for those living with dementia is to recall memories from events and experiences from the past to relive which are generally positive and significant. This form of therapy is super effective as it can be used at varying levels of cognitive impairment [77], some of which may need to be prompted specifically [113], compared to other types of therapies such as behaviour therapy or validation therapy [162] as it can help those who have lost their ability to vocally express themselves. After reminiscence, people living with dementia would appear less anxious, frightened or depressed, [159] have improved social skills, cognitive skills and motor skills [238].

Many different types of stimulus have been used to trigger reminiscence, from photographs [13], to music [135], a mix of these stimulus could further enhance reminiscence in individuals as shown in Bass and Greger's study where participants going through reminiscence therapy had scored lower depression scores afterwards than those in a control group [55]. The possibility of using more advanced technologies, such as 3D printers, to print out small, realistic-looking objects can also be used as a stimulus for reminiscence [102], which the families of participants have said to be more impactful than just being shown a picture of the object.

Gesture-based technology such as Microsoft Kinect have been used to allow users to interact with a virtual world in a natural way whilst also feeling immersed and present in the virtual environment [239]. Reminiscence can be triggered through the actions they express or from the virtual world they see, this type of gesture-based technology has been perceived to have a positive effect in terms of pleasure and alertness [194] however may trigger negative emotions such as fear and anxiety too. In these types of technologies, immersion is the key concept, where by lowering the perception of the real world, enhances how effective the virtual environment can be [212].

From these studies, stimuli can trigger positive reminiscence for people living with dementia using pictures, videos, sounds, and objects; however, there is still a chance that reminiscence can allow negative memories to be brought up and may cause distress to those living with dementia. It is also beneficial that individualised prompts can help aid reminiscence [102] to make the experience more personalised, allowing the individual living with dementia to express more about themselves.

Although reminiscence therapy is generally considered safe it typically delivers small and inconsistent benefits across outcomes, settings, and delivery methods [274, 247, 206]. These mixed effects can create unrealistic expectations if reminiscence therapy is presented as a route to large improvements in cognition, mood, communication, or quality of life. Reviews also point to lack of standardisation in content and facilitation (for example, life review versus general reminiscence; group versus individual sessions; variable facilitator training), which makes results harder to reproduce and can frustrate participants and staff when procedures differ between sessions [274, 247]. One large randomised controlled trial of joint carer–person reminiscence groups reported no gains on primary outcomes and a small increase in carer anxiety at longer follow-up; the clinical importance is uncertain, but it signals the need for careful screening, consent, and clear opt-out points when working with dyads [274]. Finally, resource and cost considerations matter: some formats – especially digital or immersive approaches – require staff time, specialised materials, or technology that may limit access and reduce cost-effectiveness in routine services, as suggested by economic evaluations linked to group reminiscence trials [247]. In practice, reminiscence therapy is best framed as option-based, consent-sensitive, and facilitator-led, with protocols for pausing or redirecting sessions, and as one component within a broader mix of present-focused and interest-based activities.

A further limitation is that reminiscence therapy centres almost exclusively on the past. While revisiting memories can be comforting, a persistent backward focus can crowd out the present and the future, narrowing opportunities for choice, agency, and growth that are central to personhood [150, 34, 124]. Critics in dementia care and Human–Computer Interaction warn that interventions primarily framed around loss and recall can perpetuate a deficit narrative, positioning individuals as repositories of former abilities rather than as current agents with preferences, relationships, and goals [266, 152]. Person-centred practice, therefore, argues for balancing memory work with present-focused and forward-looking activities (e.g., creative expression, sensory engagement, and co-created experiences) that affirm identity in the here-and-now and support continuity of self [268, 192, 54, 178]. In this framing, reminiscence is one option among several, used selectively and in ways that connect memories to present meaning and future intentions, rather than becoming the default template for care.

2.2 Personhood

"I feel as if I'm losing all my leaves. The branches, and the wind, and the rain. I don't know what's happening any more." [280]

This quote from Florian Zeller's *The Father* perfectly encapsulates the confusion and emotional disintegration that many individuals living with dementia experience. Dementia strips away not only memory and cognitive abilities but the very fabric of *selfhood* [199, 150]. Everyday tasks become unfamiliar, and once-comfortable spaces transform into disorienting landscapes. As dementia progresses, individuals often find themselves retreating from social life – not out of choice, but because their worlds become increasingly difficult to navigate.

2.2.1 Importance of personhood

Until a few decades ago, dementia was largely understood as a straightforward narrative of decline, with the focus primarily on cognitive impairment and functional loss [204]. The medical model dominated, emphasising the pathological aspects of the condition and neglecting the broader social, emotional, and experiential dimensions of living with dementia [266]. This perspective, often reflected in dementia care technology design, can unintentionally position individuals as passive recipients, limiting their ability to take initiative and overlooking their valuable skills and experiences [111, 152].

For decades, the dominant narrative around dementia has framed the condition as a steady erosion of the self. As cognitive abilities decline, traditional accounts suggest that individuals living with dementia experience a progressive loss of identity, to the point where they are often seen as "no longer a person" or as undergoing a "death of the self" [94]. This view presents dementia as a destructive force, which strips away memory, identity, and social roles leading to the perception that little remains out of the individual's *personhood* as the condition progresses. Such perspectives have severe implications for how people living with dementia are treated, often resulting in their marginalisation in both care settings and the society, where they become passive receptors of care rather than active participants in their lives and communities. The dialogical approach to identity, rooted in psychology and philosophy, offers an alternative by emphasising that identity is not fixed but co-constructed through ongoing interactions. This concept resonates with person-centred care [34], where the focus is on understanding individuals not just as patients, but as whole persons with evolving identities shaped by their unique preferences, emotions, and experiences. This idea has also been applied in HCI, where technology becomes a participant in shaping identity, reflecting the user's evolving preferences, emotions, and experiences, rather than merely serving as a tool. Scholars and practitioners in dementia care have embraced relational views of the self. Kitwood [150] argued that *personhood* is not inherently lost as cognitive functions decline, as it can be maintained and reinforced through social recognition, empathy, and care. Thus, maintaining *personhood* in people living with dementia involves far more than focusing solely on cognitive rehabilitation. It is important to create spaces and opportunities for people living with dementia to express their emotional experiences and social roles, which are core elements of their identity.

2.2.2 HCI approaches to personhood

More recently, however, the field of Human-Computer Interaction (HCI) has begun to challenge the deficit-based model in technology design, advocating for a shift towards person-centred designs that acknowledge the full scope of personhood in dementia. These approaches emphasise the importance of considering context, embodiment, sensory experiences, and emotion alongside cognitive function [113, 266, 74], through concepts like personhood [269, 268], felt experience [192], or the Third Hand, a concept from art therapy proposed by Lazar et al. [163] that describes the empowering role of facilitators in supporting creative expression without overtaking the process. Such ideas align with the concept of "critical dementia," which, as articulated by Lazar et al. [160], critiques the dominance of biomedical narratives and embraces a broader understanding of knowledge and personhood in dementia care. Rather than seeking to "fix" cognitive impairments, this perspective encourages a shift towards supporting existing abilities and facilitating new forms of engagement that acknowledge and value the lived experiences of people living with dementia [216, 266, 33, 152].

In recent years, HCI researchers have recognised that much of the technology designed for dementia care has focused on addressing cognitive decline and functional limitations, such as through memory aids and safety monitoring, as signalled by Knowles et al. [152]. The authors argue that by focusing narrowly on cognitive decline and functional limitations, much of dementia care technology reinforces ageist stereotypes and misses the essential goal of personhood care – the emotional, social, and human aspects that *make a person who they are*. In response, a growing movement in HCI is challenging this deficit-based model by exploring how technology can support broader, more empowering and experience-centred approaches to dementia care, often through forms of artistic expression. Wallace's deeply impacting projects are grounded in the understanding that personhood is "internally changing and externally nurtured through relational and social contexts" [268]. Her design work with people living with dementia has been instrumental in driving this shift, from the redesign of a 'reminiscence room' in a dementia care ward [269], to the thoughtful, gradual exploration of aspects of selfhood with a couple – Gillian and John, with Gillian having received a recent diagnosis of dementia – through digital jewellery creation [268]. *Mariana's Song* [54] is another key example of an experience-centred project. Collingham et al. [54] proposed a multisensory user-led experience, facilitated by expert arts practitioners, and designed to support personhood through a blended physical-digital installation. Sas et al. [228, 227] explored how craft-based interventions can support self-defining memories, which are often tied to significant relationships, personal achievements, and hardships. These memories were shown to be strongly linked to physical objects or places that evoked rich emotional recall and played a crucial role in maintaining a sense of self. Morrissey et al. [192] turned to music and performance to engage people living with dementia in the design of technologies aimed at supporting a sense of community in publicly-funded care settings. Their work suggested that participation in music sessions for people living with dementia is about "touch and intimacy, connection via movement, shifting roles, materiality and using props to disengage." What makes these projects especially significant is (i) how they maintain a sense of agency in individuals living with dementia by allowing them to control and shape their experiences, spaces, or objects thereby reinforcing their ongoing connection to identity and personhood; (ii) the commitment to the meaningful inclusion of people living with dementia as co-designers in the creation of artworks that will embed their life stories.

This line of research, initiated by scholars like Lindsay et al. [170], Hendriks et al . [123, 122], and Holbø et al. [126], uses traditional participatory design methods to explore how people living with dementia can be actively included in the co-design process. While co-designing with dementia patients poses distinct challenges due to cognitive impairments that hinder engagement with complex design [118, 248, 263], research demonstrated that through sensitivity, patience, and adaptable approaches, it is possible to accommodate varying levels of participation. By enabling communication through visual and sensory methods, which are often more accessible than verbal or written inputs, participants can intuitively engage in the design process and contribute to idea generation [123, 215, 258]. This also addresses the limitations of co-design studies where the process tends to focus on the input of other stakeholders, as they may find it easier to articulate their ideas [97, 103, 270], showing that such challenges can be overcome with appropriate adjustments. However, despite the potential of such interventions, Goodall et al. [111] point out – in their systematic review on the use of technology in creating individualised, meaningful activities for people living with dementia – that technologies are still mostly designed *for* older adults rather than *by or with them,* leading to solutions that may not align with their actual needs or desires. This is particularly true in the design of VR applications, as presented in the next section.

While the personhood perspective has profoundly shaped design approaches in dementia care, much of the evidence supporting its impact remains qualitative, relying on observations and interviews rather than measurable outcomes. This makes it difficult for healthcare professionals to evaluate its effectiveness alongside more clinical interventions [83]. Although qualitative findings highlight meaningful emotional and relational benefits, research [36, 43, 282, 166] has noted the ongoing challenge of translating these person-centred insights into quantifiable and comparable measures of well-being or cognitive change.

From a theoretical standpoint, personhood in dementia is deeply tied to the sense of self. Damasio [63] argues that consciousness, the sense of self, is grounded in the present moment but remains shaped by what has been in the past and what is anticipated to come in the future. This aligns with Kitwood's [148] conception of personhood as something sustained through ongoing relational engagement rather than a static identity. Seeing personhood as something grounded in both physical and emotional experience helps balance theory with practice. A reminded that while personhood is a rich and human concept, it can be difficult to measure or apply in healthcare settings.

2.3 Immersive technologies

Design research work focused on the creative use of media in facilitating reminiscence or social interaction has mostly included technologies such as television-like screens [105, 269], mobile devices [6, 12], sound players [128, 264], or olfactory devices [9]. This shows how valuable sensory engagement can be in helping people living with dementia reconnect with parts of themselves or their past that might otherwise feel distant or inaccessible. *Aesthetic embodiment* suggests that physical engagement is central to accessing emotions and memories, making the body a vessel for self-expression [153]. Through sensory interaction, individuals can re-experience and project their identity, connecting to both the self and the world around them [40]. Building on this, immersive technologies such as VR, augmented reality (AR), mixed reality (MR), and multisensory environments (MSEs) offer new directions for enhancing immersive experiences. These technologies can simulate rich settings that incorporate multiple senses such as sight, sound, touch, and even smell, to increase immersion. Despite this potential, the application of immersive technologies like VR in dementia care remains under-explored.

VR is a multisensory human computer interface which allows the user to be in a three-dimensional space that can be interacted with and changed internally or externally. VR is built upon three main factors, interaction, immersion and imagination, [212] using factors such as visuals, audio, interactivity, the user will experience different intensities of immersion. This makes it an environment for users to experience differently from semi-immersive ones such as large projections or no immersion like desktop-based VR. It is shown that there is an increase in arousal and attention in VR compared to use of a computer screen [87] as this is due to the immersion and separation of the 'real world' whilst using a head mounted display (HMD), this can allow the user to feel like they are 'present' in a new environment safely while still being able to have emotions and experiences similar to being in the physical location.

2.3.1 Virtual reality for healthcare

VR in healthcare has increased in popularity recently due to its ability to encourage active learning, provide therapy and give challenging environments whilst in a physically safe situation for the user [109]. As VR becomes more accessible with improved quality at lower costs, makes this platform suitable for non-pharmacological interventions. The uses of these applications can range from psychological-therapy, rehabilitation, and training relevant personnel such as doctors or medical students in ways to improve real practices in the safety of a virtual environment.

Psychological-therapy in VR can allow patients to be in specific environments that they can use to improve their conditions, such as people with symptoms of schizophrenia [67] in which research experiments have been completed to detect changes in behaviour after patients with symptoms of anger [73], aggression [283], psychotic symptoms [98], impulsiveness [46], conflict resolution [130] and empathy [234] have been shown different situations; to expose relevant behaviours or possible offenders. It can also train the patients how to deal with these situations without taking physical harm or harming others in a safe location. Through environments such as simulations of the attacks on the World Trade Centre for people with PTSD [73] or to test a patient's empathy, allow them to role-play as a virtual female being verbally abused by a virtual male character to recognise what fear is and differentiate it against happy emotions [234].

Interventions such as rehabilitation can be used for different mental health problems such as symptoms of anxiety and depression including flight anxiety [218], panic disorders [205], social anxiety [140] and even types of phobias such as arachnophobia [188]. VR exposure has proved itself to be as useful as traditional interventions [188] which can greatly reduce the symptoms of various mental health conditions [218] and with the convenience and advancement of technology, this makes virtual reality exposure therapy an effective treatment both short-term and long-term [205].

VR has also been used in therapeutic contexts such as self-counselling. In one study, Slater et al. [242] explored Solomon's paradox which says "*it's better when advice is given to others in need than ourselves.*" by recording the user discuss their own issues which is then later replayed back to them, allowing them to hear their own advice from the perspective of a virtual Sigmund Freud avatar. This allowed users to respond to their own concerns as if counselling another person. The self-guided approach led to more impactful outcomes compared to a scripted Freud avatar, highlighting the value of changed perspective in immersive therapy.

VR can be also used as a training system to help medical professionals' practice in situations within a virtual environment before real patients. From completing difficult surgeries [237] which shows that students who have been trained in VR complete the surgeries at a faster rate and less likely to make mistakes in surgery than those who were not trained in VR. Aside from direct medical uses such as surgeries, VR has helped in ways of confronting patients in a real life scenario such as denying patients the access of more antibiotics [203], the study proved that trainees were less likely to confront the patients compared to general practitioners in the simulated environment and the participants felt that the immersive experience was realistic and took the situation seriously.

2.3.2 Virtual reality for dementia care

Researchers from multiple fields have explored emerging technologies, including virtual reality, to support people living with dementia. Because immersive systems can create a strong sense of being in another place [241], virtual reality is widely discussed as a non-pharmacological approach for psychological therapy and rehabilitation [188]. At the same time, the overall evidence remains mixed: reported effects on mood, engagement, and cognition are variable across studies; samples are often small; interventions differ substantially in content and facilitation; and follow-up tends to be short. Consequently, current findings should be treated as preliminary and context dependent rather than as generalisable proof of effectiveness.

A number of studies report that reminiscence delivered through virtual reality can support memory recall [29] and in some cases is associated with cognitive gains [22]. Other work suggests that emotionally engaging scenes may offer calming or stimulating experiences that relate to well-being in care settings [10]. However, not all trials observe clear benefits; gains are not consistent across outcomes; and effects appear to depend on individual preferences, tolerance for immersive displays, and the quality of real-time support provided by staff. Safety is generally acceptable, but cybersickness, visual discomfort, and fatigue are non-trivial considerations for older adults and for people living with cognitive or perceptual changes [42]. These realities point to the need for careful screening, conservative session lengths, the ability to pause or stop easily, and skilled facilitation that can adapt content on the fly.

Beyond outcomes, several methodological issues limit what can be concluded. Many studies rely on convenience samples from single sites; few report concealed allocation or blinded outcome assessment; adherence and dropouts are not consistently documented; and outcome measures vary widely, ranging from observational engagement scales to short cognitive screens. Novelty and staff attention can also influence responses, making it difficult to separate device effects from the impact of social interaction during sessions. Future work would benefit from pre-registered protocols, clearly reported adverse events (including mild symptoms such as nausea or eye strain), and longer-term follow-up to examine whether any benefits persist after the novelty wears off.

2.3.2.1 Existing applications of virtual reality for dementia

Virtual reality has been explored across several formats for people living with dementia, including interactive environments [92], social scenarios [183], image-based attention tasks [177], and immersive video experiences [250]. Feasibility is demonstrated in many of these studies, yet effectiveness varies by task, setting, disease stage, and facilitation. For example, Siriaraya and Ang described screen-based, interactive environments in long-term care that sometimes supported storytelling; the same sessions also required close guidance to avoid distress when personally meaningful materials touched on difficult memories [239]. Hodge and colleagues reported striking moments of connection in a music-themed setting for a country music fan; such responses, however, are highly individual and cannot be assumed for all participants [125, 10]. A broader review observes that virtual reality is being used for training, screening, and testing, while also pointing out gaps in understanding subjective experience and needs that are specific to dementia, such as meaning-making and social interaction in everyday contexts [240, 101].

Taken together, the literature suggests that virtual reality can sometimes serve as a catalyst for conversation, enjoyment, or short-lived relaxation, but effects are not uniform and may depend on fine-grained details of the session. Content that resonates with a person's interests or past experiences can be engaging, yet personal materials can also surface grief, loss, or confusion, which means staff should be prepared to redirect or stop. Generic content can feel safe and pleasant, but may fail to sustain attention without active support. These trade-offs indicate that the value of virtual reality is closely tied to how it is introduced, paced, and socially supported, rather than to immersion alone.

2.3.2.2 Semi-immersive experiences

Semi-immersive systems, such as large projections with camera- or sensor-based interaction, can be easier to supervise and may be more comfortable for some users. In the work by Siriaraya and Ang, participants could tour a reminiscence room or tend a virtual garden with a tablet controller; some sessions enabled meaningful sharing, while other moments required careful facilitation to prevent distress around sensitive memories [239]. Studies of a virtual forest report mixed responses: increases in pleasure and alertness for some participants coexisted with increased fear or anxiety for others, and staff perceived stronger benefits for middle stages compared with very early or very late stages of dementia [194]. Compared with paper-and-pencil tasks, a semi-immersive attention task was preferred and described as more engaging, yet performance on object finding was better on paper because some participants struggled with the input device [177]. Early work using a joystick on a large screen found no significant increase in simulator-sickness symptoms after sessions with people in the early stage of dementia, although the generalisability of this finding to other groups remains uncertain [92].

From a practical perspective, semi-immersive formats can simplify hygiene procedures, enable participation by small groups, and allow staff to monitor posture and affect without removing head-worn hardware. At the same time, these systems can still demand dedicated space, stable audiovisual equipment, and staff time, which may limit regular use in busy clinical environments. Decisions about whether to use semi-immersive or fully immersive formats should therefore consider space, staffing, infection-control policies, and the sensory preferences of the individuals involved.

2.3.2.3 Fully immersive systems and their use in dementia care

Fully immersive systems, such as head-worn displays, can increase the sense of presence and place, but they also introduce comfort and safety challenges that must be managed in real time. In a study that simulated an interview at a conference table, people diagnosed with behavioural variant frontotemporal dementia spoke more and gave fuller answers in the virtual setting, and no immediate adverse effects were reported [183]. A pilot using head-worn video suggested that participants could select preferred scenes with staff assistance and generally tolerate the experience; however, the workflow required repeated removal of the headset to switch videos, which reduced practicality for routine care and interrupted conversational flow [250]. More broadly, reports of benefit are promising but inconsistent, and results depend on the fit between content and interests, facilitation quality, session length, and individual comfort.

In addition to comfort and safety, issues of access and equity matter. Head-worn systems and high-quality content require procurement, maintenance, and training. Some sites may lack the bandwidth, storage, or technical support needed to run high-resolution content smoothly, which can increase setup time and reduce enthusiasm among staff and participants. Given these constraints, a pragmatic approach is to start with brief, staff-supported sessions; to select content collaboratively with care teams and family when possible; to establish clear stop rules; and to build local procedures for cleaning, charging, and troubleshooting. Future studies would benefit from describing these practical steps in detail, since implementation choices often determine whether an intervention is used outside a research context.

2.3.2.4 Virtual reality to encourage art engagement

Emerging tools and platforms, such as interactive storytelling systems [113, 266, 163], sensory stimulation devices [192, 269], and immersive technologies like VR [187, 240], offer a glimpse into a future where technology can help individuals reminisce about the past, connect with others in the present, and continue to participate in meaningful activities that enrich their lives. However, to realise this potential, research recommends a person-centred approach that tailors solutions to individual needs, preferences, and abilities, while upholding dignity, autonomy, and privacy [74, 161]. Achieving this involves participatory methods that make older adults co-creators, yielding insights into their lived experiences and ensuring that resulting technologies are both meaningful and transformative. Yet, an analysis of 644 HCI papers on ageing and technology design by Vines et al. [266] showed persistent gaps in involving older adults as active participants – particularly in ways that accommodate the diversity of their experiences and capabilities. Creative art-based therapies (cABT) may help address these challenges. As Manji and Fallavollita [178] showed in their scoping review, engaging individuals living with dementia in personal expression and meaningful activities can reinforce identity and emotional well-being. Still, more work is needed to integrate their varied communication needs and cognitive abilities into technology design. Additionally, the potential to support embodiment and sensory engagement – essential for identity and emotional connection – remains under-explored.

The transition to the VR environment takes co-created physical art to a new level of immersion. VR technology can enable us to transform these physical art pieces into immersive experiences, effectively extending the creative process [251, 138]. The immersive nature of VR can provide a sense of escapism, allowing individuals to experience different realities, which can be calming and therapeutic [214, 176]. Moreover, the use of abstract or generic VR environments appears to be more beneficial than personalised VR experiences related to memories for people living with dementia [194, 177]. This is crucial as it shifts the focus from reminiscence to living in the present and engaging with new experiences. Abstract VR environments stimulate imagination and creativity, providing a refreshing contrast to the real world. They offer a sense of novelty and discovery, which can be exhilarating and empowering.

2.3.3 Space and Place - making VR experiences meaningful

Although research into VR for dementia care has made notable progress, significant gaps remain in understanding how immersive technologies can uphold personhood and transform digital **spaces** into emotionally meaningful **places**. Much of the current work emphasises cognitive stimulation, reminiscence, or emotional regulation, these approaches are valuable, but often reduce users to recipients of stimuli rather than active participants in meaning-making. Many studies employ VR for tasks such as cognitive training or exposure therapy, yet they infrequently consider how virtual environments might reflect lived experiences, social connections, or deeply held values of those living with dementia.

The distinction between *space* and *place* has long been explored in architecture, anthropology, and HCI [49, 50, 78]. Within this framework, a **space** refers to a physical or abstract environment that exists independently of human experience [48, 167], whereas a **place** emerges when that environment acquires personal, social, or cultural significance through interaction and interpretation [78, 167]. Scholars describe three core dimensions of place: the *spatial*, referring to tangible attributes such as layout, scale, and sensory atmosphere; the *situational*, relating to context, activity, and social engagement; and the *subjective*, encompassing personal memories, emotions, and symbolic meaning [107]. A space becomes a place when individuals project their experiences, relationships, and identities onto it, turning it into a setting of belonging rather than a neutral container.

In virtual environments, this transformation can occur through design elements that evoke recognition, agency, and emotional resonance. Immersive technologies, unconstrained by material limitations, enable the seamless blending of real-world familiarity with creative reinterpretation. As Rzeszewski [223] notes, the social and sensory affordances of virtual environments enable users to develop attachment and meaning, provided the environment reflects something personally or culturally relevant to them. For people living with dementia, this distinction is vital: while a generic virtual space may provide temporary distraction or relaxation, a meaningful place can offer comfort, reinforce identity, and support a sense of continuity in life.

Despite these insights, VR research in dementia care continues to prioritise technological performance and quantifiable outcomes over experiential and relational depth. For example, studies such as Tabbaa et al. [250] highlight the effectiveness of VR in stimulating emotional responses or reducing agitation, but pay limited attention to long-term engagement or how the experience supports personal narratives. This emphasis on technology has led to interventions that, though functional, often feel detached from the realities of those who use them. Moreover, people living with dementia are rarely involved in shaping the environments themselves, resulting in virtual experiences that reflect designers' assumptions rather than participants' identities. The consequence is that many systems succeed in providing digital **spaces** (technically impressive but emotionally generic) rather than lived **places** that hold meaning and belonging.

Transforming a virtual space into a place requires design approaches that centre on identity, memory, and emotional continuity. HCI research on place-making emphasises participation, adaptation, and sensory engagement as catalysts for meaning [50, 78]. Translating this into dementia care means designing VR interventions that evolve with the person: environments that can be co-created, modified, and revisited as extensions of everyday life. Participatory design methods, long employed in inclusive technology development, can help elicit personal histories and translate them into spatial and sensory cues that evoke a sense of familiarity and safety. Similarly, adaptive personalisation, such as integrating favourite sounds, textures, or landscapes; can strengthen recognition and belonging.

Ultimately, creating meaningful places in VR is not only a matter of visual design but of relational and ethical design. When people living with dementia, caregivers, and designers collaborate to shape the virtual world, technology becomes a medium for shared understanding and emotional connection. In this sense, the challenge is not simply to build more realistic or engaging environments, but to design with empathy and responsiveness, so that virtual experiences become extensions of the self and the social world. Through this shift from technological achievement to lived meaning, VR can move beyond providing temporary stimulation to supporting long-term well-being and the preservation of personhood.

2.3.4 Importance of connection and personalisation

Personalisation plays a significant role in enhancing engagement and emotional connection in immersive experiences for individuals living with dementia, yet its effects are not always positive [8]. It is essential to critically evaluate the role of personalisation in dementia care and determine whether personalised, interest-based, or generic approaches are most effective.

Research suggests that personalisation in VR can enhance engagement, mood, and cognitive stimulation by incorporating biographically relevant materials such as photographs, videos, and music. Customised reminiscence therapy has been shown to stimulate memory recall and improving social interaction, such as the use of digital life storybooks and multimedia biographies have been particularly effective in improving the quality of life for people living with dementia [85] and even improving depression scores [246]. Personalisation also helps individuals maintain a sense of self, as engaging with familiar content allows them to see themselves beyond their diagnosis, reinforcing their identity [8]. Moreover, studies indicate that individuals tend to prefer personal materials over generic alternatives when both are available [226]. The emotional impact of personalisation can be profound [246], as seen in cases where individuals have responded to personalised content in ways that surprised caregivers, such as a participant who, after hearing familiar music and seeing old photographs, spontaneously sang in Latin, revealing a previously unknown ability [82].

However, personalisation is not always necessary or beneficial. Some studies suggest that generic materials can still be effective for reminiscence and engagement [105, 113, 13], particularly in the early stages of an intervention or when participants struggle to process personalised content. Additionally, obtaining suitable personal materials can be challenging, as caregivers may struggle to find meaningful content, and the quality of available materials may vary. The effectiveness of personalisation also depends on the ease of gathering relevant biographical content, including photos, videos, music, and text-based memories [8].

Caregivers also play a crucial role in determining what content is used, but their preferences may not always align with those of the person living with dementia. In some cases, caregivers may avoid topics they perceive as distressing, such as war-related memories [82], despite the fact that the person living with dementia may still want to engage with these experiences. This highlights the need for a careful balance between ensuring emotional well-being and respecting individual preferences. A structured approach to selecting personalisation materials is necessary, and developing a checklist for clinicians and caregivers could help guide the process and ensure that images and experiences are chosen in a way that minimises potential risks while maximising engagement.

Given these complexities, a flexible and person-centred approach to personalisation is needed. Personalised immersive experiences should focus on meaningful moments, ensuring that the individual's well-being remains central to the experience. Personalisation should also be adapted to the user's cognitive ability and stage of dementia [8]. A home-based, individualised approach may be preferable for some individuals, creating a greater sense of security and privacy, whereas others may benefit more from a group-based experience [222]. The effectiveness of reminiscence therapy is not just about the content itself but also about allowing the individual to control how they interact with it [82]. Providing options for individuals to manage the content they engage with enhances their autonomy and participation [246], making the experience more empowering. Additionally, technology plays a critical role in supporting personalisation, with tablets, apps, and immersive technology offering dynamic spaces for memory elicitation and interaction. However, usability remains a key concern, and individuals living with dementia may require support to ensure they can fully benefit from these tools [222].

2.3.5 Conclusion

This chapter has reviewed the role of immersive technologies, particularly VR, in dementia care, highlighting the potential benefits and gaps in existing research. VR has shown promise in enhancing cognitive engagement, supporting reminiscence therapy, and providing stimulating, calming environments. However, much of the current work has prioritised technological feasibility and short-term outcomes over meaningful, person-centred experiences that support identity and long-term emotional connections.

A critical gap in this area lies in the transformation of digital **spaces** into **places** — environments that are not merely interactive but personally and socially significant. While research has explored the benefits of reminiscence therapy and immersive engagement, many existing immersive interventions remain generic, failing to fully incorporate the histories and evolving identities of people living with dementia. Theories of personhood in dementia care emphasise the importance of designing experiences that reinforce self-identity, yet studies involving immersive technology often focus on achieving predefined cognitive or emotional results rather than facilitating meaningful interactions.

Additionally, VR research in dementia care has largely been driven by a technology-first approach, prioritising system development, interaction mechanics, and outcome measurement, as seen in studies like Tabbaa et al.'s [250] work on 360-degree videos. While these studies contribute valuable insights into feasibility and engagement, they often do not involve the individuals themselves in shaping the design process. As a result, the interventions risk being imposed rather than co-created, limiting their ability to build personal and emotional connections.

The review also underscores the complexities of personalisation in immersive experiences. While tailoring experiences to an individual's history, preferences, and interests can enhance emotional engagement, misaligned personalisation can lead to confusion, distress, or detachment. Research suggests that both personalised and non-personalised VR environments have value, with abstract and present-focused experiences often proving more beneficial than memory-based settings. However, current work lacks structured methodologies for determining what kind of personalisation is most appropriate for different individuals, stages of dementia, and emotional states.

To advance the role of immersive technology in dementia care, future research must move beyond generic cognitive stimulation and towards deeply personal, experience-driven interventions. This requires shifting the focus from technology as a tool for engagement, but as a medium for meaning-making, connection, and identity reinforcement. The next stage of research should integrate participatory design approaches that actively involve individuals living with dementia in shaping the environments they interact with. By prioritising personhood over technology-first approaches, immersive technology can evolve into a meaningful tool that not only enhances well-being but also preserves and affirms the identities of those living with dementia.

This thesis builds on these insights by exploring how immersive technology can be designed to support personhood through meaningful engagement, spatial transformation, and long-term connection. It seeks to challenge existing assumptions about how people living with dementia engage with technology and provide new design principles that prioritise emotional depth, autonomy, and dignity in immersive experiences.

Chapter 3: System development, feasibility and personalisation

Because of its ability to "teleport" users to existing and new worlds, VR is used in a variety of domains [241]. In the field of dementia care, it has been explored as a non-pharmacological way of helping people living with dementia, for example as a psychological-therapy [67] or rehabilitation [188] tool. The feasibility of VR within this context has been assessed on multiple occasions, using 3D environments [92], social interactions [183] and images [177].

Studies have shown that the use of reminiscence therapy (RT) in VR can effectively improve memory recollection [29] and produce cognitive improvement [22]. By triggering emotions more effectively, VR can stimulate emotional responses of people living with dementia, therefore enhance the conventional RT and enhance their mental well-being. Indeed, a recent study assessing the use of VR to improve the well-being of individuals with moderate to severe dementia in a locked psychiatric hospital [250], found that exposure to virtual scenarios can have a positive impact on the observed emotions (pleasure, alertness) of people living with dementia. Nevertheless the authors outlined limitations in delivering this intervention including: i) the provided scenarios were not positively received by all participants; ii) during the data collection, each time a new video was selected, the headset had to be removed by the caregiver, impacting the experience of the people living with dementia.

In this chapter, I address some of these limitations, with the goal to investigate key design factors for VR-mediated non-pharmacological interventions that can contribute to improving the emotional well-being of people living with dementia, as well as enhance their interactions with their caregivers, hence building better social connections.

To achieve this goal, there were different phases of the research, which are outlined in this chapter: i) An iterative approach to design a prototype of a VR system, which extends previous work [250] by enhancing the procedure of delivering VR interventions for people living with dementia; ii) initial evaluation and feasibility testing of the VR prototype system in a secure hospital environment whilst assessing the user experience for both people living with dementia and their caregivers; iii) personalisation of the VR prototype system by applying personal photos and allowing participants to experience them from a first person perspective; and iv) supported conversations with participants, allowing understanding of their hobbies, using this to then recommended existing VR applications to support their experience.

For this research, I collaborated with a psychiatric hospital that works with people with complex mental health needs, including those living with dementia.

3.1 Phase 1: System development process

A previous pilot study [250] which assessed the feasibility of VR for individuals living with moderate to severe dementia in a locked psychiatric hospital presents itself as the foundation of this current study. Eight participants who were diagnosed with dementia were offered a selection of five 360-degree videos to experience (cathedral, countryside, forest, rocky beach, and a sandy beach) which were specifically chosen amongst the researchers after workshops and individual ratings on each video. During data collection, the headset had to be removed before selecting a new video for people living with dementia, potentially affecting the immersion of using VR and impact the experience of the users. The VR content was then wirelessly streamed to a laptop screen which followed the point of view where the participant is looking, allowing conversations to be made with the caregiver. The following measures were then recorded before, during and after VR exposure: Overt Aggression Scale-Modified for Neurorehabilitation (OAS-MNR), Observed Emotion Rating Scale (OERS) and qualitative observations to observe interactions, behaviour, and facial expressions in response to the VR experience. Semi-structured interviews with open ended questions were asked to people living with dementia and their caregivers to discuss their experience in using VR.

In this phase, a prototype system was co-designed and built which consisted of two applications that communicate with each other through a server and database using an internet connection: i) **mobile web app**: a caregiver application that can be used on a handheld device to select videos for those living with dementia to watch, and ii) **a VR video player application**: this will be used within the HMD to download and play the selected videos from a cloud database.

I chose to continue using monoscopic 360-degree[1] videos just like the pilot study, rather than stereoscopic[2] or volumetric[3] formats, to prioritise comfort and feasibility for both users and hardware. Monoscopic content provides an immersive experience without the added depth which may cause discomfort for individuals living with dementia. These videos are also significantly less demanding in terms of storage and viewing, this enables smoother offline playback on the headsets.

This technology is intended for people living with dementia and caregivers to utilise wirelessly and conveniently without the need for a wired computer connection, a user will be wearing a VR headset whilst the other user (e.g., caregiver) will have an application on their mobile device that can select different types of videos, that can be watched without the VR user needing to select the videos for themselves nor the caregiver having to take the headset on and off to choose different videos for the user to see. These choices were made to maximise the convenience of the system and create a comfortable experience for users, these are important factors to enable people living with dementia and researchers to gain the most benefit from the activity.

3.1.1 Iterative design approach

This study builds upon Tabbaa's [250] study by producing an improved dual-device system with a user-friendly interface to practice similar research: enhancing the procedure

[1]A panoramic format where users can look around, but the video has no depth.
[2]A 3D-like 360-degree format using two slightly offset video streams to simulate depth.
[3]A fully 3D capture allowing users to move through the scene, not just look around.

for data collection and the user experience for those living with dementia to maintain streamline immersion. Several factors were improved from the pilot study such as: the overall flow of the intervention by removing the need to remove the headset every time a new video needs to be selected, the ability to provide a greater selection of scenarios aimed for different users and the ability to use this system remotely in different locations - allowing families and caregivers to potentially use this system even if they are separated and cannot visit each other for reasons such as a socially distanced lockdown scenario. The prototype system was tested to assess its feasibility for use with people living with dementia in a secure hospital environment, as well as to identify potential areas for improvement based on this experience.

Stage	Objectives (Ox.x)	Major tasks (Tx.x)	Outcomes (Rx.x)
1	O1.1 Design a user-friendly system for participants living with dementia and their caregivers	T1.1 Develop an application to be used on a VR headset T1.2 Develop an application to be used by staff members to select videos for participants living with dementia	R1.1 Initial prototype system produced with user registration, video selection/-control and 360 video synchronisation between VR and the caregiver application
2	O2.1 Identify possible problems which may occur during VR intervention	T2.1 Receive feedback on site with staff before using system with participants living with dementia	R2.1 Positive feedback – "Easy to use and serves as a meaningful activity" R2.2 Personalised content for individuals would be more meaningful R2.3 Videos watched were blurry – Less immersion to evoke emotions
3	O3.1 Optimise quality of videos	T3.1 Increase resolution of the videos T3.2 Balance the quality of video and size of the video file	R3.1 Resolution of video player and videos were increased
4	O4.1 Enhance streaming aspect to allow better conversations	T4.1 Implement head tracking to see the point of view of user from the caregiver application	Achieved real time synchronous video streaming allowing caregivers to share the experience with user
5	O5.1 Optimise video running smoothly in VR and app	T5.1 Modifications to the information transfer between video player and streaming destination so video runs smoother	R5.1 Finalised version of the system, working well on site with minimal issues
6	O6.1 Testing and execution	T6.1 Run the intervention with people living with dementia, supported by caregivers and gain their feedback	R6.1 5 participants living with dementia was involved in the interventions (2 of which used it again)

Table 3.1: Iterations of prototype model

Once the initial prototype had been designed and built, the software was installed on a Meta Quest and given to the research staff at the psychiatric hospital to test for problems such as internet connection or general application issues. Several issues were raised by the research team and physicians during the procedure, which are listed in Table 3.1 (stages 2-5). After each version update, the application had to be reinstalled onto the Meta Quest using *SideQuest*[4]. After the final stage (6) had been completed, only then it was to be used with participants.

3.1.2 Prototype development

The previous pilot study [250] faced issues with a small population size, limiting the generalisability of the findings. Researchers also had to remove the head mounted device whenever a new virtual environment was selected, which could disrupt the flow and immersion of the user experience. The main objective of this study was to create an application that can be used to explore our research questions in an efficient manner without disturbing our participants, who have volunteered to help with the research.

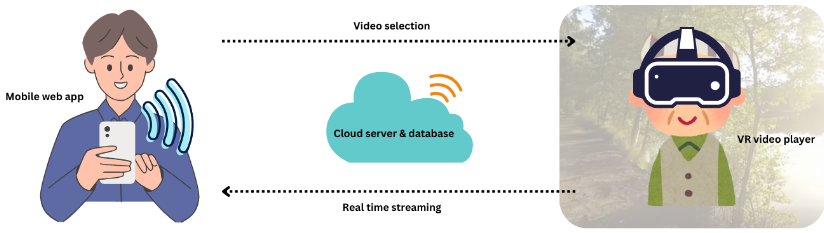

Figure 3.1: System usage

3.1.2.1 Mobile web app

The first part of the system I created is the web app that included different web pages connected together to allow intuitive use throughout the application aimed for a caregiver, family member or researcher. Both the front- and back-end of this application were developed with the caregiver's convenience of use in mind.

Ionic framework was used to create the mobile web application for caregivers to select videos for the participant wearing the VR headset to view. This application can allow

[4]https://sidequestvr.com/

the user to register or login to an account, select videos to play in VR, upload personal videos to the system, and then watch video feedback from the headset, showing exactly what the user is seeing and tracking the head movements that they make. This application was aimed to be used on an Android application only, where the application had to be manually installed onto the device every time there was an update, this was later changed to a progressive web app (PWA) that is accessible on any device with internet connection. This change was made so it did not limit only android applications to use it, also the real time streaming function not being able to work efficiently from the android package (APK) file but was able to produce smoother and higher quality video streaming if used on the PWA. An important aspect used in this system is SocketIO, a JavaScript library for real-time web development, which allows a consistent communication between the mobile web app and the VR video player.

User interface design: The web app can be accessed online via computers and mobile devices, with the added benefit of being able to be saved directly to a mobile device's home screen for convenient access (See Appendix A for more details of each app page). As shown in Figure 3.2, the main route is identified through the red arrow. From the welcome page, the user can access the login page if they have used the application before (if not, the user can register a new account), upon entering, a selection of videos are shown and if available, a selection of account-linked personal videos are also shown too. This application has an added option to upload your own 360 degree videos for personal use that are only linked to your account. Once a video is selected, it will be directed to the play screen where the user can play and pause the video in their own time while also being displayed a screen where you can see exactly what the VR user is watching, this enabled this activity to be a two person activity rather than as an individual, enabling conversation through what can be seen on screen.

Amazon web services integration: Some features of the back-end development was done alongside the application interface mentioned previously. Amazon web services (AWS) – EC2 instances – played a crucial role in facilitating the core functionalities of the system framework, acting as a reliable intermediary between the mobile web app and the VR headset. Its integration ensured seamless communication and efficient data transfer for hosting the streaming capability. To enable real-time interaction between

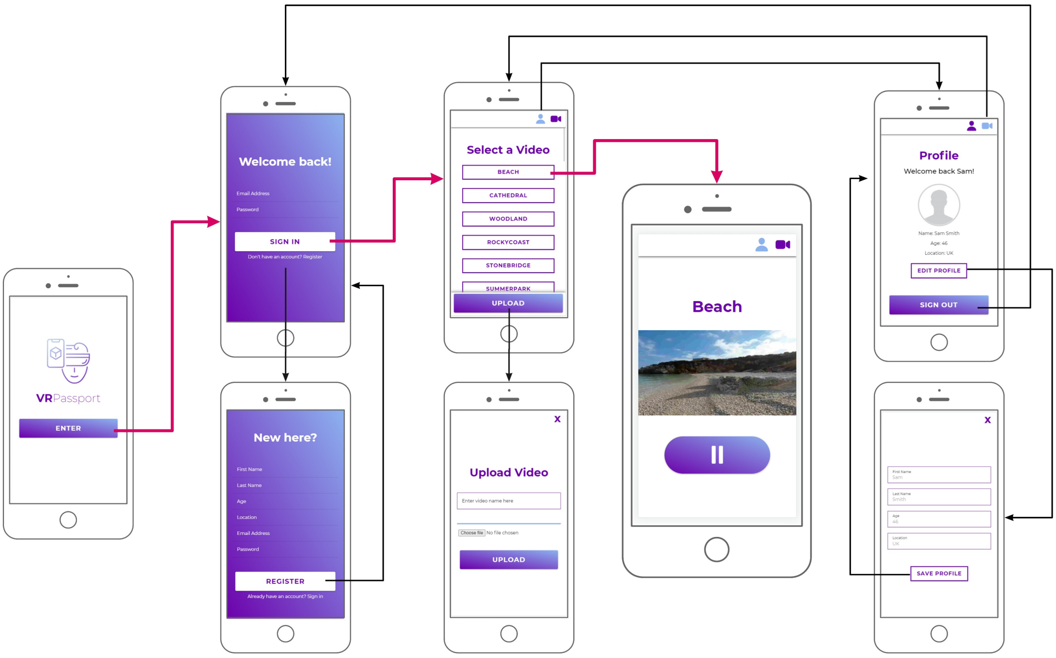

Figure 3.2: Architecture of mobile web app

the web app and the VR video player, a relay server was developed and hosted on AWS. This server was responsible for transmitting critical information, including: i) user authentication: identifying which user was logged in, allowing for personal video access. ii) Video control: relaying commands such as play and pause, and finally, iii) video selection: communicating the specific video chosen by the user to check if the video is installed in the headset device – if not, then it will download the new video onto the headset from the cloud database ready for viewing.

Hosting the relay server on AWS provided several advantages: i) global accessibility: the system could be accessed from anywhere with an internet connection, making it ideal for diverse user environments, including care homes or personal residences. ii) Flexibility: AWS also offers a range of hosting services, allowing for iii) cost-effective pay as you go plans to be carried out throughout the study period. iv) Security: AWS offered robust security measures to protect user data, important when working with personal data and media especially with patients in a secure psychiatric hospital.

In addition to serving as a communication hub, AWS hosted the video streaming web-page, ensuring uninterrupted playback from the VR headset. This integration enhanced the experience by providing a reliable bridge for user-caregiver interactions.

Firebase implementation: Firebase[5], a platform by Google for application development, was the main component of the overall system framework, managing both user authentication and data storage. Its integration ensured secure, efficient, and personalised experiences for users, particularly in storing account information and video files.

Firebase facilitated the storage and retrieval of key data, enabling seamless communication between the mobile web app and the VR video player. The system utilised Firebase for the following functionalities: i) user authentication: Firebase provided a secure and straightforward authentication system, allowing each user to have a unique account ID (UID). This ensured that users could access their personal data and videos while keeping their information private and secure. ii) Video storage: all video files, including global videos — a shared library of content that are accessible to all users on the platform — and user-specific videos, which were privately and specifically uploaded by a researcher or caregiver, and accessible only to the individual user to maintain privacy and enhancing the personalised experience, were stored in Firebase's cloud storage. This provided reliable access and smooth downloading of videos from the VR video player based on the user's selection.

Firebase's role in authentication and data storage was crucial in creating a secure, scalable, and personalised system for VR interactions, meeting both the technical and ethical requirements of the project. However, at the time of development, the Meta Quest platform did not natively support Firebase or other Google play services. This posed a challenge in integrating essential features such as user authentication and video storage. To overcome this, a REST API was implemented to act as a bridge between the VR application and Firebase. The API enabled secure and efficient communication, allowing the system to use Firebase's features without relying on direct integration which made it inaccessible.

Real time streaming: To enhance interactivity and facilitate meaningful conversations with caregivers, it was essential to implement a streaming feature that allowed staff and caregivers to view the VR participant's perspective in real time. This ensured that caregivers could monitor the system's functionality and provide timely, appropriate prompts to engage with the user.

[5] https://firebase.google.com/

An asset from the Unity Store, the FM Exhibition Tool Pack (FMETP), was used to achieve this functionality. FMETP enabled the system to capture the participant's point of view by streaming the scene from the headset to the web app. This captured feed was transmitted to a separate server hosted on AWS, allowing real-time access to the user's VR environment from external devices.

How the streaming feature worked: i) FMETP captured the participant's point of view during the selected immersive video they were experiencing. ii) The captured data was then sent to an AWS-hosted server, where it was processed and streamed onto a separate web page which is accessible via a web browser. iii) After a video was selected on the web app, the stream was retrieved from the server and displayed on the screen with the play controls. This enabled caregivers and staff to see exactly what the VR user was experiencing, sharing understanding and facilitating better communication all from the web app. iv) To ensure a smooth experience, the system's frame rate and frame quality were optimised through several iterations (as seen in table 3.1) to find the optimal balance between quality and latency, as a higher quality stream would cause the stream to have high traffic and cause a delay in the output stream, which would not allow users to interact in real time. This balanced latency and improved visual clarity, allowed web app users to view the video clearly with minimal stuttering.

Integrating this streaming feature allowed us to enhance monitoring, so the caregivers can ensure the system was functioning properly and that the user was engaging with the content as intended. This also improved communication, as by seeing what the user in VR was experiencing, caregivers could tailor their conversations and prompts to align with the user's current activity, enhancing the overall user-caregiver experience. Real-time streaming enabled shared experiences and an increased engagement, building a deeper connection between the participant in VR and their caregiver.

3.1.2.2 VR video player

The VR video player is the second component of the prototype system that delivers the immersive video content to individuals living with dementia. Designed to work with the mobile web app, the VR video player receives instructions to play selected videos chosen by the caregiver and plays them in an engaging, 360-degree environment. This ensures that users can experience content in a format that enhances presence and emotional connection.

The video player is designed to be as simple and intuitive as possible, minimising cognitive load for individuals living with dementia. There is no navigation within the VR application, only the caregiver can control the display to facilitate interaction. Technically, the VR app was developed using the Unity 3D game engine, optimised for standalone VR headsets to ensure accessibility in clinical and home settings. Once videos are downloaded initially, they are stored locally and do not need to be downloaded again for future use, balancing performance and accessibility when there is poor network availability. However, some challenges remain, including hardware constraints, potential discomfort associated with headset use, and ensuring high-quality video streaming.

Video selection: For this prototype application, users could select from two categories of videos: i) **global videos** – videos that can be accessed by any user on the platform and ii) **personal videos** – videos that are only available depending on the account that is logged in, this is to avoid other users seeing personal videos from different users. For the global videos, it was decided that the five videos that were selected for the pilot study carried out by Tabbaa et al. [250] were used, as these videos were carefully selected after an extensive exclusion criteria such as sudden transitions, loud audio or computer generated contents, to find the most appropriate videos for the initial pilot, these were the countryside, rocky beach, cathedral, sandy beach, and forest (see Figure 3.3 respectively for scenarios).

Figure 3.3: Videos from pilot study

Personal requests: To expand from the pilot study, it was decided that different videos would be added to test what reactions other videos could elicit. These videos were selected based upon what clinicians thought the participants would like to see, these videos were shown during the feasibility study (see Section 3.2) which elicited greater positive reactions than the initial videos from the pilot study. These videos ranged from hobbies such as football and fishing, to special places and themes such as going to Disneyland.

Display hardware: To expand from the pilot study, a *Samsung* mobile phone along with the *Samsung Gear* HMD but this platform for VR had become outdated; it was discussed that the prototype would need to have potential in expanding further in the future, so it was decided to use the Meta Quest and then the Meta Quest 2 after its announcement.

3.2 Phase 2: Feasibility study

Five people living with dementia who were able to give consent for themselves were recruited from the locked psychiatric hospital, they were able to complete the intervention and offer feedback on the prototype system over the course of two weeks. Prior to the sessions, the researcher was informed of the types of videos that the upcoming participants would like to watch, so that specific videos could be sought out and uploaded to the system before being used with the specific individual. This approach not only aimed to increase engagement and obtain meaningful feedback, but also recognised the value of making the most of the opportunity to work directly with participants, ensuring that their time and involvement were met with content that was personally relevant and thoughtfully prepared.

The consent was given in writing or verbally from the participants and the care staff who were involved in the study before the intervention took place. After consent had been given, the session was then audio recorded and encrypted for the researcher to analyse. Brief questions were asked before using the VR prototype system, to get a better understanding of how the participants were feeling before the use of immersive technology. After that, the care staff assisted the participant with wearing the headset after initial setup. Each patient was given thirty minutes maximum to spend in VR, with breaks throughout. With the headset on, the caregivers would initiate conversations with the participant to see what kind of video they would like to watch, whilst engaging in meaningful conversations with the participant regarding what they can see in the 360-degree video. When the participant wished to stop using the VR, several questions were asked to the participant and caregiver regarding the intervention that they had experienced and what could be improved in future designs.

3.2.1 Research questions

The aim of this feasibility study is to investigate if and how VR experience, co-curated by caregivers through interaction with people living with dementia, can help improve the well-being of people living with dementia in care contexts. Specific objectives are:

1. To examine how a VR system can be designed to effectively facilitate the co-created VR experience
2. How the system used by caregivers and people living with dementia can create a meaningful and personalised VR experience
3. To study the perception and the acceptance of technology of caregivers and people living with dementia on using VR in dementia care

Given the safety constraints from the COVID-19 pandemic in the midst of national lockdown, conducting the feasibility test remotely emerged as a practical and effective alternative to on-site interventions. This approach not only ensured safety and accessibility but also provided an opportunity to evaluate the feasibility of remote deployment for future applications. Additionally, integrating remote connectivity into the system allows for broader engagement, enabling long distance family members and caregivers to connect with individuals living with dementia through the VR platform, maintaining participation beyond physical limitations.

3.2.2 Study methodology

3.2.2.1 Ethical considerations

Ethical approval was obtained through the Research Ethics Advisory Group (REAG) from the University of Kent as the project worked with human participants. Participants were recruited by the staff at the locked psychiatric hospital and met the following criteria: understood verbal English instructions, diagnosed with early-mid stages of dementia, and had the mental capacity to consent. All information obtained was kept strictly confidential in accordance with the University of Kent and the hospital's guidelines. Personal data were pseudonymised and research data archived for future research. Informed consent was obtained from research participants, if the patient could not write, verbal consent was recorded or witnessed instead.

3.2.2.2 Participants

Five patients from the locked psychiatric hospital's dementia ward were recruited as participants for this study to gather feedback for the VR prototype system. Patients were diagnosed with early to mid-stages of dementia, as determined by the Global Deterioration Scale (GDS), they were capable of maintaining good conversations with caregivers. This facilitated interviews before, during, and after the intervention.

3.2.2.3 Interventions

This study was designed as a feasibility test to evaluate the functionality and usability of the prototype system in a real-world dementia care setting. The goal was to determine how well the system could be used by care staff and individuals living with dementia, assess its ease of use and level of engagement, and identify any technical or practical challenges before further development.

The study was structured into three distinct phases – before, during, and after testing – to ensure a systematic approach to setup, usability evaluation, and post-test reflections.

Preparation phase: Before testing with participants, the system was first tested with care staff at the locked psychiatric hospital to ensure technical functionality and stability of the connection between the VR video player and mobile web app. This phase allowed caregivers to familiarise themselves with the system and confirm that the technology was working as intended before introducing it to individuals living with dementia, as it was important to make use of the participant's time and avoid disappointment. During this phase, on-site guidance was provided, ensuring that caregivers understood how to operate the system, adjust the headset for comfort, and navigate between video selections. An audio recorder was also set up to record the testing procedure, allowing for later review of caregiver interactions and participant responses.

Study procedure: This phase involved testing the system with individuals living with dementia. The session began with caregivers selecting a general video to introduce participants to the VR experience and ensure they were comfortable. Rather than following a rigid structure, this phase was designed to be flexible, allowing caregivers to adjust the flow of the session based on the engagement levels of the participant. Using the VR prototype system as a co-curative tool for engagement and interaction rather than a purely passive experience, some individuals used this to explore a single virtual environment in depth, while others preferred switching between different videos. The primary focus was not only on system usability but also on how well the VR experience facilitated engagement and overall enjoyment for the participant living with dementia.

Post-study procedure: Following each of the sessions, caregivers documented feedback from the participants and their own reflections on the system's usability. Participants were asked how they felt before and after the experience, whether they enjoyed using the system, and whether they would be interested in using it again. Care staff also reflected on the ease of use, participant engagement, and any technical challenges they encountered during the process. The post-study procedure provided valuable qualitative insights into the effectiveness of the system in a real-world setting. It allowed for an assessment of how well the VR experience was received by individuals living with dementia and highlighted areas for improvement, such as optimising comfort or refining content selection to enhance engagement in future iterations.

At the conclusion of the feasibility study, all five participants successfully completed the interventions whilst conducting a semi-structured interview through all 3 stages (See Appendix B for a selection of questions asked), resulting in the production of five transcripts. Notably, two participants expressed active interest in using the VR system again, indicating a positive reception and potential for continued engagement. The remaining three participants did not explicitly request additional sessions to use the system, suggesting an overall mixed response where the VR system is accepted by the users, with some wanting to interact it with multiple times, but not something all participants sought after to use.

3.2.3 Interviews and observations

The feasibility study with five participants provided valuable insights into the usability and emotional responses of individuals living with dementia when using VR. Through observations and participant–caregiver feedback, I identified key similarities and differences in how participants and staff engaged with the VR system. To analyse this material, I used reflexive thematic analysis (RTA) [31, 32] to identify recurring patterns across participant experiences. The analysis followed Braun and Clarke's six-phase process but was adapted to the specific context of dementia research, where verbal feedback is often limited.

I began by familiarising myself with the data through repeated reading of transcripts, observation notes, and field reflections, paying close attention to tone, gesture, and non-verbal reactions that could reveal emotional or cognitive responses. I then carried out open, inductive coding across the data, coding both verbal and non-verbal behaviours such as smiles, laughter, disengagement, or curiosity as meaningful indicators of experience. These initial codes were reviewed and refined into early patterns describing how engagement occurred, for example, through familiarity, caregiver involvement, or sensory stimulation. I then examined the relationships between these patterns to develop broader candidate themes, revisiting the transcripts and recordings to ensure that each theme captured the essence of participants' and caregivers' experiences.

Because several participants communicated only partially, much of the interpretation relied on non-verbal cues, caregiver insights, and contextual understanding. This process emphasised meaning-making as a collaborative and interpretive act rather than a purely descriptive one. While the findings highlight the potential of VR as a tool for reminiscence and engagement, they also underline challenges related to personalisation, practical implementation, and accessibility. The following findings, derived from participant interviews and observations, are denoted as PX, where X represents a unique participant number.

3.2.3.1 Acceptance and enjoyment

Across the transcripts, participants generally responded positively to the VR experience, with many expressing enjoyment and curiosity. P1 described the experience as *"marvellous"*, while P2 displayed strong engagement, enthusiastically exclaiming *"GOLF!"* when seeing a familiar activity and even insisting on signing the consent form himself.

Even when feedback was initially negative, staff members interpreted it as humour rather than genuine dissatisfaction. For example, P3, who bluntly stated that the experience was *"rubbish"*, later engaged in meaningful reminiscence, recalling childhood visits to Cornwall. This suggests that even participants who appear less receptive at first may still benefit from VR-based memory recall and engagement.

For non-verbal participants, alternative communication methods were useful in assessing responses to VR. P5, who was unable to provide verbal feedback, used a visual scale to express that the experience *"feels great"*, indicating that even those with limited verbal communication could engage meaningfully with VR.

3.2.3.2 Reminiscence and emotional response

VR frequently acted as a trigger for memory recall and emotional responses. Several participants connected virtual environments with real-life experiences, reinforcing VR's potential as a reminiscence therapy tool. P1 also recalled memories of Scotland, while P2 associated the fishing environment with being at home, later connecting a beach scene to Scotland. P3 reminisced about going to a forest at age six, and when viewing videos of Cornwall, he expressed feelings of homesickness. These instances highlight how immersive environments can evoke deep emotional connections and past experiences.

However, reminiscence was not always positive. P1 experienced emotional distress when the session reminded him of a negative impression with another staff member, demonstrating that certain triggers can unexpectedly evoke negative associations as well.

3.2.3.3 Comfort and convenience

From a usability perspective, staff generally found the VR system easy to operate, although some noted that the initial setup process required time and adjustment. Care staff commented that headset comfort was important, with some participants finding it slightly heavy or difficult to adjust.

While most participants found the experience physically manageable, there were exceptions. P2 fell asleep during the session, P4 reported feeling tired afterwards, and a staff member who had trialled the VR themselves noted experiencing motion sickness. These findings suggest that while VR can be beneficial, physical comfort and sensory adjustments must be carefully managed for each individual.

3.2.3.4 Personalisation benefits

A recurring theme in the findings was the importance of tailoring the VR experience to individual interests and memories. Participants engaged more deeply when content was personally relevant, reinforcing the idea that generic VR environments may not be as impactful as personalised content.

P2 expressed excitement at seeing familiar fishing gear, while P3 specifically requested videos of Cornwall, demonstrating that recognisable locations and activities can offer positive engagement. Staff members also highlighted personalisation as a crucial factor, suggesting that future VR content should be tailored to match individual interests and memorable life moments as much as possible.

In contrast, when VR environments lacked personal significance, responses were less enthusiastic or even neutral. For example, some nature-based scenes did not resonate as strongly unless they had personal meaning for the participant. These findings highlight the need for a flexible approach to content selection, ensuring that each user receives an experience that aligns with their preferences or past experiences.

3.2.3.5 Technical and practical challenges

While VR was generally well-received, technical challenges occasionally disrupted the experience. Staff reported issues related to technical inconsistencies, blurred images, streaming issues, and internet connectivity, which at times caused delays in starting the VR sessions. In a dementia care setting, where individuals have structured daily routines, including scheduled meals, rest periods, and other activities, ensuring that VR sessions run efficiently and without unnecessary delays is important. Extended setup times or troubleshooting interruptions not only risk disengagement but may also cause distress if participants become confused or frustrated by the wait.

These connectivity challenges were due to the hospital's secure internet networks that were not necessarily optimised for streaming video data. In some cases, the physical location where the intervention took place in the building also made connections inconsistent. Although the VR content itself was downloaded in advance and played offline on the headset, difficulties came when the system attempted to stream the live view of the VR user's experience back to the caregiver interface on the laptop application. This live feedback was intended to help caregivers monitor and support conversations with the participant, though it often struggled under poor network connections. In future iterations, this functionality could be redesigned to use local device communications (Bluetooth) or internal mini-servers to avoid relying on the inconsistent internet connection. To enhance feasibility, system reliability must be improved, focusing on stable connectivity and simplified headset adjustments to minimise disruptions and allow for a smooth, uninterrupted experience.

Beyond technical limitations, staff also raised concerns about the practical implementation of VR in dementia care settings. Several noted that the system setup took time, requiring a quiet space and multiple devices. Additionally, staffing requirements were a challenge, as at least two caregivers needed to be present during a VR session, particularly for participants who were more mobile. One staff member noted the risk of participants standing up suddenly or attempting to move, underscoring the importance of close supervision during VR use.

Despite these challenges, staff recognised the potential benefits of VR, particularly in providing new experiences for individuals in a hospital setting where opportunities for stimulation are often limited. However, they emphasised that for VR to be a sustainable tool, training and funding would be necessary to ensure wider adoption.

3.2.3.6 Variation in engagement

Engagement with VR was not uniform across participants, with differences observed in levels of interest, responsiveness, and content preferences. While some individuals were highly engaged, others displayed lower levels of interaction or required encouragement from staff.

Verbal communication abilities also influenced how much participants could express their thoughts on the experience. P5, who was non-verbal, relied on gestures and visual scales, while other participants engaged in conversations about the VR content, linking it to their past experiences. These differences suggest that multiple ways of assessing engagement are necessary, particularly for individuals with limited verbal abilities.

Visual clarity also played a role in determining the effectiveness of VR. Some participants with poor vision found the experience less immersive due to blurry images, indicating that future adaptations may need to consider visual accessibility features.

Additionally, participants showed different content preferences, with some enjoying nature-based environments, while others preferred city tours or activity-based content. This further reinforces the need for a diverse and personalised VR content library, allowing experiences to be matched to individual interests.

3.2.4 Beyond the feasibility study - Care beyond borders

Beyond the findings from the feasibility study, an additional evaluation of the same prototype VR application was conducted by Jawharieh et al. [137], offering insights into how family members and care staff perceived its impact on dementia care. Their findings reinforced the role of VR in strengthening relationships and promoting engagement, aligning with participant experiences in our research. However, this study also highlighted additional social benefits, including its potential to reduce family caregiver guilt and build trust in professional care staff. Moreover, the study noted that staff attitudes toward VR changed positively when participants responded well, suggesting that successful VR implementation could influence caregiver motivation and job satisfaction. These insights provide a broader context for understanding how VR may fit into dementia care beyond individual engagement, emphasising the importance of organisational adoption strategies and integration into structured care plans.

3.3 Phase 3: Personalisation through treasured memories from photographs

In the next two sections, I look into alternative routes of personalised immersive content for those living with dementia. Following initial feasibility testing with our prototype system, I observed minimal response and engagement from participants. This lack of engagement could be attributed to several factors:

1. **Cognitive decline and communication difficulties** - Many participants struggled to verbally or physically express their thoughts or provide feedback.

2. **Limited relevance of VR environments** - The generic VR environments shown, such as natural scenes (woodlands, beaches, a cathedral), did not always evoke a strong reaction.

3. **Personal relevance matters** – Some videos included more tailored content (e.g., fishing, lions, Disneyland, based on caregiver input), and these yielded better engagement, reinforcing the importance of personalisation in VR experiences.

These insights pushed the idea that if personalisation can be extended even further to create novel environments based upon the participant's life, this could elicit a stronger engagement with participants. This raised the fundamental question:

How can we create a novel yet personalised VR environment that evokes stronger engagement for individuals living with dementia?

Given the mixed findings on personalisation [8, 226, 246, 82, 105, 113], this study seeks to evaluate whether integrating personal elements into virtual environments enhances engagement and well-being or whether a more flexible, interest-based or abstract approach may be preferable. This is particularly important given the potential risks of memory distortion in dementia, where an incorrectly reconstructed environment could lead to distress rather than comfort and joy. The research then explored whether personalised VR experiences improve reminiscence and emotional connection, the risks of misaligned personalisation, and how technology can be designed to balance personalisation and accessibility. Understanding these dynamics will contribute to the development of more effective and ethically responsible VR interventions for individuals living with dementia. There are several ideas that were considered to explore this area:

Method	**Advantages**	**Disadvantages**
Filming a known personal location	Highly familiar, high-quality video	Requires travel; may not be feasible for all participants
Manually creating a 3D VR environment from scratch	Fully customisable, extremely personal	Time-consuming, complex to integrate into the prototype app
AI-generated VR scenes based on images or text descriptions	Conceptually strong, scalable	No existing function produces perfect VR outputs
Face swapping personal faces into other VR scenarios	Creates a social connection	Risk of confusion, may worsen disorientation
Expanding an image into VR (e.g., using AI to generate a 3D world from a single photo)	Time-efficient	No current technology can fully convert 2D images into 3D VR scenes accurately

Table 3.2: Advantages and disadvantages of various personalisation ideas

Due to technological limitations, I ultimately opted for a hybrid approach:

Embedding personal photographs into existing 360-degree virtual environments, with added interactive elements (e.g., animations and soundscapes), inspired by Facebook's Memories VR[6] approach to personalisation.

3.3.1 Iterative design

To see how personal artefacts can be integrated into the application, I explored how personal photographs could be meaningfully integrated into VR environments, I adopted an iterative design methodology [18], working with research staff at the locked psychiatric hospital. Due to the sensitive nature of using personal photographs, which may trigger unintended distress, the staff members and I decided that it was better to collaborate within the circle of the research team members first during this early stage, before introducing the study to participants living with dementia. By collaborating with staff, we were able to assess the feasibility of this exploratory design process and discuss the appropriateness of different types of images that would be most suitable for integration into VR. This allowed us to refine our approach and co-develop a selection criteria for using personal photographs into VR. The iterative process involved collaborative design with staff, where personal photographs are provided for initial prototyping, offering insights into which images are usable and engaging for individuals living with dementia.

I acknowledge that direct feedback from people living with dementia would offer richer insights, as they are the focus audience of this research. However, this staff-led phase was a necessary and protective step. It ensured that sensitive design elements, such as the use of personal photographs, were first evaluated by care professionals who understood the individual intricacies and preferences of those in their care. This process helped protect participants' emotional well-being and allowed us to iteratively refine the approach in a responsible manner.

[6]https://www.engadget.com/2018-05-01-facebook-vr-memories.html

3.3.2 Ethical considerations

The research staff from the hospital and I, obtained ethical approval through the Integrated Research Application System (IRAS), a national-level ethics framework for researchers required for conducting health care related research involving hospital patients in the UK, this was particularly important as we were working within a secure hospital setting. Unlike standard ethics approvals for academic studies, gaining access to participants in clinical environments, especially those in specialist dementia care, involved extensive coordination between multiple parties.

The process required submitting an ethics application to the Research Ethics Committee (REC), alongside detailed documentation, including participant information sheets, consent forms, and study protocols. Given the vulnerability of the participant group, additional safeguards were necessary to ensure that ethical considerations were thoroughly addressed. This included repeated revisions and responding to multiple rounds of feedback from ethics reviewers and the research team at the psychiatric hospital.

The final stage involved attending a formal committee meeting, where the research was critically evaluated for its ethical integrity and potential risks. Further clarifications and refinements were required before final approval was granted, reflecting the rigorous standards necessary when conducting research with individuals in highly regulated healthcare environments. This extensive process underscores the significant ethical and procedural challenges involved in ensuring that the study met national regulations and the highest standards of participant protection.

3.3.3 Case study: test photos

Through iterative design using the selection of photos given, I identified key findings regarding how best to integrate personal photos into VR. The process involved a structured workflow to ensure that each element – whether original or referenced – was carefully adapted for an immersive experience.

To construct the VR environments, the research team followed a multi-step approach:

1. **Obtain images** – Gather personal photographs submitted by staff or participants.
2. **Brainstorm feasibility** – Evaluate which images could be adapted into VR and shortlist those that were viable.
3. **Find reference photos** - Identify similar images that could serve as backgrounds or be combined with the original image (if applicable).
4. **Apply originals to reference photos** – Where possible, combine participant-submitted images into reference backgrounds to ensure a natural blend.
5. **Add sound & animations** – Incorporate relevant environmental sounds (e.g., wind, sea, human chatter) and animations (e.g., moving clouds, tree rustling) to enhance realism and avoid it looking like a static image.
6. **Modify & refine in Photoshop** - Further clean, adjust, or modify images to match the VR setting.
7. **Assemble the scene in Adobe Premiere Pro** – Combine cleaned images, animations, and sound to construct an immersive VR environment.

By carefully following this workflow, we ensured that each VR adaptation was as immersive and realistic as possible while considering technical limitations and ethical constraints. This process also allowed us to evaluate how different combinations of personal photos, references, and environmental enhancements influenced the overall experience for dementia-friendly VR applications.

To illustrate the process of integrating personal photographs into VR, I tested multiple different images provided by staff. However, since these images contained identifiable elements, I have recreated them as simplified stylised representations for inclusion in this section. These stylised graphics retain the key features of the original photographs, allowing me to show why certain images were feasible and others were not. In the figures that follow in this section, the left-hand side shows the stylised staff-provided image, whilst the right-hand side shows a snippet of the corresponding 360-degree VR environment that was recreated for testing.

3.3.3.1 Simple scenery

Figure 3.4: On the left, a stylised graphic to represent a familiar landmark. On the right, the corresponding 360-degree VR environment developed from this image, allowing participants to experience the landmark in immersive form.

Some submitted images showed scenic holiday destinations (see Figure 3.4). Since these locations are often well-known landmarks, recreating them from scratch poses a significant challenge. Not only would this be technically demanding and time-consuming, but it also leaves little room for error, as any inaccuracies could make the scene feel unrealistic to those who have visited, we sourced 360-degree environments from existing online databases. These environments could either be pre-recorded 360-degree videos or panoramic images, where we enhanced static scenes by adding subtle animations, such as moving clouds and environmental sounds, to improve immersion. This method was straightforward, allowing us to accurately recreate the essence of the original image using external sources. However, staff feedback raised an important concern:

"If the environment is primarily created from online sources, what is the point of asking participants for a personal photo?"

This highlighted the need to balance the authenticity of the original image with the realism of the VR experience. Integrating the participant's actual photograph into a VR setting introduced new challenges, such as expanding the image from scratch or finding a closely matching reference photo to seamlessly blend with the existing scene. Maintaining this balance was crucial to ensuring that the VR environment felt both familiar and personally meaningful to participants.

3.3.3.2 Picture of a picture

We explored another approach where we directly placed a photograph into a VR scenario. The selected image featured a bust shot of a dog within a picture frame (see Figure 3.5, which initially posed a challenge — since the original image only showed the dog's head, there was no reference for what its body looked like. One idea was to partially obscure the lower half behind a bush, ensuring only the head remained visible. However, this appeared unnatural and would be disproportionately small within the VR environment.

Figure 3.5: On the left, a stylised graphic to represent a framed photograph of a staff member's pet dog. On the right, the corresponding 360-degree VR environment developed to incorporate this image, allowing participants to immerse themselves in a forest with the respective dog from the photograph on the left.

To create a more seamless experience, the dog was placed in a forest setting, aligning with the background of the submitted image. I then identified the dog's breed and sourced reference images of similar dogs, carefully stitching them together to reconstruct the lower half. In the future, AI-driven object recognition could potentially automate this process, identifying missing details and matching them to appropriate environments.

To enhance immersion, we incorporated animated environmental elements, such as moving clouds in the sky, accompanied by ambient wind sounds and occasional dog barks. The staff member who submitted the image found no issue with the transformation, stating that the forest placement felt natural. Additionally, the extended lower half of the dog was a fortunate match, as the staff member confirmed that it was a skinny dog

-— if a different body type had been used, the result would have felt visually inaccurate. However, since the dog's face remained unchanged, they could still recognise that it was their dog, ensuring a familiar and meaningful experience.

3.3.3.3 Panorama

Following this approach, ensuring that the original photo was retained while placing it within an immersive setting at a photo spot. I identified where the image was taken and sourced an appropriate 360-degree background to seamlessly integrate the photograph. See Figure 3.6 for example, a panoramic group photo was placed within a matching background of its original location, enhanced with animations, environmental sounds (wind, human chatter), and traditional music to enrich the immersive experience.

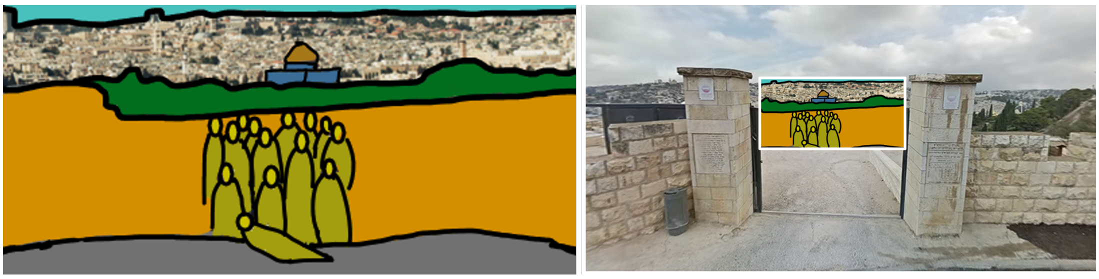

Figure 3.6: On the left, a stylised graphic to represent a group photo of people standing in front of a famous landmark. On the right, the corresponding 360-degree VR environment developed from this image, allowing participants to immerse and re-experience the time that this photo was taken with the group in the same location.

While this approach successfully transformed a static image into an interactive VR scene, staff feedback raised an unexpected issue – the way the image was presented did not align with their expectations. Rather than focusing on the surrounding location or audio, staff member expressed that their primary concern was the people in the image. However, because the original photograph featured a group of people positioned far from the camera, translating it into a 360-degree immersive scene made it difficult to bring the subjects into clearer focus. This raised another important design question:

What aspect of this type of personal photograph is most important to the participant – the people or the environment?

The challenge of maintaining the intended focus of the image while adapting it into an immersive format became a key consideration in this research. The feedback highlighted that designing with the participant's perspective as the priority is more important than any technical or artistic choices, ensuring that the experience remains meaningful for them. This shows that for this design approach to work, the focus point of the photograph would need to be brought forward and use the immersive technology to support and bring out the emotions from the picture, rather than, having the photograph present itself as a "feature" of the immersive technology.

3.3.3.4 Is it too much?

While immersive environments can enhance engagement, modifications that overly alter personal content can sometimes overwhelm the user or fail to meet their expectations, leading to negative emotional responses rather than positive ones.

One of the submitted images featured a rainbow behind two houses (see Figure 3.7). Since the rainbow was the central focus, we aimed to preserve the authenticity by embedding it into an immersive VR environment. Given the impossibility of sourcing the exact street due to privacy concerns, a similar-looking 360-degree view of a street was selected that allowed us to position the houses as accurately as possible. However, when this adaptation was shown to the corresponding staff member, it elicited an unexpected reaction. The area depicted in the original image was extremely familiar and personally significant, and its relocation to a different setting created a jarring disconnect. The staff member described the experience as a "weird sci-fi reality," highlighting how misalignment between memory and representation can jeopardise its immersive potential.

This raised an important concern – for individuals living with dementia, placing a highly familiar element into an unfamiliar setting could be disorienting and confusing. Since many participants already experience memory distortion [175] and spatial disorientation [210], altering the context of a deeply personal image could potentially blur the lines between real and reconstructed memories, leading to further confusion rather than comfort. This reinforced the idea that we cannot take something deeply familiar and embed it into an environment that does not match its original context, as doing so may disrupt the participant's sense of reality.

Figure 3.7: On the left, a stylised graphic to represent a rainbow near a familiar street. On the right, the corresponding 360-degree VR environment developed from this image, allowing participants to immerse themselves on a street of houses to admire the rainbow.

3.3.3.5 Blurry visions

Continuing the efforts to integrate personal photographs into immersive VR environments, I explored the concept of emphasising the central focus of an image while intentionally blurring the peripheral elements. This approach aims to maintain the clarity of the main subject (such as a person or feature) while softening the surrounding background to prevent unnecessary visual distractions. To implement this, I used NVIDIA Canvas[7] to create a blurred scenario fitting around an image of a man and his dog (see Figure 3.8), aiming to blend it seamlessly into a virtual environment.

The concept was developed to address previous risks faced by individuals living with dementia if familiar images are inaccurately contextualised, causing memory disorientation. The goal is to prevent distortion of memory by blurring the image's background, creating a familiar environment without specific details, therefore avoiding conflicts with actual memories. Additionally, this technique also addresses scalability concerns. While AI-driven methods may eventually allow VR environments to be generated from a single image, current limitations cannot accurately reconstruct missing details behind a subject. Instead of forcing a best guess that could feel unnatural, blurring or abstracting the background allows us to maintain a balance between realism and adaptability, ensuring that the final scene is not too out of place, but also not an exact mismatch.

[7]https://www.nvidia.com/en-us/studio/canvas/

Figure 3.8: On the left, a stylised graphic to represent a man with his dog during a hike. On the right, the corresponding 360-degree VR environment developed from this image, allowing participants to immerse themselves amongst the mountains standing in front of the man and his dog, with clear focus on the man whilst the surrounding environment is blurry.

This method aligns with foveated rendering [271], a technique commonly used in VR to concentrate visual clarity on the focal point while rendering peripheral areas with less precision. A similar approach was also explored by Facebook's Memories VR, which used AI-based photogrammetry to reconstruct immersive memory spaces from 2D photographs whilst blurring the surrounding environment.

However, due to time constraints, this approach was unable to be tested with staff members. However, its potential is recognised as a scalable and user-friendly method to create personalised immersive experiences that enhance the user's original memories without disrupting them. Future research could explore the impact how technically simplified environments that blur the line between abstraction and realism may be used, particularly when exact contextual detail is either unavailable or could cause distress.

3.3.3.6 Not everything works

Despite manual efforts to adapt images into a VR format, there were images that were excluded and could not be used due to a variety of factors. One significant limitation was the angle at which some images were captured. Photos taken from angled perspectives made it difficult to integrate them into a virtual environment, as matching the exact viewpoint from the reference image proved challenging. Without a corresponding reference or adaptable angle, these images could not be effectively reconstructed for VR (see images 1 and 4 in Figure 3.9).

Figure 3.9: Examples of source images that were excluded for VR translation. These stylised versions represent staff-provided photos that presented challenges when adapting into 360-degree VR environments. For example: (1) images taken at an unusual angle; (2) group photo of people only showing above the torso; (3) unknown location without knowledge of where it could be; (4) an image taken at an elevated height; and (5) an image that has little information to work towards recreating within VR.

Additionally, some images required highly specific backgrounds to maintain consistency within the virtual environment. If an appropriate matching background or reference image could not be sourced, the resulting scene risked disrupting the user's memory recognition and immersion. For example, in the previously used image of a rainbow on a street (see Figure 3.7), an inaccurate background substitution could lead to disorientation, heading away from an intended meaningful experience. This issue highlights the dependency on external image sources for this manual study, which, if unavailable, currently limit the feasibility of certain transformations, however AI can potentially surpass this limitation by generating backgrounds that match the required scene, reducing dependency on existing image sources.

Another challenge involved partially captured subjects within the images (see image 2 in Figure 3.9). While some cases, such as the image of the dog, allowed for a successful reconstruction by identifying and integrating a suitable lower half, this approach is not always viable. When human figures are only partially visible, reconstructing the missing portions without introducing inaccuracies becomes highly difficult. Without advanced AI-driven techniques capable of generating realistic reconstruction, using these images remain impractical. However, even if these techniques were adopted, their use would raise important ethical considerations. As personal photographs often contain sensitive information, AI-based reconstruction should be processed locally, through secure systems rather than external cloud-based servers, for data protection. These constraints show the limitations of our usage of image-to-VR transformation, emphasising the need for further advancements in AI-based image synthesis, scene reconstruction, and automated perspective correction to enhance the viability of this process.

3.3.4 Key insights & limitations

Through iterative testing, staff feedback, and technical challenges, we identified several key insights about embedding personal images into VR for dementia care. These findings ultimately shaped our decision to step back from this approach and pivot towards a more user-preference-driven method, as discussed later in Section 3.4.

One of the most significant takeaways from our discussions with staff was the importance of context in selecting and integrating photos. Certain images naturally fit themselves to VR transformation, while others posed challenges. The subject of the image also played a critical role in how it was perceived in VR. For example, an important question arose — what would the participant want to re-experience using this? As a researcher or designer, you can build a scenario using a participant's photo, but the contributor might envision or prefer a different interpretation for their experience. This also develops into a deeper concern, if the resulting environment is significantly different from the participant's original mental memory, especially for someone living with dementia, this unfamiliarity could cause disappointment and even disorientation. Many people already experience memory distortion and spatial disorientation [175, 210], these effects can intensify as dementia progresses, making users more vulnerable to the risks of blurring reality and reconstructed memories. This reinforced the importance that personal elements in VR are placed in settings that are reasonable in context, with priority to participant comfort and safety over testing design novelty.

Another major challenge was determining the acceptable parameters for editing photos to fit them into VR. Should the contributor, whether a caregiver, family member, or participant, have input on modifications? How much involvement should a clinician have in this process, given that participants are diagnosed with dementia and may have difficulty recalling the original image? These questions reinforced the need for a structured approach to selecting and adapting images, including the development of a checklist for clinicians. Such a tool would help guide conversations with participants, ensuring that suitable images were chosen while managing expectations if no viable photos were available.

Another question that emerged from this research was whether transforming an image into VR actually added value to the reminiscence experience. One of the key issues was determining whether the participants preferred to view the transformed VR version of a personal photo or simply looking at the original photograph. However, I could not manage to include photos from participants living with dementia, due to the small amount of viable transformations that fit the criteria. Though, it would be beneficial to consider their perspectives in future research to better understand the effectiveness of immersive technology in dementia care.

This realisation led us to reconsider the fundamental goal of using personal photos in VR. Rather than presenting VR transformations as a direct way of "immersing participants into a personal photo," maybe a more effective approach would be to use these images as inspiration for creating relevant, emotionally resonant VR experiences. Instead of attempting an exact recreation of a participant's past, the focus could be on curating VR scenarios that captured the essence of their memories without sticking to a static image.

Another limitation that was encountered was that many personal images did not translate well into immersive experiences. A high number of contributed photos from the staff had to be excluded due to issues such as difficult perspectives, missing elements, or information constraints. Given this high rejection rate, it was questioned whether it was viable to continue with this approach, particularly considering that it might lead to frustration for participants who expected their images to be used but later found they were unsuitable. One possible way to mitigate this issue would have been to send a questionnaire alongside the photo submission to collect additional contextual details — such as where the image was taken, what memories it held, and what environmental elements (e.g., sounds or lighting) would be meaningful. However, even with added context, many images would still be impractical for VR transformation, reinforcing the difficulty of making this a scalable and reliable approach for personalised immersive experiences in dementia care.

3.3.5 Final reflection

After extensive testing with staff, it became evident that while some images worked well in VR, many did not translate effectively, either due to technical challenges or the risk of memory distortion and confusion. The amount of time and effort required to manually adapt each image was not scalable, and the risk of creating a misleading or unsettling experience outweighed the potential benefits. As a result, it was determined that proceeding with participant testing posed too great a risk at this stage and instead, the focus should be on a more adaptable, user-driven approach that prioritises participant preferences and interests rather than strict personal photo integration. This transition is explored further in Section 3.4, where I discuss VR personalisation that are designed to be flexible but still meaningful for individuals living with dementia.

Additionally, staff expressed concerns about raising participant expectations and the risk of disappointment if a submitted photograph could not be successfully adapted into VR. Since many images were unsuitable for transformation, participants may be let down if they had been invited to submit a meaningful image only to be told that it could not be used. Given the emotional sensitivity of reminiscence therapy, ensuring that the experience remained positive was a key consideration in the decision to step back from this approach.

However, it remains unclear whether all participants would respond negatively to such an experience. Since no direct participant testing was conducted, it is possible that some individuals may still find enjoyment in immersive adaptations of personal photographs. While the current research has chosen to follow the guidance of staff, future studies could explore whether a controlled version of this approach, with clearer participant guidance and safeguards, could still be beneficial for certain individuals.

Since the time of this study, there have been great advances in generative AI which introduce new possibilities for incorporating personal photographs into immersive environments. These tools could significantly reduce the manual labour required which can make the process more scalable, whilst also enabling a wider range of images to be classed as suitable to transform effectively into VR. But, at the same time, they introduce important ethical considerations, such as ensuring that AI-generated alterations do not distort personal memories in ways that could cause confusion and distress.

This highlights a broader challenge in dementia research - balancing safety with the potential for meaningful engagement. Moving forward, achieving a careful equilibrium between ethical responsibility and innovative intervention design will be crucial in ensuring that immersive technology remains a supportive tool rather than a disruptive experience. Personalisation must prioritise the participant's perspective over technical feasibility, if a familiar image is placed in an incorrect or unexpected setting, it risks causing disorientation rather than enhancing reminiscence. Moving forward, achieving a balance between immersion and realism will be critical in ensuring that immersive experiences remains a beneficial and accessible tool for individuals living with dementia.

Even with future AI integration, the significance of this research is its person-centred process. While generative AI may excel in terms of technical adaptation of images, it cannot replicate the connections and personal understanding from the positive and meaningful interactions and experiences with participants. The findings from this phase, particularly regarding sensitivity to personal meaning, can inform future AI workflows, but should never be replaced by them, nor should efficiency be prioritised over the safety and emotional well-being of participants.

3.4 Phase 4: Personalisation through hobbies & interests

3.4.1 Rationale for shifting focus

Following the challenges faced in attempting to personalise VR environments using participant-submitted photographs, the focus of this study shifted towards hobby and interest-based personalisation as an alternative approach. Research suggests that engaging in personally relevant activities can reduce challenging behaviour, and improve quality of life in individuals living with dementia [189]. Since personalised imagery did not always translate well into immersive environments, this approach explored whether off-the-shelf VR experiences tailored to participants' hobbies and interests could provide a more effective and scalable method of engagement.

While the earlier phases primarily focused on recruiting participants living with early to mid-stages of dementia, this phase also included individuals living with more advanced dementia. This inclusion served both ethical and practical purposes. Ethically, this decision was to be more inclusive to those living with dementia, ensuring those in later stages, who may be excluded from research due to limited verbal communication, could still have opportunities to participate meaningfully. Including individuals living with severe dementia allowed the study to explore how engagement might be shown through non-verbal or sensory responses, rather than relying solely on verbal feedback.

On the practical side, this approach also helped broaden the recruitment range and give the potential space to increase the sample size, giving a bigger picture of how immersive experiences might be used across the dementia spectrum. Recruitment of individuals living with severe dementia required additional ethical procedures, and this was approved through the IRAS review process. In cases where participants were unable to provide informed consent, a nominated personal or professional consultee provided agreement on their behalf. All sessions were supported by familiar care staff to ensure comfort and ethical participation at all times.

To ensure that the VR content was aligned with participants' preferences, a structured selection process was developed in collaboration with caregivers and research staff. The process began with discussions with research staff to identify a range of potential videos that could be suitable for participants. From these discussions, a menu-like document was created, containing snippets of various video types, allowing caregivers to introduce options to participants and gauge their preferences.

After the interview with the participants, they vocalised what videos they preferred, then a catalogue was developed that contained a preview image for each video, along with information on video length and level of immersion. This helped both caregivers and participants understand what to expect from each video. During the intervention process, participants were able to choose what they would like to watch from this catalogue. While most selections were based on their pre-identified preferences, participants also had the flexibility to explore additional content beyond their initial choices.

To ensure a diverse selection, the initial menu was structured into six different categories, each containing a set of up to six videos covering a broad range of interests. The categories were designed to encourage conversation between caregivers and participants, helping them identify preferred content while also allowing for new suggestions to emerge. The six categories included:

1. Nature, sea, and animals – Wildlife videos, underwater exploration, and scenic nature landscapes.
2. Art, music, and history - Classical concerts, music sessions and virtual museum tours.
3. Sports and hobbies – Football, golf, fishing, and other activity-based interests.
4. Travel, cities, and tours – Virtual narrative walking tours of famous cities, fishing boat rides, and aerial drone footage.
5. Fantasy, scary, and space - Immersive fantasy experiences based on fantasy novels, space exploration, and roller coasters.
6. Active involvement – Physical engagement, including interactive VR exercises like meditation sessions and "walk the plank" challenges.

By categorising the available content in this way, the selection process became a guided yet flexible experience, ensuring that participants had agency over their choices while also receiving support from caregivers to explore new interests. This participant-driven approach aimed to maximise engagement while avoiding the technical and ethical challenges associated with personal photo integration.

Personalised reminiscence therapy, when tailored to an individual's past hobbies and interests, has been shown to be effective in triggering positive emotions and maintaining attention [277].

Unlike static images, activity-based personalisation allows participants to engage dynamically, potentially providing a greater sense of agency and involvement in the experience. Given these potential benefits, this study investigated the following.

1. How interest-based VR personalisation affects engagement and emotional responses in individuals living with dementia.
2. Whether interest-based interventions mitigate some of the disorientation and technical challenges observed in photo-based VR personalisation.
3. What technical or practical limitations emerge when integrating participant interests into VR-based reminiscence experiences.

However, due to delays caused by the COVID-19 pandemic, technical issues, and time constraints for the second phase of data collection, parts of the prototype application became outdated. This particularly impacted the real-time streaming functionality of the VR video player, which was a key feature designed to facilitate conversations between participants and staff. As resolving these issues would have required significant time and manual effort, it was best to shift the platform to the in-built YouTube application in the Meta Quest headset. This alternative allowed the project to continue to investigate the effectiveness of personalised videos, while ensuring that the activity remained accessible and engaging for both participants and staff.

3.4.2 Study methodology

3.4.2.1 Ethical considerations

The ethical framework for this study followed the same IRAS application as the previous section (see Section 3.3.2), enabling the inclusion of participants living with severe dementia who were unable to provide informed consent. Given that this study specifically targeted individuals living with advanced cognitive impairment, ethical approval was necessary to ensure that participation was conducted in an ethically sound manner.

As in the previous study, participation was facilitated through caregivers or legally appointed nominated consultees, ensuring that all decisions were made with the best interests of the participant in mind. The primary ethical considerations included ensuring participants' preferences were respected, while caregivers guided the selection of VR content, the process aimed to preserve participant agency by offering choices within a structured environment and if they no longer preferred to take part in the study, then the process would be terminated with their call. Distress would be minimised since this study moved away from personal photo-based VR, it was considered lower risk, as the content did not directly involve manipulating personal memories. Since the focus shifted from highly personalised memory-based VR to interest-based engagement, the ethical risks associated with memory confusion and distress were reduced. However, caregiver involvement remained crucial in ensuring that selected activities aligned with what was most appropriate for each participant's cognitive state.

3.4.2.2 Participants

This study involved six participants, recruited from the locked psychiatric hospital, who had a primary diagnosis of Huntington's disease (4), Organic personality disorder (1) and other degenerative diseases of nervous system (1), who were at advanced stages of the disease (see Table 3.3 for more details). The inclusion criteria involved participants with a diagnosis of dementia from mild through to severe level and individuals who can understand verbal English instructions. Individuals who are substantially visually impaired were excluded, this was justified for the purpose of the study as the VR intervention required individuals to see the virtual world in order to engage with it. Individuals who had a history of motion sickness were also excluded due to the known risk of nausea and disorientation associated with VR, that can sometimes simulate that of motion sickness. This was justified for the purpose of the proposed study as it reduced the risk of potential harm to participants. As dementia affects individuals differently, variations in engagement were expected depending on cognitive ability, prior VR experience, and individual preferences.

Pseudonym	Primary diagnosis	Age	Gender
P6	Huntington's disease	51	Female
P7	Huntington's disease	56	Male
P8	Organic personality disorder	59	Male
P9	Huntington's disease	37	Male
P10	Huntington's disease	56	Male
P11	Other degenerative diseases of nervous system NEC	90	Male

Table 3.3: Patient diagnosis and demographics

3.4.2.3 Interventions

The intervention followed a structured process to ensure that participants were supported at every stage, this was carried out by a member of the research team at the psychiatric hospital, from initial engagement to post-study reflection. The procedure was designed to be flexible and accommodating, particularly for individuals living with fluctuating levels of engagement.

Preparation phase: Before each session, the research team notified the ward in advance to coordinate with staff and prepare for the data collection exercise. Upon arrival, a handover was received from the nursing staff, providing important updates on participant well-being, availability, and any immediate concerns that might impact participation. Participants were then approached with support from the nursing staff, ensuring that the introduction was familiar and reassuring. Each participant was reintroduced to the study and reminded of their prior consent to participate, offered the opportunity to engage in the VR session that day and given the option to decline, postpone, or request participation later. For participants who chose to proceed, a quiet and accessible space was prepared, ensuring that mobility challenges did not pose a barrier to participation. The VR equipment was then set up, allowing for a comfortable experience.

Study procedure: Once the participant was comfortably settled, they were warmly welcomed, and gratitude was expressed for their involvement. A brief overview of the session structure was provided to ensure everything was clear, covering key components such as the pre-questionnaire, video viewing and a post-questionnaire. With the participant's consent, the pre-questionnaire was completed, allowing researchers to gather initial insights into mood and expectations. With additional consent, the VR headset was placed on the participant and then the chosen VR video was then played. The fit was adjusted for comfort and ease of use, with ongoing support available throughout the experience. After this first exposure, an initial segment of the post-questionnaire was completed. To accommodate memory and concentration difficulties, the session was broken up with additional videos, ensuring that participants were not overwhelmed by the length of the questionnaire task. The final portion of the post-questionnaire was then completed, gathering feedback on the participant's engagement and comfort.

Post-study procedure: At the conclusion of the session, participants were thanked for their time and engagement. Staff members were then asked to complete a staff questionnaire, providing insights into the participant's behaviour and any noticeable changes following the VR session. In addition to staff feedback, the research staff documented observations, capturing any notable participant reactions or unexpected outcomes that came from the study. Finally, a handover was given to the nursing staff, ensuring that all relevant information was documented in the medical record system. This handover facilitated continuity of care, allowing nursing staff to note any participant feedback, reactions, or follow-up actions needed after the intervention.

3.4.3 Observations

This study explored how individuals living with dementia engaged with VR experiences tailored to their hobbies and general interests. By offering content such as music videos, animals, and scenic environments based on prior interviews to identify preferred themes, the study assessed how interest-driven VR could support engagement and emotional responses.

Unlike the feasibility study, which relied on transcripts produced from recorded interviews, this phase utilised structured questionnaires, observation notes, and caregiver reflections. Because many participants were living with advanced dementia, communication was often limited by speech difficulties, requiring alternative response methods. Some data were gathered through forced-choice questions, where participants indicated "yes" or "no" by pointing to visual response options, ensuring that all participants, regardless of verbal ability, could contribute meaningfully.

To analyse the data, I again used reflexive thematic analysis [31, 32], adapting the process to reflect the more structured and behavioural nature of this dataset. I began by familiarising myself with all responses and observational notes, then coded patterns of engagement, such as smiling, leaning forward, or turning away, alongside caregiver interpretations of these reactions. Codes were organised into broader categories that reflected recurring experiences for instance, enjoyment through sensory stimulation, curiosity toward specific content, or fatigue during longer sessions. Compared to the earlier feasibility phase, this analysis was more deductive, focussing on identifying consistent patterns of engagement between content types rather than developing open-ended exploratory themes. This reflexive process emphasised the importance of interpreting both behavioural and affective cues, acknowledging that meaning in advanced dementia is often expressed through gesture and emotion rather than speech. The findings revealed strong engagement and enjoyment overall, though responses varied depending on individual preferences, emotional resonance, and physical comfort.

3.4.3.1 Enjoyment and engagement

Across the study, participants generally responded positively to the VR experiences, with excitement and curiosity observed during sessions. Many participants expressed enjoyment, with some actively moving or vocalising their enthusiasm. P6, for example, reacted energetically to dancehall music videos, showing movement and engagement, while P10 showed strong interest in puppy videos, demonstrating that VR content aligned with personal hobbies and interests could sustain engagement.

Staff also observed that participants were often absorbed in the experience, with some exhibiting a sense of presence or transportation, feeling as if they were truly inside the virtual environment. Several participants commented that they felt like they were "there" or "inside the video," reinforcing VR's immersive power. However, perceptions of realism varied, with some participants describing it as feeling like "watching a TV," while others reported a stronger sense of being present within the scene.

3.4.3.2 Memory recall through interests

Although this study did not focus on direct reminiscence-based personalisation, some participants spontaneously recalled past experiences triggered by the VR content. P6, for example, reminisced about attending dancehalls with a close friend, while P9 was reminded of their mother and past visits to the London Eye. Similarly, P11 felt a connection to their wife after watching the video of Paris, highlighting how interest-driven content could still evoke personal and emotional memories.

However, emotional responses varied, with some participants expressing a deep connection to the content, while others remained neutral or unaffected. For example, P9 described feeling closer to their mother, while P8 reported a strong emotional reaction, describing the experience as feeling "free." In contrast, other participants enjoyed the VR experience but did not report any significant emotional shift, suggesting that personal connections to content play a crucial role in emotional engagement.

3.4.3.3 Personalisation and control

A common theme that emerged was the desire for greater personalisation and control over VR content. Several participants expressed a preference for choosing their own content, incorporating personal photos or videos, or even creating their own virtual environments. This aligns with findings from the previous studies in Sections 3.2 and 3.3, which indicate that personalisation enhances engagement and emotional connection.

Additionally, most participants preferred to use the VR independently, rather than having engaging with caregivers. Some verbalised wanting to "just get on with it", suggesting that VR could provide a more autonomous experience, allowing individuals to immerse themselves at their own pace. However, while most preferred independent use, engagement with caregivers varied – some actively interacted with staff during the session, while others became so absorbed that they seemed unaware of staff presence.

3.4.3.4 Variation in content

One of the most significant findings was the diversity in content preferences. Different participants engaged with different types of content, reinforcing the need for a flexible and varied VR library to accommodate individual tastes and preferences. For example, P6 showed strong engagement with dancehall music videos, while P9 preferred Eminem's music videos, and P8 found the Mozart video most enjoyable. VR experiences should offer a broad range of genres to ensure accessibility for different users.

Similarly, physical responses to VR varied – some participants moved or danced along with the content, while others showed minimal emotional expression. For example, P6 exhibited physical movement during the dancehall video, whereas P10 maintained a passive mood throughout. These differences suggest that while some individuals may engage physically with VR content, others may experience enjoyment more passively.

3.4.3.5 Physical comfort and practical challenges

While most participants enjoyed the VR experience, some reported physical discomfort related to the headset's fit and weight. A few described the headset as feeling tight or heavy, which could impact the length of time they were willing to use it. P9, for example, felt tired after the session.

Beyond individual comfort, practical challenges were also identified in implementing VR in a dementia care setting. The need for staff supervision, sufficient setup time, and a quiet space were noted as barriers to seamless integration into daily routines. Some caregivers pointed out that if VR is to be adopted widely, it needs to be easily deployable, require minimal setup time, and fit within structured care schedules.

3.5 Limitations

While this chapter provides valuable insights into the feasibility and personalisation strategies of immersive experiences (mainly VR) for individuals living with dementia, several limitations must be acknowledged from this work for VR implementation in care settings.

One significant limitation was the small sample size across the studies. Given the challenges of recruiting individuals living with dementia for research, even by including those living with moderate to severe cognitive impairment in Section 3.4, the number of participants was still limited. As a result, findings may not be fully generalisable to broader dementia populations, particularly in different care environments or among individuals living with different stages of the condition. Future studies with larger, more diverse participant groups could strengthen the reliability of these findings and explore how responses to immersive experiences may vary across different stages of dementia and care settings.

Finally, caregiver involvement played a crucial role in facilitating VR engagement, but their availability and experience with technology varied. While some caregivers actively encouraged participants and helped guide interactions, others were more passive. The differences in caregiver engagement may have influenced participant experiences. Future research should consider caregiver training programs to ensure more consistent facilitation and better integration of immersive technology into dementia care routines.

Despite these limitations, the findings from this chapter provide valuable groundwork for future immersive technology research in dementia care. Addressing these challenges in future studies will making interventions more accessible and integrated into care settings, ensuring that individuals living with dementia can benefit from immersive experiences in ways that enhance their well-being and engagement.

3.6 Conclusion

This chapter has explored the feasibility, engagement, and personalisation strategies of VR for individuals living with dementia (a summary of all phases in this chapter shown in Table 3.4), highlighting both the potential benefits and challenges of implementing immersive technology in dementia care settings. The findings from the feasibility study demonstrated that VR can elicit positive engagement and reminiscence but also underscored the importance of system reliability, ease of use, and careful content selection to avoid distress. The hobbies and interests study further revealed that VR engagement does not always need to be memory-based, interest-driven experiences can offer meaningful and enjoyable interactions, providing an alternative approach for individuals who may not benefit from purely reminiscence therapy that focus on memory recollection.

Despite these promising outcomes, technical challenges, internet connectivity issues, and caregiver support requirements were key barriers to seamless implementation. The study findings highlight the need for more efficient, offline-capable VR systems that can function reliably in secure hospital environments and care settings with limited infrastructure. Additionally, ensuring personalisation and adaptability will be critical in making immersive technology a widely accepted intervention in dementia care.

Ultimately, these studies lay the groundwork for further development and refinement of immersive technology for dementia care, paving the way for future research into adaptive immersive experiences and scalable deployment strategies that can enhance the well-being and quality of life for individuals living with dementia.

Phase & Objectives	Key findings
Phase 1: System Development Development of a prototype VR system for dementia care, including a caregiver mobile app and VR video player, designed for convenience and integration into care routines.	• Dual-device design to improve usability, allowing caregivers to manage content easily. • Technical feasibility was shown, including live streaming potential. • Early feedback suggested suitable for use with people living with dementia.
Phase 2: Feasibility Study Explored feasibility and acceptability of VR prototype, focusing on user engagement, enjoyment, and caregiver interactions.	• VR was generally well-received, participants enjoyed and reminisced moments. • Personalisation was essential to sustain engagement, though responses varied. • Practical challenges included internet reliability and caregiver support needs.
Phase 3: Personalisation through Photographs Iterative design with staff to assess how personal photos could be adapted into VR environments, considering feasibility and risks.	• Some images worked well, but others risked confusion or memory distortion. • Context and interpretation were critical for safe and meaningful use. • Ethical risks limited scalability for use with those living with dementia.
Phase 4: Personalisation through Hobbies & Interests Tested off-the-shelf VR content based on participant hobbies and interests as a scalable alternative to personal photos.	• Videos related to hobbies still provided accessible and enjoyable engagement. • A diverse VR content library is needed to be able to support varied interests. • Practical challenges persisted, including headset comfort and supervision requirements.

Table 3.4: Summary of Chapter 3 Phases: Objectives and key findings

Chapter 4: Creative expression

Building on the prototype development, feasibility testing, and early explorations of personalisation discussed in Chapter 3, this chapter shifts focus towards a more participatory and expressive approach to designing immersive experiences for individuals living with dementia. While the previous chapter examined basic personalisation strategies, such as incorporating familiar imagery and interest-based content into immersive environments, the findings revealed limitations in cognitive accessibility, engagement variability, and the potential for distress when reminiscence-based immersive experiences was not carefully curated. These challenges highlight the need for alternative methods that empower individuals living with dementia to contribute to their own immersive experiences, ensuring that personalisation is not simply imposed but co-created through participatory, expressive, and sensory-driven approaches.

Historically, dementia research has focused on cognitive decline and functional loss, often overlooking the social and emotional connection aspects of living with the condition. This perspective has influenced technology design, positioning individuals living with dementia as passive recipients rather than active participants. However, Human-computer interaction (HCI) research has begun to challenge this approach, advocating for person-centred design that recognises emotional experiences as central to dementia care [113, 266, 74]. Emerging tools such as interactive storytelling, sensory stimulation devices, and VR demonstrate technology's potential to enhance meaningful participation. Yet, research highlights a persistent gap in participatory design, with individuals living with dementia often excluded from co-creation processes. Creative art-based therapies (cABT) offer a promising direction, reinforcing identity and emotional well-being, but further work is needed to integrate adaptive communication strategies and sensory engagement into dementia-friendly technology design.

This chapter addresses the need for more inclusive and participatory methods that prioritise personal expression and personhood in designing technology for people living with dementia. Designing with care is not the work of a single individual or discipline, but a shared, co-creative process that values the voices of people living with dementia, caregivers, artists, and researchers alike. To embody this framework, I integrated cABT-inspired methods and person-centred design practices into an immersive, multisensory intervention shaped directly by the lived experiences of people living with dementia. Over several weeks, we worked closely with 34 individuals living with dementia, their caregivers, and professional artists to co-create small-scale physical worlds, engage in storytelling, and layer soundscapes, before translating these creative expressions into immersive VR representations of these environments. Unlike the earlier studies in Chapter 3, which focused on co-curation through the selection of existing content, this phase moved towards co-creation, where participants and artists produced new environments and soundscapes together.

This holistic process – from art-making and storytelling to virtual immersion – did more than produce a technological artifact. It actively engaged participants in shaping the resulting intervention. By centring their perspectives and abilities, our approach challenged traditional deficit-based models and enabled meaningful engagement, emotional connection, and an affirmation of identity. Rather than relying on technology alone, it was the thoughtful, human-centred integration of creative practices that made a transformative difference in reconnecting participants with their sense of self and creativity. Our work builds on and extends previous efforts to align technology with the lived realities of individuals living with dementia, showing how participatory, person-centred approaches grounded in creative art-making can harmonise technology's potential with the nuanced experiences it aims to support. In sharing these guiding principles and insights, I demonstrate how future interventions can become more inclusive and meaningful by embracing critical dementia perspectives.

4.1 Background

This research begins by examining the development of person-centred technologies and how they support emotional and sensory engagement for people living with dementia. I then consider how immersive and sensory systems like VR build onto these ideas, helping to preserve memory, identity, and self-expression through responsive and competent design. Finally, I explore co-creation as a pluralistic approach to technology development – one that values the voices of people living with dementia, caregivers, and designers alike.

4.1.1 Creativity and emotional engagement in dementia care

For decades, the prevailing narrative surrounding dementia often presents it as a relentless decline, a “death of the self” in which individuals progressively lose memory, identity, and social roles [94]. Such deficit-based viewpoints marginalise those affected, often reducing them to passive recipients of care and overlooking their agency and intrinsic value. In contrast, an emerging perspective – rooted in the dialogical approach to identity – emphasises that personhood is co-constructed through social and relational interactions. Rather than viewing people living with dementia as diminished versions of their former selves, person-centred care [34] recognises them as whole, evolving individuals, who continue to be shaped by their unique emotions and experiences. From this standpoint, [150] argued that personhood is not inherently lost with cognitive decline, but can be maintained and reinforced through social recognition and meaningful participation. Acknowledging personhood thus involves creating opportunities for people living with dementia to retain agency, express themselves, and sustain their sense of selfhood, even as their cognitive abilities change.

Creative approaches in dementia care, rooted in the concept of creative ageing, build on a person-centred understanding of care and are underpinned by principles such as Animation, Transcendence, Selfhood, Humanity, Expression, Connection, Possibility, Involvement, and Awareness [57]. These approaches offer concrete opportunities for self-expression and engagement, even as cognitive abilities decline [272, 255]. Activities like painting, music, and collaborative art-making empower individuals living with dementia to maintain agency and interact meaningfully with their surroundings [38, 231, 178], thereby affirming their intrinsic creativity and reinforcing personhood [25, 141]. Research highlights that aesthetic experiences – such as selecting colours, textures, or sounds – offer sensory stimulation that reconnects individuals with their identity [235, 59] and allow emotions, skills, and memories once thought lost to dementia to resurface through embodied expression. When these expressions are recognised and valued, they affirm a person's continued role in shaping their own narrative [39]. In group settings, shared artistic activities further promote a sense of belonging and social connection [145, 84, 221], strengthening both local and broader communities of care [249].

4.1.2 Personhood-centred technologies for emotional and sensory engagement

Building on the recognition that creativity and self-expression are central to affirming personhood in dementia care, HCI research has increasingly embraced these principles to reimagine the role of technology. Historically, many technologies for dementia care have been shaped by deficit-focused approaches that prioritise compensating for cognitive decline, but research by Holbø et al. [126], Kitwood [149], Knowles et al . [152], Lazar et al . [160], Vines et al. [266], Wallace et al. [268] shows these designs often reinforce ageist stereotypes and overlook the emotional and social dimensions central to personhood. Over the past two decades, HCI has increasingly embraced creative and participatory elements in designing technologies that align with the principles of person-centred care, creating opportunities for agency and meaningful connections. For example, Wallace's work exemplifies the integration of creative approaches, being grounded in the understanding that personhood is "internally changing and externally nurtured through relational and social contexts" [268]. Their projects include the redesign of a 'reminiscence room' in a dementia care ward [269] and a thoughtful, exploration of selfhood through the co-creation of digital jewellery with a couple navigating dementia [268]. Similarly, Lazar et al. [163] explored how art therapy, guided by the concept of the "Third Hand," empowers older adults through creating and sharing, enhancing social bonds and identity. Projects like Mariana's Song [54] have demonstrated how blended physical/digital installations can support self-expression and emotional engagement. Other approaches, such as craft-based interventions [228, 227], show how physical objects and activities can preserve self-defining memories and evoke emotional recall. Music and performance also hold transformative potential. For example, participatory music sessions have been shown to create opportunities for connection, touch, and sensory engagement while building community [192].

Immersive and sensory technologies, including VR, offer new opportunities to deepen engagement and sustain personhood through tailored, multisensory experiences. Early projects like CIRCA [113] and multimedia biographies [64] demonstrated how interactive systems can evoke memories and affirm identity using personalised content such as photographs, music, and narratives. Complementary methods using screen-based interfaces [105, 269], mobile devices [6, 12], sound players [128, 264], or olfactory devices [9], have shown the role of aesthetic embodiment [153], where physical and sensory interaction enables self-expression and reconnection with personal history [40]. These approaches align with attentiveness in care ethics through their focus on individual experiences and emotional needs. Building on these earlier efforts, VR has introduced immersive environments that support reminiscence, identity, and emotional engagement, such as virtual reminiscence rooms and gardening experiences [239] have shown promise in promoting well-being and rekindling identity. Similarly, customised VR environments, such as simulated concerts or calming landscapes [125], have helped individuals rediscover expressions of self, providing moments of joy and emotional resonance. Despite these advancements, as Skurla et al. [240] observe in their systematic review, the application of VR in dementia care has predominantly focused on cognitive training and assessment, often overlooking subjective lived experiences and emotional well-being. While applications like the Virtual Supermarket [284] or Tai Chi exercises to enhance cognitive and physical function [129], they fail to address the sensory and relational dimensions of care. Furthermore, studies in this domain have provided limited insight into the subjective experiences of individuals living with dementia, focusing instead on task-based outcomes like way finding [61, 262]. As García-Betances et al. [101] argues, immersive technologies like VR and sensory-driven systems provide distinctive ways to enhance creativity, connection, and self-expression by delivering emotionally engaging, multisensory experiences. Research suggests that such tools can facilitate reconnection with memories and help preserve identity by allowing individuals to re-engage with meaningful elements of their personal history and environment, sustaining a sense of personhood [120]. Understanding how to design and integrate these systems effectively, while ensuring they prioritise emotional resonance and person-centred care, is essential for supporting personhood in dementia care. The following section examines co-creation as a critical approach to achieving these objectives.

4.1.3 Co-creation in dementia care

What distinguishes some of the projects that were presented in Section 4.1.2 is their commitment to two principles: (i) empowering individuals living with dementia to shape their own experiences, spaces, and objects, thereby reinforcing their connection to identity and personhood; (ii) meaningfully including them as co-designers in the creation of artworks and technologies that reflect their life stories. This line of research, initiated and developed by scholars like Lindsay et al . [170], Hendriks et al. [123, 122], Holbø et al. [126], Wallace et al. [269, 268], Lazar et al. [163, 161, 164], among others, uses traditional participatory design methods to explore how people living with dementia can be actively included in the co-design process. At the same time, co-design with individuals living with dementia presents distinct challenges. Cognitive impairments can hinder engagement with complex design activities [118, 248], while the brevity of many co-design engagements can limit the depth of involvement. Research often treats co-design as instrumental — a practical means to an end — without fully exploring its potential for empowerment and emotional connection throughout the process itself. Deepening this understanding requires sensitivity, patience, and the use of adaptable methods that accommodate varying levels of participation [123, 215, 258].

Despite the potential of co-creation, it is still underutilised in many areas of technology design for dementia care. As Goodall et al. [111] highlights, technologies are still predominantly designed *for* older adults rather than *by or with them*, leading to solutions that may not fully align with their lived experiences or needs. This is especially true for VR, where many applications focus on cognitive training and assessment rather than sensory and emotional engagement [240]. Furthermore, individuals living with dementia and their caregivers are often unfairly labelled as "technophobes," a stereotype that oversimplifies their relationship with technology [162]. Although including caregivers and family members in the design process has been shown to enhance practical and emotional outcomes [103], current research often lacks systematic approaches for engaging these stakeholders meaningfully and consistently. Moreover, there is limited exploration of the diverse roles caregivers play and how their varying perspectives influence design outcomes. Evidence suggests that both individuals living with dementia and their caregivers, when thoughtfully engaged, can contribute to unexpected and innovative uses of technology. However, the processes that facilitate such creativity and the barriers to broader participation remain under-explored, highlighting the need for more inclusive and nuanced approaches to co-design.

4.2 Methodology

4.2.1 Our approach

Our approach integrates co-design through art-making with experiencing VR, combining the strengths of creative expression and immersive technology to support individuals living with dementia. Rooted in a *'creating with care'* perspective, the research team viewed participants as active, relational partners in shaping both the process and outcomes. Rather than using VR and art-making as separate tools, we sought to create a continuum of engagement – where artistic expression allowed individuals to reflect on their experiences, and immersive technology enabled them to re-inhabit and interact with their creations in sensory-rich and embodied ways.

The study consisted of five weekly collaborative art-making sessions, followed by a final VR session where participants experienced their creations in a virtual environment. The entire process is summarised in Figure 4.1 and images from the workshop are presented in Figure 4.3. We collaborated with 44 participants across four locations, in partnership with a specialised arts organisation. Out of the participants, 22 people living with dementia experienced the resulting VR environments, and interviews were conducted with 10 of them. During the five-week process, participants engaged in 2-hour long sessions, supported by different artists at various stages (including a writer, a model-box maker, and a sound designer), to co-create *model boxes* – scaled-down 3D physical representations of elements they found meaningful. These artists were involved as paid collaborators through the partner arts organisation, to ensure consistency and quality of deliverables for the project. These boxes incorporated visual, tactile and auditory elements, allowing participants to express their memories and identities in a tangible form [269]. In the final session, Session 6, participants were immersed in VR environments that were specifically created based on the physical model boxes developed by their respective groups. Each participant experienced only the VR environment corresponding to the model their group had created, and did not explore environments developed by other groups. This approach was intended to enhance sensory and emotional engagement though aesthetic embodiment by allowing participants to experience their work from a new perspective. In this study, the full process of creating immersive environments was examined. This included: (i) participants' reflections and conceptualisations of meaningful places; (ii) their collaborative efforts in building physical representations of these places, and (iii) the ways in which the experience of the VR content was shaped by their active involvement in its co-production. Finally, I explored (iv) the emotional impact of being immersed in the VR environments they had helped create [173].

4.2.2 Rationale

4.2.2.1 Using physical model boxes over digital ones

While I acknowledge that immersive VR experiences can make subjects more creative, the co-creation process began with physical model boxes rather than modelling the environment directly in VR. This decision was based upon practical and person-centred considerations. Firstly, many individuals living with dementia enjoy familiar hands-on activities such as drawing and colouring, which are often used in care settings. Secondly, introducing a digital interface for these creative activities would likely have added technical and cognitive barriers, particularly for participants unfamiliar with this form of technology or those experiencing motor challenges. Thirdly, the tactile nature of the workshop also offered participants a sensory-rich and social environment to express their ideas without judgement of learning new technology. There was value in allowing participants to create in the real world first, then see their work translated into VR. This bridged the physical and digital worlds, helping participants recognise their own creations within the new immersive space. This transition maintained their personal connections with the art that they made, our aim was to make the creative process as comfortable and inclusive as possible, rather than requiring them to learn unfamiliar creative tools in a virtual environment.

4.2.2.2 Collaborative model box making over individual activity

I also acknowledge that although memory and meaning are inherently personal, the decision to build model boxes collaboratively rather than individually was intentional. Working as a group created opportunities for social connection and collective storytelling, all of which are known to enhance engagement and emotional well-being for individuals living with dementia [155, 39]. This process encouraged conversation between participants and reduced pressure on any one individual to recall memories or their artistic ability, whilst building a sense of shared ownership of their creation.

Initially, the research team did consider inviting each participant to create their own model box, as this could have produced more directly personal outcomes. However, this approach would have been both time and resource intensive, especially the physical demands for the team to help construct multiple boxes within the workshop sessions. Additionally, digitally translating each individual box into their own VR environments would have required significant development time, which would potentially limit our ability to refine these designs. The group format therefore represented a practical balance that prioritised the inclusion and creative engagement across all participants in the sessions.

While we recognised that group creations could introduce potential confusion, for instance, encountering objects that are connected to other participant's memories, we later found that participants typically recognised their own contributions or, when they did not, interpreted the other's shared content in personally meaningful ways to them. This observation aligns with previous findings suggesting that people living with dementia can project personal meaning onto generic content, using it as a flexible prompt for imagination or reminiscence rather than as a literal representation of memory [13].

In an ideal scenario, with no limits to time and resources, future work could balance both group and individual approaches, where participants first explore group co-creation for social connection and confidence building, which is then followed by opportunities to develop individual personalised environments. Nevertheless, within this study, the group-based format proved to be a powerful enabler of creativity and connection, helping participants feel part of something larger while still preserving moments of personal expression.

4.2.3 Our participants

The research team collaborated with Bright Shadow, a specialist arts organisation, which facilitated recruitment for this study and managed participant selection. They identified 44 participants, 34 of whom were living with dementia at various stages – ranging from early to mid-stage, with one participant in a more advanced stage – and 10 participants who were caregivers or family members. The organisation's existing relationships with participants ensured a seamless and inclusive selection process. While detailed demographic data (e.g., age, disease stage) was not collected, this decision aligned with the charity's established approach to participant engagement and data privacy. However, the group included a balanced representation of genders and ages, reflecting a diverse range of experiences. The primary focus of this study was to explore creative and emotional engagement rather than to make comparisons based on individual characteristics.

In this study, it was intentionally decided to not refer to participants by anonymous identifiers, as this approach did feel dehumanising and inconsistent with our person-centred methodology. Instead, each participant was assigned a pseudonym, allowing us to refer to them by name when presenting findings. This choice reinforces the individuality of each participant and aligns with the study's emphasis on personhood and narrative integrity. While earlier sections (e.g., Chapter 3) may reference participants using identifiers for clarity during discussion, this chapters adopts pseudonyms to better reflect participants' experiences and honour their contributions in a more humanising way.

To ensure the highest standard of ethical care, one researcher completed two NHS-certified courses: one on dementia care, focusing on supporting well-being and understanding the condition, and another on the Mental Capacity Act, covering areas such as assessing mental capacity, making best-interest decisions, and safeguarding vulnerable individuals. This preparation ensured that participants who might lack capacity were fully supported, and their rights were upheld throughout the study. The researcher's training equipped the team to make ethically sound decisions and respond sensitively to participants' cognitive abilities. Throughout the sessions, staff from the arts organisation and some participants' caregivers were present, providing additional support and creating a comfortable, secure environment. This collaborative approach ensured participants felt at ease and supported during the workshops.

The study received approval from the Central Research Ethics Advisory Group of University of Kent (application no: CREAG059-04-22). All participants gave informed consent, signing forms designed with simplified language and images to aid comprehension. Consent was re-confirmed before each session, and participants could withdraw from the study at any time, with no obligation to participate in the final VR experience if they preferred not to.

4.2.4 Immersive co-creation journey

To facilitate the exploration and co-creation of personal and meaningful places, we conducted a series of six workshop sessions, which we detail and illustrate in Figure 4.1.

4.2.4.1 A personal narrative collage - Session 1

This activity was carried out in collaboration with *the writer*, whose role was to help participants articulate and narrate their personal stories, enhancing emotional connec-

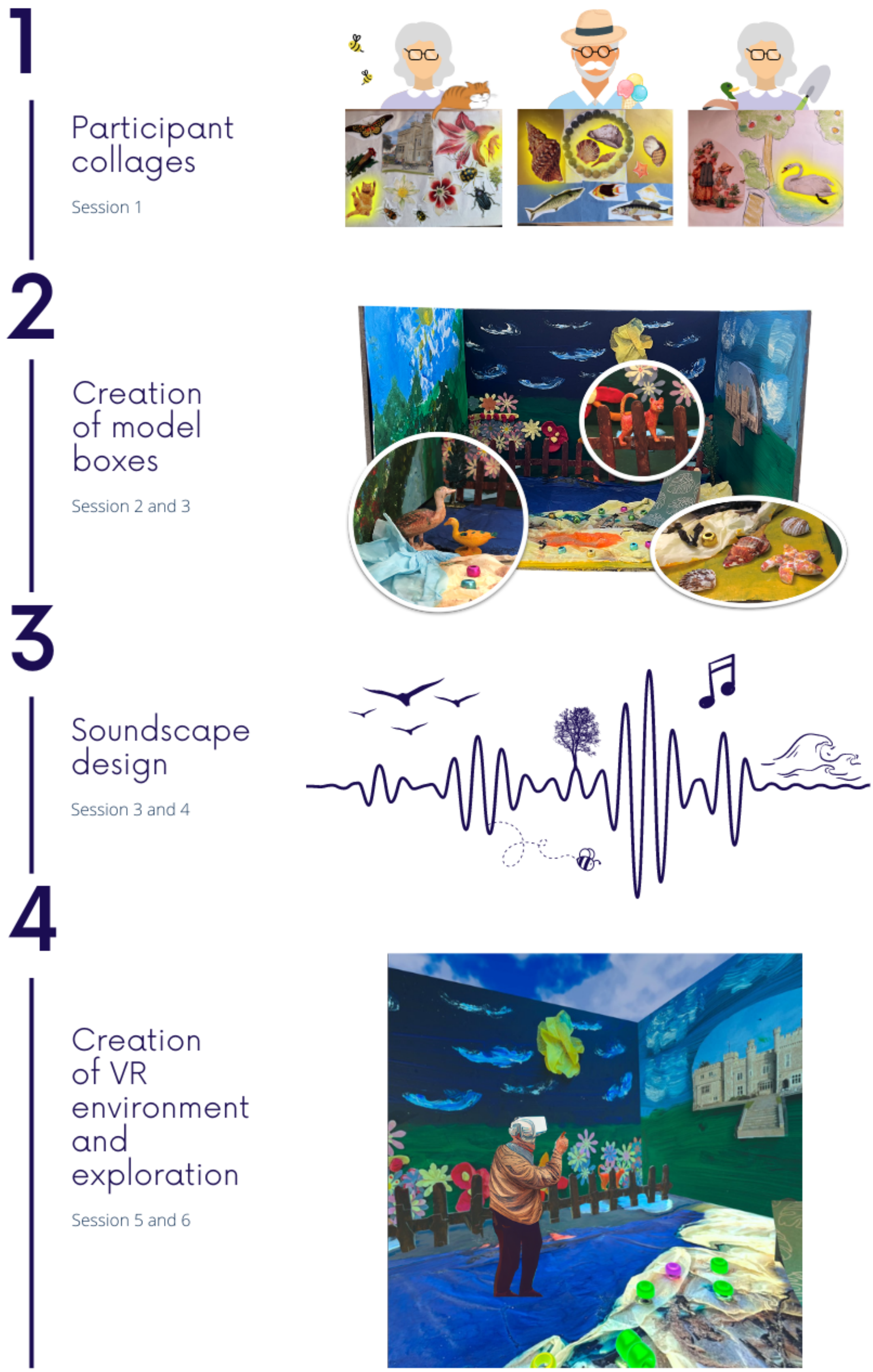

Figure 4.1: Overview of the VR creation process across six sessions.

tions to *"meaningful places"*. For this, we asked each participant to create a 2D collage based on the brief *"What is a meaningful place for you"*? Before the session, we asked participants to bring some photos or objects associated with their favourite places. These were scanned and reprinted to be used as collage materials together with wax pastels, promarkers, chalks, paints, textured paper/fabric and graphic-designed collage books. While the participants worked on their collages, the research team engaged in conversations with them about their creations. The final collages (see Figure 4.2 for a selection) were shared during a group discussion, where common themes were collaboratively identified by the facilitators – including researchers, artists, and the organisation's staff members – for use in the group *model box* co-creation in the next session.

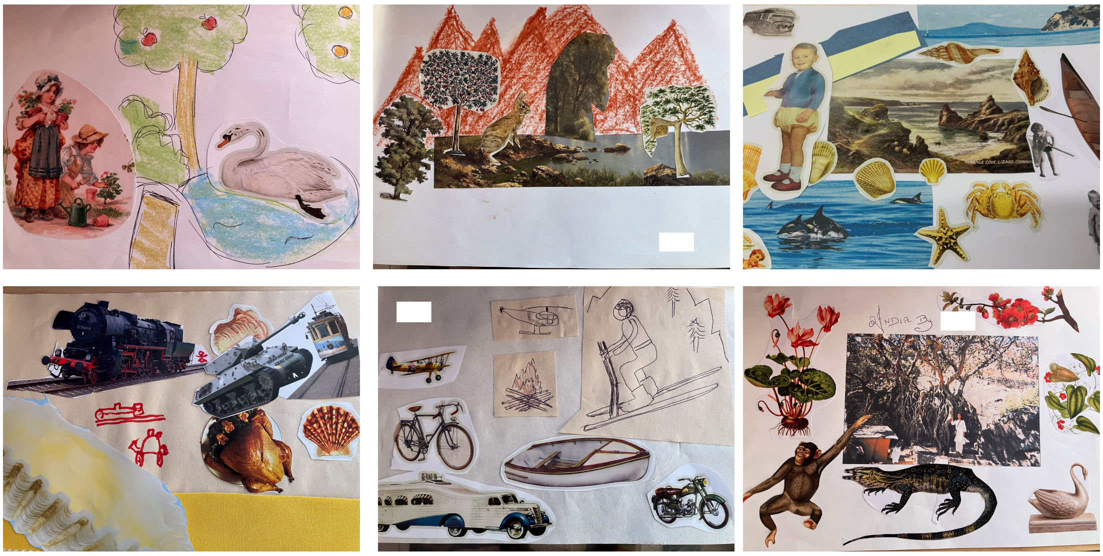

Figure 4.2: Six collages created by participants represent their meaningful places.

4.2.4.2 Model box co-creation for building shared visions - Sessions 2 & 3

After analysing the collages from Session 1, key themes such as *woodlands*, *farmland*, and *beach* settings were identified. These became the foundation for the collaborative creation of *model boxes*, which took place during Sessions 2 and 3 across four different locations. Each group of participants worked together on a single model box, bringing their individual and collective ideas to life within a shared, tangible representation of "meaningful places". We collaborated with a *model maker artist* to guide this process to transform the participants' abstract ideas into three-dimensional environments. Each model box was crafted with a base and three walls, resembling a theatre stage.

Figure 4.3: Images from workshop activities

In Session 2, participants began by designing and constructing low-fidelity model boxes, incorporating their chosen themes. By Session 3, they added more detailed elements, personalising the spaces with artwork and props that represented their interests, such as pets, trees, or gardening tools. The model maker and facilitators provided technical guidance, while also encouraging meaningful conversations about the participants' creations, deepening their engagement with the process.

Many of the participants' ideas were more symbolic than literal, this reflected their personal memories and present emotions through colour and texture, rather than through exact replication. In this study, this concept is referred to as **abstract representations**, these creative forms are imbued with meanings or feelings, even without directly reproducing the exact scenes. This approach allowed participants to express their ideas in a flexible and imaginative way, to communicate what was meaningful to them.

4.2.4.3 Soundscape design - Session 3 & Session 4

In the final phase of the co-creation process, participants collaborated with a sound designer to enhance their *model boxes* with personalised soundscapes, transforming them into immersive, multisensory experiences. Session 3 was shared between continuing the creation of the model boxes and initiating the soundscape design. Participants began by identifying and recording ambient sounds connected to their chosen locations, using these sounds to evoke personal memories and emotions, deepening connections within the group. In Session 4, further exploration of sounds took place, with activities like recreating journeys through forest or water environments using violin sounds and spoken word to inspire movement and expression. Participants were also invited to imagine themselves in environments like “The enchanted forest” or “Under the sea” through guided poetry and spoken word activities. This provided them an opportunity to write and read aloud their creative pieces, which were recorded for inclusion in the final soundscapes. To strengthen the communal experience, a group singing segment was incorporated. Songs like “Somewhere over the rainbow” were sung in different versions, both a cappella and with accompaniment, with participants singing together. These recordings were integrated into the soundscapes, enhancing the emotional and collective aspects of the final virtual environments. The inclusion of singing was meant to create a sense of identity, belonging, and shared memory, reinforcing personhood through collective and individual expression. The sound designer composed a single audio track per environment that consisted of the ambient environmental sounds, participants’ singing, and guided poetry.

4.2.4.4 Model boxes to virtual experiences - Session 5 & implementation

The co-creation phase culminated in Session 5 with a final presentation where each group showcased their model boxes alongside their bespoke soundscapes that was played from a laptop. After this, we thoroughly documented the *model boxes* and their accompanying soundscapes. These materials served as the foundation for developing their immersive versions using the Unity 3D game engine. Our goal was to remain as faithful as possible to the original artwork produced by the participants because the creative process and the personal meanings embedded in their art were central to their sense of identity and emotional connection. Preserving the authenticity of their work in the virtual environment helped ensure participants could recognise and feel connected to their creations during the immersive experience. This approach respected their contributions and reinforced the participatory *designing with*, person-centred nature of the project.

Figure 4.4: Model boxes created by participants were transformed into virtual spaces in Unity

To translate the physical boxes into digital environments, we used Maya 2023 to model the objects and Substance Painter for texturing and colouring. Unity 3D was then used to assemble the digital assets into immersive environments (see second image in Figure 4.4). We carefully referenced photos and image documentation to accurately replicate the proportions of the physical objects, while the participants' original drawings were used as textures in the virtual spaces. We also digitally integrated the final soundscape into the virtual environment to enhance the multi-sensory experience. This audio track was set to automatically play when the participant entered their VR environment, creating an immersive environment that reflected the creativity of their original model box design. To unify the work of the four groups into a cohesive art piece, we connected the four spaces as extensions of a single gallery. When users entered the experience, they began in a lobby (see Figure 4.5), which featured four doors representing the locations of the workshops. Users could select which environment to explore from there. The lobby's design drew inspiration from the tea & biscuit gatherings during the workshops, where participants would come together, share stories, and connect over tea and snacks. This communal atmosphere was mirrored in the virtual space, maintaining the sense of familiarity participants experienced during the workshops.

4.2.4.5 VR immersion – Session 6

After creating the VR environments, the research team organised a Session 6 at all four workshop locations to allow participants to experience the virtual environments they had helped create and to explore their reactions to these immersive spaces. Session 6 began with a reintroduction to the project, where participants were reminded of their work by showcasing the physical model boxes they had previously built. This was followed by an icebreaker activity to re-engage them. Those interested in experiencing the VR environments were invited one by one to a quiet space where the VR setup was introduced carefully to ensure their comfort. Using Meta Quest 2 headsets, participants were immersed in the digital recreation of their group's model box, giving them the freedom to explore by walking around or sitting and observing.

Of the groups, 22 participants chose to engage with VR experience, and 10 of them agreed to participate in follow-up interviews. These semi-structured interviews, lasting between 15 to 30 minutes, were conducted to gather their reactions and insights. Some of the questions explored how participants felt during the VR experience and whether they made personal connections to the virtual environment. For instance, they were asked, *"How does this environment make you feel?"* and *"Does this place remind you of anywhere or anyone?"* (See Appendix C for other questions asked).

It is important to note that participation during the VR immersion session was voluntary and that participants chose to select themselves to try out the technology. This meant that the findings of this session represent the perspectives of those who felt comfortable and motivated to try the headset, rather than all participants as a whole. Although this respected personal choice, it may have biased the results to individuals who have more positive views toward new creative technology. To mitigate this skew, we complemented participant interviews with researcher observations, which offered additional perspectives on engagement, including those who chose to not use the headset. This provided a more balanced interpretation of the outcomes from this session.

4.2.5 Data collection and analysis

In our data collection, we adopted a flexible, experience-centred approach rather than a rigid methodological framework. Aligned with the third wave of HCI [119, 79, 28], this approach acknowledges the importance of situated action and the phenomenological nature of interactions. Our focus was on the lived experiences of participants and the relational dynamics that emerged throughout the co-design process. Through this, we allowed participants to shape the process organically, ensuring the technology supported their personhood rather than compensating for cognitive decline.

During the workshops, observational notes were systematically taken to document participants' emotional and creative expressions, as well as their interactions with facilitators, peers, and the artistic or virtual environments. These observations were complemented by audio recordings, which captured verbal contributions and discussions during both the workshop sessions and the semi-structured interviews, which were later transcribed for detailed analysis. Additionally, occasional photographs were taken to visually document the creative process, the artwork produced, and participant engagement. These photographs were used to contextualise the discussions and provide visual references during analysis. Altogether, these materials — transcriptions, observational notes, and photographs — formed the primary data set for analysis. For data analysis, we employed reflexive thematic analysis (RTA) [31, 32], a flexible method well-suited for capturing the complexity of participant experiences and integrating multiple data sources. Consistent with the principles of RTA, which emphasise reflective engagement rather than rigid procedural adherence [32], we intentionally did not seek inter-coder reliability. Instead, we embraced our own perspectives and assumptions throughout the process, recognising that our interpretations were shaped by our roles as researchers. This approach allowed us to focus on participants' subjective meanings and emotional responses, which was crucial given the deeply personal nature of the project. To complement this, we applied the *critical incident technique* (CIT) [90, 265] to identify significant moments during the workshop. CIT enabled us to pinpoint key shifts in engagement, creativity, and interaction, offering deeper insights into how participants responded to the co-design process and VR experiences. These critical incidents illustrated how participants' behaviours, emotions, and interactions evolved, as well as the role of the creative environment and facilitation in shaping these changes. To further contextualise these insights, we crafted *vignettes* – narrative snapshots of specific critical moments – to bring the experiences of participants to life. Each vignette focuses on the experience of a single participant, yet reflects broader patterns and themes observed across the group. Drawing from observational notes, transcriptions, and reflective accounts, these narratives capture pivotal moments that represent shared experiences and key insights from the workshops. This approach foregrounds participants' voices and highlights the collaborative and relational nature of the research process, anchoring our analysis in the lived and emotional realities of the workshop sessions.

A sub-group of three researchers, with backgrounds in HCI, immersive technologies, and dementia care (two of whom were present at the workshops), conducted the analysis. Throughout the analysis stage, we held regular meetings to identify data patterns related to themes such as *agency*, *emotional engagement*, *creative expression*, and *the transition from physical to virtual interaction*. These meetings allowed us to iteratively refine the codes, determining which were most useful for interpreting relevant themes, how they could be grouped by shared meanings, and which could be discarded. Following the initial identification of potential themes, two additional meetings with the wider research team provided opportunities for others to enrich the analysis with their diverse perspectives and experiences. Through this iterative and reflective process, we identified six themes aligned with our research objectives. In a final session with the entire team, we critically discussed and collectively agreed on the final content of the analysis.

4.3 Findings

As outlined in the Section 4.2.5, we used *vignettes* to capture pivotal moments identified through the CIT. Each vignette, written from *the first-person perspective of the researchers*, *focuses on the experience of a single participant* while reflecting *broader patterns observed across the group*. Drawing on observational notes, transcriptions, and reflective accounts, these narratives bring to life the critical incidents where participants engaged with the co-creation process or the VR environments. Following our commitment to focusing on experience as the central object of study [151], and inspired by Collingham et al. [54] and Gamboa [99], the vignettes provide a grounded and relatable entry point into our findings [225]. Each vignette introduces a result theme, offering insights into participants' lived and emotional realities. These narratives are followed by a broader reflection, linking the critical moments to the theme being explored, the wider dataset, and relevant literature.

4.3.1 Caring for identity by anchoring memory and sensory experience in personal landscapes

Vignette 1: Holly adds a lighthouse. *[During the workshop, Holly began by drawing her own version of Woolacombe Bay, not exactly as she remembered it but as she envisions it now. She did not engage much with the collage materials at first, preferring to sketch from her own memory. When shown some shells, she decided to include them in her design to represent the beach. Fond of rabbits, she added a hare in the scene. Finally, she placed a lighthouse overlooking the sea – a feature not part of her original memory, but one she felt belonged to the landscape she was now creating. This blending of memory and imagination stood out to us, as it reflected how memories, even those of familiar places, can evolve and transform in the moment.]*

The workshops often began with personal memories – childhood landscapes, meaningful places, and relationships that had shaped participants' lives. However, as they engaged in the creative process, these memories became a foundation for new ideas (see a selection of collages reflecting this in Figure 4.2). Holly's creative process highlights how personal memories and imagination work together to reframe meaningful places, offering a dynamic connection to identity. Holly's design blended remembered details with imagined elements – like the lighthouse – showing that memory is not a static repository but an evolving construct influenced by present emotions and perspectives. Michael recalled the stream at the bottom of his garden, where he would splash in Wellington boots, watching wildlife. As the art-making process unfolded, his collage became more imaginative, featuring exotic animals. He later wrote onto his collage, "Where is Michael?" suggesting a deeper reflection on his identity and sense of self as dementia shaped his experience. Abby recalled the garden where she was evacuated during the war as a safe space during childhood uncertainty. Similarly, Adam described his Whitstable garden full of insects and butterflies, a symbol of his lifelong connection to nature and a reminder of loss as the wildlife diminished over time. Other participants focused on places tied to social bonds, such as Penny's memories of Nepal, where she formed deep connections with a community, or Jill's recollections of family holidays on

Cornwall beaches, which celebrated shared joy and togetherness.

Sensory details, particularly sounds, emerged as powerful anchors for these memories. Cowbells from Austrian meadows, seagulls calling in Whitstable, and the hum of supermarket checkouts brought immediacy and emotional depth to participants' stories. For Bertie, the sound of waves and eagles at Walpole Bay evoked feelings of being "cool, free, calm, and happy," while Rosemary associated the noise of children running with pure joy. For Doris, the Norwegian Church in Rotherhithe brought memories of her father playing the organ and Christmas carols sung around a tree. Trevor remembered the bugle from his sea cadet days, and the smell of seaweed, while Penny described the delicate chime of prayer bells. These sensory cues often provided stronger emotional connections than visuals alone, reinforcing the multi-dimensional nature of the meaningful places of our participants.

Many of these sensory and cultural details were deeply tied to participants' heritage, highlighting the need for technological interventions to embrace cultural sensitivity. However, current designs often fail in this regard as shown by Khan et al. [142] in their review, where they report that only 3.5% of dementia-focused technology explicitly integrates cultural contexts. This lack of cultural awareness risks making such interventions less inclusive and less effective for diverse populations. For individuals like Liz, whose memories revolved around Indian ashrams with chattering monkeys, or Amber, who cherished ice skating on Dutch lakes, embedding these culturally resonant elements into sensory-focused technologies could significantly enhance their engagement and emotional well-being.

Technological interventions for people living with dementia should move beyond static memories and generic experiences to embrace the evolving and multifaceted nature of personal narratives. Many current applications, including VR, rely on serene but impersonal settings like forests or gardens [35, 125, 1], which may offer relaxation but fail to engage with the deeper, more personal layers of memory, identity, sensory experiences, and cultural heritage. This highlights the critical need for technologies to incorporate culturally resonant and sensory-rich elements that reflect users' diverse backgrounds, fostering inclusivity and emotional well-being [142]. Personalisation in technological design should leverage sensory triggers – such as sound, touch, and visuals – not only to anchor users in familiar contexts but also to offer opportunities for self-expression and reflection [211, 157]. Whether through immersive VR, tactile installations, or soundscapes, these flexible, multisensory approaches could empower individuals to shape experiences that align with their evolving narratives.

4.3.2 Art as a medium of care for expression and recognition

Vignette #2: Nora is painting a blue sea. *[Nora was not particularly talkative when we first met her, offering only brief responses to questions about a memorable place. But as soon as the collage-making session started, something changed. As her hands moved through the materials, memories began to emerge. She had brought along a postcard of a beach from her home in New Zealand and softly shared how much she missed it. "Nothing will beat the beaches in my country," she said with pride while painting a blue sea. The art activity helped Nora to open up. As she grew more comfortable, her stories began to flow. Creating art provided her with a new way to express herself, blending memory and creativity in ways that words alone could not capture.]*

Art was our primary form of communication throughout the project, helping us connect with participants and build rapport. For individuals living with dementia, verbal communication can often be fragmented or challenging [219], and this was true for many of our participants. Creative activities gave participants a way to share personal memories, emotions, and stories that might not have come up in conversation [168], helping to bridge communication gaps while respecting their individuality and letting them express themselves in their own way. Nora's story in *Vignette #2* illustrates how art can become a powerful alternative to verbal communication, particularly for individuals living with dementia.

Similarly, Liz was initially reluctant to speak much, but as she worked with one of us on creating a Banyan tree model, she gradually opened up, sharing stories of her time in India and her deep connection to nature. This art-making activity was not just about being creative as it opened the door to memories and emotions. It turned the process into a shared experience, where Liz and the researcher worked together, almost like a team, connecting through the act of creating. The playful addition of a clay monkey (see first image in Figure 4.5) – suggested by the researcher, inspired by her stories – made Liz feel proud and remark, *"I'm proud of what we've done."* This also shows the bond which has formed between participant and researcher as a result of the co-creative activities. Through this process, the participants felt seen, valued, and understood, this supporting relational personhood [96]. Interestingly, several weeks later, when Liz returned to try on the VR headset and see her group's final creation, she expressed her disappointment when she did not see her Banyan tree in the virtual world, saying, *"We haven't got anything that we did there... you made a lovely monkey."* Liz's reaction at not seeing the Banyan tree in the final VR environment points to the importance of both the creative process and the final representation in co-designed projects. Undeniably, much of the power of participatory art lies in the shared experience of creation. However, Liz's emotional reaction reminds us that participants also form strong attachments to the tangible outcomes of their creative work. For Liz, the Banyan tree represented a meaningful connection to her past and identity, and at the same time a materialisation of the bond she created with the researcher. The process of creating art enables emotional connection and self-expression, and the final product serves as an important validation of that journey, reinforcing a sense of ownership and representation [170].

Figure 4.5: Assets produced by participants and VR replica of tea and biscuits time.

What became evident during the sessions was that artistic skills did not matter – everyone found ways to express themselves, regardless of ability. While some participants, like Alice, created detailed and elaborate collages, others, like Nora, painted simple images such as a blue sea. The wide range of artistic responses allowed participants to feel comfortable and encouraged creativity without the pressure of artistic perfection. This ensured that no one felt intimidated by their skills, making the art-making process a space for exploration and self-expression.

Beyond serving as a tool for researchers to connect with participants, art also played a vital role in nurturing connections between the participants themselves. Throughout the sessions, participants often shared materials, commented on each other's creations, and reflected on shared experiences. For instance, during one of the sessions, participants began working with natural objects like tree bark, which led to discussions about their love of nature and past outdoor adventures. These moments reflect how shared creativity can stimulate conversations about common interests and experiences, building a sense of community within the group [229]. Art became the common thread linking their diverse experiences, offering a space where they could reflect on their lives, interests, and memories in a collaborative way and make meaningful connections not only with the researchers but also with each other.

4.3.3 Caring across time – balancing past, present, and future

Vignette #3: Bruce's dad. *[During the VR session, Bruce surprised us with a moment of deep reflection. When asked what he might want to experience again, he paused and said, "I'd like to see my Dad again." It was a poignant revelation, a desire to use VR as a way to reconnect with a deeply personal piece of his past. But almost as quickly, his practical side surfaced: "I don't know if that's a good thing, actually," he added, with a trace of hesitation. This tension between longing for the past and guarding against its emotional weight seemed to echo Bruce's character throughout the workshops.]*

The nuanced role of memory in dementia care indicates the importance of engaging with the past, present, and future. While reminiscence can provide comfort and continuity, it must be balanced with activities that foster present engagement and future aspirations to avoid frustration and promote well-being [21, 131]. Our study found that removing the pressure to remember allowed participants to engage more naturally with their memories while also exploring new possibilities.

Engaging participants across temporal dimensions revealed diverse approaches to connecting with identity. Reminiscence brought joy and a sense of continuity, as seen in Michael's recollection of splashing in a stream during childhood. Present-focused activities encouraged creativity and active participation. During the workshops, participants started by recalling memories and then they reimagined them. For instance, Bruce moved from pragmatic survival memories to crafting a surreal, Monty Python-inspired scene. These activities reinforced their sense of agency and belonging [224, 37, 268], showing that creativity enhances engagement and connection in the moment. Looking toward the future brought hope and motivation, demonstrating the enduring importance of aspirations in dementia care. In the VR sessions, participants imagined new possibilities. Richard envisioned a 3D flying simulation after describing flying through the clouds as *"one of the best days I've ever had."* Holly expressed a desire to virtually visit Venice and London. Bruce's wish to "see his dad" demonstrated how immersive technologies can tap into personal memories while inspiring forward-looking aspirations.

Immersive experiences added a new layer to participants' creative journeys, enabling them to move beyond memories explored during the workshops. Tools like VR allowed participants to revisit the past and to actively connect with it in the present, creating emotional and sensory bridges between timeframes [153]. For many, these experiences became a means of navigating time, evoking profound reflections and inspiring future-oriented creativity. Bruce's wish to *"see his dad again"* exemplified the emotional depth of these interactions. Similarly, Richard's description of flying through the clouds as *"one of the best days I've ever had"* highlights the capacity of immersive environments to foster joy and a sense of freedom. These experiences often extended beyond reminiscence, sparking imaginative ambitions, such as Richard's vision to create a 3D flying simulation: *"I'd like to create a flying version of me flying an aircraft above ground."*

These findings indicate the potential of technologies – not just VR but any immersive, creative, or interactive systems – to empower individuals living with dementia to engage with the past while envisioning new possibilities. This approach shifts the focus from static reminiscence to a more dynamic engagement with memory and imagination, providing meaningful opportunities to shape narratives that extend across past, present, and future, as recommended by Basting [21].

4.3.4 Balancing realism and abstraction in dementia-focused design

Vignette #4: Dan's castle and Holly's sky. *[Dan brought a photo of a castle, a symbol of his memories, which became a centrepiece in the group's model box and was later translated into the VR world. As each participant entered the virtual environment, their reactions brought new interpretations. Bruce immediately exclaimed, "Canterbury Tales!" – the VR castle sparking reflections on his past, leading to a deep conversation about architecture and survival. Holly was enchanted by the "lovely sky" and familiar elements, like birds and the castle, which made the experience comforting. Ron, struggling to recognise the castle, recalled a thrilling memory of a double-decker bus ride through the West Gate Towers. Though the castle remained a puzzle for him, the VR brought joy and connection, reminding him of past adventures.]*

Research on memory and perception highlights the importance of both authentic and abstract elements in triggering meaningful engagement with virtual environments [243]. Authentic, realistic elements can anchor a participant in a familiar reality, helping to evoke memories and emotions associated with specific places or events. For example, studies have shown that people tend to respond to certain visual cues or environmental triggers that help evoke autobiographical memory [146]. In our study, participants like Bruce and Ron made these connections when they saw the VR castle, interpreting it through the lens of their own experiences, such as Bruce's reflections on architecture and survival, or Ron's memory of riding a double-decker bus near the West Gate Towers, which look similar to the castle.

However, abstraction plays a key role by creating space for personal interpretation, imagination, and emotional resonance. Abstract elements can be more flexible, allowing participants to "fill in the gaps" with their own memories or emotional responses [65, 195]. The generic VR castle, for example, enabled different participants to associate it with various locations or memories, leading to diverse interpretations. Holly was comforted by the abstract blend of the sky, birds, and castle, creating an emotionally meaningful connection for her. Visual elements like landscapes or the sky are often easier to abstract, as they naturally lend themselves to broader associations. Yet, some abstract elements designed to imitate real-world interactions were less convincing for participants, who expressed dissatisfaction when these elements fell short of their real-world counterparts. This highlighted the importance of ensuring that certain aspects of the virtual world meet user expectations. For example, attempts to mimic realistic object interactions, such as opening doors or picking up objects, sometimes failed to engage participants when they did not function as expected.

This raises design questions about how technologies for individuals living with dementia should be constructed. Should these technology-mediated experiences focus on authentic, realistic elements to anchor participants in familiar memories, or use abstraction to allow for personal interpretation and imagination? Abeele et al. [1] identified digital nature and scenic views as particularly engaging for older adults. In our case, we also leaned toward representing outdoor spaces because these were the environments participants found meaningful in the first session. However, by combining different elements from each participant's memories and translating them into VR, the result was far from a simple representation of the physical world. The final VR experience became something surreal – an unexpected blend of real places and personal memories that did not resemble a true-to-life environment. Despite this, participants still connected with this world in personal ways. This interplay between abstraction and connection aligns closely with Dewey's theory of aesthetic experience [72]. Dewey describes art as a dynamic process that engages the imagination, emotions, and senses, creating a sense of wholeness and continuity. His emphasis on imagination as a bridge between the known and the novel resonates strongly with the potential of personalised technology experiences for individuals living with dementia. Rather than aiming for realism, these technologies could engage users by creating spaces that invite personal interpretation and connection.

4.3.5 Technology for *being and doing*

Vignette #5: For Sofia, ο ήλιος (i.e., the sun in Greek) is magic. *[Sofia was initially hesitant about the VR experience, but with encouragement from her friend and our conversation in Greek (i.e., her native language), she agreed to try it. Her reactions focused more on the immediate sensory experience than the virtual content or its connection to the physical model box. She seemed emotionally stirred by our shared Greek heritage rather than the technology itself. For Sofia, the VR was less about understanding the connection to the model box, and more about enjoying the sensory and aesthetic experience of the moment.]*

The VR experience evoked a range of emotional responses, often rooted in a sense of awe and immersion. In Sofia's case, the technology offered a momentary pleasure, without prompting a deeper connection. Others were similarly drawn to elements like the sun, the sky, or the overall ambiance, focusing on the aesthetic and immediate experience rather than any specific narrative. These moments of being fully present, however brief, carry immense value for individuals living with dementia. They provide opportunities to inspire curiosity and spark meaningful engagement. Studies support this notion, showing that minimal sensory interaction, even when not connected to a narrative, can positively influence emotional well-being in dementia care [89, 54].

While some participants, like Sofia, engaged with VR as a space for simply *being*, enjoying the sensory novelty and aesthetic immersion, others, like Richard, sought opportunities for *doing* [15]. His attention was first drawn to the *"amazing blue sky,"* but soon after, he related it to a personal memory, saying, *"I used to fly like this... the blue sky is lovely."* This initial observation led to a creative impulse as he shared, *"I'd love to do a painting like this, a 3D painting,"* and then asked, *"Do you use special inks?"* He then shared his idea: *"I'd like to make a Christmas scene, in a forest of green conifers with a Christmas tree and white baubles on the end of it"*, which he made sure to communicate it to the carer with a sense of pride after the interview was over. Richard's comment on the *"amazing blue sky"* transitioned into a memory of flying and led to creative action, embodying a form of self-expression. This flow shows how people living with dementia continue to make meaning through relational, social, and embodied contexts, where memories are not confined to an internal process but are actively shaped by their surroundings. Similarly, Ben's appreciation of the sensory aspects led him to express curiosity: *"I would be tempted to search the background, and see what it's all about,"* shifting from passive engagement to an active search for meaning. Jack, too, found value in the novelty of the experience, remarking, *"It made a nice change... nice to experiment with different things,"* reflecting a desire for exploration and new experiences. In each case, the participants moved between aesthetic embodiment, by being immersed in the sensory experience, and cognitive engagement, as they sought deeper connections or new opportunities within the virtual environment.

For some participants, like Holly, the absence of a clear purpose created uncertainty. She remarked, *"It's a bit weird but it's very interesting. Sunny bright place. Nice. So what's meant to happen?"* Once prompted to explore, she began engaging with the environment, suggesting the importance of balancing open-ended sensory experiences with some direction. However, for Debby, even these cues were insufficient, as she expressed dissatisfaction: *"I don't really know what it [the VR art] is meant to be... I'd like to know what I'm looking at in there, and you know, real. It wasn't interesting."* When asked how the experience could be improved, she reflected on her fondness for narratives: *"I do know, I quite liked storyboard things... when I was young, we didn't have television, so what we did was storybooks."*

These varying responses highlight the need to balance technology designed for *being* with that designed for *doing*. While moments of sensory immersion can provide emotional well-being and human flourishing [236, 54, 268, 44, 45, 209], opportunities for purposeful interaction can enhance the experience for users seeking narrative or agency. Designing for dementia care requires flexible environments that cater to both, allowing users to just *be* when they wish while also enabling them to *do* when ready.

4.3.6 Social reinforcement in technology adoption

Vignette #6: Maya's first step, leading the way. *[At first, interest in trying VR remained lukewarm, the VR headset sat untouched. Then, Maya's daughter quietly broke the silence by trying it first. Her excitement was contagious, "That was amazing," she said, her excitement quietly spreading to the others. Soon after, Maya tried the VR herself. Her quiet smile on her face revealing her enjoyment as she shared the moment with her daughter. Gradually others grew curious by her reaction. They hesitated at first, but one by one, they decided to give it a try. Their expressions of wonder were unmistakable, and a few participants even walked around the room with the headset, exploring the virtual world. What began as a typical tea and biscuits gathering had transformed into a moment of shared discovery, where curiosity, not biscuits, became the treat everyone savoured.]*

There was a certain hesitation among the participants in trying the VR. Unlike the art-making activities, where they readily participated, the VR headset was met with some resistance. For some, it was viewed as something that might *"take over the world,"* while others expressed fears of disorientation, discomfort, triggering anxiety, or skepticism about its realism. This led us to adjust our approach, as we decided to introduce the VR experience during the familiar tea and biscuits session for some participants. We hoped the shared energy of the group setting would encourage more organic interactions with the VR experience.

We observed that after Maya's daughter tried the VR headset, her reaction motivated the other participants, demonstrating the role of social reinforcement in encouraging technology adoption. Though Maya's own verbal feedback was minimal, her willingness to engage with VR after her daughter's excitement illustrated how peer influence can break down barriers of hesitation and change perceptions around unfamiliar technologies. On another occasion, Drew, who had initially avoided VR, agreed to try it after a carer briefly encouraged him. He thoroughly enjoyed it, prompting the carer to try it as well. We encountered a similar resistance from Sofia, who only agreed after repeated encouragement from a friend who had tried it. Her friend's positive reaction, along with the researcher speaking to her in her native language, eased her concerns and made the experience less intimidating. This is something we observed repeatedly throughout the project, demonstrating the significance of community and familiar social dynamics in promoting curiosity and overcoming technological anxiety among older adults [156].

4.4 Discussion

This project embarked to explore how VR can be designed to help people living with dementia connect with their identity, strengthen their personhood, and enhance their well-being. We built on inspiring previous work in the area [160, 269, 268, 125, 54], we collaborated with a team of artists, and took a person-centred approach to *create with care*. We began with physical art-making sessions, where participants co-created meaningful places, explored and conveyed their emotions, memories, and experiences in a creative way that words alone might not capture. Through art, participants could visually represent important aspects of their identity, shaping a narrative that was deeply personal and reflective of their life stories. These sessions also facilitated connection – both with themselves and with others. By sharing their creations and stories, participants were able to form deeper bonds with the researchers, caregivers, and fellow participants. The art-making process created a collaborative and social environment, where participants felt seen and understood, reinforcing a sense of belonging and community. These personal creations were then transformed into immersive VR experiences, allowing participants to explore the environments they had designed. This enabled a sense of aesthetic embodiment for some, deepening their engagement with their memories and enhancing the connection between past experiences and present realities.

While the results of this project were largely positive, it is also important to reflect on the moments that also proved less successful. Not every participant engaged in the same way, and some faced barriers that shaped their overall experience. Of the 22 participants who experienced the VR environments, only 10 went on to participate in the follow-up interviews. This difference was not due to negative reactions but rather due to practical factors. The interview sessions were conducted within structured activity schedules, where time constraints along with fatigue and physical room space often limited the availability for additional discussions. Some participants did show signs of tiredness after the immersive session, while others preferred to return to the group activity. Some participants found the headset heavy, the visuals blurry, or the experience confusing. These reactions highlighted the importance of timing and emotional readiness when introducing new technologies to people living with dementia.

Acknowledging these mixed experiences provides a more balanced and realistic understanding of the findings. It reminds us that while immersive VR can open new pathways for engagement, it also introduces physical and cognitive challenges that must be considered in future work. Designing for flexibility, such as offering shorter sessions, lighter headsets, or non-VR participation through screen-based viewing, could help each individual engage in a way that feels meaningful and comfortable to them.

While the novel immersive qualities of VR did play a part in participants' enthusiasm to begin with, the strongest connections seemed to emerge from the personal and creative process that took place in the workshops. Many participants mentioned the details they recognised in the model boxes and placing their own meaning to them. This suggests that personalisation were a key part to emotional engagement, whilst the immersion of VR acted as a powerful but secondary amplifier. The excitement of the immersive technology provided an entry point to interest the participants, but it was the familiarity and art that was within the environments that gave the experience emotional meaning and impact. Future work could build on this by comparing personalised co-created experiences with pre-made VR experiences to better understand how personalisation shapes engagement and find the impact of personalisation over the novelty of immersive experiences.

Through this process, it can be seen that VR holds great potential for engaging individuals living with dementia in new ways, though it cannot be the sole focus of an intervention. VR's immersive qualities can evoke powerful memories and sensory experiences, but on its own, it often falls short of creating a meaningful, lasting impact. The challenge, therefore, is not just about designing a VR experience but rather developing a comprehensive intervention that addresses the limitations of this technology while amplifying its benefits. This intervention should include co-design, creative pre-engagement activities, human support, multi-sensory integration, and post-VR reflection to enhance personalisation and emotional connection. This ensures the technology is part of a holistic, person-centred approach rather than a stand-alone experience. Below,the challenges and successes that were encountered are reflected upon and a series of insights are proposed that can inform the design of such interventions.

4.4.1 Do not disenfranchise people living with dementia in the design of technology

Involving people living with dementia in meaningful co-design activities of VR experiences is key to making sure the technology truly fits their needs and feels personal. This project demonstrated that, despite cognitive challenges, participants showed a strong ability and desire to make decisions, express preferences, and contribute meaningfully to their creative outputs. This participatory approach provided them with a sense of ownership, purpose, and accomplishment, reinforcing their personhood and agency. This aligns with findings from Kontos et al. [155], who noted that individuals living with dementia retain their capacity for creative expression when supported in the right environment. However, to the best of our knowledge, most studies in this space fail to meaningfully involve users in the design process [240], and focus primarily on evaluating the final product or the cognitive abilities of the users. This misses an opportunity to create tools that are both functional and deeply personal [125, 1]. For instance, Hodge et al. [125] reflected on their limited time for true co-design with participants but noted how essential it was to have even a brief, meaningful engagement that informed the creation of a tailored VR environment. Similarly, Abeele et al. [1] compiled guidelines for designing VR environments for people living with dementia based on existing literature, but rather than developing new experiences, they evaluated an existing commercial app using those guidelines. This highlights a gap between theory and practical, user-driven design. As noted by Knowles et al. [152], excluding older adults from tech design leads to missed opportunities for insight and risks creating technologies that do not fit their needs.

While it was initially envisioned that the co-design process was going to be a stepping stone toward creating a technology (in this case, a VR experience), it quickly became evident that the journey itself was profoundly transformative for our participants. The artists' presence and guidance built a safe and supportive environment where individuals felt comfortable expressing themselves and exploring their creativity. Over several weeks of shared artistic endeavours, a remarkable blossoming of confidence, connection, and self-discovery was witnessed. Participants like Liz, initially hesitant, opened up and shared stories as she crafted her Banyan tree. Nora, once quiet, found her voice through vibrant paintings. As researchers, we too were transformed by the process. Our participants became collaborators, offering insights into their needs and perspectives that would have remained hidden in a purely technological or short-term approach. This experience revealed that co-design is not just a means to an end but a vital part of designing meaningful and inclusive technology.

Co-design in dementia research extends beyond the typical goals of promoting ownership and agency by addressing the specific challenges faced by individuals living with cognitive impairments. In our study, participants demonstrated the ability to express preferences and contribute meaningfully, despite these challenges, gaining a sense of purpose and reinforcing their personhood. Unique to this context, co-design creates supportive environments that accommodate non-verbal expression, facilitate emotional connection, and encourage creativity — key needs for people living with dementia. Unlike many studies that focus on pairs (e.g., participant-caregiver dyads) [268, 125], our approach engaged participants in larger groups. This setting built a sense of community and mutual inspiration, as participants could draw on each other's ideas and energy. The involvement of specialists, such as artists, was crucial in demonstrating competence by bridging gaps left by traditional, verbal approaches, enabling participants to share emotions and memories in alternative ways. By integrating co-design into the technology development process itself – rather than treating it as a preliminary step – this study demonstrated its capacity to build trust and responsibilities through tailored activities, and creative engagement. Thoughtful projects that engage users over extended periods [269, 268, 125, 160, 192, 228] reinforce the importance of designing with responsiveness to participants' evolving abilities and involving specialists in delivery. To advance these practices, we propose creating a centralised, accessible library of documented co-design projects. This resource could provide concrete examples of tailored activities, strategies for data collection, and shared challenges, equipping researchers and designers with the tools to navigate the complexities of co-design with vulnerable populations.

4.4.2 Building trust takes time but it is essential for creating with care

Trust was a cornerstone of this project, shaping the success of both the process and the outcomes. Collaborating with a specialised arts organisation allowed us to prioritise meaningful engagement and creative expression while also streamlining recruitment and selection. This freed us, as HCI researchers, to focus entirely on facilitating the art-making process and ensuring participants felt comfortable and willing to immerse themselves in the activities.

A strong foundation of trust, built over time, was key to overcoming initial hesitations. Many participants were reluctant to try VR or found aspects of it physically or emotionally uncomfortable. Complaints about the weight of the headset, visual disorientation, or the inability to see their own feet highlighted the challenges of adapting technology to users' needs. Others expressed apprehension about using unfamiliar tools, fearing they might be judged or laughed at. In these moments, the trust we had established became crucial. Having a trusted facilitator to guide participants through the VR sessions, explain what to expect, and offer reassurance during moments of uncertainty made a significant difference. This aligns with findings from Kontos et al. [155], emphasising the importance of relational engagement in dementia care.

The involvement of artists further reinforced this trust. Artists from various disciplines – storytelling, sound design, visual arts – helped participants translate abstract ideas into tangible outputs. For example, a sound designer worked with participants to create custom audio, such as bird sounds or personal music preferences, which were then integrated into the VR environments. These personalised details not only enriched the virtual worlds but also strengthened participants' sense of connection to the process. Visual artists helped participants bring abstract ideas like "a happy place" or "a childhood memory" to life through models that were later recreated in VR. While this professional involvement was important in establishing trust and producing high-quality deliverables, it also introduced the practical challenge of cost. The artists involved in this project were paid professionals, which is unlikely to be feasible in every care context. However, participants' existing trust with their caregivers suggests a possible path forward: lighter, adapted versions of the method, where care staff are supported with training or creative toolkits to facilitate similar expression as the project. This way, the principle of co-creation can remain without relying on costly professional involvement.

This approach demonstrated how trust, combined with interdisciplinary collaboration, could unlock deeper engagement and emotional expression. Over several weeks of shared artistic activities, participants became more confident and expressive, developing connections that would not have been possible in a shorter-term project. At the same time, only a single VR testing session was held, so this raises the question of novelty versus sustainability. It is possible that some of the feedback was influenced by the novelty of the experience rather than a long-term pattern of engagement. Many established creative activities in dementia care, such as music, reminiscence, or art therapy, are sustained through consistency that continue to offer meaningful outcomes. Co-creation of model boxes might seem difficult to repeat at a large scale, but the underlying concept of collaborative creation does not rely on building new artefacts each time. Lighter or adapted versions such as smaller creative tasks or revisiting an existing box could retain the sense of authorship without becoming tedious. This reflection complements the emphasis on trust, as trust builds gradually, it is important to consider how engagement with immersive environments evolves after the first encounter. Care ethics, as articulated by Tronto [257] and Held [121], emphasises attentiveness, responsiveness, and relational engagement – principles that are particularly vital when working with vulnerable populations. In the context of our project, trust-building activities, such as facilitation by familiar and supportive facilitators or artists, embody these principles of care. They prioritise participants' comfort and sense of agency, creating an environment where individuals feel safe to express themselves and engage with the process. Trust as a form of care can help future researchers and designers show how important it is for meaningful collaboration and co-design, especially when working with the complex needs of individuals living with dementia.

4.4.3 Art can take one places

Throughout the project, art was central – not just as an outcome but as a method. Participants were involved in the creation process from the beginning, shaping the environments they would later explore in VR. It is known that art has a powerful impact on our emotional and cognitive well-being. Research shows that both creating and experiencing art are essential to being human — they allow us to express ourselves, release emotions, and reflect on our identities [72, 29]. Unfortunately, people living with dementia – some being in care homes – have fewer opportunities to access art. Care environments often focus on practicality, leaving little room for creative or sensory experiences. There is also a misconception that art might not be relevant for people living with dementia, or that cognitive decline diminishes the value of engaging with art [39]. Thankfully, initiatives from Collingham et al., [54] Wallace et al., [269] and Lazar et al., [160] are changing this, showing how much impact sensory-rich aesthetic experience can have in care homes, helping residents reconnect with memories, emotions, and creativity, even in the later stages of dementia.

Our project builds on this work and shows technologies such as VR can be a powerful tool for sensory and artistic engagement. It felt rewarding to watch participants create and then connect with VR worlds that reflected their own artistic visions. The VR environments that were created, prompted different reactions from participants. For Richard, it inspired artistic expression – the vivid blue sky reminded him of his flying days, and he became motivated to create a 3D Christmas painting. Sofia, on the other hand, found emotional comfort in the soft light and soothing bird sounds, which gave her a moment of peace and calm. Jack saw the VR experience as a chance for exploration and discovery, enjoying the novelty and finding excitement in trying something new. These varied reactions show that sensory-rich and interactive technologies offer much more than just a digital experience. They create spaces for self-expression, comfort, and exploration. What sets immersive technologies apart from traditional art is their ability to *be inside*, to immerse participants in the artwork, allowing them to interact with the environment [182]. Just as musicians experimenting with different virtual spaces find that the environment itself shapes their creative output [208], our participants' experiences were deeply influenced by the sensory and spatial qualities of the VR worlds they entered. This kind of active participation gives people a sense of control and independence, which can be especially empowering for those facing cognitive challenges.

4.4.4 Personalisation and customisation in dementia care design

One of the key insights from the study is the distinction between personalisation and customisation when creating meaningful experiences for people living with dementia. In the earlier feasibility study (see Chapter 3), caregivers engaged primarily in co-curation, where they collaboratively select and arranging existing VR videos rather than producing new content. This represented an initial step in understanding how caregivers interpret what may be meaningful for those they support.

Customisation refers to tailoring a design to an individual's specific needs or preferences, often requiring significant resources and one-to-one effort. In contrast, personalisation, as observed, can emerge dynamically when shared environments are designed with flexible, multi-sensory elements that allow users to connect with what resonates most for them. Personalisation here is not about pre-defining an experience for each participant but enabling them to interpret and shape the experience in ways that feel personal.

In the study, customisation was evident in moments where participants' individual inputs directly influenced the design. For instance, elements like Holly's lighthouse, Ron's recollections of a bus ride, or Bruce's request to see his feet in VR were integrated into the virtual world based on their specific contributions during the workshops. Personalisation, however, extended beyond these customisations to encompass how participants engaged with shared environments. Participants in our VR sessions interpreted the same digital spaces differently, drawing from their memories and preferences. This reflects what Gaver et al. [106] term interpretive flexibility, where users make meaning through their own associations. For instance, while one participant associated a VR castle with the Canterbury Tales, another recalled a double-decker bus ride, and a third found comfort simply in observing the birds and the sky.

In the study, personalisation was achieved by incorporating multi-sensory elements, that participants could engage with, in ways that resonated with their personal histories. These flexible elements gave them the freedom to connect with whatever parts of the environment mattered most to them, showing that personalisation can come through sensory engagement rather than direct customisation. By giving individuals the space to project their own stories onto the experience, a deeper, more personal connection was created without needing to design specifically for each person.

This distinction also reflects a broader methodological progression across this thesis, from co-curation (guided selection) to customisation (individual adaptation) and finally to personalisation (interpretive meaning-making). The distinction between customisation and personalisation has important implications for technology design, particularly in dementia care. Customisation can address specific individual needs, while personalisation through interpretive flexibility enables richer, more inclusive engagement. By designing environments that balance these approaches, incorporating shared spaces rich enough to support diverse interpretations alongside individualised elements, designers can create meaningful, empowering experiences for people living with dementia.

4.4.5 Give it a body! Anchor the self in the world

One aspect that was not initially considered in designing VR for people living with dementia was how their physical bodies would or would not align with the virtual world. While this typically does not affect most users, it proved to be an issue for some people living with dementia that participated, sometimes causing disorientation and discomfort. During one session, Bruce looked down and, seeing nothing where his feet should be, said, *"It's weird. I know my feet are there, but they've disappeared."* This disconnect between what he felt physically and what he saw in VR caused a sense of disorientation, and he was not alone. Other participants also experienced confusion, particularly when the virtual environment did not align with their bodily sensations. Although these sensory mismatches are a well-recognised challenge in VR generally, their impact appeared amplified in our context, highlighting how pre-existing spatial difficulties in dementia can intensify these reactions.

This reaction reflects something deeper: embodiment [213] – the idea that the ability to think, perceive, and make sense of the world is closely tied to the physical human body. In virtual environments, embodiment is formed by the congruence between what the body feels and what is visually seen. A misalignment in this connection, such as the absence of limbs or latency between movement and response, is a well-documented challenge in VR that can affect any user [241, 143, 244]. These incongruences often lead to disorientation or reduced presence. When the virtual world breaks that connection, the effects can be particularly significant for individuals living with dementia, who may already experience cognitive difficulties.

A sense of self is often rooted in physicality, not just through seeing one's body in an environment but also through physically engaging with it. Activities like art-making, where participants use their hands to shape, paint, or build, reinforce this embodiment, offering a tangible way to connect with their sense of self through physical action.

To create more accessible and comfortable experiences, whether mediated by technology or through hands-on creative activities, ensuring bodily continuity is important. Features that reflect or respond to participants' physical presence – such as tools that incorporate hand gestures, tactile responses, or visible bodily representations – can help users feel anchored and reduce feelings of disconnection. This principle aligns with the broader theory of embodied cognition, which has long emphasised that perception, thought, and a sense of self are grounded in bodily experience with the environment [184, 193, 108, 100, 51, 20]. In the context of immersive environments, this view has been further developed by Riva et al. [214], who emphasises that maintaining a sense of bodily connection is key to feeling present and immersed within virtual environments. Misaligned sensory inputs or a lack of physical engagement can disrupt this connection, as was seen with Bruce's reaction. This approach also supports person-centred care, helping individuals feel secure and connected to both their physical and virtual surroundings. Whether through designing physical tools for hands-on creative expression or ensuring that sensory cues align in digital tools [58], the goal should be to activate a sense of agency and accomplishment through physical engagement [39].

4.5 Limitations

While this study produced promising results in enhancing emotional well-being and personhood through co-design and virtual reality, several limitations must be acknowledged. These factors could influence the generalisability of the findings and point to areas for improvement in future research and application.

- *Focus on specific stages of dementia:* Most participants were in early to mid-stages of dementia, which may not fully reflect the needs and abilities of individuals in later stages of the condition.

- *Data collection methods:* The qualitative nature of the data collection was often messy and fragmented, with participants' cognitive challenges making it difficult to capture consistent responses or fully structured feedback, which impacted the clarity and completeness of the findings.

- *Novelty from limited VR exposure:* Participants only experienced the VR environments once, reported enjoyment may have been influenced by novelty, which restricts understanding of long-term engagement and potential benefits of sustained use.

- *VR participation and recruitment:* Engagement with the VR experience was based on self-selection, meaning not all participants chose to take part. This reduced the comprehensiveness of the findings and may have introduced confirmation bias, as those who volunteered were likely more open to creative or technological activities. This might cause the data to be skewed towards positive engagement, potentially overlooking barriers to adoption that some individuals may face who were less motivated to try VR.

4.6 Conclusion and future work

This study began seeking to create VR experiences for people living with dementia. Yet, through the process and the people who shared their stories, what truly mattered is not just building technology, but creating with care. Co-design and art became more than methods – they became vessels for self-expression, connection, and relational care, inviting participants to weave memories and emotions into the present, in ways that deficit-based models cannot hold.

These findings show the need to shift from technology-driven approaches to care-centred co-design, prioritising emotional well-being, creativity, and inclusivity. While this work captures only a fraction of that journey, the richness and sensitivity of these experiences cannot be fully conveyed through traditional academic outputs alone. This work encourages future research to explore alternative ways of presenting and engaging with this kind of deeply human data, ensuring that the voices and stories that emerge through co-design are represented with the depth they deserve [279].

Chapter 5: Design directions

5.1 Introduction

5.1.1 Purpose of the chapter

This chapter explores future immersive design directions tailored for people living with dementia. Building on insights from the previous studies reported in chapter 3 and chapter 4, and the challenges identified in traditional and immersive dementia interventions, the proposed concepts in immersive technology strive to create meaningful experiences that promote emotional well-being, encourage social connection, and support cognitive and sensory engagement, therefore supporting personhood. The chapter highlights the creative and methodological process involved in conceptualising these designs and their potential impact on dementia care.

The design directions presented in this chapter result from a creative synthesis of user-centred principles, insights from prior studies, and the integration of diverse features found in the work conducted in the thesis and also in literature, such as reminiscence, sensory stimulation, and shared experiences. Each design offers solutions that range from improving memory recall to providing calming, multisensory environments. The chapter is structured to introduce each design concept in detail, including its purpose, key features, and potential opportunities. By examining these directions, the chapter seeks to provide a roadmap for future immersive technology development in dementia care, emphasising the potential for personalised, impactful interventions that address users' emotional and practical needs.

5.2 Methodology for developing design directions

5.2.1 Inspiration and framework

The design directions presented in this chapter are deeply rooted in the insights gained from the prior two studies conducted as part of this thesis. The studies provided a deep variety of information on the unique challenges, preferences, and needs of people living with dementia, which served as a foundation for developing immersive experiences tailored to this population. Through addressing these key insights, the design directions aim to provide inspiration for technology design that overcomes the limitations of previous approaches while enhancing engagement and quality of life.

One of the most significant barriers identified in the previous chapters was the difficulty in obtaining reliable verbal feedback from people living with dementia. In the first study, while participants engaged with VR videos, many struggled to articulate their preferences or emotions during and after the sessions, particularly those in the later stages of dementia. Similarly, in the second study, while participants could express their opinions when creating physical model boxes, there were notable gaps in communication, especially when it came to nuanced emotional responses. The communication barriers highlighted the need for design directions beyond reliance on traditional verbal feedback. Informed by the challenges of measuring engagement in people living with dementia, the beginning of this third study was initially aimed to analyse physiological signals (e.g., heart rate, electrodermal activity, temperature) as potential indicators of engagement during different activities. Preliminary data was collected and analysed, but the data showed no statistically significant differences between the activities that were tested. This lack of clear findings may have been due to several factors, such as participants not fully absorbing the activity content in ways that influenced their physiological responses, and the analytic methods applied at the time may not have been optimised to detect the subtle patterns that participants elicited. With more time and resources, deeper analysis could have been carried out, potentially revealing more significant readings.

Because of these challenges, the study was put to aside, as pursuing it further within the time frame of this PhD risked not showing the more user-centred contributions of the research. Although physiological data hold promise, it cannot be solely relied upon. Future research could revisit this route with larger datasets and refined algorithms, to find significance in physiological responses and ensure they reflect the meaningful engagement from those living with dementia. For this work to provide useful data in the future, procedures should include repeated exposure to activities rather than single trials, whilst also applying more advanced analytic methods in order to capture subtle patterns amongst and within participant data. Using this perspective of approach, physiological measures could act as a quantitative assessment of engagement for those living with dementia.

Nevertheless, this study was valuable. It highlighted the need for approaches that are less dependent on complex data analysis and more focused on user-centred design. This insight led to design directions emphasising observable behaviours and interactive engagement as user experience indicators. Whilst physiological data remains a valuable avenue for future exploration, the designs proposed here focus on creating immersive environments that would benefit various areas of dementia care.

Throughout the previous studies, participant behaviours and feedback consistently underscored the importance of familiarity and personalisation in VR experiences. In Chapter 3, participants responded positively to content that resonated with their personal histories and interests. In Chapter 4, the physical model boxes created by participants often reflected elements of their past, such as favourite places or cherished objects, demonstrating the significance of reminiscence and familiarity in building engagement. Caregivers and family members frequently emphasised the value of activities that encouraged emotional connection and provided a sense of comfort. These findings inspired design directions prioritising on the user rather than the feasibility of technology, allowing users to co-create or interact with immersive environments that reflect their unique identities. By incorporating features such as life story narratives, cultural elements, and adaptive content, the designs aim to create a more profound sense of connection and emotional well-being.

5.2.2 Selection of key features

The design directions proposed in this chapter are grounded in a set of **12 key features**, each carefully selected for their potential to address the needs and preferences of individuals living with dementia based on the findings from the user engagement studies, including the feasibility study mentioned in Chapter 3 and the model box study mentioned in Chapter 4. By combining features in different ways, the design directions address a broad spectrum of user needs, from relaxation and reducing anxiety to enhancing social connection and promoting cognitive engagement. This method of feature selection allowed the design concepts were diverse and adaptable to be applicable in the real-world.

Here is a brief explanation of all the features followed by a summary of features categorised into different groups in Table 5.1

5.2.2.1 Personal and emotional connection

- **Memory recall**: Activities or environments that evoke past memories, such as familiar places, sounds, or objects. Reminiscence has been shown to reduce stress and improve mood in individuals living with dementia by reconnecting them with their personal history. Throughout the studies, many moments of memory recall occurred organically, often triggered by unexpected connections. During VR sessions, some participants began reminiscing about their family members, and others unlocked memories of past holidays when experiencing a beach scene or even from talking with caregivers. These findings highlight that memory recall is not solely dependent on visual accuracy, but can be stimulated by sensory cues and emotional connections. Immersive reminiscence experiences do not need to exactly replicate past events but rather provide rich and engaging environments that encourage spontaneous reflection and connection to personal history.
- **Life story and narrative**: Interacting with personalised elements that reflect the user's own life story, like a virtual scrapbook or memory timeline. This strengthens identity and provides an opportunity for storytelling, which is both cognitively

stimulating and emotionally fulfilling. During our model box study, participants were able to contribute pieces of their own story, memories that they cherished. The act of creating the model boxes itself became an event to remember, much like scrapbooking. The process of building and sharing these memories was not just about reflecting on the past, but about actively shaping a narrative, turning it into a shared, meaningful experience. This highlights how storytelling tools in immersive technology can serve as both a reflective and generative experience, offering individuals living with dementia not just a window into their past, but an opportunity to create new, cherished moments in the present.

- **Cultural and personal significance**: Integrating culturally relevant themes or personal identity markers to create familiar and meaningful immersive experiences. The familiarity and cultural resonance help users feel more comfortable and engaged in the virtual world. This was evident in Sofia's interaction with researchers, she was initially reserved and distant, but upon discovering a shared language connection, she became more interactive. This shift in engagement highlights the importance of cultural familiarity in building trust and creating a sense of belonging, making her more comfortable in exploring the immersive environment. By incorporating familiar cultural elements, immersive experiences can help individuals living with dementia feel at ease and encourage active participation, ultimately making immersive technology more inclusive.

5.2.2.2 Sensory and cognitive stimulation

- **Multisensory stimulation**: The benefits of integrating an immersive experience allows the addition of sound, visuals, touch, and potentially smell to fully engage the senses all in one setting. This helps create a more immersive experience, particularly for users with limited cognitive or verbal abilities. This was evident in the workshop when Liz interacted with the section of tree bark, where the touch and smell of the bark triggered deeper memories, allowing her to share more in-depth stories than she initially had. Combining sensory elements can unlock richer storytelling and engagement, making immersive experiences more meaningful and interactive for individuals living with dementia.

- **Physical interaction**: Encouraging movement through gestures or interaction with virtual objects to engage motor skills and provide tactile feedback. This focus promotes physical activity, which is beneficial for overall well-being, and increases engagement. Many individuals living with dementia are eager to engage in hands-on activities, as observed during collage-making and physical model box creation. This enthusiasm for interactivity extended to VR experiences, where participants did not hesitate but instinctively wanted to walk and explore the virtual environment. Physical interaction in immersive environments may provide a smooth transition between real-world activities and immersive experiences, allowing individuals to engage in familiar movements in an unfamiliar context. By designing immersive environments that incorporate tactile engagement, immersive technology can serve as a natural extension of real-world activities.

- **Problem-solving and cognitive stimulation**: Light puzzles or cognitive tasks designed to stimulate mental activity without inducing stress. This can support cognitive stimulation, which can help maintain mental sharpness and engagement. For some participants, passively observing an experience was not engaging enough, as Debby expressed whilst viewing their model box, saying "*I don't really know what it [the VR art] is meant to be... It wasn't interesting*", showed the experience lacked purpose. This suggests that different users may require more proactive stimulation, that provide a sense of engagement and direction. Light cognitive challenges could help sustain interest by encouraging active participation rather than passive observation.

5.2.2.3 Social connection

- **Shared experiences**: Allowing participants to engage in immersive activities synchronously or asynchronously, to promote social connection. This can build a sense of community, reduce isolation, and enable bonding moments with family or peers. As observed when Maya's engagement with VR encouraged others to try it, seeing a peer interact with the headset reduced hesitation and created a ripple effect of engagement. This highlights how shared experiences break down barriers, making new technologies feel less intimidating and more accessible. By integrating group-based immersive activities, immersive technology can serve as a social catalyst, transforming immersive experiences from an individual activity into a communal experience for collective participation.

- **Family and caregiver interaction**: Providing opportunities for caregivers and family members to participate in, or customise immersive experiences. This can enhance collaboration between users and their caregivers, strengthening emotional bonds and improving the care giving experience by understanding what users need most. Beyond improving engagement for individuals living with dementia, immersive experiences can also positively impact caregivers by influencing caregiver motivation and job satisfaction [137]. This increased motivation and sense of accomplishment can enhance the quality of care giving. As a result, caregiver involvement using immersive technology as a medium is not just beneficial for individuals living with dementia, it also contributes to a more motivated, and compassionate care giving environment.

- **Virtual companions**: Interactive avatars or virtual pets that provide guidance, comfort, and companionship during the immersive experience. Some participants may feel overstimulated or uncomfortable during human interactions. This can reduce feelings of loneliness and builds trust in immersive technology. During the feasibility study, staff feedback reported that participants expressed a preference for videos that included verbal narration (e.g., narrated tours), pairing with participants in Section 3.4 that preferred if caregivers let them to be fully immersed in the virtual environment. Having a virtual companion would provide gentle guidance that could enhance user interaction, making immersive environments feel less isolating without distraction. Beyond this, virtual companions also address a practical challenge in dementia care environments, where care staff often have limited time for interactions with residents. A virtual companion in an immersive environment could ensure that individuals receive consistent interaction even when staff are occupied.

5.2.2.4 Creativity and exploration

- **Exploration and discovery**: Creating opportunities for curiosity-driven activities, such as exploring virtual landscapes or discovering hidden elements. This was reflected in the experience of one participant, who described the VR model box environment as "*not invasive but relaxing, it would tempt me into searching further*." This response highlights the virtual environment encouraging the desire for gentle exploration, where it can provide a calm yet engaging space for the curiosity of individuals living with dementia, creating a sense of adventure and reinforce autonomy.

- **Creative expression**: Providing tools for drawing, building, or crafting mixed within the immersive experience. This can encourage self-expression and for those living with dementia, to share and express their feelings in the form of art, which enhances emotional well-being and provides a sense of accomplishment. The value of this feature was reflected in Nora's experience during the workshops, where she had previously spoken very little in social settings. However, when given the opportunity to draw and create art, she became more engaged and verbal, sharing thoughts and stories.

5.2.2.5 Engagement feedback

- **Assessing engagement**: Tracking physiological or behavioural responses (e.g., eye-tracking, heart rate) to evaluate which immersive elements resonate most with users. This feature would help caregivers and designers understand what users find meaningful, enabling personalised adjustments, even without being already familiar. This is particularly useful in dementia care contexts, where researchers and designers may not have the opportunity to develop a relationship with the user beforehand. This is based from the previous studies, where verbal communications with some participants were minimal and was unable to gauge their engagement, this highlights the potential for biometric tracking or behavioural analysis to provide objective insights into user engagement.

Category	**Feature**	**Reason for inclusion**
Personal and emotional connection	Memory recall	Encourages reminiscence and emotional engagement.
	Life story and narrative	Strengthens identity through storytelling.
	Cultural and personal significance	Adds familiarity and emotional resonance.
Sensory and cognitive stimulation	Multisensory stimulation	Creates immersive, engaging environments.
	Physical interaction	Encourages motor skills and tactile engagement.
	Problem-solving and cognitive stimulation	Provides light cognitive stimulation.
Social connection	Shared experiences	Builds community and bonding.
	Family and caregiver interaction	Strengthens caregiver-user collaboration.
	Virtual companions	Reduces loneliness and builds trust.
Creativity and exploration	Exploration and discovery	Encourages curiosity and autonomy.
	Creative expression	Provides opportunities for self-expression.
Engagement and feedback	Assessing engagement	Tracks physiological and behavioural engagement.

Table 5.1: Features and their reasons for inclusion across different categories

The final design directions represent creative creations of these prioritised features. By combining features in meaningful ways, each direction is tailored to achieve specific beneficial outcomes while keeping people engaged. On one hand, they focus on delivering enriching activities that bring enjoyment, curiosity, and fun. On the other hand, they offer supportive benefits such as potentially reducing stress, alleviating loneliness, and enhancing overall emotional well-being.

5.2.3 Creative process: a morphological approach

Immersive experiences were designed for individuals living with dementia with a balance between systematic structure and creative exploration. With inspiration using *Morphological Analysis* [7], a structured problem-solving method that breaks down complex systems into fundamental components, allowing for innovative recombination of features. This approach allowed generation of design concepts that were novel and beneficial.

To develop immersive experiences tailored to dementia care, I used the 12 core features drawn from the findings in Chapter 3 and Chapter 4 as building blocks to start these ideas from (see Table 5.1).

Morphological Analysis: I applied a randomised feature combination to explore unexpected synergies. This process involved selecting three random features from different categories, ensuring each concept combined distinct elements. This technique forced novel pairings that might not have been intuitively selected together. (See Figure 5.1 for a graphical display how the random selection resulted in different designs.) In this study, I opted to randomly selected three features for each combination instead of only using two features which could risk producing overly simple or obvious connections, leading to ideas that felt less exploratory. By contrast, combining four or more features might introduce too much complexity, making concepts harder to refine into clear and feasible directions. Selecting three created a balanced level of complexity, enough variety to create unexpected synergies of ideas, but still manageable for analysis and development into interesting design directions. Each combination was brainstormed and refined, ensuring that feature combinations resulted in meaningful intent rather than random connections.

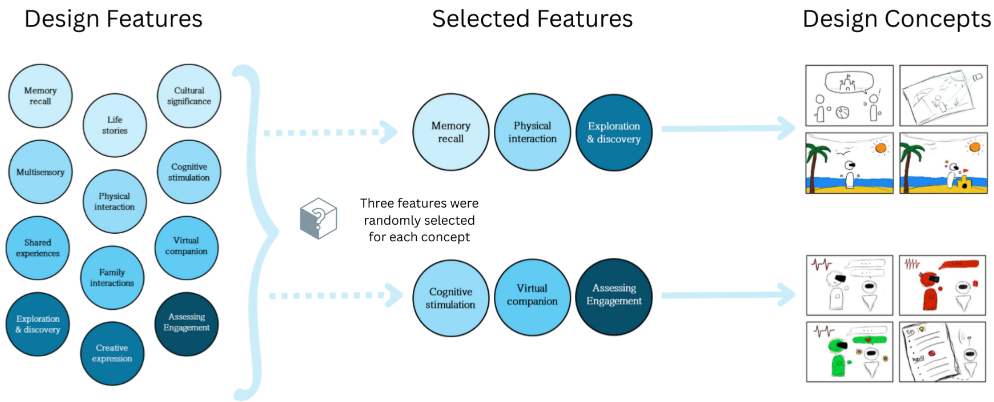

Figure 5.1: Morphological analysis process. From the full set of design features (left), three features were randomly selected (middle) to generate novel design concepts (right)

Evaluation and selection: Following the initial ideation phase, the concepts underwent an evaluation and selection stage, where ideas were discarded or reworked based on their practicality or alignment with dementia care. Ideas that lacked strong meaningful interaction were reconsidered to ensure that each design direction made use of immersive technology. Concepts that were passive or overly simplistic, providing not much more than a traditional screen-based experience, were removed in favour of those that enhanced presence and sensory engagement. Additionally, ideas that did not align well with dementia-specific needs, such as those that lacked clear benefits, were refined to ensure relevance and impact. At this stage, the process was researcher-led, concepts were iteratively reviewed and refined in supervisory meetings, where we considered technical feasibility, relevance to dementia, and novelty of each idea that was built on the twelve design features identified earlier. A full look of these initial design sketches, with green-marked concepts that were selected and red-marked concepts that were discarded, can be found in Appendix D (see Figure 3).

Refinement and synthesis: After generating initial ideas, the brainstorming moved to a synthesis phase, where concepts were refined and iteratively improved. Concepts were then sketched as storyboards to visualise user interaction and progression within the immersive experience. Rather than involving field experts directly in this phase, refinement came from the methodological structure of the morphological analysis and the discussion amongst the supervisory team. Insights from earlier studies, including feedback from staff and participants, helped indirectly shape this stage by supporting the speculative directions from the previous lived-experience data. We then discuss the plausibilities, opportunities, risks and make relevant connections within the scope of dementia care.

5.3 My design contributions

In this section, I will present several ideas that I have carefully designed, through the help of randomising the features gained from the prior two studies.

1. *MemoryScape*: An immersive experience developed from personal pictures.
2. *ImagineScape*: An immersive art experience, making creations come to life.
3. *Cultural Touchstones*: An immersive experience of home, far from home.
4. *Comfort Guide*: A virtual friend for comfort, clarity, and care.
5. *Waypoints AR*: Enhancing life through moments remembered and yet to come.

There will be a basic overview of each idea, why and who it is designed for and what an example scenario would be, this is presented as a story of several imaginary characters in the following sections. I discuss the technical plausibility of these ideas and then look into possible opportunities that could arise from this initial idea and list potential pitfalls and ethical responsibilities that may also come from these with potential solutions to mitigate this. To further strengthen these design directions, relevant literature is integrated to contextualise how each concept is relevant and ensures that each idea is not only innovative but also aligned with evidence-based approaches in dementia care.

The following example scenarios will be accompanied by a visual storyboard which are intended as supportive conceptual illustrations rather than fully resolved design proposals. They serve to communicate the core interactions, emotional logic, and intent of each concept, rather than detailed technical specifications. Each storyboard visually summarises how the proposed system might mediate engagement, memory, or creative expression, offering a foundation for future development and evaluation. The simplified sketch format reflects the exploratory stage of this research, where clarity of concept took priority over detailed visuals.

While the design directions in this section are informed by earlier findings, they have not yet been evaluated directly with stakeholders, such as those living with dementia, caregivers or staff members. These concepts should therefore be viewed as speculative design ideas intended to initiate discussion and inspire future evaluation of immersive technology in dementia care.

5.3.1 MemoryScape

Overview: *MemoryScape* is a VR application that transforms personal photos into immersive 3D environments using AI. The application allows users to explore memories in virtual space by reconstructing scenes from images and interact with the environment. The system focuses on automated scene generation, making it accessible for caregivers and families looking to create personalised memory spaces without extensive manual setup.

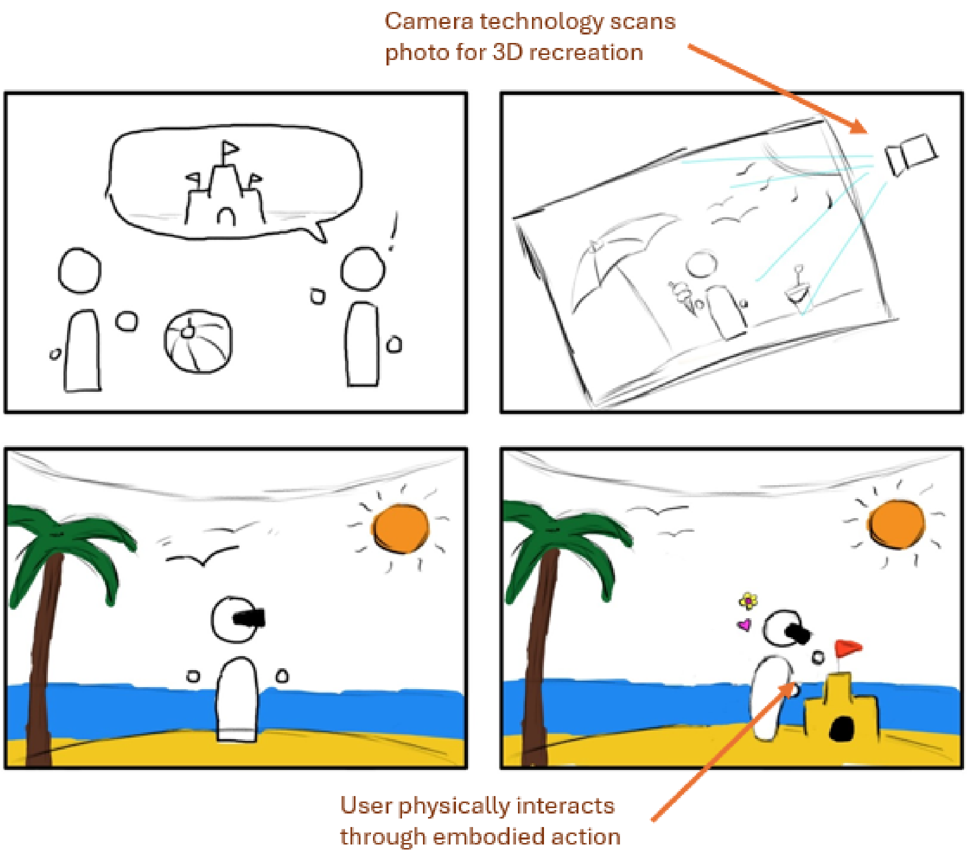

Figure 5.2: MemoryScape

How it works: *Imagine Margaret, a 78-year-old woman living with dementia, she participates in a local reminiscence therapy session where Emily, their therapist, guides her to talk about their past based on the theme of the day.*

1. **During the session:** The therapist brings out a beach ball to the session themed around summer. Emily asks Margaret what the beach ball reminds her of, to which she replies "The seaside!," she talks about many summers going to the seaside, even with many memories fragmented, but still remembering how much she loves building sandcastles.

2. **Seaside memory:** The next session, Margaret brings an old picture of her younger self at the seaside. When Margaret thinks of the seaside, she thinks of this picture and how she misses the days of her childhood playing in the sea. Emily takes this image and scans it using *MemoryScape*.

3. **Entering the virtual space:** With the VR headset on, Margaret finds herself standing in the sand of a beach, seeing the sand between her toes. Gentle ambient sounds, like squawking seagulls and the sea crashing to the shore, fill the space. The lighting is soft, casting a warm, golden glow that enhances the calming atmosphere. Emily asks Margaret what she would like to do when she's here as she hints to the sand.

4. **Interacting within the environment:** Margaret notices the sand move from the movement of her feet, she lowers herself and starts to shape the sand together, and before long, she creates a sandcastle like the ones she made in her youth. This process allowed her to recollect and share more locked memories; the car journey to the beach, the sounds of coins at an arcade, and the traditional fish and chip dinner with her family afterwards.

From the feature framework: Related discussions in earlier studies touched upon the idea of personalised memory environments, the idea for *MemoryScape* was developed by systematically exploring different combinations of key features. The three features that were randomly selected as the foundation for this concept are memory recalls, physical interaction and exploration and discovery.

By combining these three distinct yet complementary elements, the concept of *MemoryScape* was designed to create an experience that balances reminiscence with emotional well-being. The goal was to move beyond static reminiscence therapy by providing an interactive, immersive way to re-experience with meaningful moments.

- **Memory recalls**: Users engage with reconstructed 3D environments derived from personal photos, allowing them to step into meaningful scenes from their past. Using AI to expand these images into immersive spaces, such as a childhood home, a favourite garden, or a family gathering. Interactive elements within the scene, like family members, a piece of furniture or a family pet, can trigger short narratives or animations that enhance the recall process. This interaction helps evoke vivid memories, building a sense of continuity and identity by reconnecting users with important moments from their lives. The ability to interact with these environments helps ground the user in familiar experiences, reducing anxiety and confusion.

- **Physical interaction**: Rather than just passively observing, users can physically engage with their reconstructed environment through intuitive actions such as walking around, interacting with familiar objects, and triggering small interactive responses, such as brushing sand together to build a sandcastle or touching a childhood toy that expands into a memory clip. By encouraging movement and embodied engagement, *MemoryScape* aims to bridge the gap between real-world sensory engagement and immersive memory recall, offering a more natural form of reminiscence.

- **Exploration and discovery**: *MemoryScape* encourages curiosity and rediscovery, allowing users to explore their reconstructed environments at their own pace, uncovering hidden details, sounds, and interactive elements that bring their memories to life. Instead of presenting a static scene, the experience is designed to encourage wandering and spontaneous discovery, much like how memory itself can be triggered by unexpected sensory cues. This sense of exploration reinforces autonomy, giving users a sense of control over their journey through past experiences, rather than just reliving a set narrative.

Technical plausibility: Advancements in AI-powered scene generation make automated photo-to-3D VR reconstruction increasingly feasible. Blockade Labs[1] uses AI to transform simple text prompts into immersive 360-degree environments, demonstrating how generative AI can assist in reconstructing missing details of a virtual scene.

AI tools like NeRFs (Neural Radiance Fields) [186] or photogrammetry-based AI can extract depth and texture from 2D photos, creating immersive technology-compatible spaces. Missing portions of an image can be reconstructed through AI extrapolation, similar to Blockade Labs' ability to generate scene elements from limited input. User-friendly tools could allow caregivers and families to adjust generated environments, personalising them for maximum emotional connection. Recently, *Project Turntable*[2] has showcased the ability to rotate 2D drawings to be explored from new viewpoints allowing access in a 360-degree space from a single static drawing, expanding the potential to use artistic handmade drawings as well as photos from users. While fully automated real-time scene reconstruction remains an emerging field, *MemoryScape* builds upon these advancements, making memory reconstruction within immersive environments increasingly plausible for use in dementia care.

While the AI-based reconstruction would aim to replicate personal photographs as direct as possible, there is no guarantee that these systems would always reproduce every detail with exact accuracy. Even if visual accuracy cannot be fully replicated, the experience would still convey the emotional significance and atmosphere of the original memory. The intention of *MemoryScape* is not only to produce exact visual recreations but also to express the feeling and context in that captured moment, allowing users to connect with the emotional meaning even if the reconstructed environment differs slightly.

[1]https://www.blockadelabs.com/
[2]https://www.adobe.com/max/2024/sessions/project-turntable-gs3-9.html

Potential opportunities: This design direction can go beyond passive reminiscence, offering multiple ways for users to actively engage with their memories in immersive ways. Instead of simply viewing photos, users can explore, reconstruct, and expand upon their memories within the immersive VR environments.

One idea is where users can combine multiple images into a single scene. This approach is particularly useful when photos are incomplete (e.g., damaged) allowing users to merge elements from different images to recreate a meaningful dynamic memory. Users can continuously update and modify the merged image, reflecting the evolving nature of how people remember memories in fragments rather than an exact memory [56, 230]. For example, if one photo captures a childhood home but another contains a missing family member, the system can blend these elements into a single interactive space, offering a richer and more complete experience of that past moment.

This could also function as a cognitively stimulating tool through an interactive "fill in the blanks", sticker book-like feature. When an image is scanned, the AI can present a partially incomplete environment, prompting users to reconstruct missing details. This can be done in multiple ways to adapt to different cognitive levels such as verbal recall, object placement or drawing reconstruction. For example, in a family dinner scene, a user might notice that a favourite dish is missing from the table. They can describe it aloud, select it from a set of options, or draw an outline to prompt the system to fill in the gaps.

Additionally, the experience can be social and interactive. Users can engage with AI-generated representations of loved ones, allowing for simulated conversations based on existing data. To ensure realism, the system would analyse speech patterns from past recordings or social media interactions to create a more authentic interaction. This feature would require careful research and ethical considerations, ensuring that these interactions remain comforting rather than unsettling. Through these potential features, *MemoryScape* can evolve from a static reminiscence tool into a dynamic and cognitively engaging experience, allowing users not just to revisit, but to actively participate in their past memories.

Potential risks: A key concern with *MemoryScape* is the potential for disorientation among individuals living with dementia, as realistic immersive reconstructions may blur the line between past and present, causing confusion or distress. To mitigate this, the system should include clear visual markers distinguishing virtual memories from reality and provide gentle transition features to ease users out of the experience if needed. Some memories may evoke grief or sadness, particularly when revisiting deceased loved ones or lost homes. To address this, the system should allow users or caregivers to filter out potentially distressing memories and provide an opt-out feature for emotionally challenging content. A quick-exit function, manual or automatic, should also be available for users to leave the experience if overwhelmed.

Since *MemoryScape* relies on personal photos, recordings, and potentially social media data for external opportunities, data privacy and security are critical concerns. Strong encryption measures, informed consent protocols, and transparent data management policies must be in place to maintain user trust and compliance with privacy regulations. The integration of AI-generated voices or interactions introduces ethical challenges, particularly if users struggle to distinguish AI-generated content from real memories. To address this, *MemoryScape* should provide clear disclosure of AI-generated content and allow users to enable or disable AI-driven interactions based on personal comfort levels.

Excessive visual details, sounds, or interactivity may overwhelm users, particularly those with advanced stages of dementia. Adjustable settings for environmental complexity and interactive elements should be available to customise the experience to individual tolerance levels. A guided engagement approach can help users navigate the environment comfortably without overstimulation.

Due to how its trained, a limitation of AI systems often produce generic rather than personal content, which risks undermining the authenticity of meaningful items, such as a favourite object. The AI in MemoryScape should be used as a supportive tool rather than a replacement for personalisation, with an importance on having caregivers or users refining the outputs to keep them meaningfully aligned with the individual.

Relevance to dementia: Traditional reminiscence therapy has been widely used in dementia care, making use of familiar stimuli such as photos, music, and personal objects to help individuals reconnect with their past and reinforce identity. However, cognitive neuroscience suggests that memory retrieval is inherently reconstructive rather than exact — people recall past events by piecing together fragmented details rather than retrieving a perfect, unaltered memory [56, 230]. A unique aspect of *MemoryScape* lies in its ability to extend the traditional reminiscence process beyond passive reflection by providing an interactive and immersive experience of reconstructing their memories. *A picture is worth a thousand words* — especially in memory, where a single photograph can encapsulate a lifetime of moments. In everyday life, people use photographs as compact triggers that, when viewed, allow them to decompress rich, personal memories, reliving and interpreting those experiences in deeply meaningful ways. *MemoryScape* builds upon this natural cognitive process by enabling users to decompress stored memories out into a virtual space, re-experiencing them in a multisensory, interactive place. Through different ideas, *MemoryScape* could go beyond reminiscence, positioning itself not just as a nostalgic reminiscence tool but as an engaging cognitive exercise that promotes active participation in memory recall and creative thinking.

While this design builds upon similar ideas that were explored in Section 3.3 using personal photographs despite the approach being abandoned due to ethical risks, it does so in a safer framework. The earlier study revealed the emotional and practical challenges of transforming user's personal photographs into immersive environments, especially the risks of memory distortion. *MemoryScape* reimagines this process with these lessons in mind, putting AI-assisted reconstruction as a supportive tool for reminiscence. This version would put emphasis on sensitivity and contextual awareness, offering a safer continuation of the earlier approach.

Future evaluation with caregivers and individuals living with dementia would be essential to determine the acceptability of this approach in real-world settings.

5.3.2 ImagineScape

Overview: *ImagineScape* is an arts application designed for individuals living with dementia, enabling them to draw, design, and construct their own virtual worlds. These creations are instantly transformed into immersive environments in real time, enriched with interactive elements and appropriate soundscapes. This application also provides a platform for users living with different stages of dementia to create art in varying ways: such as freehand drawing mode where users can sketch their imagined world using virtual tools, and the system transforms their drawings into immersive 3D spaces. Block-based assembly mode where users place and arrange building blocks to construct their scene. This method is an accessible way to engage in creation but can still take an active role in shaping their environment. Alternatively, voice-guided world creation enables participation through verbal descriptions, using an AI-assisted system generates the scene in response. This approach maintains engagement by offering a way for individuals to participate in emotionally enriching experiences without requiring fine motor control. In the following example, I explain this idea through the freehand drawing mode.

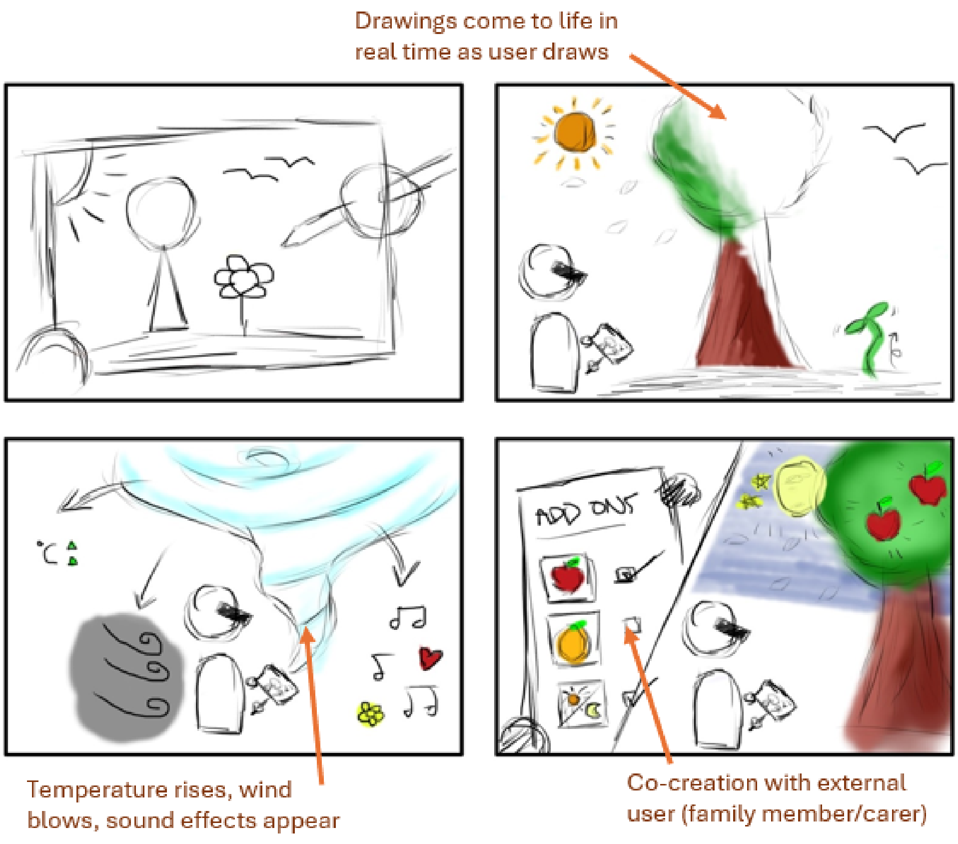

Figure 5.3: ImagineScape

How it works: *Imagine Annie, a 65-year-old woman living with dementia, who has a passion for drawing. She loves to use her pencils and crayons in her spare time to draw objects around her or create fantasy scenes where her imagination takes her. One day she misplaced her art supplies and was saddened that she could not could draw out her imaginations. Her grandson, Liam, suggests that she tries out ImagineScape with his VR headset to bring her imagination to life without the need for pencils or crayons.*

1. **Drawing like usual:** Annie enters the blank canvas of a VR environment, she stands in front of a virtual pen and paper, and like fish to water, she grabs the pen and started drawing a landscape, using simple shapes and visions from her mind.

2. **The scene grows:** As she is drawing the scene, she looks up to see a great tree grow up from the ground, standing mighty above her, leaves fill with colour as the tree grows taller. Plants start to grow around her, placed carefully like the drawing she created on the virtual paper. The sun comes up and lights up the environment with birds flying across the sky, she notices that the drawing she created is appearing before her eyes like magic.

3. **The scene comes alive:** The virtual scene evolved into a beautiful landscape as she had pictured, this inspires her to add more. She notices a difference in the world around her, she could feel the breeze in the air, temperature rises and hear the birds chirping above as they fly above her head. She is not only creating the environment, she is living inside it.

4. **Co-creating with others:** Liam asks how she is doing, to which she replies she is having fun, but thinks the sun she drew is too bright. Liam opens the connecting application on his device and enters her world, he changes the scene to night, and draws a few apples onto the trees she drew, the sun goes down then the moon rises up, the lighting dims and temperature drops. Bright red apples start to appear on the trees and they talk about what a nice addition it added to the scene as they continue to build this scene together.

From feature framework: Related discussions in earlier studies highlighted the importance of creativity and accessibility in immersive experiences for individuals living with dementia. The idea for *ImagineScape* was developed by exploring different combinations of key features. The three features that were randomly selected as the foundation for this concept are creative expression, multisensory stimulation, and shared experiences.

By integrating these three distinct yet complementary elements, *ImagineScape* was designed to provide an inclusive and dynamic platform where individuals can engage in creative activities tailored to their abilities. The goal was to move beyond traditional art-based interventions by offering an adaptable and interactive space where users can express themselves and collaborate with others in an immersive and meaningful way.

- **Creative expression**: Users can draw or build objects using simple digital tools, like painting with virtual brushes. These intuitive actions allow participants to create their worlds naturally and without complexity, expressing their creativity without being hindered by technical hurdles. Simple approaches such as using building blocks, voice recognition or gestures such as touching or pointing can modify the environment in real-time (e.g., pointing to the sky makes clouds move or turn into stars).

- **Multisensory stimulation**: *ImagineScape* automatically enhances the user's creations with multisensory elements, like adding appropriate soundscapes and animations. For example, drawing a bird would not only bring it to life visually but also add chirping sounds and subtle vibration feedback when the bird "flutters" nearby, and greenery adds ambient rustling leaves or calming breezes. The environment also adapts lighting and weather based on the user's creation, making it a truly dynamic and sensory-rich experience.

- **Shared experiences**: Caregivers can join and guide the user in exploring their creations, sparking conversations and reminiscence through the designed world. This turns the individual activity into a joint activity that both parties can enjoy, collaborate and discuss over.

Technical plausibility: Current advancements in VR development platforms, such as Unity and Unreal Engine, provide robust tools for free-hand drawing. Gesture-based drawing interfaces have been implemented in applications like Tilt Brush[3] and OpenBrush[4] demonstrating that painting in immersive environments is both technically possible and widely accessible.

For users with limited motor function, speech-to-image AI models, such as OpenAI's DALL-E[5] or Midjourney[6], showcase the capability to generate detailed images from verbal descriptions. Similar technology could be adapted to create immersive environments based on spoken prompts. Advancements in eye-tracking technologies can further enhance accessibility for users with limited dexterity. Eye-tracking, as seen in platforms like the Tobii XR SDK[7], can be integrated to allow gaze-based selections, enabling individuals to design their environments using simple eye movements rather than complex hand gestures and movements.

Given these technological advancements, *ImagineScape* is technically feasible with current AI and adaptive input technologies, providing an inclusive and engaging platform for creative expression in dementia care.

Potential opportunities: Expanding further, different aspects of the environment could change automatically based on the user's mood to paint a scenario unique to the time the user creates the scenario (e.g., happy mood automatically brightens the scene with warmth and sun when a more neutral or sad mood may dim the lights for a more comforting vibe).

The design direction is currently focused on this being an individual space for creation with potential contributions from a caregiver or family member. But this could be expanded to a creative space for other peers to create a collaborative creation between two or more people just like the model boxes that were created in Chapter 4. This idea could then also be expanded to three stages: creation, immersion, and finally, play. Users design their own environments or artworks, transforming their imagination

[3]https://www.altlabvr.com/tilt-brush
[4]https://openbrush.app/
[5]https://openai.com/index/dall-e-3/
[6]https://www.midjourney.com/home
[7]https://developer.tobii.com/xr//

into virtual worlds. These creations then become immersive spaces where users can step inside, explore, and live within their art. Finally, the experience evolves into interactive play, where the artwork becomes a dynamic, game-like environment. Inspired by *Nintendo's Super Mario Maker*[8], this approach enables users to transition seamlessly from creators to participants, actively engaging with their art in innovative ways.

Beyond this, the process opens opportunities for those unrelated to family or caregivers, to engage with their creations and experience the design process from the perspective of someone living with dementia. By exploring the worlds crafted by participants, outsiders can gain a deeper understanding of their thoughts and lived experiences, promoting empathy and a unique appreciation for the challenges and joys of dementia care.

Potential risks: One of the challenges with this concept is the equipment required to bring these ideas to life. Creating a multisensory experience would need specialised devices, such as haptic feedback systems or equipment capable of simulating physical changes like a breeze or temperature shifts. The space needed and the cost of such equipment could be difficult to place, especially for care home environments operating on limited budgets.

In addition to logistical and financial constraints, there is the question of user preference. Not all participants may find this style of activity engaging or meaningful. For example, during our studies, one participant expressed finding little purpose in experiencing the art, whether it was their own or that of their peers. For users who are not naturally drawn to artistic recreation, it becomes challenging to bring genuine enjoyment or participation. However, by integrating alternative aspects – such as the proposed interaction or game-based elements that could be a potential opportunity – this concept could potentially appeal to users who lack interest in traditional art creation but may find value and enjoyment in dynamic, interactive, cognitively stimulating experiences.

Relevance to dementia care: Creative expression has been widely recognised as beneficial for individuals living with dementia, with research indicating that engagement in artistic activities can engage attention, social behaviour and self esteem [16]. However, due to the progressive nature of dementia, not all individuals can engage in

[8]https://www.mariowiki.com/Super$_{M}ario_{M}aker$

creative activities in the same way. Differences in motor function and experience with art can limit participation, making it essential to design tools that are adaptable to each individual's abilities. To address this, *ImagineScape* can offer different formats of creative interaction, allowing users to choose the level of engagement that best suits their abilities and preferences. Freehand drawing mode provides users with direct creative control, enabling them to sketch their environment using virtual tools, which then transform into immersive 3D spaces. This option supports fine motor engagement and self-expression, particularly for those with artistic backgrounds or mild cognitive impairments. Block-based assembly mode offers a more structured approach, where users can place and arrange pre-made building blocks to construct their scene. This method provides an intuitive and simplified way to engage with world-building, benefiting those who may find freehand drawing too complex but still wish to take an active role in shaping their environment. Lastly, voice-guided world creation is aimed towards users with limited motor function, allowing them to describe what they want, while an AI-assisted system generates the landscape in response. This approach encourages passive yet engaging participation, ensuring that all users, regardless of physical or cognitive ability, can take part in a way that feels meaningful to them. By incorporating these multi-modal design strategies, *ImagineScape* supports creativity and inclusivity, ensuring that immersive environments remains a personal and emotionally engaging experience for individuals living with dementia.

Future evaluation with caregivers and individuals living with dementia would be essential to determine the acceptability of this approach in real-world settings.

5.3.3 Cultural Touchstones

Overview: *Cultural Touchstones* is a solo immersive experience that takes users into a tranquil and familiar environment filled with culturally significant artifacts and activities aimed for people living outside of their nationality home and/or away from family. Through simple physical interactions, users can reconnect with their heritage, engage with meaningful symbols, and relax in a calm, sensory-rich setting which includes haptic feedback and smells. The experience emphasises personal and cultural connection, blending gentle interactivity with moments of mindfulness.

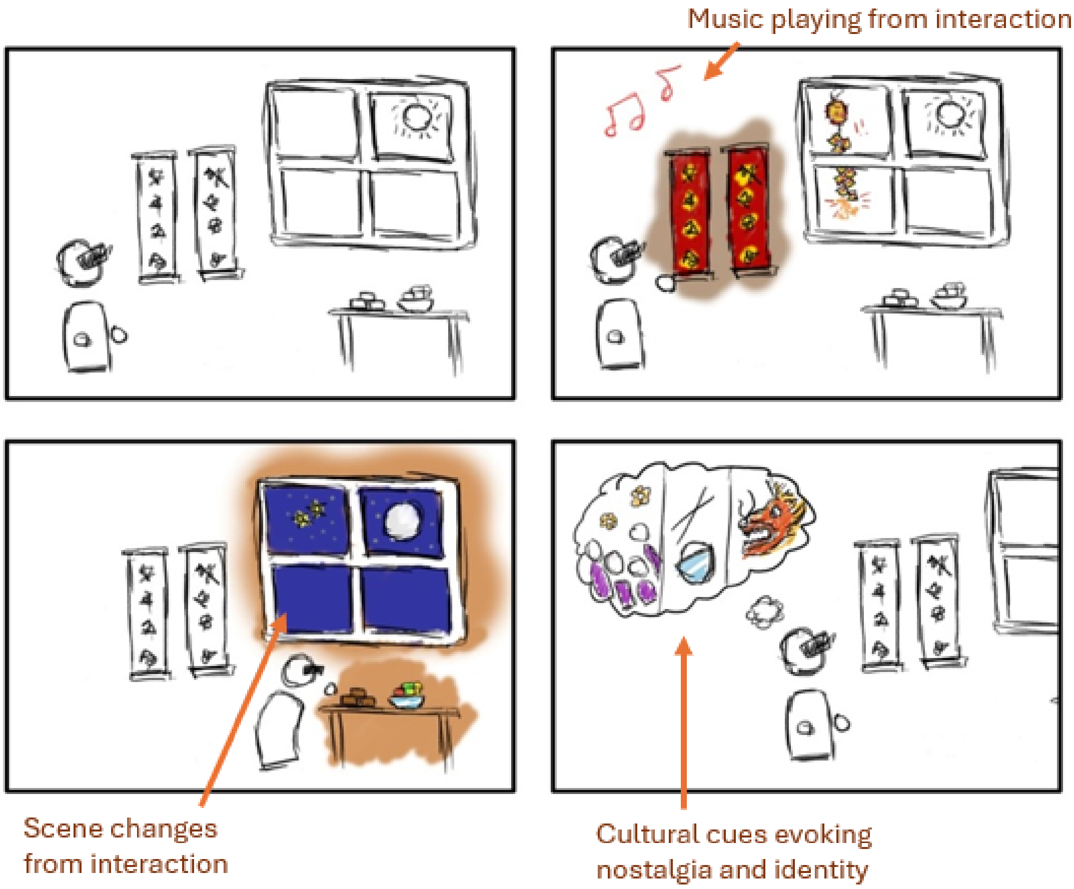

Figure 5.4: Cultural Touchstones

How it works: *Imagine Lee, an 88-year-old man living with dementia, a Chinese immigrant who moved into a care home due to difficulties with living independently after his children moved abroad. His family does not visit often and staff at the care home knows that he talks fondly of traditional Chinese holidays but hasn't had chance to celebrate or experience the festivities since living at the care home. The staff decides to use Cultural Touchstones to help Lee experience and reconnect with his roots once again.*

1. **Entering the experience:** The staff notices Lee misses his family, they select a cultural experience within *Cultural Touchstones* for Lee to experience during his recreational time. Lee enters the environment for what awaits to be a room in a Chinese home, the lighting is warm with the sun up outside the window, walls decorated with red banners and the table has a selection of traditional Chinese snacks.

2. **Interactions with the environment:** Lee walks up to the decoration posted up on the wall, as he moves closer to the banners, traditional Lunar new year music is played. A familiar noise happens from outside the window, he goes up for a closer look and sees Chinese fireworks being set off, a sight to behold as he reminisces the time he took his children to see such a sight during Lunar new year.

3. **Variety of events:** He starts to move away from the banners and the music fades away, he sees and smells a familiar snack on the table and proceeds to move closer and interact with them. Upon closer inspection, he sees Moon cakes, a festive food item in respect to Mid-Autumn festival, interacting with the moon cakes dimmed the lighting, changing the scene to night whilst the moon shines big and bright. This evokes memories spent with family outside in the garden, talking, eating, and admiring the full moon.

4. **Time to reflect:** Lee appreciated being shown this experience, he sat and reflected about his past and the root of his heritage. Thinking about his family, the food, and the traditions he partook. He was able to connect with his identity even though being far away from family and friends.

From the feature framework: The concept for *Cultural Touchstones* was developed by exploring the intersection of cultural identity, sensory engagement, and emotional well-being in VR. The three features that were selected as the foundation for this concept are family and caregiver interaction, cultural and personal significance, and multisensory stimulation.

By integrating these features, *Cultural Touchstones* was designed to provide a meaningful way for individuals living with dementia to reconnect with their heritage and personal identity. Rather than relying solely on passive immersive experiences, this approach emphasises active engagement with culturally significant visuals and activities, providing a sense of belonging and familiarity. The goal is to create a soothing yet immersive environment that supports emotional well-being while strengthening connections to one's cultural roots, even when physically distant from home.

- **Family and caregiver interaction**: This design encourages collaborative participation between users and their family members or caregivers, making the immersive experience more personalised and meaningful. Caregivers or relatives can assist in setting up the virtual environment, contributing culturally specific details that reflect the user's heritage. They may also provide an opportunity to caregivers by sharing their traditional experiences for caregivers to learn and understand more about them. These interactions provide opportunities for shared cultural expression, and help users feel more at ease and understood.
- **Cultural and personal significance**: Interactive elements are tied to the user's cultural background, enhancing the sense of familiarity and personal connection. The immersive environment includes culturally significant elements, such as traditional architecture, symbolic items, or traditional music, tailored to the user's heritage. Family members or caregivers can input details about the user's cultural background to personalise the experience further, ensuring meaningful engagement. Activities like arranging a family dining table for a festival or planting regional flowers to make a deep sense of cultural identity.

- **Multisensory stimulation**: By integrating sight, sound, and touch, this experience creates a richly immersive cultural environment that engages users on multiple sensory levels. Traditional music, ambient environmental sounds (e.g., bells, market chatter, rustling leaves), and tactile feedback enhance realism and deepen emotional connections. Elements such as the texture of fabric or the scent of cultural foods could be incorporated through haptic feedback or multisensory simulations. These sensory cues help users connect more deeply with their culture and personal histories, reinforcing their identity.

Technical Plausibility: The *Cultural Touchstones* concept is technically feasible due to recent advancements in AI-driven content generation, multisensory integration, and adaptive storytelling in immersive environments. By leveraging these technologies, the system can provide culturally relevant immersive experiences for individuals living with dementia.

To enhance engagement, haptic technology such as the bHaptics TactSuit[9] can provide physical feedback, simulating sensations like feeling the warmth of a fire, or the vibration of traditional music. However, while this shows what might be technically possible, it may not be the most feasible for individuals living with dementia, given the bulkiness of such equipment. But the aim is less about recommending heavy suits and more about demonstrating the feasibility of multisensory engagement. Lighter and more accessible alternatives, such as subtle vibration through handheld devices, are likely to be more appropriate. Technologies such as Meta's Ray-Ban[10] glasses show how sensory capture and immersive media can be delivered in more wearable and less intrusive forms, which may point toward more realistic pathways for future dementia care applications.

Olfactometer devices allow different smells to be produced and controlled, bringing the possibility to control what smell is in the air at a given time, such as the work done by Niedenthal et al. [197]. Meanwhile, AI-powered real-time translation tools such as Google's live translate can help overcome language barriers, allowing residents and caregivers to communicate more effectively and ensuring that cultural narratives can be shared in the user's preferred language. This concept can also benefit from cultural

[9] https://www.bhaptics.com/tactsuit/
[10] https://www.ray-ban.com/uk/ray-ban-meta-ai-glasses

memory libraries and open-source heritage repositories. A combination of platforms such as Google Arts & Culture[11] and Sketchfab[12] provide access to historical artifacts and architectural reconstructions that can be integrated into immersive experiences. These resources allow users to interact with culturally significant objects meaningfully.

By combining AI-driven content generation, real-time language translation, multisensory integration, and accessible deployment for immersive environments, *Cultural Touchstones* has the potential to offer a deeply personalised experience for individuals living with dementia, enabling them to reconnect with their heritage in an engaging and interactive way.

Potential opportunities: Aside from simply going near artifacts, users could also physically move and use culturally significant items as much as their motor functions can allow them to, such as arranging traditional pottery or organising a festive display, sparking familiarity and pride. They can create their own scene and narrative, preparing a festival space or decorating a family celebration area for an event, the environment can also contain personal items which are provided by themselves or their family members, which may be more familiar with the user to create more intuitive interactions. Alternatively, the user does not have to be consistently interacting with objects, they can simply exist within the VR space and enjoy the ambience of the culturally familiar environment.

This space could potentially be expanded to be a shared lobby with other participants, potentially from different places of care who are also unable to experience their heritage roots as often, creating a communal space to share old memories and new experiences similar to that of VR Chat[13] but with the main focus on the environment and personal rekindling of their heritage.

Potential risks: However, this design should not assume the general culture being a one-size-fits-all approach for people within that heritage, some may even have family-specific traditions that are unable to be recreated unless family members partake in the co-creation of this environment, misrepresenting this can lead to a lack of authenticity

[11]https://artsandculture.google.com/
[12]https://sketchfab.com/
[13]https://hello.vrchat.com/

or potential offence. With any potential new ideas that are suggested that may be beneficial, certain settings may still potentially evoke unintended negative emotions that could be tied to past experiences or when facing the reality that they may not be able to experience the scene in reality, especially with family that are no longer present.

Creating culturally significant environments presents challenges, as these spaces are often deeply personal and specific to individuals or cultural traditions. It is unlikely that a single setting could cater effectively to a diverse population. To address this, several approaches could be considered: offering a wide selection of features that users can customise within the system, facilitating co-creation workshops where users collaborate with environment designers, or leveraging AI to generate tailored environments - though relying heavily on AI introduces the risk of inconsistencies in cultural authenticity, which may impact the overall immersion and accuracy of the experience.

Relevance to dementia: Globalisation has led to increased migration among older adults, resulting in a significant number of elderly individuals living outside their native countries. This demographic shift presents unique challenges in terms of cultural adaptation, and identity preservation. Older migrants may experience loneliness differently than local ageing populations, as their social connections are shaped by their migration experiences and cultural backgrounds [202]. Additionally, language barriers can significantly impact their well-being, studies suggest that while maintaining strong connections within one's native-language network can positively influence well-being, limited communication in their second-language may impact the social relationships in their current residential environment [207].

In dementia care settings, this cultural diversity presents both challenges and opportunities. Caregivers, particularly in multicultural care homes, may struggle to engage residents from different cultural backgrounds due to language barriers and unfamiliar traditions. A care worker trained in one cultural context may find it difficult to provide meaningful engagement for residents from different backgrounds. However, integrating *Cultural Touchstones* into immersive experiences can help bridge this gap, offering a means for residents to reconnect with their heritage while also educating caregivers and peers about their culture. This reciprocal process can create meaningful interactions and strengthen relationships, making residents feel more valued and reducing feelings of isolation. By creating spaces where elderly migrants can share their traditions and memories, immersive technology can support both reminiscence and social learning, promoting a greater sense of belonging in diverse care environments.

Future evaluation with caregivers and individuals living with dementia would be essential to determine the acceptability of this approach in real-world settings.

5.3.4 Comfort Guide

Overview: *Comfort Guide* is an immersive experience designed to create a safe and empathetic conversational environment for individuals living with dementia. Users engage and converse with a virtual companion that uses real-time behavioural monitoring to assess emotional responses. When signs of stress or discomfort are detected, the companion adjusts the conversation to alleviate distress. This experience provides users with a reliable personalised emotional support while offering valuable insights to caregivers about potential emotional triggers or sensitive topics, this feature can benefit those who are new to understanding dementia, for family members that are struggling to understand the behaviour changes in their recently diagnosed loved ones or researchers to understand and provide personalised support in a concise manner despite not being already familiar with them.

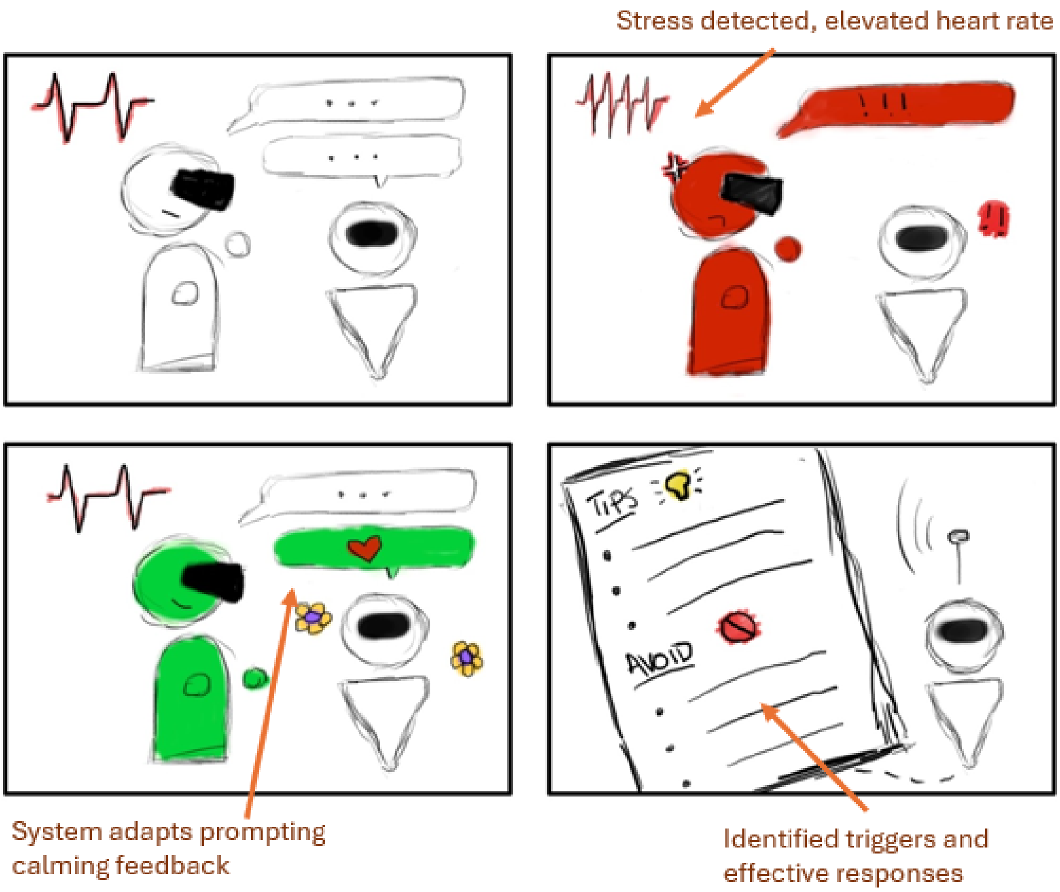

Figure 5.5: Comfort Guide

How it works: *Imagine Susan, a 72-year-old woman living with early-stage dementia, a care home resident, whose family lives abroad. She wants to chat with someone but her caregiver, Monica, has a few errands to make and other residents to tend to, she sets up Susan to enter the Comfort Guide immersive experience to talk with a virtual companion she has conversed with before.*

1. **Meeting an old friend:** Susan is greeted by "Willow", a friendly virtual companion designed to match her preference for a soothing voice and gentle demeanour. Willow starts the conversation with neutral topics, such as Susan's favourite hobbies or her childhood pets.

2. **Detecting emotional shifts:** As Willow gently shifts the topic to family holidays, the system detects a slight increase in Susan's heart rate and notices her gaze wandering. Recognising potential discomfort, Willow softly reassures Susan, saying, "We can talk about this another time. How about we explore something relaxing instead?"

3. **Redirecting to calm topics:** The conversation transitions into description of a serene beach, and Willow begins talking about the sound of waves and the feel of warm sand underfoot. Susan visibly relaxes, and the conversation continues on this soothing topic.

4. **Session insights for caregivers:** After the session, Willow provides a report highlighting the topics that caused Susan slight discomfort and the calming subjects that helped her relax. Her caregiver, Monica, uses this information to tailor future interactions and avoid potentially distressing topics.

From the feature framework: Related discussions in earlier studies highlighted the importance of emotional well-being, calming interventions, and interactions for individuals living with dementia. The idea for *Comfort Guide* was developed by exploring different combinations of key features. The three features that were randomly selected as the foundation for this concept are virtual companions, assessing engagement and problem-solving and cognitive stimulation.

By integrating these three distinct yet complementary elements, *Comfort Guide* was designed to provide a safe conversational environment that challenges their cognition whilst also adapting to the emotional responses of the user. The goal was to offer an interactive experience with a virtual companion that not only supports individuals through real-time emotional monitoring but also provides caregivers and researchers with valuable insights to guide meaningful and reassuring interactions.

- **Virtual companions**: The user interacts with a virtual entity designed to offer gentle, empathetic dialogue and emotional support. This companion provides a calming presence, helping to guide conversations in a non-intrusive manner. Its friendly and approachable nature builds trust and makes difficult topics more approachable. The virtual companion helps users feel supported and understood, offering emotional connection without the social pressure of human interaction.

- **Assessing engagement**: The system continuously monitors physiological signals (e.g., heart rate, electrodermal activity) and behavioural cues (e.g., gaze direction, speech patterns) to assess the user's engagement and emotional state. It detects subtle signs of stress or discomfort and adjusts the companion's interactions accordingly. This feature ensures that the user's emotional well-being is prioritised, tailoring the conversation to their comfort level and avoiding topics that may cause distress.

- **Problem-solving and cognitive stimulation**: This design promotes active participation by encouraging users to engage in meaningful conversation – cognitive stimulation through verbal interaction. Additionally, the virtual companion can introduce light problem-solving activities, such as guiding users through structured conversations, thought exercises, or interactive tasks that encourage mental engagement. By providing a dynamic, responsive space for expression and mental stimulation, this feature ensures that interactions are not just emotionally supportive but also cognitively enriching.

Technical plausibility: The development of *Comfort Guide* is supported by advancements in AI-driven conversational agents, real-time emotional analysis, and adaptive sensory technologies. AI companions like Replikant Chat[14] have demonstrated the ability to engage users in personalised and empathetic conversations, adapting responses based on previous interactions. These AI-driven models offer a stepping stone for designing a virtual companion that can provide emotional support for individuals living with dementia.

To ensure that conversations remain sensitive and appropriate to the user's emotional state, *Comfort Guide* can integrate real-time emotional recognition technologies such as ones from Affectiva[15], which analyse facial expressions, tone of voice, and other gestures to assess emotions and cognitive states. These insights can be further enhanced through gaze-tracking solutions in platforms like the Tobii XR SDK, ensuring the virtual companion adjusts its interactions accordingly based on the user's responses.

Beyond verbal communication, physiological monitoring technologies such as *Fitbits* can track heart rate variability and stress indicators, offering an additional layer of emotional assessment. Adaptive environmental responses, such as smart lighting solutions from *Philips Hue*, can provide calming ambient adjustments, helping to regulate mood and create a more soothing atmosphere. Haptic feedback systems can also play a role by delivering subtle vibrations through wearables or chair-based actuators, offering a sense of presence and reassurance in moments of distress. One recent designer-led study by Zhou [281] showcased their affective robotic touch, which found naturally generated patterns of tactile sensations to express different emotions, revealing strategies mimicking human touch. This highlights how haptic interfaces could be leveraged to create richer emotional connections, expanding the possibilities for non-verbal emotional support in assistive technologies.

A key feature of *Comfort Guide* is its ability to function as a "continuity carer" by leveraging AI-driven memory. Unlike human caregivers, who may change across shifts or settings, the virtual companion retains and recalls past interactions, preferences, and emotional responses. This persistent memory enables it to maintain a consistent, evolv-

[14]https://replikant.com/replikant-chat
[15]https://www.affectiva.com/

ing understanding of the individual, building a sense of familiarity and trust. Similar to Replika, which builds personalised emotional connections through ongoing conversations, and PARO the therapetuic robot[16], which learns from interactions of those living with dementia to provide comforting engagement, similarly the concept of *Comfort Guide* adapts to the user's needs and personality over time. By remembering what topics are comforting or distressing, the system ensures a personalised and responsive experience that aligns with the individual's emotional needs.

Potential opportunities: The session insights would provide caregivers with detailed reports on emotional triggers and topics that resonate with the user. This allows for more tailored and empathetic approaches. *Comfort Guide* could also be used as a tool for emotional therapy, helping users process difficult memories or emotions in a controlled and supportive environment. The current design idea would divert away from distressing topics, but an alternative direction could help those living with dementia or other vulnerable populations overcome these situations. This system could also benefit by incorporating wearable devices like heart rate monitors or EEG headbands, the system can gain even more precise insights into the user's emotional state, improving responsiveness. The virtual companion in question could be further personalised based on the user's preferences (e.g., tone of voice, appearance, conversational style), enhancing user comfort and trust, they could be a human character, a robot or even an animal.

Potential risks: Collecting physiological and emotional data raises privacy concerns. Clear data usage policies and user consent are crucial to ensure ethical handling of sensitive information. Physiological responses can sometimes be ambiguous. For example, an increased heart rate might result from excitement rather than discomfort, leading to potential misinterpretation by the system, this system would either need to be well trained or potentially have additional input from caregivers to better understand the user's preferences. This system should also not suggest to caregivers to overly rely on the system's insights, neglecting the importance of direct, human connection and interaction which is equally, if not more, as important. Emotional triggers and comfort levels vary greatly among individuals and cultures. The system must be adaptable and sensitive to these differences to avoid generic or inappropriate responses.

[16]http://www.parorobots.com/

Another risk is potential cognitive overload, where this virtual companion, if too conversationally active, may unintentionally overwhelm individuals living with dementia. This could then limit opportunities for creativity or quiet reflection. To mitigate this, the companion system should offering gentle cues that support engagement while leaving space for user interaction. This way, the technology complements rather than takes over the person's agency and ability to choose their own way.

Relevance to dementia: For individuals living with dementia, consistent and personalised care is essential, yet it is often difficult to achieve due to the practical limitations of human caregivers. Caregivers are not always available, as they must divide their time between multiple individuals, manage administrative tasks, and attend to personal responsibilities [114]. This can lead to moments where a person living with dementia may feel unsupported or disconnected, particularly in care settings with limited one-to-one interaction. AI-driven virtual companions, such as *Comfort Guide*, can help bridge these gaps by providing continuous and personalised engagement, ensuring that individuals receive emotional support even when human caregivers are unavailable or maybe even unwanted, as it may sometimes even feel overwhelming [275].

In addition to gaps in care, loneliness is a common concern among people living with dementia, as cognitive and communication challenges can gradually reduce their ability to maintain relationships [127]. Reduced social interaction has been linked to early symptoms of cognitive decline [76, 165]. AI companions with memory retention capabilities can offer a sense of familiarity, simulating aspects of connection by remembering past interactions and topics of interest. This aligns with research on digital and robotic interventions, such as PARO the therapeutic robotic seal, which has been shown to provide comfort and companionship while improving the condition of brain activity in dementia care settings [267].

Maintaining consistency of care is a major challenge in dementia support. Frequent caregiver changes can disrupt routines, create stress, anxiety and irrational behaviours, consistency, familiarity and routine are important to those living with dementia by decreasing these behaviours such as aggression and agitation [3]. A system like *Comfort Guide*, which retains memory of prior interactions and emotional responses, can act as a “continuity carer,” ensuring a stable presence that adapts to evolving needs. AI-driven memory systems, such as Replikant Chat and PARO, have shown how technology can remember past conversations and use this to build trust and familiarity over time [267]. By retaining key insights and passing them to human caregivers, AI can support consistency in care, complementing human efforts rather than replacing them.

Future evaluation with caregivers and individuals living with dementia would be essential to determine the acceptability of this approach in real-world settings.

5.3.5 Waypoints AR

Overview: *Waypoints AR* is an augmented reality (AR) experience designed to enhance memory recall and encourage spontaneous, in-the-moment engagement with familiar locations and everyday activities. Rather than being confined to structured therapy sessions for activities like reminiscence, *Waypoints AR* integrates into daily life, allowing users to interact with their surroundings in a way that blends past memories with present experiences. For instance, a user visiting their favourite cafe might receive an AR overlay of a past visit — recreating a moment shared with a loved one over a now-discontinued pastry. However, this design direction is not limited to reminiscence. It also looks towards the future, incorporating elements of anticipation and future engagement. By blending memory recall with real-time experiences and future-looking prompts, *Waypoints AR* helps build active participation in the present and future. This dynamic and contextual approach to AR reminiscence and future anticipation helps individuals living with dementia feel more connected to their environment, bridging past, present, and future in an interactive way.

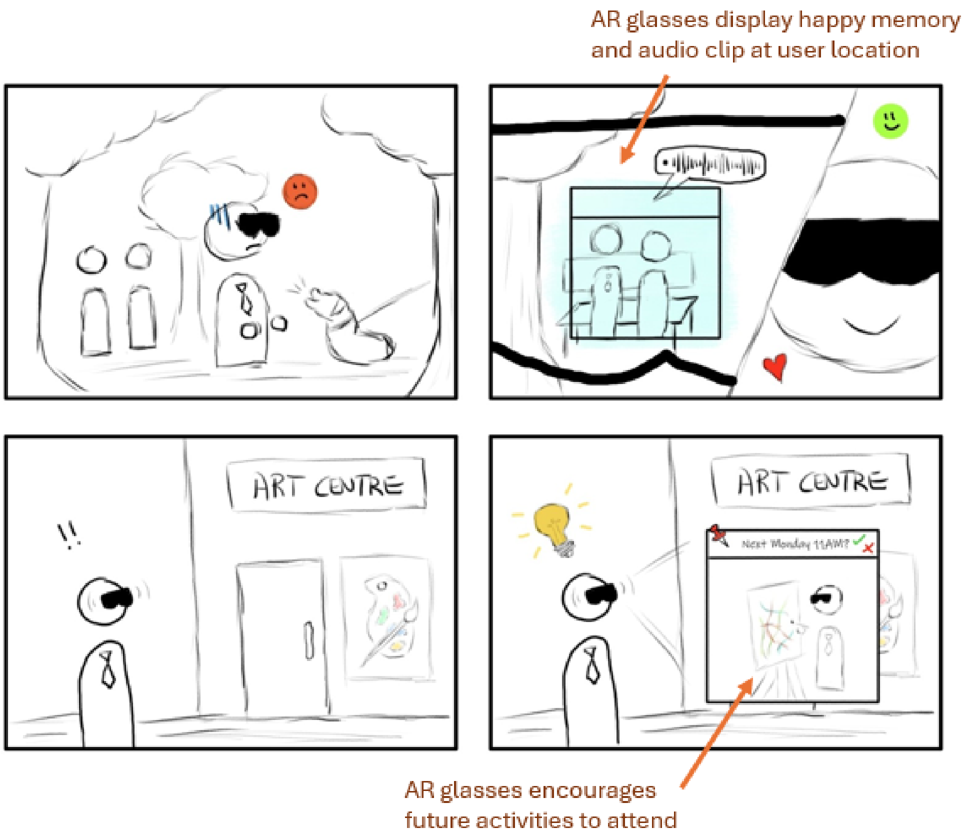

Figure 5.6: Waypoints AR

How it works: *Imagine Ted, a 70-year-old man living with dementia, is meeting up with a friend at a new restaurant for lunch, which they suggested that Ted should try. But this route was not common for him to take, so he is a little nervous.*

1. **A world of uncertainty:** Ted wanders through the city into a busy park that he is unfamiliar with. The bright sun, public chatter, dog barks, overwhelm him and his senses, making it difficult for him to focus and causing distress. As he slows down, he receives a gentle notification from his AR device.

2. **Moment of comfort:** Looking through *Waypoints AR*, Ted sees a familiar photo overlayed onto the park scene — a picture of him and his daughter sitting on this very bench years ago with a voice note left by his daughter "Always with you, Dad." A sense of comfort and familiarity comes to him, bringing a smile to his face. This memory helps ground him in the present, making the park feel less overwhelming and more personal.

3. **Friendly reminder:** As Ted continues walking, he passes by the city's arts centre, a place he once visited regularly but hasn't engaged with in a while. *Waypoints AR* sends another subtle notification, prompting him to look up.

4. **That's a cool idea:** Ted glances and sees a flyer for an upcoming art event next week. Within it, a calm visual of himself participating is shown – brush in hand, engaged in the activity. It serves as a gentle nudge, allowing him to feel a renewed sense of connection and possibility.

From the framework: Discussions from earlier studies highlighted the importance of engagement, interactive reminiscence, and meaningful activities for individuals living with dementia. The idea for *Waypoints AR* was developed by exploring the random selection of key features, the three elements that shaped this concept are physical interaction, life story and narrative, and exploration and discovery.

By integrating these three elements, *Waypoints AR* was designed to provide an engaging and intuitive experience that bridges past memories with present-day interactions. The goal was to create a dynamic, in-situ AR experience that not only stimulates memory recall through familiar locations but also encourages movement and social interaction, offering a more immersive and purposeful way to connect with personal history, whilst looking forward to future events as well.

- **Physical interaction**: Rather than relying on traditional interfaces like computer screens, *Waypoints AR* encourages users to engage through movement and alignment with real-world locations. By passing familiar places — such as a dining table, a street corner, or a restaurant — they trigger immersive prompts tied to past experiences or future events. These physical interactions support light movement and intuitive engagement, which is particularly beneficial for individuals living with dementia. They ground digital experiences in real-world actions while avoiding the complexity of traditional technological interactions.

- **Life story & narrative**: *Waypoints AR* transforms everyday surroundings into entry points for personal storytelling, helping users reconnect with their life history through meaningful locations. Instead of passively remembering the past, users become active participants in their own narratives — walking past a restaurant might prompt a memory of a family celebration, while a familiar street could resurface a moment from childhood. At the same time, *Waypoints AR* supports forward-looking narrative building — suggesting events or activities tied to the user's interests, such as a future concert at a place they once visited. This balance between past experiences and future opportunities creates an evolving life story from the user's real environment, as opposed to limiting a life story to events from the past.

- **Exploration and discovery**: This application encourages users to re-explore their homes, neighbourhoods, and daily routes not as static spaces, but as layers of personal significance. A walk through a garden might reveal forgotten memories of planting flowers with a loved one, while the same path might also highlight an upcoming seasonal event or reminder. This blending of past discovery with future prompts creates a sense of adventure and curiosity. Rather than guiding users through a fixed narrative, the system lets them uncover content at their own pace, helping to maintain cognitive engagement and emotional richness through both what they remember and what they might still look forward to.

Technical plausibility: Waypoints AR builds on existing technologies in AI-driven memory retrieval, augmented reality spatial mapping, and contextual recognition to create an intuitive experience. Several established platforms demonstrate the feasibility of this concept, particularly in their ability to connect digital content with real-world locations. One of the key inspirations for this system is *Facebook*'s "Memories" feature, which surfaces past images and events based on timestamps. Similarly, Waypoints AR could retrieve personal memories by linking user-uploaded photos, GPS history, and social media check-ins to specific real-world locations. This would allow the system to dynamically surface relevant past moments at meaningful times and places. Current AI-driven tools such as *Apple* photos already use image recognition to group and categorise photos based on location and subject, showcasing the viability of memory integration in digital experiences.

The system's AR capabilities align with existing location-based AR interaction models, such as *Pokémon GO*[17], which use GPS and real-time AR overlays to place digital objects in physical locations. By using these methods, *Waypoints AR* could allow users to interact with memory overlays tied to specific places, enriching real-world spaces with both reminiscence and forward-looking engagement, transforming that *space* into a memorable and interactive *place*. Additionally, using image recognition similar to Google Lens, it could enable the system to identify landmarks and trigger AR content, matching real-world locations to stored digital memories. This ensures a dynamic reminiscence experience, where memory recall becomes effortless and immersive rather than a structured, deliberate activity such as a therapy session. Further enhancing the experience, dynamic AR overlays — inspired by *Snapchat*'s Landmarker Lenses[18] - could allow the system to augment real-world objects with personalised or contextually relevant digital content. Instead of only focusing on past events, this feature enables future-looking interactions, such as previewing an upcoming menu item at a cafe or displaying historical context at a familiar location. This combination of past, present, and future engagement extends the traditional reminiscence model, ensuring that *Waypoints AR* remains a tool for both memory recall and active participation in daily life.

[17]https://pokemongolive.com/?hl=en
[18]https://developers.snap.com/lens-studio/features/location-ar/guide

Waypoints AR could integrate speech-to-text AI to analyse conversations and provide contextually relevant memory prompts or future engagement suggestions. Additionally, advancements in wearable AR technology, such as the *Meta Ray-Ban* smart glasses and the *Apple Vision Pro*, highlight a growing trend toward on-the-go AR experiences, making a system like *Waypoints AR* both feasible and practical for every day use.

Potential opportunities: This idea was initially seen to work as if the user is wearing AR goggles, but this can also be used with a tablet with an AR camera if the user does not prefer to wear an AR headset. Similar AR-based experiences could include scavenger hunts, where users search for specific items in their homes or surrounding environment based on clues or visual prompts, rather than being triggered by their location initially. These activities could be designed to encourage both mental stimulation and physical movement. For instance, a user might be prompted to find and scan a specific item, which then triggers a short story about its significance and reminds the user why they own it. The system could offer varying levels of difficulty to cater to users at different stages of dementia. For example, simpler modes might provide clearer hints or automatically highlight potential matches just for the user to view and experience, while advanced modes could require users to solve small puzzles or answer questions to unlock a memory scene. The AR system could also enable family members or caregivers who are not physically present to participate remotely. Through live streaming or shared AR sessions, distant family members could connect within the AR memory scene, partake with their activities and talk to them, for example across the dining room table having dinner together.

Potential risks: There will be concerns over this idea due to the overlap of true reality and augmented reality, some memories may cause sadness or distress, particularly if associated with people who user's have lost. The system should allow users or caregivers to curate content to avoid potentially upsetting experiences. If the AR overlay doesn't accurately align with the real-world environment or is too abstract, users might become disoriented or confused. Just like how the misaligned rainbow image from Section 3.3.3.4 lead to disconnection with the immersive environment that could further lead to withdrawal from the activity.

Relevance to dementia: Waypoints AR is designed to address key challenges faced by individuals living with dementia by integrating cognitive engagement and environmental familiarity into everyday life. Traditional reminiscence therapy often occurs where memory recall is a deliberate and sometimes passive process [274]. In contrast, Waypoints AR offers a dynamic reminiscence experience, allowing users to actively engage with their surroundings and reconnect with meaningful places in real-time.

By linking AR-enhanced memory prompts to real-world locations, Waypoints AR provides contextual reminders that help reinforce personal history and identity, supporting individuals in navigating and engaging with their surroundings. Familiarity with places outside the home is essential for maintaining participation and a sense of security, as it helps individuals recognise personal memories in external spaces that aid in orientation [180]. By preserving and augmenting familiar locations with personalised AR cues, Waypoints AR aims to provide a stable and continuous experience, promoting confidence and independence in daily life.

Additionally, Waypoints AR encourages physical activity and exploration, which are crucial for maintaining cognitive and physical health. This system motivates users to move through their environment, interact with their surroundings, and engage in goal-oriented activities. Research has highlighted the benefits of physical movement in dementia care, showing that regular activity can improve cognition [198]. Finally, Waypoints AR provides a bridge between past experiences and future engagement, counteracting the idea that individuals living with dementia are always "stuck in the past." By integrating forward-looking elements, such as previewing upcoming events or suggesting familiar places to visit, the system encourages active participation in daily life rather than passive reminiscence looking back in the past.

Future evaluation with caregivers and individuals living with dementia would be essential to determine the acceptability of this approach in real-world settings.

5.4 Discussion

The design directions presented in this chapter expand the empirical work from the earlier studies into conceptual and practical pathways for creating immersive experiences that are engaging, ethically grounded, and person-centred. They are informed by the feasibility and personalisation insights from Chapter 3 and the co-creative, expressive work from Chapter 4, while being situated in the wider research landscape introduced in Chapter 2. The goal is not only to propose new interactive forms but also to explain how immersive technologies such as VR and AR can support personhood and emotional connection for people living with dementia.

Much of the existing research in dementia care technology has focused on functional or clinical outcomes — reducing agitation, maintaining cognitive ability, or measuring usability [14, 13, 12]. As discussed in Chapter 2, such work has advanced evaluation but often underplays the experiential dimensions that make an intervention meaningful. The directions proposed here aim to bridge that gap by connecting design practice with theories of personhood [150], space and place [233], and emotional engagement in human–computer interaction. They explore how immersive systems can move from being instruments for stimulation to tools that help individuals and their caregivers build shared, emotionally resonant experiences.

5.4.1 Enhancing user engagement

Chapter 3 demonstrated that engagement was strongest when participants encountered environments related to their life stories or hobbies. Personal photographs, familiar landmarks, and nature scenes prompted smiles, gestures, and conversation. These reactions support earlier findings that sensory cues and familiarity strengthen emotional recall and comfort in dementia care [154, 10]. At the same time, the study revealed that technology acceptance depended on comfort and caregiver presence.

The *MemoryScape* and *ImagineScape* concepts are built upon these observations. They combine personalised visual and auditory material with opportunities for light creation and exploration, extending engagement from remembering to living and making. This reflects the co-creative spirit observed in Chapter 4, where participants built model boxes and soundscapes that later became virtual environments. The resulting engagement was not limited to nostalgia; it included curiosity, humour, and a sense of accomplishment, qualities that align with design literature arguing for play and creativity as drivers of well-being in later life [164].

From a theoretical standpoint, these approaches echo the transition from space to place [233]: spaces become places when they are filled with personal meaning and lived experience. By allowing participants to imprint aspects of their identity – such as objects, sounds, colours, and textures – onto immersive environments, VR becomes a medium for reaffirming selfhood rather than replacing reality. In this view, engagement is achieved through resonance and agency rather than spectacle or novelty.

5.4.2 Supporting caregivers and families

As noted in Chapter 3, every successful session involved active caregiver participation. Caregivers prepared the equipment, explained the experience, and provided emotional reassurance. Their involvement shaped whether VR felt safe or intrusive. Previous studies in dementia care similarly stress that technology is most effective when embedded within a social ecology of care [14].

The design directions extend this relational dimension. The *Comfort Guide* explores how bio-adaptive systems can support emotional connection by using physiological data to help caregivers recognise and respond to a person's comfort levels in real time, promoting a shared sense of care rather than automated monitoring. *Waypoints AR*, encourages relational continuity by prompting families to revisit meaningful locations or memories through augmented reality, connecting past experiences with present moments. Such shared authorship reflects the findings from Chapter 4, where participants' engagement deepened when others acknowledged and celebrated their creative output. It also connects to HCI work on reciprocal care-giving and empathic mediation [155, 154], showing how technology can help sustain togetherness rather than isolate users.

By including caregivers as co-designers and co-participants, immersive systems can become tools for communication and mutual understanding. They can help caregivers recognise subtle signs of emotion or interest—an eye movement, a smile, a pause—that are difficult to capture through formal assessment. In this way, immersive technology can complement existing relational care practices rather than displacing them, fulfilling the call from Chapter 2 for technologies that respect both the person living with dementia and those who support them.

5.4.3 Challenges and considerations

Comfort and accessibility. Chapter 3 documented practical concerns with headsets (fit, weight, motion sensitivity) and the need for supervision; Section 3.4 noted physical comfort and setup constraints; and the limitations section pointed to deployment hurdles (space, schedules, staffing). The designs therefore recommend graded immersion: seated experiences by default, short scene durations, stable locomotion, and a "pause/hand-back" mechanism that lets a caregiver instantly step in without friction.

Abstraction vs. realism. Chapter 4 found that abstraction can reduce confusion and cognitive load, while over-literal environments can overwhelm or distract. Chapter 3's photo-to-VR work similarly showed that some source images do not translate well, and misaligned or visually busy scenes can break presence. The design directions incorporate "visual gentleness" (simplified palettes, focused depth cues) or adjustable detail levels to avoid problematic scenes.

Emotional safety and consent. Revisiting memories can soothe or unsettle. Both Chapters 3 and 4 stressed careful curation and the value of having a clear exit path when distress appears. Designs should therefore include caregiver commands, simple stop/skip controls, and session prompts that state the intent upfront ("We will visit a quiet seaside walk" rather than vague labels). Pairing this with brief, repeated approval and annotated logs supports informed, ongoing participation.

Personalisation vs. scalability. Chapter 3 demonstrated the benefits of tailored content but also the cost of preparing one-off materials and the limits of connectivity in care settings. The directions balance those tensions in three ways: (1) interest-first libraries that are broad and pre-vetted; (2) lightweight co-creation (e.g., simple scene assembly, voice notes, chosen music) that can scale; and (3) offline-ready delivery to avoid streaming failures.

Measurement and interpretability. The studies showed that verbal feedback can be limited and that engagement is often visible through behaviour rather than speech. In the proposed designs, engagement markers are intended as supportive insights for caregivers rather than definitive judgements. For example, in the *Comfort Guide* concept, physiological cues such as heart rate are translated into simple, human-readable summaries, that should remain human-readable ("stayed longer in calm scenes; smiled at birdsong") to assist caregivers in interpreting responses, these summaries should not replace caregiver observation and understanding.

5.4.4 Shaping future research and design

The morphological analysis introduced in this chapter provided a structured way to combine features from the previous studies—personal connection, sensory stimulation, social interaction, and creativity—into coherent design ideas. This creative framework demonstrates how generative design methods can bridge empirical insight and innovation. However, continued iteration with stakeholders is essential. Future work should involve small, co-design cycles with people living with dementia and their caregivers, integrating rapid prototyping and situated testing to evaluate usability and practical constraints.

Beyond VR, the proposed *Waypoints AR* concept suggests new directions for hybrid experiences that blend digital and physical worlds. This aligns with current discourse in HCI on extended realities for health and well-being [241]. Such work can explore how AR markers, tactile objects, and ambient soundscapes can make care environments more supportive without isolating users from everyday life.

Ethically, future research must continue to prioritise consent, accessibility, and co-ownership of data. As noted in Chapter 2, trust and transparency are central to maintaining dignity in technology-mediated care. Collaboration across disciplines such as engineering, design, psychology, and the arts, will be key to developing systems that are technically feasible and emotionally appropriate.

In summary, the design directions outlined here demonstrate how insights from feasibility, personalisation, and creative expression can be synthesised into design principles that bridge theory and practice. By reconnecting to the literature on personhood, reminiscence, and meaningful place-making, this chapter repositions immersive technology as a medium for shared, creative, and situated engagement, this being a foundation for the broader discussion that follows in Chapter 6 on how such approaches can transform dementia care.

5.5 Conclusion

This chapter has presented a range of innovative design directions aimed at enhancing the engagement and well-being of individuals living with dementia through immersive technologies. Drawing on insights from previous studies and guided by a framework of key features, these concepts address critical challenges in dementia care, such as building meaningful engagement and supporting caregivers in understanding the needs and preferences of users.

The proposed designs, such as *MemoryScape*, *Comfort Guide*, and *Waypoints AR*, aim to balance creativity, personalisation, and emotional support. They offer opportunities for users to connect with their past, express themselves in new ways, and experience moments of joy and relaxation. By integrating elements like life stories, multisensory environments, and real-time engagement tracking, these designs pave the way for user-centred and benefitting applications of immersive technology in dementia care.

Importantly, these design directions not only benefit users but also empower caregivers and researchers. Through features like engagement markers, session insights, and shared experiences, caregivers gain valuable tools to tailor interventions and provide more personalised care. Researchers, in turn, can use these insights to refine their understanding of how individuals living with dementia interact with immersive technologies, enabling more effective and impactful future studies.

This chapter highlights the potential of immersive technology to transform dementia care by providing accessible, engaging, and supportive environments. While challenges such as technological feasibility and ethical considerations remain, these designs lay potential opportunities for advancing the field and improving the quality of life for individuals living with dementia. Future research and development can build upon these concepts, ensuring that immersive experiences continues to evolve as a powerful tool for both therapeutic and recreational purposes.

This chapter not only outlined innovative design directions but also introduced a creative methodology for their development. By identifying key features from my prior studies and applying *Morphological Analysis* [7], this research developed a structured yet flexible framework for designing immersive experiences. The process of randomised feature combination and iterative refinement ensured that the proposed concepts were both user-centred and innovative. This approach facilitated the exploration of unique feature combinations, not limited to just three; it could range from as little as two or four, five or even more, resulting in designs that balance engagement, support, and personalisation. This method offers a scalable framework for future research, providing a playful yet purposeful way to co-create impactful immersive experiences with users, caregivers, and researchers.

5.6 Limitations

Despite the promising design directions proposed in this chapter, several limitations must be acknowledged, which may affect the feasibility, scalability, and real-world application of these concepts. Addressing these limitations will be important in future research and ensuring the designs achieve their intended impact. Some common limitations with these designs are as follows:

- *Technological constraints*: Many of the proposed designs rely on advanced immersive technology, including VR headsets, AR-enabled tablets, and haptic feedback devices. The cost and availability of such equipment may limit their implementation, particularly in care homes or low-resource settings. Additionally, ensuring compatibility across different hardware platforms can present challenges, as not all devices may support the same level of interactivity or immersion.

- *Accessibility and usability*: While the designs aim to be user-centred, there is a risk that the technology could be overwhelming or inaccessible to some users, particularly those diagnosed with late-stage dementia or physical impairments. For example, VR headsets may cause discomfort or motion sickness, and interactions requiring precise gestures could be difficult for users with limited motor abilities. Ensuring simplicity and ease of use for a diverse range of participants is a critical yet challenging goal.

- *Ethical considerations*: The integration of personal memories and physiological data raises important ethical concerns. For example, revisiting certain memories may evoke distress or confusion for some participants, potentially leading to emotional discomfort. Additionally, the collection and analysis of physiological data must be conducted strictly to privacy and consent protocols to protect users' sensitive information.

- *Personalisation vs. scalability*: While personalised experiences can enhance user engagement and emotional connection, creating these tailored environments may require significant time and resources, particularly when involving family members or caregivers in co-creation processes. Balancing the need for individualised experiences with the scalability of these designs for broader application remains a challenge.

- *Lack of quantitative validation*: Due to time constraints within the PhD, the proposed designs could not be shared directly with key stakeholders such as caregivers or participants, nor tested in real-world settings. As a result, their relevance and practical suitability remain unverified. Even though the concepts based on prior research and user feedback from earlier studies, they have not gone through empirical validation or received input from professionals in the field. This limitation is closely linked to the practical and emotional challenges identified in Chapter 3, where issues such as internet reliability and emotional sensitivity shaped how the immersive experiences could be realistically implemented in care settings. Without direct stakeholder evaluation, it is difficult to determine how well these speculative designs would perform in addressing those earlier concerns. Future work should therefore prioritise evaluation with caregivers and individuals living with dementia to assess its usability and emotional response, ideally through prototyping and iterative feedback sessions.

5.7 Looking ahead

The design directions presented in this chapter show varying innovative applications of immersive technologies in dementia care. While these concepts address critical challenges, such as improving engagement, supporting caregivers, and promoting emotional well-being, they also open different paths for further exploration and refinement. This section outlines the next steps required to translate these ideas into impactful real-world applications.

Iterative prototyping and testing: The next phase involves developing prototypes of the proposed designs and conducting small-scale user-centred testing. By involving individuals living with dementia, caregivers, and healthcare professionals in these trials, researchers can gather valuable feedback to refine the designs based on those insights. From there, prototypes could be developed into more robust systems and evaluated in longitudinal trials to explore not just short-term reactions but also sustained impact. Using this approach, from pilot testing, to co-refinement, to deployment, it would provide a balanced foundation based off different stakeholder's perspectives, which are needed to assess their therapeutic and practical benefits and ensure the experiences are both engaging and accessible.

Expanding technological capabilities: As of now, advancements in immersive and AI technologies will be needed to offer exciting opportunities to enhance the proposed designs further. For example, improved AI algorithms could provide more accurate engagement tracking and personalised interactions. Integrating lightweight, low-cost VR and AR hardware could make the designs more accessible to care homes and individual users. Enhanced haptic feedback systems and multisensory devices could also deepen immersion while maintaining user comfort.

Bridging research and practice: To maximise the impact of these designs, collaboration with care facilities, dementia support organisations, and technology developers will be essential. These partnerships can facilitate the deployment of immersive experiences in real-world care settings, allowing researchers to assess their effectiveness on a larger scale. Training caregivers and clinicians on how to use these tools will also be critical to their successful implementation.

Broadening user involvement: While the current designs are tailored to individuals living with dementia, future research could explore their applicability to other populations, such as those with different cognitive impairments or mental health conditions. Additionally, involving more diverse participants in the design and testing phases — across different cultures, stages of dementia, and living environments - will ensure the solutions are inclusive and adaptable to a wide range of users.

Ethical considerations and safeguards: Looking ahead, it will be crucial to continue addressing ethical considerations, particularly around data privacy, emotional safety, and informed consent. Developing robust protocols for data security and creating mechanisms for caregivers to monitor and guide the experiences will help maintain trust and safeguard user well-being.

Toward personalised, bio-adaptive VR: Future work could focus on creating bio-adaptive immersive systems, where real-time physiological data informs the environment. For instance, the system could automatically adjust the intensity of sensory stimuli based on the user's stress or engagement levels, ensuring a continuously comfortable and personalised experience.

By advancing these design directions, future research can further unlock the potential of immersive technologies to improve the quality of life for individuals living with dementia. These efforts will not only enhance therapeutic and recreational experiences but also contribute valuable insights into the evolving intersection of technology, dementia care, and human connection in human-computer interaction.

Chapter 6: Discussion and conclusion

The final section of this thesis concludes the findings from the previous three chapters to critically reflect on the feasibility, design, and potential impact of immersive experiences for individuals living with dementia. It addresses the core research questions, exploring the broader implications of the results for research and design. The chapter begins by addressing these research questions of the thesis, and how this advances understanding in the fields of immersive technology, dementia care, and human-computer interaction.

Following this, the discussion delves into the implications of the findings for various stakeholders, including individuals living with dementia, caregivers, family members, clinicians, and developers. These reflections aim to bridge the gap between theory and practice, offering actionable insights for future immersive technology interventions. Limitations of the studies are critically evaluated, providing a balanced view of the challenges faced through this research and their potential impact on the validity of the findings and how this area of research can be expanded for large-scale deployment.

Finally, the chapter concludes by proposing directions for future research and development based on the limitations of this research, with a particular focus on the role of immersive technology in creating meaningful spaces and its broader applicability in dementia care. By tying together feasibility, personalisation, and innovative design, this chapter provides a narrative that underscores the transformative potential of immersive technology for enhancing the lives of individuals living with dementia and beyond.

6.1 Addressing research questions

6.1.1 RQ1: How feasible and acceptable is the use of VR technology in delivering immersive and engaging experiences to individuals living with dementia?

To address this research question, insights from the pilot study by Tabbaa et al. [250] and findings from our own research collectively highlight the potential and challenges of immersive technology such as VR as a tool in dementia care to answer:

Why is VR worth exploring for dementia care?

Tabbaa et al.'s study demonstrates the feasibility and acceptability of VR in providing immersive and calming experiences for individuals living with moderate to severe dementia, particularly in locked psychiatric hospitals where access to external stimuli is often restricted. Using 360-degree video-based virtual environments (VEs), the study showed that VR could transport patients to new or familiar environments, offering meaningful engagement. Portable VR hardware, such as the Samsung Gear VR, proved effective in settings with space and time constraints, and the well-accepted nature of VR to those with severe dementia underscores its potential as a beneficial supportive tool. Positive outcomes included reductions in aggressive behaviours and observable emotional uplift after the VR sessions. These findings suggest that VR can help relieve behavioural challenges in dementia care.

My research builds on these findings by exploring VR's feasibility and acceptability in other dementia care contexts, including residential care homes and specialised arts organisations. In Study 1, participants engaged with VR video content tailored to their preferences, demonstrating the importance of personalised VR experiences for engagement. Similar to Tabbaa et al. [250], I observed that when participants interacted with content that resonated with their interests or past experiences, such as nature walks or music, they displayed more positive emotional responses and greater engagement. However, key challenges were also identified, such as communication barriers, which complicated the ability to understand the participants' true preferences in real-time.

Additionally, while the pilot study focused on a designer-led approach within a psychiatric hospital setting, Study 2 expanded this by investigating co-creative immersive experiences. By allowing participants to contribute to the design of virtual environments, such as translating physical model boxes into VR spaces, it was discovered that user involvement enhances the emotional connection to their own digital content. This participatory design approach complements the findings of Tabbaa et al. [250], as it underscores the need for flexibility and adaptability in VR content to cater to the diverse needs of individuals living with dementia.

Despite the promise of VR, my findings, alongside those found in the pilot study [250], highlight several barriers for large scale development. Physical challenges, such as discomfort from VR headsets, remain significant, particularly for individuals with mobility issues. Furthermore, while tailored content proved effective, achieving real-time personalisation remains a technical and logistical challenge, due to current technology advancements and the ethical dilemma of recreating personalised environments for participants who may find it disorientating. Study 1 demonstrated that participants struggled to provide verbal feedback on their experiences, making it difficult for caregivers and researchers to assess engagement effectively. This limitation suggests that VR systems could benefit from assessing engagement tools, such as eye-tracking, physiological measures or EEG signals, to provide non-verbal insights into user preferences.

The research collectively suggests that immersive technology such as VR is both feasible and acceptable for individuals living with dementia, particularly when tailored to individual needs and preferences. It offers an opportunity to reduce behavioural challenges, enhance emotional well-being, and provide meaningful engagement in environments that often lack stimulation (e.g., a locked psychiatric hospital). However, to optimise its effectiveness, future research should focus on addressing physical accessibility barriers, refining personalisation methods, and expanding VR's application beyond its current use cases. By integrating insights from related studies, the development of immersive interventions can better align with the needs and preferences of individuals living with dementia, caregivers, and care institutions alike.

6.1.2 RQ2: How can immersive experiences for individuals living with dementia be designed to transform generic spaces into meaningful places?

The concept of "meaningful places" is a key theme within this thesis, emphasising the transformative potential of immersive experiences to evoke emotional resonance and create environments that are more than just immersive — that they are deeply personal, impactful, and supportive. This section explores the principles and methods identified throughout the research to achieve this transformation.

Space is often described as an objective material arrangement of structures and objects within the world [48, 167]. In contrast, place emerges when space is infused with social and cultural significance through an individual's interactions and lived experiences [48, 167, 78]. In physical places, meaning is naturally layered over time, shaped by cultural narratives, historical associations, and personal memories [17, 259]. Places evoke curiosity and invite exploration, offering opportunities for discovery that build emotional connections through direct lived experiences [184, 30, 259]. However, in VR, these contextual layers of meaning do not naturally exist, as users are typically encountering the environment for the first time. Unlike a physical home filled with memories or a historical site rich with cultural significance, a virtual space begins as a blank slate. This presents a challenge:

How can VR designers ensure that virtual spaces become meaningful places for users?

I have identified three ways how meaning can be imbued into immersive experience to support people living with dementia:

1. Personalisation – By integrating familiar objects, locations, and narratives, immersive environments can provide a sense of identity and emotional connection, reinforcing place attachment and lived experiences.
2. Abstract representation - Rather than relying on exact replications, immersive experiences can also use symbolic cues and suggestive imagery to evoke meaningful

connections, making experiences more emotionally resonating without necessarily being directly represented.

3. Shared and collective experiences – Spaces gain meaning through social interaction, and immersive experiences can be a platform to build participatory and co-creative environments, where users engage with caregivers and peers to strengthen their sense of belonging and connection to an immersive space.

To enable virtual spaces become meaningful places, immersive experiences must provide a head start in constructing meaning. This can be achieved by incorporating personalised elements, allowing users to shape and interact with the environment in ways that reflect their identities and histories. For individuals living with dementia, integrating familiar objects, places, and sounds from their past can help establish a sense of continuity and belonging. Additionally, social interactions within immersive environments can transform generic spaces into meaningful places, mirroring the way shared experiences in physical settings contribute to place-making.

The goal is not simply to create engaging spaces for users to experience, but to design immersive experiences that connect with the users on an emotional level, helping them feel a sense of belonging, comfort, and identity. Borrowing from place attachment theory [110], this research informs us that place-making is key to build these emotional bonds, ensuring that virtual environments feel familiar and are deep in personal history, memories, and relationships. By identifying the elements that build these meaningful experiences, the research outlines a framework for transforming neutral virtual *spaces* into personalised, emotionally resonant *places*.

Personalisation as the foundation of meaning

A core finding of this research is that personalisation plays an important role in making immersive experiences meaningful for individuals living with dementia. The ability to connect with familiar environments, objects, and narratives provides a sense of security, identity, and emotional connection, especially as dementia progresses. Research shows that people living with dementia experience a gradual reduction in their lived space, meaning that the places they can access and interact with become increasingly limited over time [95]. This highlights the importance of restoring a sense of place by integrating familiar and meaningful elements within future immersive environments.

Personalised spaces in architecture, such as private homes and care facilities are designed to reflect the history, identity, and preferences of their inhabitants [66]. Similarly, immersive environments can incorporate personal elements, such as familiar objects, locations, and sounds, to create a greater sense of connection and engagement. Personalisation can take multiple forms, ranging from basic generalisation, such as selecting immersive content based on an individual's hobbies or interests, to more immersive, co-creative approaches, where users actively contribute to shaping their own environments. This aligns with findings in architectural research, which highlight that environments that reflect personal identity can provide a greater sense of attachment, well-being and identity [220]. By incorporating personal artefacts, images, and scenarios tailored to an individual's memories and preferences, immersive experiences can offer a stronger emotional connection for users. This informs **RQ2** by showcasing the role of personalisation in elevating generic immersive spaces into meaningful places. Personalised content aligns with users' interests and memories, creating deeper emotional connections and making immersive experiences more impactful and supportive.

Power of abstract representation

Designing environments for individuals living with dementia involves more than just physical accuracy – it requires creating spaces that evoke a sense of familiarity, security, and identity. Studies in dementia care environments suggest that familiarity and recognisable cues are essential in helping individuals navigate and feel comfortable in a space [181]. However, exact replications of environments are not always necessary to trigger meaningful connections. Instead, immersive experiences can integrate symbolic representations and abstract cues, using sensory elements to prompt memory recall and emotional responses.

For example, an immersive environment does not need to fully recreate a person's childhood home to feel meaningful — it can incorporate key sensory and spatial cues, such as familiar colour schemes, layouts, or sounds. In literature, Astell et al. [13] also looked into the difference in reaction when users are shown personal family photos which may seem more of a memory test, whilst generic photos elicit different reactions from different people, encouraging storytelling and reminiscence in a social context. In the contexts of designing immersive experiences, this means that selective elements that can leave lasting impressions can be more effective than purely realistic recreations in creating meaningful places for individuals living with dementia. In dementia care, where memory recall may be fragmented, abstract representations can allow for flexible and personalised interpretations, making immersive spaces more adaptable and emotionally resonant for different users. Instead of focusing on how perfect the recreation is, design in immersive environments can utilise cues, storytelling, and suggestive imagery to create spaces that feel meaningful without needing to be exact replications of environments. This flexibility informs **RQ2** by demonstrating that creating meaningful places does not rely on exact visual accuracy alone. Instead, similar abstract elements can evoke emotional stimulation, offering a practical and scalable way to design immersive environments that connect with users' memories and emotions.

Shared and collective experiences

Places gain meaning not only through individual experiences but also through shared interactions and relationships. In architectural design, spaces that encourage social interaction — such as communal gardens or open living areas— are known to build emotional connection and well-being [245]. Similarly, immersive environments can be designed to enable shared experiences, allowing individuals living with dementia to interact with family members, caregivers, or peers in meaningful ways [91].

Research on place-making shows that spaces become meaningful when they facilitate social interaction and emotional connection [86]. Immersive experiences can integrate these principles by allowing users to personalise virtual spaces with objects, images, and narratives that reinforce identity and belonging, participatory design plays a key role in this transformation. Just as architectural co-creation promotes agency and well-being [53], immersive environments can become a platform where users and caregivers collaboratively shape environments. Features that encourage conversation and shared storytelling enhance individual's identity, turning virtual spaces into socially enriching experiences.

Just as a house becomes a home through relationships and personal touches, immersive environments gain depth when they accommodate shared interactions. By integrating collaborative place-making, the design of immersive experiences can move beyond passive individual experiences and towards participatory, co-created spaces that provide comfort, familiarity, and social connection for individuals living with dementia. In answering **RQ2**, this work demonstrates that making a space meaningful is not solely about individualisation; it is equally about building shared and collective experiences. By integrating the relational bonds of place-making, immersive experiences becomes a fresh technological bridge between users and their surrounding loved ones, turning virtual spaces into homes imbued with connection, warmth, and shared memories.

6.1.3 RQ3: What are the key design considerations and challenges in creating personalised immersive environments for individuals living with dementia?

To address **RQ3**, the research findings reveal that personalisation in immersive experiences for dementia care exists on a dynamic spectrum. This spectrum (see Figure 6.1) also accounts for how personalisation is applied (ranging from abstract to literal) and the depth of system understanding (ranging from passive to predictive personalisation). Understanding this framework allows developing meaningful and effective immersive interventions that cater to the diverse cognitive needs and experiences of a wide population of individuals living with dementia.

Our research explored different points within this spectrum through distinct studies and design directions, each representing a different approach to personalisation. The first study (circled 1 in Figure 6.1) examined a generic approach, where literal video content was provided based on what caregivers and researchers believed participants might enjoy. This approach assumed that directly tailored past experiences or recognisable environments would provide meaningful engagement. However, it is seen that there are many other ways to consider personalisation beyond just literal personalisation. This encourages the concept to future researchers or practitioners to consider personalisation in a more abstract direction.

The second study (circled 2 in Figure 6.1) focused on a model box approach, where participants co-created their own artistic, abstract representations of spaces. This shifted the focus from past-based personalisation (e.g., meaning that was derived from exact accuracy) to interpretative personalisation (e.g., meaning that was derived through self-expression). This study demonstrated that participants can form personal connections with non-literal, co-created immersive spaces, suggesting that engagement does not necessarily depend on exact reconstructions of personal memories.

These findings indicate that while both literal and abstract approaches have their own advantages, there are significant gaps in how personalisation of immersive technologies are explored. The spectrum not only helps categorise existing approaches, but also highlights areas that remain under-explored.

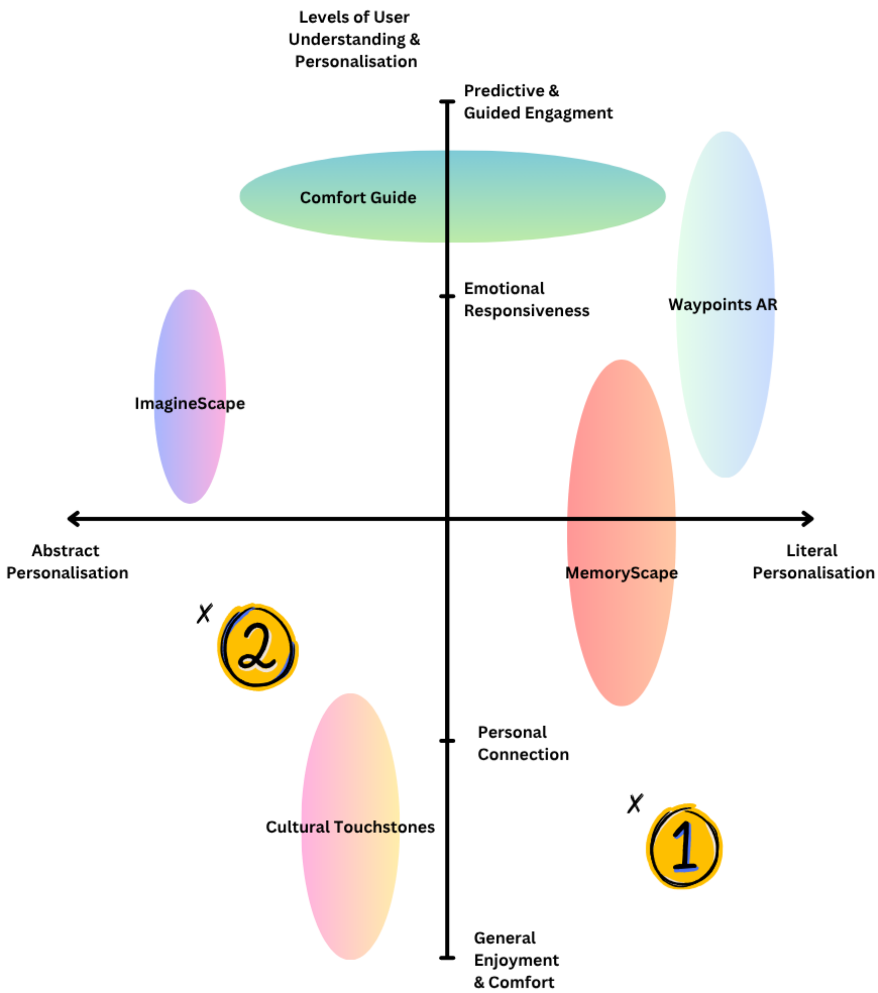

Figure 6.1: Conceptual framework mapping two dimensions of personalisation in immersive dementia-care design: the mode of representation (abstract to literal) and the different levels of user understanding and system adaptation (from general enjoyment to guided engagement). The framework highlights that these axes represent different but connected design considerations rather than hierarchical levels of effectiveness.

The spectrum of personalisation in VR for dementia care

From my research, personalisation is not a one-size-fits-all approach but can be seen to fit along two key dimensions. The two dimensions are separated because they describe different but complementary aspects of personalisation. The first concerns the form of representation (abstract to literal representation), where it defines what is being shown and how literally it reflects the user's memories, while the second (levels of user understanding & system adaptation) concerns how the experience responds to or guides the user. By treating them as different axes would help to illustrate how immersive design can vary both in expression and interaction. (as shown in Figure 6.1):

1. **Abstract to literal personalisation** – This axis shows how personal content is incorporated, ranging from abstract and open-ended representations (e.g., co-created environments that allow for flexible meaning-making) to literal recreations of past places or experiences (e.g., reconstructed childhood homes, personal photographs in immersive environments). In my studies, I observed the benefits of abstract representation (see Section 4.3.4), where ambiguous elements allowed participants to construct their own meanings and share their personal stories, encouraging personal exploration and emotional engagement. However, this level of abstraction is not suitable for everyone. As noted in Section 4.3.5, another participant remarked, "*I don't really know what it [the VR art] is meant to be,*" revealing that for some individuals, a more literal and recognisable representation is necessary for the experience to feel relevant and engaging.

2. **Levels of user understanding & system adaptation** – This axis considers how much the system understands the user. It is important to note that the levels along this scale are not hierarchical. "General enjoyment and comfort" does not sit in opposition to "guided engagement", but each level represents a different form of interaction suited to varying cognitive abilities and emotional states. Some users may find comfort in gentle, non-demanding environments, while others benefit from more structured or responsive interactions. This framework reflects a spectrum of design intentions rather than as a progression from simple to advanced. These levels are divided into 4 layers:

General enjoyment & comfort: At this level, personalisation introduces familiar and generic enjoyable content that provides comfort without requiring extensive individual tailoring. These experiences, such as nature scenes or music performances, offer a gentle introduction to immersive technology and providing passive enjoyment. In Study 1, for instance, a participant expressed clear enjoyment while watching a VR video featuring dancehall music. It reminded her of playful moments shared with a friend, and when asked if she would like to experience anything else, she simply requested more videos with dancehall music, demonstrating that even general content, when aligned with a person's broad preferences, can be deeply meaningful. This stage of personalisation is particularly suitable for individuals who may struggle with communication or cognitive complexity, yet still benefit from soothing, recognisable, and emotionally uplifting immersive experiences.

Personal connection: Deeper personalisation incorporates specific elements from an individual's life, reinforcing self-identity, this includes familiar places or personal significant objects. This stage supports reminiscence, strengthening a person's connection to their past and sense of self. In Section 3.3, I experimented with embedding personal photographs into virtual environments, and when carefully executed, these reconstructions elicited positive emotional responses with the research staff. However, as discussed in Section 3.3.3.3, it was also found that if the photo was not presented in a way that matched the user's memory or expectations, it could lead to confusion or disorientation. This underscores that this sort of understanding is very effective but is in need for careful curation and sensitivity when incorporating this level of personal material, ensuring that the experience feels authentic and emotionally safe.

Emotional responsiveness: Beyond static personalisation that responds commonly to the past, immersive experiences can adapt in real-time based on a user's emotions or engagement levels. Content can adjust dynamically to maintain comfort or re-engage users when they become disengaged. In dementia care, where mood and cognitive abilities fluctuate, this level of personalisation ensures that immersive experiences remains a positive experience. During the research with the model boxes, it was revealed the importance of playing off participants' responses in the moment. During the creative workshop, a participant began talking about their meaningful place, and as the conversation continued, they became increasingly creative with artistic ideas, whilst they shared stories with researchers enthusiastically. This shift not only deepened the engagement, but also showed how emotional momentum can be harnessed into creativity when experiences are aligned with the user's interests and emotional state. These moments highlight the potential for immersive systems to not just react, but to gently guide the experience in ways that amplify the emotional connection within the moment.

Predictive & guided engagement: This level of understanding is not only based on past information, but also future-oriented participation, using patterns of interaction to suggest meaningful activities, rather than simply reacting to the past. My proposed design direction, *Waypoints AR*, exists as an example that can serve as a bridge between past memories and future engagement. For example, after revisiting a favourite restaurant memory, a user might be shown a prompt for an upcoming lunch with a friend, encouraging future real-world social interaction. This gentle form of guidance can help people living with dementia stay connected to routines and interests, particularly when planning and memory become difficult. It also offers care staff and families a way to support autonomy, turning immersive technology into a co-pilot for daily living. By blending the familiar with subtle prompts for future events, predictive personalisation can reinforce identity, encourage continuity, and extend the benefits of immersive experiences beyond the screen for longer lasting effects in the real-world.

This framework helps inform how immersive experiences can be customised to meet the diverse needs of individuals living with dementia, balancing emotional significance with cognitive accessibility. To further illustrate its practical application, I have also plotted the approximate area of each design direction (mentioned in Chapter 5) across the spectrum, offering a visual estimation of where each concept sits in relation to the personalisation and levels of user understanding. This mapping helps to identify which aspects of the design space are being explored, and where opportunities may exist for further development, ensuring an inclusive approach to personalisation in using immersive technology in dementia care.

Design challenges

While personalisation offers a promising way to make immersive experiences more engaging and meaningful for individuals living with dementia, its implementation presents several challenges. These challenges must be carefully addressed to ensure that immersive environments remain adaptable yet remain impactful.

1. **Balancing specificity vs. flexibility**: One of the fundamental challenges in designing personalised immersive environments is ensuring that personalisation remains meaningful without becoming too specific. Highly specific personalisation, such as recreating exact real-world locations, may not always align with user expectations or provide the intended emotional benefits. For instance, while one user may expect an immersive experience of a childhood home to feel deeply immersive, another may focus on different aspects — such as the presence and connections of family members rather than the physical space itself. This variability in personal memory recall means that immersive environments must be flexible, allowing users to engage with elements in their own ways that are personally meaningful to them rather than dictating a singular experience.

2. **Scalability vs. individualisation**: While deeply personalised environments may be the most engaging to users, they also pose challenges in terms of labour and scalability. Manually creating personalised environments for each individual is not practical for large-scale implementation, especially in care homes or healthcare settings where resources are limited (staff, recreational space etc.) To address this, designers must explore immersive environments where templates can be adjusted to reflect personal preferences. Additionally, AI-driven personalisation could automate elements of the design process, adapting environments dynamically based on user preferences, interactions, or even physiological responses (e.g., heart rate or EEG signals) These scalable solutions allow for meaningful personalisation without requiring extensive manual input for each user, this is immensely important as each person's diagnosis and progression of the disease can vary greatly, requiring personalised considerations in immersive environments.

3. **Cognitive load & overstimulation**: Another key consideration is ensuring

that personalised immersive experiences do not become overwhelming or cognitively demanding for individuals living with dementia. While immersive environments can be engaging, they can also introduce too much complexity, leading to confusion or distress. For example, immersive environments that attempt to reconstruct deceased relatives in an interactive manner may be emotionally overwhelming or difficult to process, blurring the lines between memory and reality. This can create unintended emotional distress rather than comfort, highlighting the importance of careful consideration when designing memory-based immersive experiences. In contrast, if an immersive experience is too simplified, it may fail to sustain interest. During our research, one participant expressed disinterest in experiences that did not offer enough cognitive stimulation, reinforcing the need for an appropriate balance. Immersive environments should be engaging enough to maintain attention and spark curiosity but not so complex that they become confusing or overwhelming. To achieve this balance, designers should focus on structured, guided interactions that offer meaningful engagement at a pace that suits the user. Features such as gradual environmental changes, predictable interactions, and intuitive navigation can help users interact with the immersive environment without feeling lost or overstimulated. Additionally, offering adjustable complexity levels — where users can choose between passive experiences or more interactive, cognitively engaging tasks - this can ensure that immersive experiences remains enjoyable and accessible across different cognitive abilities.

4. **Adapting over time as dementia progresses**: Dementia is a progressive condition, meaning that user needs and capabilities change over time. What may be an engaging and accessible experience at an early stage of dementia may become confusing or overwhelming at later stages. This poses a challenge for personalisation, as a single immersive environment may not remain suitable or effective throughout the progression of the disease. Future immersive systems should explore adaptive personalisation, where experiences can adapt to changing cognitive abilities, engagement levels, and feedback from caregivers. For instance, an environment that initially allows for active creation and interaction might later shift towards passive, guided experiences that still provide comfort and familiarity but require less direct engagement from the user.

5. **Collaborative vs. individual personalisation**: Personalisation in immersive environments does not always have to be an individual activity. While some users may benefit from environments tailored directly to their memories and experiences, others may find greater meaning in shared and co-created spaces. For example, family members or caregivers can contribute to the design process, helping to select meaningful objects, places, or themes for the user. Additionally, multi-user immersive experiences can transform from an isolated activity into a shared social interaction, helping users build connections and engage in collaborative storytelling. This shared approach to personalisation enhances the social dimension of immersive technology, making it a tool not only for individual engagement but also for strengthening relationships.

6.2 Implications

6.2.1 Contributions to immersive technology research for vulnerable populations

This research contributes significantly to the understanding and advancement of immersive technologies, particularly within dementia care. By demonstrating how personalised immersive environments can enhance engagement and well-being, it highlights the transformative potential of immersive technologies for vulnerable populations. The findings extend user-centred design principles to address the unique needs of individuals living with dementia, providing insights for fields such as human-computer interaction (HCI), ageing studies, and healthcare technologies. These contributions also lay a foundation for future studies exploring the role of personalised, meaningful environments in providing emotional and cognitive stimulation.

Several important novel contributions were made during this research to HCI and dementia care. Instead of putting the focus on whether immersive technology can work in these contexts, I show how immersive experiences can be designed to be more personal and creative, yet still meaningful. This work moves the focus from technological feasibility towards approaches that are more centred on people's identities.

One of the most valuable contributions is the demonstration of a participatory forward-thinking methodology. By working with people living with dementia over several sessions during the model box creation, the project showed how participants actively shaped their own digital environments. This wasn't just about the final product, or a way of generating content for them to experience, the creative process itself proved to be most impactful. It supported confidence, built emotional connections, and gave participants a stronger sense of personhood. This approach offers a practical model for bringing arts-based co-design into care settings.

The research also proposes a new way of thinking about personalisation. Rather than assuming personalisation must mean literal reconstructions of past memories, I introduced a framework that works along two dimensions, from abstract to literal representations, and across different levels of user understanding and system adaptation. The studies showed that abstract, creative representations can be just as engaging as literal ones, and sometimes even safer and more impactful, since they avoid the risks of confusion or distress caused by potentially inaccurate recreations. This framework gives future designers a more flexible and sensitive way to create meaningful immersive experiences.

Finally, the third study turned these insights into practical design concepts. Such as, **Waypoints AR**, which uses everyday locations to trigger reminiscence and also encourage future activities, making it a supportive tool rather than just a traditional reminiscence aid. Or **MemoryScape**, which uses AI to transform personal photos into immersive digital environments, which blends memory recall with active, imaginative engagement. Together, these designs show how immersive systems can move beyond entertainment or reminiscence to become tools for creativity and care.

6.2.2 Practical implications

For patients: This research highlights the potential of immersive tools to provide meaningful and engaging activities tailored to individual preferences, creating moments of joy, connection, and emotional resonance for individuals living with dementia. By incorporating personalised memory recall, interactive storytelling, or creative expression, immersive environments enable individuals to reconnect with meaningful aspects of their identity and experiences. Additionally, the immersive nature provides a unique platform for individuals to express their emotions and feelings in ways they might otherwise find challenging. This aligns with the principles explored in the model box study, where external users could experience and interpret the creations of the participants, allowing a deeper understanding into their emotional world. Similarly, immersive environments designed with life-story narratives and memory-rich settings allow individuals and their families to engage in shared experiences, creating opportunities for deeper connection and positive emotional impact.

For family members: Immersive experiences provides an innovative platform for family members to connect with their loved ones through shared experiences. Co-creative activities, such as contributing photos or voice recordings, allow families to collaborate in shaping immersive environments that resonate with the user.

For caregivers: The research underscores the value of immersive experiences as a tool for caregivers, providing structured activities that can integrate seamlessly into daily routines. Engagement tracking and real-time feedback mechanisms, such as session summaries, empower caregivers to better understand user preferences and emotional triggers. For individuals living with advanced dementia, immersive experiences serves as a non-verbal communication bridge, enabling caregivers to interpret reactions and adjust care approaches accordingly. By offering a flexible yet engaging activity, immersive tools alleviates caregiver burden while enhancing care quality.

For clinicians: Clinicians can use immersive experiences as a complementary recreation tool, using it to provide cognitive and emotional stimulation. Given that immersive tools can be used seamlessly by clinicians without external help, they can allow clinicians an immersive option for their patients, especially given that they can explore the immersive digital world and not affect the busy schedule of clinicians. In future research, the integration of engagement metrics from immersive sessions offers an additional layer of insight into a patient's emotional and cognitive state. These data-driven insights can support diagnostic evaluations, monitor behaviour progress, and refine external intervention strategies. By combining traditional practices with immersive experiences, clinicians can enrich the overall care experience for individuals living with dementia.

For developers: This research provides guidelines for developers creating immersive environments for individuals living with dementia. Prioritising personalisation, abstract representation, and co-creation, the findings encourage developers to adopt user-centred approaches. Involving caregivers and family members in the design phase ensures that immersive experiences align with user needs and preferences. Features like AI-driven personalisation and multisensory interaction are highlighted as ways to further enhance engagement, creating impactful and meaningful immersive experiences in the future when technological needs are met.

6.2.3 Effects from research on the community

Reducing stigma: The adoption of immersive technologies for dementia care has the potential to reshape perceptions of individuals living with dementia. By showcasing their ability to actively engage in creative and meaningful activities, immersive technology challenges the stigma often associated with cognitive decline. It reframes individuals as active capable participants rather than passive bystanders, creating a more inclusive, resilient and compassionate view of dementia.

Promoting inclusion: Immersive technology offers a unique platform for broader community engagement, allowing individuals living with dementia to interact with others in virtual settings without the physical or cognitive barriers present in real-world interactions. These environments enable users to participate in social and cultural activities that might otherwise be inaccessible, promoting inclusion and social bonding.

Ethical considerations: While the benefits of immersive technology are significant, this research acknowledges the ethical considerations of implementing such technologies for vulnerable populations. Concerns about privacy, consent, and the psychological effects of immersive technology use must be addressed to ensure responsible adoption. Establishing frameworks for ethical implementation and monitoring is essential, including guidelines for data security and safeguarding against potential negative effects. By prioritising ethical considerations, this research area asks for a balanced approach that maximises benefits while minimising risks.

6.3 Personal reflection as a researcher

Throughout my time as a researcher in this field, I have gained insights into research methodologies, design processes, collaborative work with both academic and non-academic communities, and the delicate but rewarding task of working with individuals living with dementia. This journey has been a deeply enriching experience that has reshaped my perspective on research, its impact, and the importance of human-centred design.

One significant aspect I have learned is the importance of language and representation. I have deliberately refrained from acronymising participants or reducing them to "people with dementia." Instead, I acknowledge them as individuals living with a diagnosis, emphasising their personhood beyond their condition. This approach respects their individuality and potential, reminding us that they are not defined by their diagnosis but continue to have vibrant lives and futures. While reflecting on their past is valuable, I have learned that our work should also encourage optimism, creativity, and exploration of their present and future lives.

Ethical considerations have been a fundamental part of this research journey. Completing the ethics approval process for my studies was initially challenging, as it required significant time and effort. However, I have come to understand its critical role in ensuring that data is handled appropriately and participants are treated with respect and professionalism. Ethics is not merely a procedural hurdle but a foundation to responsible research, particularly when working with vulnerable populations.

Working directly with individuals living with dementia has been both insightful and deeply moving. I learned the importance of treating participants with dignity, recognising their capabilities, and providing a positive outlook. One particularly touching moment occurred during a remote session when a participant became emotional upon seeing me. Later, I realised that my presence had triggered memories of his son, with whom he had shared video calls in the past. This experience underscored the emotional depth of working in this field and the meaningful connections that can emerge through research.

My work in the field of human-computer interaction has also taught me that research extends beyond theory, fieldwork and results. How we showcase our work matters significantly, as part of the Designing Interactive Systems (DIS) 2023 exhibition, we presented our research in an exhibition format (see Figure 6.2), which proved more impactful than I initially anticipated. While I had always viewed our work as meaningful for both participants and researchers, seeing it displayed for a broader audience was greatly rewarding. It allowed the wider community to appreciate the brilliance and creativity of our participants' contributions. This exhibition reinforced the importance of not only conducting meaningful research about resilience but also amplifying its impact by sharing it in ways that celebrate the voices and creativity of researchers, artists and participants beyond traditional means like academic papers.

Figure 6.2: Exhibition at DIS 2023.

This reflective journey has deepened my understanding of the responsibility and privilege of working in this field. It has reminded me that research is not just about solving problems, but about connecting with the individuals at the heart of the research.

6.4 Limitations & future directions

Throughout this research, several limitations were encountered, reflecting the inherent challenges of working with emerging technologies and vulnerable populations such as individuals living with dementia. These limitations provide valuable insights into areas that require further refinement and exploration. Addressing these challenges in future research will not only enhance the feasibility and impact of immersive interventions but also ensure their broader applicability and effectiveness. For each limitation identified, corresponding future directions are proposed, offering pathways to mitigate these issues and advance the field of meaningful immersive designs.

Limitation 1 – Small sample size: One of the primary limitations of this research is the relatively small sample size across the studies. While the findings provided valuable insights into the feasibility and different personalisation concepts of immersive technology for individuals living with dementia, the limited number of participants restricts the generalisability of the results. This is particularly important when considering the diversity of dementia experiences, as responses to the interventions can vary widely based on cognitive abilities, personal history, and environmental factors of the participants.

Future direction 1 – Expanding participant recruitment: Future research should aim to recruit larger participant groups, potentially across multiple care homes, community centres, or in-home settings. Increasing the number of participants would allow for more statistical robustness, ensuring findings are more widely applicable to the broader dementia population.

Limitation 2 – Focus on early-stage dementia: This research primarily worked with participants in the early stages of dementia in several of the studies, who still have relatively high cognitive and physical function. While this provided insights into engagement and personalisation, it raises concerns about the broader applicability of immersive technology for individuals in moderate to severe stages of dementia – a group that arguably has a greater need for meaningful and engaging interventions.

Future direction 2 – Studying immersive technologies adaptability across dementia progression: An essential next step is to track how engagement in immersive experiences and usability change as dementia progresses. A future study could revisit the same participants at later stages of dementia, examining i) how their preferences evolve — do they still engage with immersive worlds the same way, or do their needs shift? ii) Which elements remain effective — do personalised environments still evoke emotions and memories in later stages? iii) What adaptations are needed – should interaction methods, content, or sensory elements be adjusted to better suit later-stages of dementia? By studying the evolving role of immersive technologies throughout the dementia journey, adaptive systems that support users at different stages can be created to ensure that immersive tools remain a meaningful and accessible companion throughout progression of dementia.

Limitation 3 – Limited cultural and ethnic representation: The studies conducted focused on a specific cultural context, with most participants coming from a similar demographic background. Given that personalisation is a core theme of this research, it is crucial to recognise that cultural background significantly influences what is considered meaningful in immersive environments. The lack of ethnic diversity in the study sample means the findings may not fully represent the needs and preferences of individuals from different cultural backgrounds.

Future direction 3 – Culturally inclusive immersive designs: Future research should explore how personalisation in immersive environments can be adapted to ethnically diverse populations, considering: i) Memory-evoking content based on different cultural backgrounds (e.g., culturally relevant locations, traditional music, or family traditions). ii) Multi-language support and cultural nuances in virtual interactions. iii) International collaborations to test immersive experiences in different countries and communities. By integrating culturally responsive design, future immersive interventions can ensure that personalisation extends beyond a single cultural framework, making the technology more inclusive and relevant to a global population.

Limitation 4 – Lack of quantitative evaluation of benefits using immersive technologies: This research primarily adopted a qualitative approach, with focus on exploring user experiences, engagement levels, and narrative insights rather than conducting quantifiable assessments. While qualitative data provides rich, in-depth understanding, it does not offer measurable outcomes that can support stronger clinical or theoretical recommendations.

Future direction 4 – Introducing quantitative and mixed-methods approaches: Future studies should incorporate quantifiable metrics to assess the impact of immersive environments on individuals living with dementia. This could involve: i) Cognitive function tests to measure memory or attention improvements after immersive activities. ii) Psychological scales to assess changes in mood, stress, or social engagement before and after. iii) Randomised control trials (RCTs) to compare immersive interventions against traditional therapies. This approach bridges the gap between qualitative insights and clinical evidence, allowing personalised immersive interventions to be evaluated with more scientific robustness and to explore ways to quantify the inherently qualitative concept of *meaningfulness*, ensuring that subjective experiences can be systematically measured and validated .

Limitation 5 – Dependence on head-mounted displays (HMDs): A significant barrier identified during the studies is that some individuals living with dementia struggled with wearing head-mounted VR devices, either due to discomfort, unfamiliarity, or sensory issues. While HMDs provide full immersion, they are not universally accessible for all users especially those living with dementia who may have physical troubles.

Future direction 5 - Exploring alternative immersive technologies: Future research should explore alternative methods of delivering immersive experiences, including: i) Augmented Reality (AR): Instead of a fully enclosed VR headset, AR experiences can overlay virtual elements onto physical environments via tablets or smart glasses, reducing discomfort. ii) Projection-based VR: Using immersive projection rooms or tabletop projections to create interactive spaces without requiring wearable devices. iii) Haptic and audio-only VR: Implementing soundscapes and physical interactions (e.g., vibration feedback gloves) to provide an immersive experience without visual dependency. By expanding beyond HMD-based VR, dementia-friendly immersive experiences can be made more accessible to those who may struggle with traditional VR headsets.

Limitation 6 - Short-term interaction & lack of longitudinal studies: The current research primarily examined short-term engagement with VR, typically lasting one or two 30-minute session at most. However, the long-term effects of repeated immersive experience exposure remain uncertain — particularly regarding whether engagement remains high over time or if novelty effects wear off. In dementia research, longitudinal studies are particularly crucial, as cognitive decline progresses over time. Understanding how engagement with immersive tools evolves as dementia symptoms worsen can provide insights into the long-term sustainability and adaptability of these interventions.

Future direction 6 - Long-term engagement and progression studies: Future research should investigate whether immersive experiences continues to offer meaningful engagement at different stages of dementia and how systems might need to be adapted to accommodate cognitive and sensory changes over time. Future studies could follow participants longitudinally, assessing: i) Changes in engagement over several months or years - does interest in immersive experiences persist, or does it diminish? ii) Cognitive and emotional effects over time - does repeated exposure to personalised immersive experiences help sustain memory recall or improve emotional well-being? iii) Adaptation of personalisation strategies – how can immersive experiences shift in response to changing needs, ensuring continued relevance even in later dementia stages? Conducting longitudinal follow-ups with participants as their dementia progresses would provide a more comprehensive understanding the role of immersive technologies across different stages of dementia. It would also bridge the gap between early-stage feasibility and later-stage necessity, ensuring that immersive technologies remains a long-term, evolving intervention rather than a one-time novelty.

6.5 Conclusion

This thesis highlights the importance of shifting from technology-driven approaches to care-centred co-design, prioritising emotional well-being, creativity, and inclusivity. The richness of these experiences cannot be fully conveyed through traditional academic outputs alone, encouraging future research to explore alternative ways of engaging with deeply human data. This research demonstrates that immersive technologies should not necessarily aim to replace existing dementia care strategies, but rather add, enhance, and complement them - offering new ways to support engagement within trusted care frameworks. Throughout the journey of this research, it became clear that the value of immersive experiences lies not in their technical sophistication and results, but in their ability to facilitate meaningful, human-centred experiences. In conclusion, the future of immersive technology in dementia care lies in creating person-led experiences that support personhood and enhance the quality of life for people living with dementia, through empathy, creativity, and connection.

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Appendix

A Details of each web app page

- Home screen: The first and foremost page of the application, this is just a basic page with the application logo and an enter button to proceed to the application. From here, users will continue through the app to the login page.
- Login page: Designed for returning users, this page ensures secure access to personal accounts, you will enter your login details and will be authenticated through the Firebase authentication system, wrong details would provide a '*wrong password*' error pop-up. New users can register by pressing 'Register' before providing basic information.
- Registration page: Designed for new users, to easily register by providing basic information such as first and last name, age, location, email address and password. After registering, their information will be stored in Firebase's authentication system ready to be verified when they return. There is a button to go back to the login page if user already has an account.
- Video selection page: Displays a curated selection of videos that any user can access as well as content that are personal and account-locked (if available). Users can browse and select a video amongst the content available, selecting a video will commence a download of the corresponding video onto the VR headset, if it is not downloaded already, and then bring up the play screen for the video.
- Upload video page: This page is dedicated for users to upload their own 360-degree videos for private viewing through the application into the cloud Firebase database. Although the upload feature was not utilised in this study, it serves as a placeholder for future development, allowing further personalisation.
- Play screen: Once a video is selected, the user is directed to this page, where they can control video playback (e.g., play and pause). Additionally, the livestream feature

displays the VR user's view on this screen, facilitating shared experiences and encouraging conversations between the user and a caregiver or family member. This page also indicates whether the video has been downloaded already onto the headset. When a user selects a video, the system checks if they already have the video installed, if not, then it would request the video to be downloaded from the Firebase database. The button on the play screen would become inactive, unless the video is already downloaded or has completed its download, then the button becomes active allowing the user to play the video for the VR user.

- Profile Page: This page can be entered from the video selector page where on the top right allows you to select between the profile or the videos. This is just an information page showing who the user is, this is convenient for caregivers to see which user is currently logged in, given that the caregiver cares for multiple participants with different sets of personal videos, making it easier and more convenient to manage the different users and video selections.
- Edit information: This page is for the user to update any new information on the participant, useful to edit a mistake or update if the user moves to a new location.

B Feasibility study questionnaire

Caregiver Questions (Before intervention but after system training)

- Do you feel confident in using the system with patients?
- Do you understand the use of this system? If not, what do you not understand?
- Do you see why this system would be beneficial for people living with dementia to use? If not, why?

Caregiver Questions (After intervention)

- Would you like to use this system again? (with the same/different patient) If yes: How frequently? Why would you like (not like) to use it?
- Did you need significant training before you could use this system? If yes: Can you tell us a couple of things you feel needed to learn? Are there any aspects that are particularly difficult? If no: was the system easy to use? Can you tell us more?
- Do you think that you will need the support of a member of the research team to be able to use this system again? If yes: Why? What needs to be done to ensure that the system is easy to use?
- Please tell us your general impression on using the VR headset with the patients.
- What do you see as benefits of using VR for people with dementia?
- What do you think are challenging issues of using VR in a clinical environment involving people with dementia, and why?
- What can we change to improve the technology for clinical use?
- Are you keen to see this technology adopted in dementia management in [Name of establishment]? If yes: what needs to be done to ensure the successful adoption?

Patient Questions (Before intervention)

- How are you feeling? (Smiley face ratings)
- Do you know what this is? (Showing VR Headset) If not, do you know what VR is? -"*It allows you to experience another environment with the use of computers using video and sounds, it should make you feel like you're somewhere else.*"
- How do you feel about trying it (VR Headset) on? (Smiley face ratings)

Patient Questions During Intervention (Conversation starters)

- Is the headset comfortable? (ask early on to prevent ruining immersion later)
- What do you see?
- Does this remind you of anything?
- How are you feeling?
- Have you been there before? If yes, when was the last time? If no, would you like to go? (places)

Patient Questions (After intervention)

- How much did you enjoy the experience (visual scale)
- What did you like/dislike?
- How do you feel now (regarding the VR exposure)? (visual scale)
- Would you like to use this system again? Why would you like (not like) to use it?
- In the VR, did you have the sense of "being there at the [VR scenario that was played]"? If yes: Can you tell us more? How did you feel?
- During the VR session, did you think of the other person(s) in the room (e.g., the caregivers)? If yes: how often did you think of them?
- Did you feel like the experience was real? (Similar to a real-life experience than looking at a picture) Can you tell us more?
- How easy was it to use? (with visual scale) If difficult: what was difficult about it?
- Did you feel like tired using this system? (Yes/No/I don't know). Why/tell me more about it.
- Did you feel engaged with your carer during the VR experience? (Yes/No/I don't know).

C Model box experience questionnaire

- Overall, how does this environment (VR experience) make you feel? – tell me more. Why this feeling?
- Did you feel like you were inside the box?
- Can you tell me more? Can you give me an example?
- Did anything in the VR felt most enjoyable/fun, if so... which aspect? Can you tell me why this aspect is fun?
- Does this look like the box you made? (in reference to the physical model box) – can you tell me more about it.
- Does this place (box) remind you of anywhere? Where? How does it remind you of this place?/ Does this place remind you of anyone? Who? How does it remind you of this person?/ Does this place relate to you? How?
- Where other places would you like to visit in VR?
- What other things you would add? What would you have liked to change? How would you change it? Why?
- Would you use it again? Why? How/when do you think you would like to use it? - If you could do anything you wanted to in VR, what would you do – games or an experience?
- Would you recommend others to try this? Why?
- Did you feel a personal connection to the VR environment?
- Did it (VR experience) make you feel more relaxed or calm or was it stressful using it? – Did you feel safe? What made it so?
- Would you want to use your own personal photos in a VR experience?

D Initial sketches for design directions

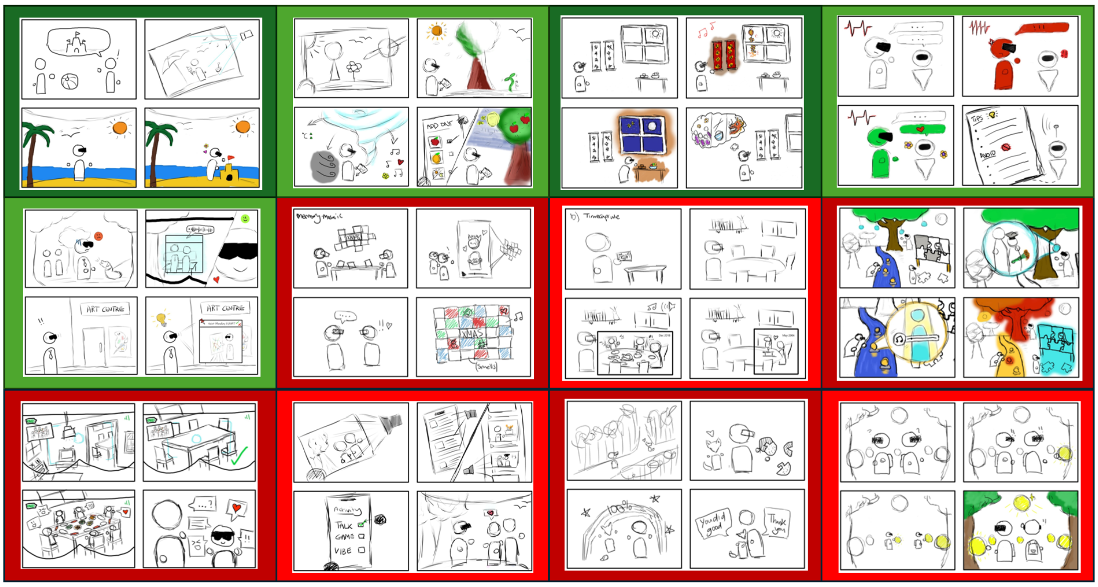

Figure 3: All initial design direction concept sketches, green background shows the ideas that were selected and the red highlights the ideas that were rejected