Designing meaningful VR experiences for adult palliative care persons

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Abstract

Virtual Reality (VR) has demonstrated efficacy for reducing stress for Palliative Care (PC) persons and distracting PC persons from pain (Ahmadpour et al., 2019). However, VR in clinical settings may do more to foster the holistic approach of PC, creating an enriching experience adjunct to focusing on clinical outcomes or as a distraction from suffering. To understand design trends, gaps and opportunities for VR in PC, we first conducted a scoping review across 4 databases. We found 14 articles that shared the design and use of VR in the PC setting, demonstrating aspects of care that VR currently supports: symptom management, embedded enrichment, personalised care and decision-making, with the former dominating the field. Dominant design strategies included: active compared to passive engagement in VR, narrative building, and supporting accessibility and mobility. It is notable that participatory approaches were underutilised. In the first part of the study, we argue that there is a need to change stance towards proactively fostering enrichment as an outcome, not just clinical outcomes, and present five mechanisms to support person-centred PC using VR.

The half of this study focused on using the design strategies identified from the scoping review to develop a VR prototype based on the Hammond Care Cancer Pain app. Current prototyping processes for VR space are time-consuming, expensive and often require heavy up-skilling to use existing tools (Ashtari et al., 2020). The high skill barrier constrains creativity in the early ideation phase of the design process. Our study created a low-cost video prototyping method using generative AI tools to speed up the ideation and feedback loop, to allow researchers to move faster into development. The final video prototype aims to addresses the needs of PC persons in a meaningful way and has been developed through feedback by healthcare clinicians in the PC space.

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Material from this appears in Chapter 3, 5, 6. I was the lead and corresponding author on this paper, with my supervisor.

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Chapter 1

Introduction

Palliative care (PC) is a "crucial part of integrated, people-centred health service" [1] which seeks to enhance the quality of life for individuals with life-limiting illnesses and their families [2]. PC is often associated with holistic approaches for relieving suffering and notably encompasses early identification, assessment and addressing physical, psychological, social and spiritual concerns [1]. Pain is a significant concern for many PC persons, and it can lead to a variety of negative outcomes such as sleep loss, decreased appetite, and worsened mental health symptoms like anxiety and depression [3, 4].

There has been a rise in the use of digital tools for symptom management in PC with non-pharmacological treatments gaining popularity, due to lower risk of adverse side-effects and drug dependence, than conventional pharmacological approaches [3, 5, 6, 7]. One digital tool that has shown great promise in reducing self-reported pain symptoms, particularly in PC for persons requiring acute short-term pain relief is Virtual reality (VR) technology [6]. There has been an increased interest in VR, as the technology has become more readily available and affordable, and has the distinct advantage of being able to create fully immersive environments compared to other platforms such as mobile devices [8]. Immersion in a 3D environment allows full capture of a person's cognitive resources, reducing their capacity to attend to the sensation of pain [9, 10]. This is key to distraction and focus-shifting strategies for managing pain and distress across a range of conditions such as cancer pain [11] which is relevant to PC [2]. Additionally, immersive VR experiences can aid pain and anxiety relief by generating positive emotional experiences such as enjoyment [8]. Enjoyment and other enriching experiences not only increase efficacy of the VR experience for PC persons [8, 2], they could provide much needed psychological relief to the person through providing meaningful emotional engagement, narratives and sensory stimulation [12].

However, many studies examining the potential use of VR as a tool in PC have fallen short of centering design at the expense of enhancing clinical robustness, and have missed the opportunity to fully harness the power of VR to both enhance the materiality of care and facilitate enriching experiences for adult PC persons that otherwise may be inaccessible [2, 10]. As studies investigating the use of VR experiences for physical symptom relief and distraction gain attention in a range of areas including adult PC, it is critical to investigate how this technology might be used meaningfully for outcomes within a holistic PC approach to care beyond what is clinically prioritised like symptom management [2]. Participatory approaches that engage clinicians, PC persons and their families would be key to these efforts. However, working with PC persons comes with ethical and logstical challenges. At the same time, working with clinicians in design might require quick prototyping to demonstrate the power of VR or exemplify what the "design" might look like when "ideas" are realised in the immersive VR space. To address these challenges, there is an opportunity to use generative artificial intelligent (AI) with the aim of quickly prototyping designs, and exploring possibilities with clinicians and when possible, PC persons and their families. This research will delve into this space, while acknowledging the limitations of conducting design research within a short capstone project. For example, while working with PC persons is ideal, during the course of this project it became apparent that recruitment of participants is challenging and ethical considerations such as access and ability to engage with researchers remotely (using technologies such as Zoom) would hinder engagement.

1.1 Aim and Research Questions

This study aims to bridge the gap in Human Computer Interaction (HCI) and Design literature to identify VR design strategies that can be used to create meaning for PC persons and their care goals pertaining to all or some of the four areas of impact in PC; physical, psychological, spiritual and social. Specifically, the project will aim to examine existing VR design strategies for PC in the literature, identify possible areas of impact, scope a feasible project within this capstone research (meaning a project that can be completed within the span of one year) and identify practical approaches to create VR through participatory approaches. Importantly, this project is conducted in collaboration with a clinical partner, Hammond Care based in Greenwich Hospital (North Sydney local health district, New South Wales, Australia) and as such, part of the scoping of the project will be considered in consultation with them. For example, the clinical partner is currently using a mobile app for supporting symptom management in adult PC persons while also considering how they might develop a VR program. As such, part of this project will investigate how existing mobile app designs for PC symptom management can be feasibly and meaningfully converted to VR. To achieve that within the time limitation of this project, it will be reasonable to use a range of generative platforms for ideation, prototyping and facilitating discussions with the clinical partner. Therefore, this approach is likely to provide insights about the use of generative platforms for designing VR experiences in the health context. I hope the outcome is able to inform future research to mindfully explore the potential application of VR interventions in PC settings.

This topic will be explored through two main research questions:

1. How can we better understand current design strategies used in VR experiences for palliative care patients?
2. How do we create and prototype meaningful experiences in VR to support palliative care patients using a collaborative and participatory approach with clinicians?

1.2 Intended Outcomes

The present study aims to make contributions in the following areas:

1. **Methodological:**

    (a) To identify and articulate a set of design features and provocations that can guide the development of meaningful VR experiences for adults in palliative care to enable enrichment in alignment with clinical goals; and

    (b) To develop knowledge about how to effectively translate mobile app strategies for PC to VR space.

2. **Artefact:** To create a meaningful VR prototype that addresses the needs of PC persons and healthcare professionals working in PC space through a participatory process that seeks clinical feedback.

To achieve these outcomes, I conducted a comprehensive scoping literature review focusing on current design strategies employed in VR experiences tailored for adults in palliative care. The review resulted in the formulation of design provocations and a set of design features aimed at cultivating meaning and fostering a person-centered approach, through enriching the experiences of persons in PC. These design provocations and feature were incorporated into the creation of a VR prototype. The prototype adapted activities from the Hammond Care Cancer Pain mobile app already being used by PC persons in Greenwich hospital. The challenge here was to align a number of design and clinical directions:

1. use findings from the literature review to create an enriching VR experience;

2. identify a feasible approach to translate what is presented in a clinical mobile app into a designed VR space in a way that meets clinical goal while creating an enriching and engaging experience; and

3. create quick prototypes to engage clinicians in this process and seek their feedback and therefore refine the design by iteration.

While working with PC persons would have been ideal in this process, my attempts to recruit PC persons were not successful. In two instances I identified and contacted willing participants and their families, however the ethics approval required me to conduct sessions remotely (to mitigate the risk of infection in vulnerable persons in PC). In both case, the participants eventually changed their mind about completing the session as they had logistical issues with join remote sessions. As a result, throughout the VR design process, clinicians and healthcare workers at Hammond Care, who are partners in an ongoing research project with Dr Ahmadpour, were engaged through online prototype demos and interviews. This helped me gather valuable feedback before iterating the prototype. There were three different major iterations of the video prototype completed between feedback session with the research team and healthcare clinicians. The knowledge created through these sessions and the use of generative platforms to quickly prototype VR experiences is unique, and an important contribution of my project.

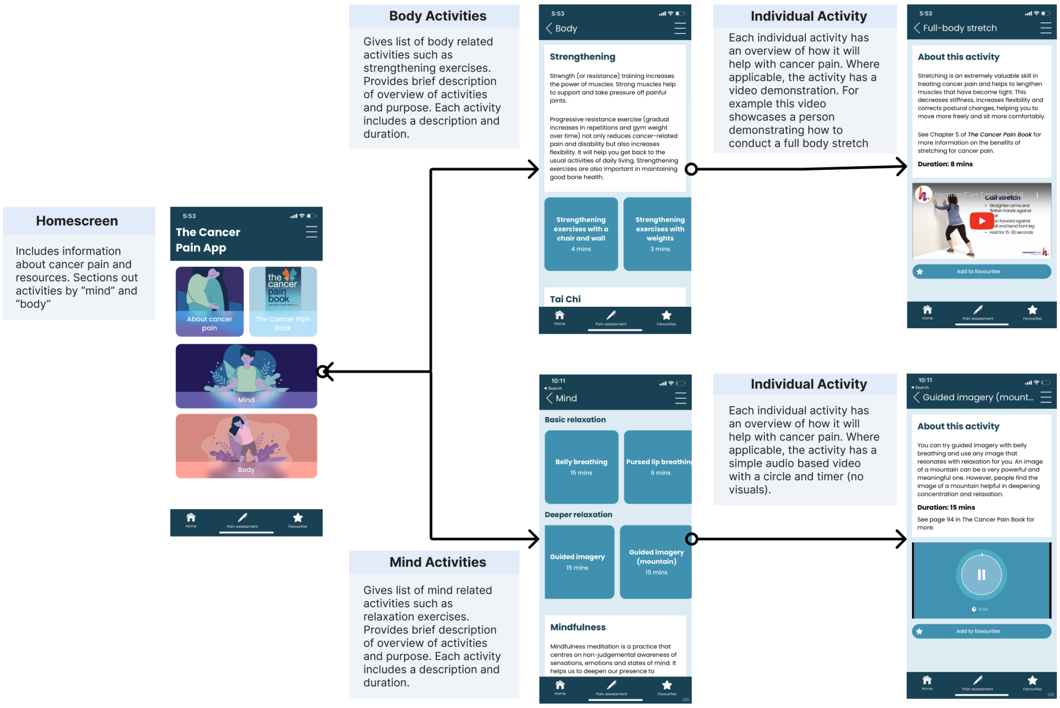

Figure 1.1: Walk through of Cancer Pain app journey
Screenshots from Hammond Care Cancer Pain app showcasing core features of the app experience

1.2.1 The Hammond Care Cancer Pain Mobile App

The Cancer Pain mobile app is aimed to support PC persons with managing their symptoms. The app was developed by the Hammond Care team for internal use and it is available publicly on app stores such as the Apple Store. At present the app is actively used across Hammond Care sites, with the team indicating that there has been a lot of interest in the app. A clinical trial of the app is forthcoming. The mobile app has a range of different activities tailored towards helping "the body" or "the mind." These activities aim to help manage cancer pain. The "mind" section of the app has activities ranging from relaxation to mindfulness while the "body" section is geared towards movement based activities such as stretching or strengthening exercises. Some activities are short (e.g. 5 minutes), while others are longer (20 minutes), accounting for different energy levels for persons in PC who are often fatigued. Figure 1.1 showcases the key journey touch points in the CancerPain app.

Chapter 2

Related work

In this chapter, I would like to present related work as necessary background needed to understand the scope and contribution of my research. The related work will also clarify opportunities for consolidating knowledge around VR for PC which I address through my scoping review as well as opportunities for designing enriching VR experiences for PC persons. Note that this chapter is part of a publication [13] in the proceedings of Australian Computer-Human Interaction (OzCHI) 2023.

2.1 End-of-life and PC in Human-Computer Interaction (HCI) research

Although end-of-life care and PC are often used interchangeably, they are distinct (but related) concepts in healthcare. PC aims to enhance the quality of life for persons and their families facing serious illnesses, regardless of disease stage, by addressing physical, emotional, social, and spiritual needs [1]. In contrast, end-of-life care specifically focuses on individuals in the final stages of a terminal illness (likely to die within 12 months) and who have stopped treatment to cure or control their disease. A person might receive PC care for an extended period of time (with an average of 18.9 days [14]). Therefore, in the context of this paper, we will use the term PC to refer to care that encapsulates physical, psychological, social and spiritual care due to a terminal illness diagnosis. Care for a person in PC may include educating them and their families about self-managing skills at any stage of disease progression. End-of-life care prioritises comfort. It involves pain and symptom management, communication to enable decision-making about medical interventions, emotional and spiritual support, preparation for death for PC persons, and support for their families [15].

Applications of HCI in PC is under-investigated, possibly due to challenges in conducting design and participatory research, high attrition rates, and recruitment challenges amongst vulnerable populations [10]. In fact a recent literature review of HCI publication in ACM digital library [16] identified three dominant themes of HCI research: digital remains; looking back; and facing death. However, out of the four areas of PC (physical, psychological, social and spiritual concerns), alleviation of suffering was not explicitly identified as areas of research. This points to a considerable gap in the field. HCI interventions also require careful assessment of potential physical or psychological harm caused by technology, including risk of infections through shared devices [17], emotionally triggering content [11] and discomfort associated with the use of devices such as headsets [2]. Furthermore, with high risk of infection in PC populations, testing and assessments may need to be conducted remotely, which demands technology infrastructure and literacy. A range of diagnoses such as cognitive decline and vertigo, language limitations and cultural mismatch of technology to the lived experience of adult PC persons (see postcolonial computing by Irani et al [18]) may exclude the participation of adult PC persons in studies.

There has been some evidence to examine the role of social media in the space of death and end-of-life experiences. Thanatosensitivity is an approach to sociotechnical systems that extends to exploring how technology may help prepare both individuals and their families for coping with death. Some of the use cases around this space include collating and organising digital memories of individuals to pass on, memorialising individuals on social media (e.g. Facebook pages) and managing an individual's digital estates and footprints post death. Evidence demonstrates the impact of technologies in helping individuals find peace, make sense of their lives, and make end-of-life decisions, while also supporting loved ones in their journey towards acceptance of death [16, 19]. However, HCI research addressing the areas of faith, religion and spirituality (FRS) are still lacking [20]. This is a key area of PC that may offer hope, and foster purpose during this critical stage of life for those with FRS beliefs [16]. Although the role of technology in the space of death and social media has been explored, further investigation is required to uncover additional ways in which technology design can support palliative and end-of-life care.

2.2 Advantages of VR over mobile applications

The use of mobile apps for pain management has become increasingly popular due to their accessibility, affordability, and resources for remote self-management. Over the past decade, the number of health-related mobile apps has rapidly increased, with 40% of the 300,000 available apps in 2017 being related to health issues, particularly the monitoring and management of chronic illnesses [21]. These apps offer a variety of tools to aid in pain management, including recording changes in drug dosages, providing coping strategies and stress management techniques, pain diary functionality, and educational content [22]. While mobile apps have been shown to be a promising tool in managing pain management, VR has the unique capability of creating presence in a 3D environment, which has distinct advantages for immersion over a 2D environment [6]. VR has a higher level of sensory immersion over mobile apps by allowing users to perform actions such as moving around in room scale environments or engaging in virtual worlds through haptic interfaces [23]. Higher levels of immersion have been associated with greater pain reduction through promotion of neuroplasticity processes [24, 25]. Moreover, the cost barriers for VR have gone down with mobile devices such as Google Cardboard now also having the capability to depict VR with attachments [26].

2.3 Virtual reality and care: from interventions to contraventions

From a clinical perspective, VR has been shown to be feasible for managing a number of symptoms such as pain in the PC context [10]. Additionally, a range of applications have been explored that demonstrate promising therapeutic benefits in physical and psychological symptom management, including reducing pain sensation in burn wound care victims for adult PC persons [27] and adolescents [28]. VR has also been shown to be effective in managing symptoms for mental health disorders such as PTSD [29], depression and anxiety [30, 29]. Furthermore, VR has demonstrated promising potential as a low-risk, non-pharmacological treatment method for reducing self-reported symptoms of pain in cancer patients [5, 6, 7].

While using VR is sometimes associated with motion sickness due to design (e.g. sudden or fast movements in the virtual space) and temporal (e.g. longer periods may result with higher likelihood of motion sickness) factors, research has shown that taking careful steps to tailor the virtual experience to the needs of users can mitigate this [31]. For example, Ijaz et al. [32] carefully tailored usability, navigation, speed and control modality for older adults performing memory tests to detect signs of pre-dementia in VR which significantly minimised motion sickness. Similarly, Goh et al. [33] used 180 degree (rather than 360) immersive videos in VR, which significantly minimised the risk of motion sickness in users receiving physiotherapy treatment for Parkinson's disease, a population with high risk of motion sickness due to tremor symptoms. Yet, it might be useful to characterise VR as a nausogenic media platform to inform design and side effect communication with users, as also pointed by disability scholars who advocate for recognising the role of media and design in contributing to accessibility politics [34, 35].

VR has shown functionality to enable enrichment and comfort in PC populations using a diverse range of design strategies. One study used VR to generate a sense of delight in adolescent cancer patients through the use of in-game companions [36] that fostered hope through the use of symbolic elements, such as growing virtual crops on a farm. Other experiences for adolescent PC populations have used fun game mechanics such as treasure hunts, shooting snowballs [37] and shooting cannons at animated objects [38]. In the older adult population, Waycott et al. [12] explored opportunities for enrichment in aged care facilities through escapism and travel to new places [12]. Aligned with this line of inquiry, Ahmadpour et al. [2] conducted a participatory study with staff at a PC facility and identified a range of opportunities for VR to cultivate enrichment and enjoyment in adult PC persons, while also fulfilling broader PC goals. They argued this requires acknowledging the importance of the materiality of care which is already embedded in PC practices [2]. For example, PC staff often seek opportunities to uplift care and demonstrate respect to foster adult PC person dignity in such a critical stage of life, as they transition from their home environment into the unknown. Examples include offering PC persons tea in a fine tea set in VR, giving them the opportunity to spend a few minutes outside (even when the individual is bed-bound), and enabling them to reflect on cherished memories through reflecting on pictures and virtual visits to places of personal significance.

Design for enrichment parallels with another emerging area of HCI research that views a counterventional framing of technology to challenge the normative intervention perspectives on curing the body [39]. Williams et al. [39] suggest countervention is inspired by a legacy of disability justice to challenge a medicalised views of healing and re-evaluating "curative" technologies, as Stramondo termed [40]. In terms of VR in the PC context, we interpret counterventions as an invitation to extend traditional clinical approaches to providing "comfort" in the final stage of life. Counterventions provide agency to persons in PC as partners who shape digital platforms such as VR and in alignment with values embedded in existing care rather than replacing PC practices with new "solutions" [2].

To achieve this, the scoping review will seek to understand how VR is currently viewed and used in the PC context. We are particularly interested in examining the diversity of the design strategies used in this area across symptom management interventions and beyond, to locate how adult PC person's goals are supported. We hope to shed light on how technologies such as VR, which are already being explored in the palliative environment, could empower adult PC persons and identify to what is meaningful to them including (but not limited to) goals such as comfort, joy, resilience and spiritual care [41].

Chapter 3

Scoping Review

The content presented in this chapter is presented in a publication [13] at the proceedings of OzCHI2023 conference. The format used for presentation of the method, findings and discussion follow the recommended conference format.

3.1 Research questions

The primary objective of this scoping review is to investigate research and design trends across the HCI literature to specifically locate the applications and design approaches to VR for adult PC. This focus on design is unique and different to previous literature reviews which focused on synthesising the current state of research by examining the outcomes and feasibility of VR as a tool for PC persons [10, 42]. It is also worth noting that the majority of papers in the PC space are focused on examining the feasibility of using VR in PC [10]. As applications of VR in PC evolves, the research should consider how to support thoughtful and ethical innovation in meaningful ways. Our review seeks to support this evolution of research by examining the design trends and opportunities that can aid meaningful use of VR as a platform in the PC context.

We have chosen to focus on adult populations as the majority of individuals worldwide requiring PC fall within this category. Approximately 69% of the estimated 20 million individuals in need of PC are adults aged 60 and above [1]. While there is evidence of VR being used clinically for both adults [31, 11] and children [9, 43] the goals, approaches and limitations (in terms of age appropriateness) differ significantly. Our scoping review explores the following research questions:

1. What aspects of PC do the papers address through the application of VR? What themes can we identify across these?

2. What design considerations are typically used to support PC aspects through VR?

3. What are the opportunities to further support PC through VR?

The findings from this scoping review are synthesised to identify current HCI gaps and trends in the use of VR in PC. In total, 14 articles fulfilled all inclusion criteria.

Our findings reveal limited use of participatory approaches with PC persons to developed VR for PC. While greatly valued in person-centered approaches, understanding the barriers to embedding participatory design in PC is crucial. Caring for persons in PC through VR was dominated by applications for symptom management, with only one study targeting enrichment, and another supporting personalised care and decision-making. The design considerations broadly concerned active versus passive engagement of users with VR content, considerations for narrative building, and considerations for accessibility to persons in PC. Our findings contribute to discussions around creating safe and meaningful VR experiences that prioritise a person-centred approach, rather than viewing the individual through the lens of their diagnosis and illness. To that end, we propose using the term ”person-centered” instead of ”patient” in the PC space to foster a more holistic understanding of individuals in PC. Furthermore, we propose a set of five design features, each outlining a range of possibilities to guide future design of VR in the PC space.

3.2 Methods

3.2.1 Search Strategy and Eligibility Criteria

A literature search was conducted in April 2023 using four databases; Scopus, Association for Computing Machinery (ACM), Institute of Electronic Engineers (IEEE Xplore), and PsycINFO. The databases were chosen based on our experience and previous scoping reviews on VR [9] to generate a range of publications in HCI and beyond. We used a combination of search terms and variations including “virtual reality,” “VR,” “palliative,” “palliative care,” “end of life,” and “terminal.” For a more detailed overview of the search strategy, please refer to Table 3.1. The selected search terms were aligned with the research questions, aiming to retrieve articles that specifically focused on VR experiences used for supporting adult PC persons. The process of study inclusion was carried out as follows: peer-reviewed articles published in English after 2011 that described VR experiences (both customised or commercially available products) aimed at managing the physical, psychosocial, or spiritual aspects of PC in adult populations (aged >18 years). Similar to other scoping reviews in this area, we choose publications after 2011 to coincide with the release of the Oculus Rift Head-Mounted Display in 2012, which increased interest, accessibility and availability to VR technology. Furthermore, publications were included regardless of where the VR experience was implemented, to include various settings such as hospitals, homes, or other types of care centres.

Excluded from the study were review articles, position papers, and posters. Additionally, studies focusing on VR applications for medical procedures unrelated to the care experience and/or management were excluded. Furthermore, studies targeting medical staff rather than adult PC persons and studies concentrating on adolescent populations (<18 years) were not considered. We also excluded studies that examined VR solely from a technological perspective without communicating design decisions such as user interactions, application content, and design strategy. Lastly, studies not involving PC persons specifically (i.e., identifying adult PC persons with serious illnesses but not specifying PC explicitly) were also excluded. This

Databases	Search Terms
Scopus, IEEE, ACM	(TITLE-ABS-KEY (”VIRTUAL REALITY” OR VR*) AND PUBYEAR > 2011) AND (TITLE-ABS-KEY (“PALLIATIVE CARE” OR ”END OF LIFE CARE”* OR ”TERMINAL”* OR ”PALLIATIVE”*) AND PUB-YEAR > 2011)
OVID - Psych-INFO	Search 1: Virtual reality (search criteria: include all variations of virtual reality). Search 2: Palliative care (included all variations of palliative care). Combine search 1 and 2 to retrieve final results.

Table 3.1: Search terms used across four databases for the scoping review

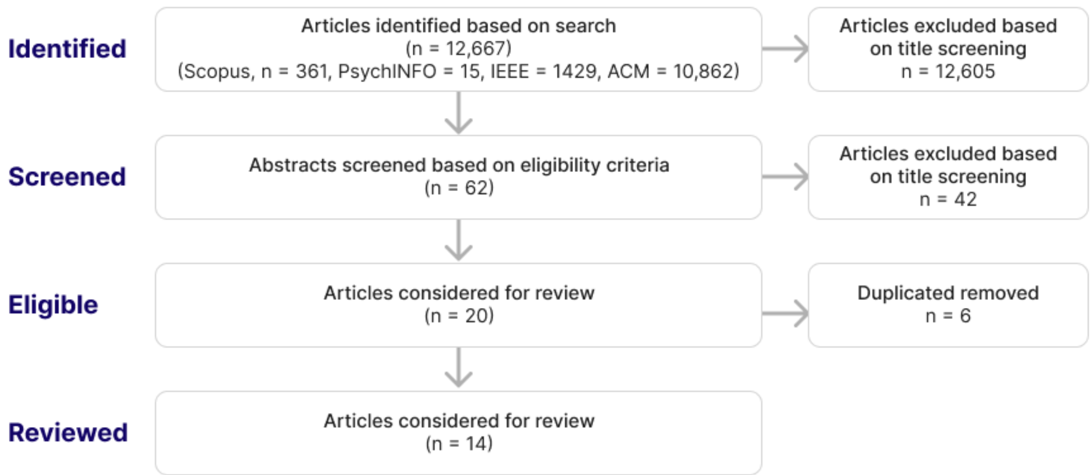

Figure 3.1: Flowchart of the literature screening and selection process
Figure 1. Flowchart of the literature screening and selection process.

was an important exclusion criterion as PC is a distinct, person-centered approach for individuals facing life-threatening illnesses, which is different from other medical treatments of serious illnesses such as cancer [2].

3.2.2 Study Selection

Overall, 12,667 articles were identified. The first author screened the titles and abstracts for relevance and eligibility criteria. If a decision could not be made based on abstract text, the full text was retrieved to make the assessment. After the title and abstract review, 41 articles were selected for a full-text review. In total, 14 articles were included in the final shortlist for the scoping review. The elimination process is shown in Figure 3.1.

3.2.3 Evaluation Process

A data collection form was developed to extract details for analysis such as author, type VR headset used, goals of study, types of VR interactions used and design strategy choices. The analysis closely focused on the two research questions to identify aspects of adult PC addressed through VR experiences (RQ1) and the broad set of design considerations that afforded interactions and experiences in VR (RQ2). Answering these two questions then allowed us to identify further opportunities, which are outlined in the discussion section.

3.3 Findings

All 14 articles collectively demonstrated the potential of VR applications in enhancing care for adult PC persons and managing their symptoms, and primarily reported high acceptance and increased satisfaction among adult PC persons who used VR. Feasibility studies (9 articles) [6, 44, 45, 46, 47, 7, 48, 49, 50] reported engagement and satisfaction with VR as well as users willingness to continue the intervention again. Articles that focused on pain and symptom management observed significant reductions in pain, anxiety, and distress symptoms, mostly within PC persons with cancer (10 articles) [51, 52, 5, 7, 48, 47, 44, 6, 50]. Two studies highlighted how VR experiences could also help empower PC persons, providing them with the confidence to make decisions about their care [53], as well as motivating them to adopt healthier behaviours where obesity was a concern [54]. In total, 12 studies conducted research in a hospital environment, while 2 studies took place at the person's home [51, 5] and one study offered both options depending on participant preference [44].

The majority of reviewed papers (11 articles) explicitly referred to the term "palliative care," with one paper using a mix of terminology such as "hospice care" [49]. One paper mentioned palliative care in recruitment but did not use this terminology beyond the recruitment section instead using terms such as advanced cancer patients [51]. Another paper [50] recruited a mix of cancer and PC persons. Finally in one paper [53] a PC team in Taiwan developed a VR intervention to enable better advanced care planning for both PC persons and the general population but did not test this intervention with PC persons, instead recruiting from a long-term care facility. The explicit reference to palliative care or closely related terminology served as an important inclusion criterion in our search strategy, as it represents a distinct, holistic, person-centered approach to care that aims to support individuals during end-of-life transitions. Therefore it was essential to distinguish articles examining VR for PC from other forms of treatment (such as other clinical, and psychological interventions), as these treatments may not encompass the comprehensive framework and principles of PC.

The majority of articles used a range of high-end commercial VR headsets such as the Oculus Quest (5 articles), Samsung VR (3 articles) and others such as HTC Vive (1 article) and Google Daydream (1 article). However, 3 studies did not specify which VR headset was used. Most studies reported no serious adverse effects of using VR headsets. All 14 articles excluded PC persons with vision or hearing impairments, vertigo or motion sickness, mental health diagnosis (e.g., dementia), non-English speakers, adult PC persons unable to provide informed consent, as well as individuals who had previously or were currently using VR for therapeutic purposes. Details relevant to the research questions are discussed in the following sections.

3.3.1 Research Question 1: What aspects of PC do the papers address through the application of VR? What themes can we identify across these?

The use of VR for PC across the final 14 articles encompassed three themes including: (1) symptom management, (2) embedded enrichment, and (3) personalised care and decision-making (see table 3.2).

Symptom Management

Regarding symptom management, 11 articles (see table 3.2) specifically examined the capacity of VR apps and platforms to alleviate symptoms such as pain (both acute and chronic) [51, 52], psychological distress (such as anxiety, distress and mood disturbance) [50, 5, 48], quality of life such as appetite and nausea [51, 52, 6, 44, 5, 47, 7, 48] and self-compassion and psychological wellbeing [50]. The primary mechanism employed in these interventions was distraction, which involves redirecting participants' attention to the virtual environment and thereby reducing their perception of pain. However, only 5 studies [52, 7, 5, 6, 50] demonstrated significant symptom improvement due to this mechanism. 3 of these studies showed significant improvement in chronic pain [6], pain caused by sleep impairment [52] and an immediate but not long term impact on person reported symptomology [5]. One of these 5 studies [50] demonstrated improvements across mental health, wellbeing and stress. Only one of these 5 studies showed significant improvements across multiple PC symptoms [7] including improvements in pain, depression and anxiety. Notably, these improvements were significant for adult PC persons who engaged in personalised VR experiences, such as virtual traveling to a memorable place with a personal connection [7]. Most studies acknowledged the need for multiple interventions and larger sample sizes (on average between 1 to 45 participants for studies with PC persons) to potentially observe more significant impacts of VR interventions. Despite these mixed results, participants either verbally expressed or were observed to show improvements in perceived pain, mood, physical relaxation and demonstrated better breathing [52, 7, 5, 6, 50].

Embedded enrichment

Beyond one study, [50], there were no specific studies that explored the use of VR as a tool to predominantly provide enrichment, rather a sense of enrichment was embedded in these studies (see table 3.2). VR proved to be a powerful platform for deploying experiences that enhance the quality of life for adult PC persons, typically by offering them meaningful experiences and connections that transcended the physical limitations imposed by their illnesses and PC context. Among the 14 reviewed articles, adult PC persons were enabled to embark on journeys through serene landscapes [6, 5, 50], or revisit meaningful places and explore new destinations

Themes	References
Symptom Management	[51, 52, 50, 5, 48, 7, 47, 6, 44]
Embedded Enrichment	[50, 6, 5, 7, 48, 51, 52, 54, 47, 45, 46, 49]
Personalised care and person-centered decision making	[50, 53, 45]

Table 3.2: Themes around how VR is used as a tool to enhance PC outcomes

[7, 49], fostering a sense of adventure and fulfilment. O'Gara et al., [50] tried to foster a sense of self-compassion by embedding compassion mind therapy (CMT) through audio as participants navigated natural landscapes. The goals of CMT is to enable participants to conjure images of warmth through breathing exercises which has been shown to be effective in improving suffering and other symptoms such as anxiety, depression and pain [50]. Furthermore, one article [54] showcased how VR experience positively impacted the quality of life for the adult PC person by reshaping their perception of their body (and obesity), subsequently increasing their motivation to adopt healthier behaviours.

VR designs and directions used in the articles embedded enrichment by creating a therapeutic and supportive environment to address the psychological and emotional needs of adult PC persons. By offering a space for relaxation and engaging activities like meditation [52, 6, 47, 48] and guided meditation [51, 46], these virtual experiences effectively assisted adult PC persons in coping with stress, anxiety, and the capacity to forget pain and escape from the current reality associated with their illness [49]. The feedback from PC persons participating in the studies indicated that the VR experience brought them a sense of joy, peace and happiness [49, 52, 45, 7], provided distraction and evoked positive memories [48, 7, 49], and facilitated the accomplishment of personal relaxation goals [46]. Some of these mechanisms, such as travelling to memorable places using Google Earth in VR [7], appear to provide combined benefits such as distraction (from pain), relaxation and enrichment. It would be challenging to isolate design attributes leading up to such outcomes or indeed separating the physical and psychological outcomes as distraction and relaxation appear to be linked (see table 3.2).

Personalised care and person-centered decision making

In one article [53], participants were recruited from a long term care facility in Taiwan were empowered to make advanced end-of-life decisions through a unique VR intervention. The VR experience provided a first-person perspective video of an adult PC person's end-of-life care journey, showcasing different settings, interviews with PC team members, and relevant clinical information and scenarios. The VR video also symbolically depicted the adult PC person's soul at the end of the video to represent the importance of spiritual care in PC. Following the experience, participants exhibited a significant increase in their preferences to refuse certain treatment options (such as CPR, life-sustaining treatments, artificial nutrients). Moreover, their uncertainty regarding medical treatment options decreased. This VR experience allowed participants to deepen their understanding of end-of-life care and utilise VR as a tool for decision-making and initiating conversations about the often-taboo subjects of death and PC with their families and healthcare clinicians.

In another study [45], PC persons had the opportunity to create a personalised soundtrack in collaboration with a music therapist, which they could then listen to while immersed in a VR landscape. The majority of participants responded positively, expressing how the experience gave them a sense of control and allowed them to temporarily detach themselves from their diagnosis and pain.

O'Gara et al., [50] created a personalised experience by consulting adult PC persons in a design workshop to co-design ideas for content. The workshop surfaced key design features important to participants some of which include the importance of voice, being able to explore the environment, being guided not instructed. Based on this feedback, the research team iteratively co-designed and developed a VR experience to a satisfactory quality determined by adult PC persons. Participants were also allowed to choose the type of environment in the intervention and other design features such as deciding whether a male or female voice led the compassion mind therapy exercise (see table 3.3 for summary).

Summary: Gaps in VR experiences for PC

Several gaps can be identified in the reviewed articles. Firstly, the focus of the studies was primarily on achieving short-term outcomes, such as immediate symptom reduction (e.g., pain, anxiety, distress) [51, 52, 48], and therefore long-term outcomes related to improved well-being and resilience were under-investigated [10]. Additionally, most studies did not provide a clear rationale for the selected duration of what was often described as the intervention period. It was unclear how the timing of the intervention was linked to achieving adult PC person goals. For example, 11 papers administered a single intervention ranging from 5 to 110 3.3 minutes, and only one study worked with participants to agree that sessions in study may not be enough to administer meaningful dose but would be enough to generate sufficient data for the goals of the VR intervention [50]. Out of 14 selected articles, found articles [51, 44, 5, 50] implemented multiple sessions lasting anywhere from 4 days to 4 weeks 3.3, with varying engagement lengths of 4 to 20 minutes. Understanding the optimal duration of VR experiences necessary to achieve desired outcomes for PC persons is crucial for achieving the appropriate level of immersion for treatment. Previous studies on PC care and that investigated the potential of VR, has already identified fatigue and lack of energy being key indicators that should guide and limit time spent in VR [2]. It is worth noting that higher levels of immersion, but not necessarily time, have been associated with greater symptom reduction, in particular, pain reduction, through promotion of neuroplasticity processes [24, 25].

Another notable gap in selected articles is the lack of adult PC person involvement and consultation in the design of VR experiences. 13 studies (see 3.3) did not incorporate adult PC person perspectives during the development process. This may be attributed to the time, availability of participants, risk of infection in PC persons,

Reference	Single Session (5 to 110 min)	Multiple Sessions (4 to 20 min)
Participatory approach with participant, family or healthcare staff	[45]	[50]
No participation or consultation on design, no choice over any elements of VR experience	[54, 53]	[51]
No participation or consultation on design but some personalising choice provided such as choosing landscape in VR	[52, 6, 46, 47, 7, 48, 49]	[44, 5]

Table 3.3: Breakdown of level of participant involvement in selected studies

and cost constraints associated with creating entirely customised VR experiences. This may have negative impacts on the effectiveness of the intervention including dropout in engagement over time [5] and boredom [45]. Only one study by O'Gara et al., [50], involved persons in PC in the design, testing and evaluation of the VR experience and the final evaluation of the feasibility of VR interventions for PC. This provided autonomy and empowerment for persons in PC to make their own decisions about how they engaged, received, participated and evaluated interventions for PC.

3.3.2 Research question 2: What design considerations are typically used to support PC aspects through VR?

In total, 11 papers utilised commercially available content from platforms like YouTube and VR stores such as the Oculus store. Among these, 3 studies employed NatureTrekVR [48, 49, 45], which involved participants exploring new or familiar landscapes. Three design considerations identified across the selected papers were classified under: (1) active vs. passive engagement, (2) narrative building, (3) accessibility and mobility.

Active vs. passive engagement

The primary strategy employed to address PC symptoms was distraction, which has been shown to engage participants' attentional resources within the virtual environment [9, 10]. Distraction is often classified into active (e.g. shifting one's attention through intended interactivity or game features) or passive (e.g. user watching content and typically not needing to provide input) [8]. Both of these strategies were evident in selected papers.

Distraction techniques involved the use of passively guided or unguided meditation played over virtual landscape scenes, with 6 articles adopting this approach [52, 6, 47, 48, 51, 46]. One study incorporated breathing and compassion meditation therapy exercises using a male or female audio voice while participants were guided through natural landscapes (beach, forest or animated mountain) [50]. Furthermore, 3 studies incorporated soundscapes synchronised with landscape imagery [51, 6, 45], with one study collaborating with adult PC persons to create a custom soundscape [45]. Additionally, 4 papers utilised 360 videos and photos of landscapes [44, 5, 47, 50], and travelling to real places for distraction [7, 49]. Experiences using NatureTrekVR and guided meditation paired with audio soundscape and landscape imagery required minimal interaction. Participants are often guided through the landscape and passively viewing content [48, 49, 45].

In a study conducted by Brungardt et al. [45], adult PC persons expressed their desire for greater customisation options within the VR environment. They wanted the ability to choose their preferred locations, seasons, and types of movements within the landscape based virtual environments. Additionally, participants expressed a need for more interactive experiences and autonomy to freely navigate and explore the virtual space. They also preferred the flexibility to engage with the VR experience during periods when they experienced fewer symptoms or felt less emotional. This feedback underscores the importance of providing adult PC persons with a sense of control and personalisation in their VR interventions to create a more meaningful experience.

Beyond distraction and active focus-shifting, Ahmadpour et al. [8] had identified the potential for using VR for building key skills to enable adult PC persons to learn strategies to manage their condition. A few of the selected studies in our scoping review explored interactive, skill-building games, however the specific design strategies employed in these games and the rationale for incorporating more interactive experiences were not clearly articulated. Only one study [5] explicitly described an interactive game called "Yuma's World," where participants were immersed in calm underwater environments and tasked with reproducing Japanese characters representing words like friendship, courage, and strength. However, this study noted a decline in engagement towards the end without further investigation into the contributing factors, such as the level of immersion or connection to the content. Understanding these factors is crucial for identifying design interactions that foster greater adult PC person engagement and increase the likelihood of intervention success (see 3.4 for summary).

Narrative building

3 articles (see table 3.4) employed bespoke VR experiences that are characterised by the narratives embedded in the experience and interactions [51, 54, 53]. One of these studies created a custom guided imagery experience accompanied by an audio soundscape for distraction, similar to many commercial applications used [51]. The content focused on guiding participants through various landscapes built upon the narrative of four seasons. The study briefly explained how each landscape targeted specific goals, such as pain reduction or creating a sense of numbness, but did not

Design Considerations	References
Active vs. Passive engagement	[52, 6, 47, 48, 51, 46, 50, 45, 5, 44, 49, 7]
Narrative building	[51, 54, 53]
Creating a safe space by improving accessibility and mobility	[49, 52, 6, 47, 50, 51, 5]

Table 3.4: Design considerations in VR for PC

provide detailed information on the techniques employed across the landscapes. One study [54] incorporated a narrative of "body swapping," which is an illusion technique where one can switch perspective to view their virtual body in VR. The study enabled the adult PC person to use first person perspective to view a skinnier version of their body in virtual reality, while their physical body was simulated outside of the virtual environment. This perspective shifting enabled the participant to correct for body size overestimation and improve body perceptions and motivation to engage in healthier eating behaviours [54]. Another study by Hsieh (2020) [53] aimed to translate traditionally paper and verbally distributed content related to end-of-life decision making into a first-person perspective virtual environment. Participants were able to experience different aspects of PC through the first person perspective of an adult PC person. Experiencing different environments (e.g. intensive care units, hospice home care) and different medical scenarios allowed participants to build more confidence in making advanced life decisions.

Creating a safe space by improving accessibility and mobility

Finally, many studies (see table 3.4) made efforts to accommodate different levels of mobility by allowing participants to engage with the VR experience while lying in bed, seated in a wheelchair, or with assisted standing [49, 52]. This appears important given that PC persons often experience lack of energy and extreme fatigue which limits their movements and ability to stand on their own to use VR controllers [2]. To enhance access to new and unfamiliar technology, some studies incorporated a training or familiarisation period, enabling participants to learn how to use controllers and become accustomed to the 3D environment [6, 47, 50]. In the case of 2 studies aiming to administer the VR experience remotely in the participant's home, researchers took further steps to enhance engagement by providing detailed onboarding videos, in-context screen instructions [51], and progressively unlocking new experiences over time [5]. These measures aimed to reduce barriers to use and enhance the accessibility of VR interventions for PC persons. Additionally, O'Gara et al., [50] through consultation with participants found improvements to certain factors related to accessibility and mobility can help create a safe space in virtual environments. These include the pace/tone of the voice guidance, flexibility to step out of experience, sign-posting in environment and onboarding, freedom to explore, being guided not instructed.

3.4 Synthesis and discussion of findings

Our scoping review of 14 articles revealed three main ways VR has contributed to supporting adult PC persons. The majority of articles focused on symptom management and emotional support, one article specifically focused on embedded enrichment, and another one used VR for personalised care and decision making. The majority of studies (12 articles) focused on using distraction techniques with passive interactions such as viewing natural landscapes with no active interactions with virtual environments through commercially available VR experiences. These included techniques already used in PC such as guided meditation and compassion mind therapy [50]. One article used narrative building [51] for distraction and 2 articles used perspective shifting [53, 54] to build confidence in care planning decision making and motivate healthier eating behaviours. Only one article explicitly used interactive skill building techniques in VR [5] for PC. In total, design strategies were characterised based on decisions around active/passive interaction, narrative building and creating safe virtual environments by improving accessibility and mobility for persons in PC. We proposed a set of five design features for VR to guide person-centred design (rather than patient-centred, in order to acknowledge the person's value beyond their diagnosis). The scoping review resulted in three main contributions:

1. Identifying common themes around how VR is used in adult PC interventions
2. Identifying a set of considerations for how to better engage and involve persons with PC in HCI research and design process to better support adult PC goals.
3. Identifying gaps and opportunities to design more meaningful VR interventions

3.4.1 Gaps in VR for PC: What is missing in HCI research?

Countervention presents an important opportunity to subvert traditional curative approaches to PC and would focus more on enriching the lives of adult PC persons in ways that are particularly meaningful for this stage of life [39]. A countervention approach privileges PC experience as a unique context and would approach design from a person-centred approach for PC beyond a clinical perspective that focuses on the medical condition of the person and their symptoms. HCI as a field can adopt a more counterventionalist approach to reimagining how VR can be used, e.g. as tool to support enrichment in PC. There is a missed opportunity to fully harness the power of VR to both enhance the materiality of care and facilitate enriching experiences for adult PC persons that otherwise may be inaccessible [2]. Examples of how HCI can use VR as a tool to facilitate enrichment include facilitating travel to new or memorable places [49, 7], building new skills [5] providing opportunities to reflect on past memories and bring aspects of home to the person through photographs, keepsakes or mementos reimagined in a virtual environment [2]. VR can also serve as a tool to help support other aspects of PC that are underserved such as social and spiritual needs of PC persons [55]. This is important to consider with world events like COVID-19 pandemic increasing chances of infection, which can limit human contact resulting in loss of social connections, deterioration in physical health and spiritual distress from loss of control and meaning in life [2, 56]. Some qualities such as expressing respect to support the PC person's dignity, specially as they transition to the unknown and taking opportunities to uplift care and communicating risk with PC persons and families were previously identified as VR opportunities by PC staff [2] yet rarely addressed in selected articles.

HCI holds the potential to enhance the accessibility of VR as a valuable tool for adult individuals, enabling them to fully embrace its therapeutic benefits within the context of PC. One of the current challenges hindering broader adoption of VR in PC is lack of accessibility of VR as a tool for PC populations. Challenges include the potential for distress in individuals with neurological diagnosis such as Dementia and Parkinson's, which may increase the risk of hallucinations [57]. In addition, limitations in mobility can impact the use of controllers for navigating virtual environments among PC populations [48]. Increased susceptibility to nausea, a common side effect in PC populations, often leads to discontinuation of VR experiences [57] though careful design is likely to address the issue of motion sickness [33, 32]. Furthermore, barriers such as discomfort with novel tools and low technological literacy, can limit interest and engagement with VR as a tool, adding to accessibility challenges. Ijaz and colleagues emphasised the importance of training to overcome this issue [31]. Without dedicated efforts to innovate and conduct research on increasing the accessibility of VR as a tool for PC populations, a persistent mismatch between users and the system will continue to exist. Innovations aimed at enhancing the accessibility of VR as a tool for PC populations can take various forms. These include: improving the design of head-mounted displays (HMDs) to make them less bulky and more comfortable to wear; exploring alternative methods of interacting with the virtual environment such as voice control [58, 59] for individuals unable to use VR controllers [57], and employing real-time algorithms to adapt to the user's behavioural responses and mitigate motion sickness [60]. The potential for innovation in making VR more accessible is vast and holds promise for improving the enrichment and therapeutic benefits of VR as a tool for PC.

While innovation in VR for PC populations may be challenging and time-consuming, researchers can still make significant contributions to the development of responsible strategies [61] that enhance the accessibility of VR as a tool in person-centred PC. Table 3.5 provides a number of high-level provocations to inspire considerations for a person-centered approach prior to administering VR experiences in PC. The provocations help us explore how participatory approach may include early engagement with persons in PC, their family and healthcare clinicians in order to identify the factors that can optimise the benefits of VR and increase it accessibility, for example tailoring and optimising the exposure time to individual needs. This is a crucial factor in the use of VR for PC populations. Lengthy exposure times can lead to discomfort, fatigue, dry eyes, and difficulties in concentration, especially when interfering with medical devices like cannulas [52, 47]. Other factors such as medication, time of day, and mood also influence an individual's engagement with the VR experience, and their effects should be considered beforehand. Additionally, adult PC individuals may exhibit aversion to unfamiliar technology, which can be compounded by low technological literacy. While some studies included a familiarisation period to help users navigate the virtual environment, insufficient attention was given to assessing comfort, technology literacy levels, and additional support required by individuals, such as avoiding overreaching in wheelchairs to reach objects in the virtual world [31]. This lack of consideration may have impacted engagement and immersion levels in the VR experience. Early consultation to improve accessibility of VR as a tool for adult PC persons can improve immersion by ensuring a comfortable experience while reducing the risk of side effects such as motion sickness [31]

3.4.2 Opportunities: Design insights for VR to support person-centred PC

We propose five design feature areas for person-centered VR for PC with a particular focus on enrichment. These are summarised in Figure 3.2. Each feature presents a range of possibilities to support design decision-making, discussion and setting intentions around VR and its experiential consequences in PC. Note these features are not intended to be comprehensive but rather we aim to use existing evidence to guide VR designers to interrogate design opportunities specifically pertaining to PC and similar contexts. PC research has limited exploration of outlined design features in VR.

Passive to active participation to assert control over the virtual environment

The majority of the 14 reviewed articles focused on employing distraction strategies using passive interactions [8] where users navigate landscape scenes without much interaction (no input from the users). A passive interaction approach may have benefits in reducing chances of motion sickness in VR [31]. Very few studies [5, 52, 6] employed active interactions with interactivity features that required user's input. For example, Austin et al., [6], enabled participants to have control over walking around a natural environment using a controller, however participants had no control over interactions with the environment. Oftentimes, a clear rationale for how these interactions supported PC was missing. Futhermore, most articles used pre-designed commercial products which may not account for the specific needs of PC persons. There is an opportunity for HCI to explore how to explore how to create meaningful interactive experiences beyond distraction that enable enrichment in VR. Figure 3.2 outlines the changes in level of participation from passive to active. It can be argued that more interaction that unlocks greater interaction and control of the virtual environment can contribute to higher enrichment, however this demands higher engagement which can be tiring for the PC persons who often experience extremely low energy and fatigue. It is the responsibility of HCI researchers to account for this design constraint when designing VR experiences for PC populations. Moscato et al., [5] showcases a VR experience that works within these design constraints while still using engaging interactions. The study used a skill based game called "Yuma's World" which used controller based movements. The app created a relaxing environment that enabled distraction by through setting the game in a calming underwater environment. Adult PC persons were able to recreate Japanese letters in the air using remote controllers using minimal, slow movements. The letters spelled represented positive concepts such as friendship and strength. This interactive experience demonstrates how VR tools can be used for distraction while still allowing active participation that fosters enrichment through

Person-centred considerations	**Provocations**
Understand how to embed enrichment in VR experience	• Work with persons in PC, healthcare support, and family members to establish what (non-)clinical goals they hope to achieve using VR across 4 pillars of PC: physical, psychological, spiritual and social aspects, • Scope out with persons in PC the opportunities to create enriching VR experience (e.g. does the person wish to visit a place they cannot? travel back home?)
Design accessible and comfortable VR experiences to create a safe virtual environment	• Identify ideal length of session time and frequency, balancing exposure time with what is practical and necessary to achieve therapeutic benefits (most studies propose 4 min to 110 min) • Understand technological literacy levels for operating VR and the level of support and training needed for the person in PC, their family, and healthcare clinicians to optimise engagement • Understand environmental factors that could reduce comfort such as mobility challenges, medication schedule, home/hospital environment, and mood

Table 3.5: Provocations to determine person-centred considerations for supporting accessible VR experiences

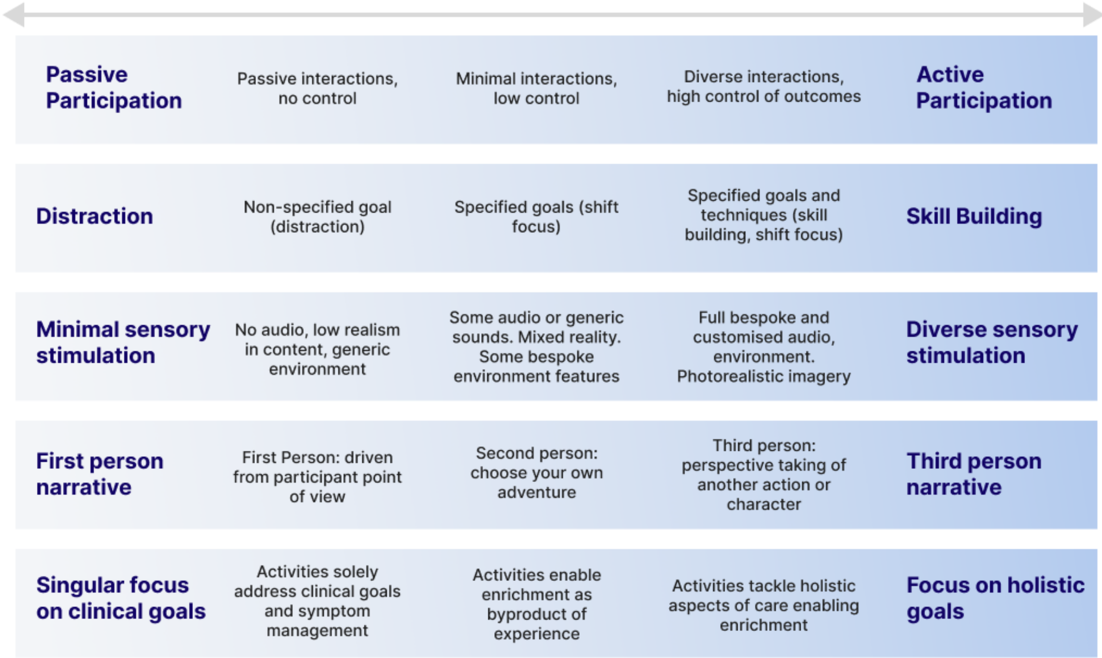

Figure 3.2: Design features to guide embedding of enrichment in VR for PC Scale shows how different levels of enrichment for PC can be achieved through choices in executing different design features in VR

learning new skills and enabling adult PC persons to have a greater sense of control of their environment and situation.

Distraction to skill building to specify therapeutic outcome

VR can provide distraction via passive or active interaction as well as enable the user to build much needed skills, for example to learn relaxation skills that might help them actively reduce pain [8, 9]. These should be aligned with the specific needs of persons in PC. Figure 3.2 suggests that skill building in adult PC persons requires greater use of specified goals and techniques. The majority of selected studies in our scoping review used free form or guided meditation in VR, typically providing skills around deep breathing and relaxation [62]. While meditation practices have shown to reduce pain [63] and alleviate psychological symptoms in persons in PC [64], the majority of studies involved no prior consultation with persons in PC or post-intervention feedback and evaluation to understand the impact of meditation on achieving PC goals. The importance of considered design strategy for PC populations is highlighted by O'Gara et al. [50] where two persons with PC provided both negative and positive feedback about the impact of breathing exercises used as part of a compassion-focused therapy. One participant had tumours in their lungs and felt that the VR guided experience had made them feel like they had failed as they were unable to hold their breath for the required time due to their physical limitations. In contrast, another participant found the breathing exercises helpful and continued to employ these skills beyond the intervention in medical scans. The chosen design strategy had very different impacts on both individuals, highlighting the importance of tailoring design strategies to meet the unique practical needs and goals of each person.

Minimal to diverse sensory stimulation

Sensory elements in 3D environments can impact immersion, enjoyment and varied impact on supporting the user's goals [9, 8]. Most reviewed articles used natural landscapes but did not explain the rationale or impact of this choice. One benefit of using virtual landscapes is the provision of neutral content that minimises the risk of causing psychological harm to adult PC persons while additionally generating positive impact on mood and stress [65]. Furthermore, landscape environments may potentially reduce the likelihood of side-effects. Most reviewed articles did not report any serious side-effects in research participants. Beyond visual elements, a range of possibilities exist to diversify sensory stimulation. This must be approached with caution again with consideration for energy level of the PC person.

Customisation of sensory elements such as audio, environment and content fidelity can enhance enrichment and enjoyment of experience for many people resulting in physical and psychological benefits. This is demonstrated in a study by Brungardt et al [45], where persons in PC created customised audio soundscapes in VR, resulting in more than half the participants stating they would either try the experience again or recommend it to their friends, demonstrating a high level of acceptance. Furthermore, feedback indicated increased sense of control of their situation, feeling greater peace and improvements in pain, chest tightness and body relaxation [45]. In both studies by Niki et al. [7] and Lloyd et al. [49] where persons in PC were able to travel to places of personal significance in VR, they felt the capacity to forget their current pain and situation by reconnecting with past memories. This personal connection to the environment also showed to have more significant impact on symptom reduction [7]. These studies demonstrate how personalisation of sensory elements in VR environments may improve participant engagement, acceptance and symptom management. However, personalisation of sensory elements in VR environment can be a costly and time-consuming endeavour. Indeed, new developments in generative AI may begin to facilitate access to new possibilities though caution is needed to not expose persons in PC to triggering elements. Where personalisation may not be practical, researchers can still consult and assess preferences for certain sensory elements (for example allowing participants to choose the type of landscape or the type of activity they interacted with).

Perspective shifting from first to third person narrative

Empowering persons in PC to make decisions about their health is a key objective [2]. Interestingly, all the studies reviewed typically employed a first-person perspective with limited autonomy for participants to shift their perspective. Figure 3.2 suggests that enabling perspective shifting may enhance greater enrichment outcomes in adult PC persons. Previous work in HCI explored design directions such as techniques inspired by theatre traditions may assist in achieving perspective shifting in VR with benefits such as new opportunities for reflection on topics of interest by users [66]. While PC research by Ryu and Price [67] was not reviewed in our study, the research provides inspiration on how to empower adult PC persons through perspective shifting. The study allowed adult PC persons to retell their life story using a motion capture system which projected an avatar version of the participant into a 2D virtual environment. Participants were able to revisit and reflect on key moments at different life stages from adolescence to adulthood. Using the motion capture system, participants controlled the avatar's speech and body movements, and temporarily gained capabilities they might not have in real life such as the ability to walk or stand. Participants expressed how perspective shifting through the avatar empowered them to explore challenging memories, express their emotions, and come to terms with difficult moments in their lives such as grief, lost childhood experiences and friendships. This study highlights the potential of perspective shifting in VR for PC to facilitate meaningful reflection and empower adult PC persons to gain a greater sense of agency and control over their lives.

Designing VR activities to support a range of clinical to holistic care goals

A major gap across all studies was the lack of exploration of how the VR could be used as a tool to design activities to support spiritual and social aspects of PC care which are considered two important aspect of PC along with physical and psychological care [1]. Figure 3.2 suggests designed activities in VR may range in focus from supporting specific clinical goals (e.g. symptom management) to encapsulate holistic models of care that include social and spiritual care that could likely provide further enrichment for adult PC persons. A study by Lin et al. [68] was not reviewed in our study but demonstrates how horticultural therapy used in VR for elderly persons can help improve general health, perceptions around meaning of life, loneliness and depression. The study spanned 8 weeks, with each session lasting 2 hours. Elderly participants engaged in various horticultural therapy activities, aiming to foster social connections with other participants, reconnect with past memories, develop mastery and promote relaxation. Some of the notable VR activities included learning steps to cultivate plants, selecting toys made from plants (bamboo boats, flower necklace) connected to childhood memories, using maze challenges involving navigating around pot plants to improve sense of direction and creating custom plants to engage in creative thinking. The study found significant short term and long term improvements across both clinical symptoms and non-clinical dimensions such as increased meaning of life, perceived mattering and reduced loneliness in participants. These improvements persisted 2 months after the intervention. Although this study focused on elderly persons, the insights gained can be applied to the PC context. Future studies looking to use VR applications for adult PC persons would benefit from exploring similarly enriching activities that promote holistic care which can potentially have long lasting benefits.

Chapter 4

Prototyping VR experiences for PC

4.1 Introduction

After the scoping review, I proceeded with prototyping a VR app based on the Cancer Pain mobile app. I will first discuss the challenges associated with traditional code-based prototyping tools and advocate for the suitability of video prototyping in capturing unique aspects of VR. I will then follow up with how recent advancements in generative AI tools can accelerate video prototype development. Finally, I will talk through the three stages involved in my prototype design:

1. the translation of the Cancer Pain mobile app to VR;
2. using generative tools for VR prototype creation; and
3. engaging in participatory approaches with healthcare clinicians for iterative development.

Throughout each stage, I will share my reflections and key findings.

4.2 Challenges of prototyping VR experiences

As the use of VR as a tool in PC care advances, there is a need to explore methods that allow researchers and low tech creators in early-design phases to rapidly prototype and iterate concepts [69] with non-technical experts such as healthcare clinicians. Prototyping allows researchers and designers to quickly create and iterate concepts, saving time in development efforts and upfront costs [70]. However, there are many technical barriers in using VR authoring tools such as Unity or Unreal engine. Barriers include knowledge of programming languages as a prerequisite [69], [71] and the need to learn numerous tools across a fragmented landscape of VR content creation [71]. Some of these tools can include learning 3D modelling software such as Blender or Maya to create bespoke 3D assets. A range of low tech prototyping methods have been adopted for VR including physical prototyping, role-playing [71] paper prototyping, body storming, video sketching and more traditional design methods such as 2D sketching on paper [72]. However, a study by Ashtari et al.

[71] revealed that designers found methods like sketching and body storming have limits in how they can accurately capture visual aspects of virtual environments and other variables such as lighting and audio. While there are more higher fidelity free software available (Figma, AdobeXD) for prototyping, they are limited to depicting 2D screen based experiences and may be simplistic in how they capture complex animations and interactions that are unique to VR such as teleportation, interaction with objects, hand gestures [72, 69]. Furthermore, these 2D prototyping tools often lack the ability to design for depth and 3D spatial environments [72]. While there are some existing authoring tools that allow low tech creators to directly build in 3D spatial environments (Tivori, ShapesXR). These programs require ownership of a specific brand of headset to use the software and they can have expensive upfront subscription costs.

Prototypes are a critical communication tool and creators to visualise ideas, enhance learning and assist in collaboration, particularly where content is co-designed across different teams and stakeholders. The early stages of prototyping are critical for validating ideas, exposing flaws in early thinking and allowing for early course correction [70]. However, the technical barriers to using authoring tools to develop high fidelity prototypes constrains early creative thinking and exploration which can potentially lead to design fixation [73]. Low tech creators and researchers are forced to expend effort in getting the technology to work rather than expending efforts on other important tasks such as formal user testing and evaluation to develop concepts and ideas [71]. To address this challenge, I will be exploring video prototyping as a potential medium to prototype VR experiences for low tech creators.

4.3 Video prototyping for VR

Video prototyping is a well-established technique in interaction design that involves using a combination of techniques such as animation, video editing, sound design and voice-overs to visually illustrate key aspects of an interaction [74]. Video is a promising format for prototyping VR experiences as it can capture different sensory elements of the VR environment in both high and low fidelity [75] such as scene changes, soundscapes, audio, animations, movement and interface interactions. Video prototyping also caters to different skill levels with lower barriers to entry for low tech creators [74] and can be as simple as piecing together images or sketches in a sequential timeline in free software such as Canva and iMovie. Video prototyping has previously been shown to be more effective for stimulating the immersiveness and authenticity of virtual environments than other 2D formats [73] such as storyboards, static images or sketches. The video prototyping process may use multiple editing tools such as After Effects and Premiere Pro. These tools have a lower technical barrier to entry in comparison to 3D authoring tools as they do not require programming knowledge. These tools also have up-to-date resources and learning materials readily available for self-learning compared to learning resources for VR development, which creators have found difficult to locate, overly technical or outdated [71]. While video prototyping is an effective way to showcase how complex VR elements intend to operate, high-fidelity video production brings its own challenges. These include time and labour costs [72] associated with key framing animations [75] and sourcing digital assets such as photos and graphics. Furthermore, there are challenges of mimicking aspects of 3D spatial environments such as depth, spatial movement in a video prototype [75].

However, recent advancements in generative AI technology holds the potential to significantly reduce technical barriers and time requirements of video prototyping. Open AI programs like Midjourney, DALL-E, and Stable Diffusion have the ability to generate hi-fidelity images rapidly based on prompts. Other programs like Pika and RunwayML create videos and animations based off text or still image prompts, while Skybox Blockade Labs can generate immersive depth maps and Skybox environments for VR for 2D desktop viewing. AI-generated programs can now also create voice-overs (ElevenLabs), sound effects and music which further aids in streamlining asset creation and sourcing processes in video creation. With easy input processes requiring limited technical expertise, generative AI tools can help low tech creators in creating a more flexible ideation environment in the early stages of design without being constrained by factors such as budgets and deadlines. Furthermore, the low tech nature of video prototyping allows creators to focus on concept ideation and user testing, allowing the co-design process to be more efficient, with faster iterations and edits. This is critical in empowering more designers and researchers to explore and create more meaningful VR experiences that are tailored to the needs of PC persons. I took inspiration from this knowledge and used generative platforms for video prototyping in my research as I will outline in this chapter.

4.4 Overview of methods and findings: parts 1 to 3

The design and iteration stage of my research involved iterative prototyping of VR experiences for persons in PC. The approach taken was participatory, which involved creating democratic ways of sharing knowledge in all phases of product development to foster mutual learning [76]. Although I was limited in engagement given my one year scope of research, I held a collaborative feedback session with lab researchers and 2 interview sessions with healthcare clinicians to help shape the prototype direction and design. These were facilitated through use of digital platforms for collaboration (e.g. Miro board, Google documents). Content analysis [77] was conducted to capture key insights focusing specifically on feedback on VR design features.

The methods and findings described in this chapter is presented in three parts using the case example of the Cancer Pain mobile app (see 4.1). Part 1 aims to develop knowledge about design strategies that can effectively support the conversion of mobile app for managing PC to VR. Part 2 aims to develop knowledge about rapid video prototyping method for translating mobile app PC strategies to VR. Part 3 aimed to iterate the video prototype based on a participatory collaboration with clinicians at Hammond Care and create a meaningful VR prototype that addresses the needs of PC persons. For each part, I will first describe the method (design activities, prototyping, selection criteria and more) followed by a reflection on lessons learned in each part.

Figure 4.1: Summary of different stages of VR prototyping
Breakdown of the key activities conducted across 3 stages of VR prototyping design

4.5 Part 1: Translating the Cancer Pain mobile app to VR

4.5.1 Method in Part 1

There were many different activities available for PC persons in the Cancer Pain mobile app. With limited resources and time constraints, I developed the following 3 criteria (see 4.2) to guide selection of a suitable activity for development into a video prototype:

1. assessing the suitability of activities for PC persons;
2. assessing duration; and
3. ease of translation of content from audio to VR medium.

I then choose the best activity for VR translation, adapted the script and content to suit a VR environment and ideated on potential image, sound and animations to suit the audio content. This stage was led by me in collaboration with the design team: Dr Naseem Ahmadpour, Dr Phillip Gough, Yidan Cao, and Dr Kiran Ijaz. The team met regularly every two weeks between August and October 2023. Discussions were captured on Miro boards, Google Documents, Slack and other note-taking applications. This process is messy and difficult to quantify.

Criteria 1: Suitability of activities for PC persons

We chose to prototype activities from the "Mind" section of the app (see 4.3) as many of the activities in the "Body" section required movement (such as stretching, tai-chi, resistance training) which may not be suitable to all PC persons who may face mobility challenges, particularly while wearing VR. More expert discussion and exploration is needed for designing embodied VR experiences which were not within the scope of this project. Furthermore, we excluded activities that were solely focused on breathing exercises as some PC persons may have challenges with these

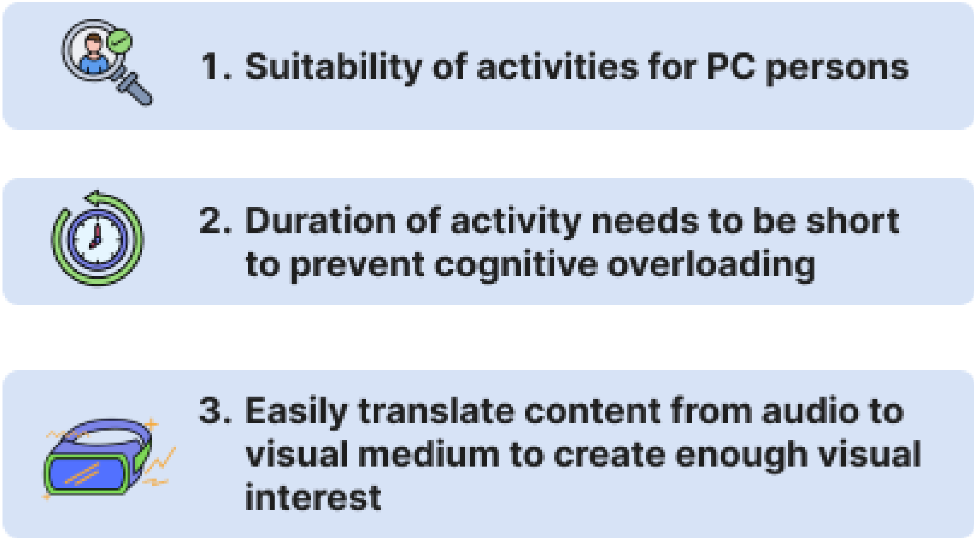

Figure 4.2: Criteria to select mobile app activity for VR translation
Breakdown of the key criteria considerations for translating activity from the Cancer Pain mobile app for VR prototype

exercises if they for example have tumours present in their lungs. The "mind" section was chosen because of the general sustainability and feasibility of the activities in this section for PC persons.

Criteria 2: Duration of the activity

It was concluded that the duration of activity needs to be short to prevent cognitive overloading. While the scoping review revealed a wide range of durations for VR experiences in PC (anywhere from 5 to 110 minutes), we focused on activities that were relatively short (less than 20 minutes). This decision was previously confirmed with the clinical partner by the design team.

Criteria 3: Easily translate content from audio to visual medium to create enough visual interest

The Cancer Pain mobile app primarily featured audio-focused exercises, with a strong emphasis on relaxation, often presenting a simple visual element at the center of a video (e.g., a circle with a timer) 4.3. Translating audio-centric content into a visual medium posed challenges in finding content that was neutral, not triggering and visually interesting to retain engagement. Considering criteria 1 and 2, we narrowed down activities to three options: guided meditation, guided imagery exercise (specifically, mountain imagery), and desensitisation. After a detailed analysis of activity transcripts, we selected the guided imagery exercise for several reasons. Firstly, the majority of papers examined in the scoping review also used natural landscape based content which had limited side effects in PC persons [5, 45, 46] . Secondly, the guided imagery exercise took users through different parts of a land-

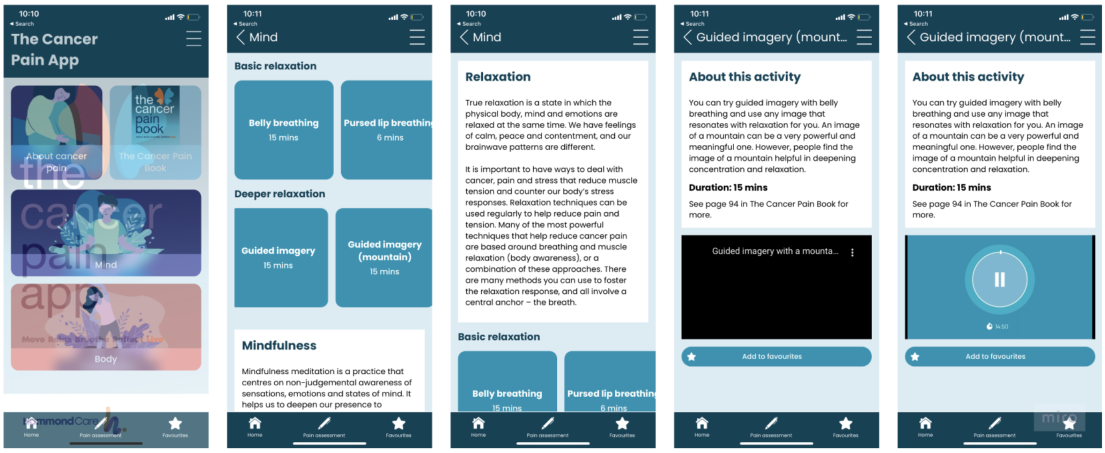

Figure 4.3: Screenshots of app interface from the Cancer Pain mobile app
Presentation of different mind related activities in mobile app

scape in audio form, such as standing in front of a large mountain, on a ledge, or in front of a waterfall. These transitions naturally lent themselves to the creation of potential visual elements in VR, enhancing the immersive experience to complement the audio content. Lastly, the guided imagery exercise excluded breathing exercises. Recognising the benefits highlighted in the scoping review such translating breathing techniques outside of VR environment into activities such as medical scans and reducing sensation of pain [50] and enabling relaxation [45], we incorporated the breathing exercise content from the guided meditation activity into the script for the guided imagery exercise.

Adapting script to cater to virtual reality environment

The guided imagery content underwent adjustments to suit virtual environments. This involved removing lines that would not seamlessly translate into a virtual reality setting, such as prompts for users to close their eyes (e.g. "you might like to close your eyes"). Additionally, we incorporated new lines inspired by successful guided imagery-based VR apps on the Oculus store (such as TRIPP, Guided Meditation VR) to facilitate smooth transitions between scenes in the virtual environment. These additions included prompts to prepare users for transitions, such as "Look into the light when you are ready to move on..." after the breathing exercise or "As you float through this space, feel the tension leaving your body..." to transition between different landscape scenes. These modifications aimed to optimise the guided imagery experience for virtual reality, enhancing user engagement and immersion.

Embedding design features for enrichment

Informed by the design features identified for enrichment in the scoping review (see 4.4), decisions for the prototype's direction when transitioning from a mobile app to the VR space were strategically made. The focus of the design strategy choices was to improve pain management and foster relaxation. For example, we sought to supplement the existing guided imagery exercise, delivered through audio content, with matching visuals in VR. Furthermore, while active participation was found to be a design feature that can enable greater enrichment in VR [13], I intentionally opted to design a passive experience, a decision influenced by testing guided imagery VR apps in the Oculus store. In these apps, users typically had low autonomy, being passively guided through different landscapes and scenes. Even without a high level of active interactions, the simplicity in visualisations and animations used in each scene allowed me to remain focused on achieving relaxation. Finally, the scoping review identified the importance of incorporating skill building activities for enrichment, I embedded this design feature by incorporating a breathing exercise adapted from the desensitisation activity in the CancerPain app.

To enhance engagement and immersion, efforts were made to customise the VR environment. While customisation choices were not available in the mobile app apart from the users having a choice to pick exercises of different length (e.g. 5 minutes, 15 minutes, etc), Vasudevan et al., [13] highlighted the importance of a tailored VR experience to enhance immersion and create more meaningful VR experiences. We included 5 customisation options (see 4.5) for: voice guidance levels, gender and accent preferences, duration, and position (lying or seated). While not a customisation feature, we introduced a feature in the app for mood self-report to enable the user to capture and measure how the VR experience would impact their (PC person's) mood over time which might inform customisation in the future. This was aligned with findings from the scoping review which identified that different life events (i.e. medication, time of day) can impact mood, which subsequently can impact engagement with the VR experience. Finally, we enabled environmental customisation by offering options for PC persons to choose different landscapes (fantasy, country based or randomly generated). All of these customisation settings were created in Figma as interface screens to be tested and validated with healthcare clinicians (see Appendix A).

Ideating visual images, animations and soundscapes to support audio content

Finally using notes and mood board references I ideated on potential images, animations, and transitions to align with the guided imagery exercise audio content. I first created a moodboard inspired by existing VR guided meditation apps on the Occulus store (see moodboard in Appendix A). I then used sticky-notes to ideate on how different references in the audio can be matched with visual references in the 3D space. For instance, phrases used in the audio content from the Cancer Pain app "perhaps you're sitting inside the depths of this mountain next to ancient trees or flowing water, perhaps you're touching a mossy stone or brushing past a vivid fern" provided clear inspiration. To bring this description to life, I considered using audio of flowing water and integrating images of gently moving ferns into the scene.

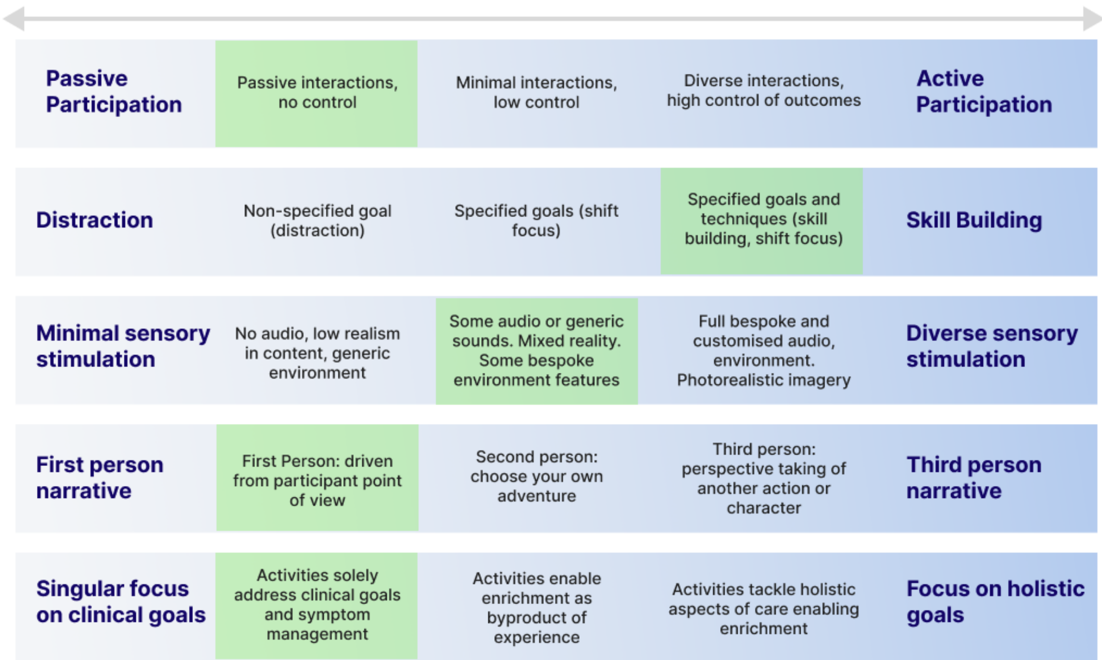

Figure 4.4: Selection of design features from scoping review
Diagram shows which design strategies were chosen to prototype VR experience

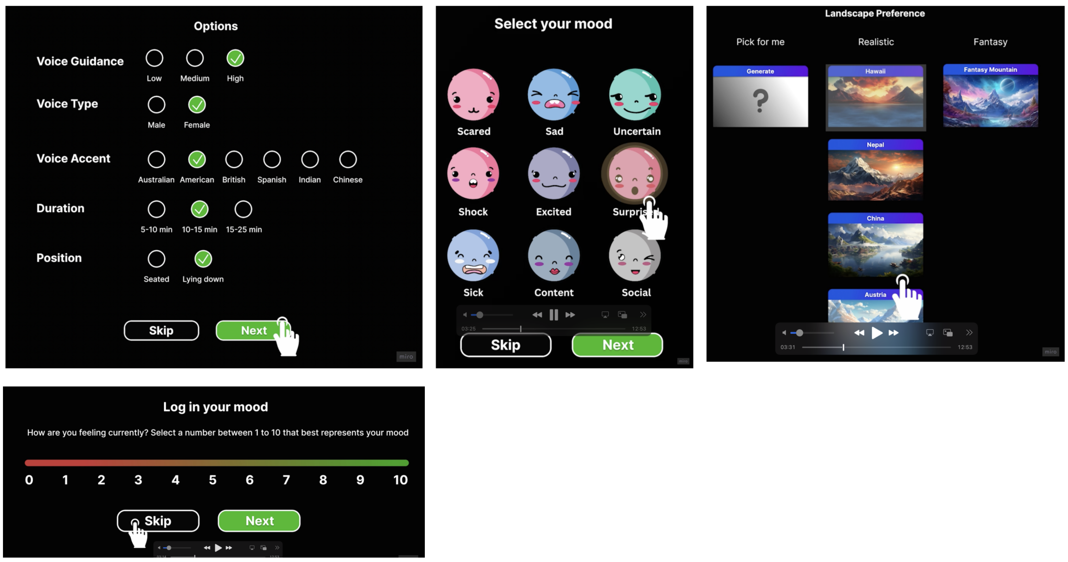

Figure 4.5: Customisation and Mood Surveys
Diagram shows design of various customisation settings and mood surveys presented to PC person before they completes VR experience

4.5.2 Reflection on part 1: develop knowledge about design strategies that can effectively support the conversion of mobile app for managing PC to VR

4.5.3 Outcome

Translating content from a mobile app to a VR setting produced three main outcomes. The first outcome involved the development of criteria to guide the selection of activities suitable for translation. This included considerations such as the suitability of the activity for the needs of PC persons, duration time and the ease of translating content into a 3D environment. The second outcome was developing knowledge about how to adapt audio content from the mobile to suit a VR environment, this included matching audio content with relevant visual content for a 3D environment. The final outcome was understanding how to apply design strategies identified from the scoping review [13], to modify the existing mobile app activity to make it a more meaningful for PC persons in VR.

4.5.4 Lessons learned

There 3 key lessons learned from this process that can guide other designers in translating mobile app content to VR.

1. Applying the design strategies from the scoping review [13] to the mobile app content helped with rapid decision making, ensuring the experience was tailored for the needs of PC persons
2. Translating existing audio content to VR needs considered content enhancements to match VR environments. For example, designers can consider adding additional audio content to help PC persons transition between different environment scenes or remove content that would not apply to a VR environment such as asking PC persons to close their eyes
3. With more time and capacity, there are opportunities to creatively interpret and translate audio content into a VR environment to create a more enriching experience. Examples include allowing PC persons to shift perspectives in the experience (navigating the environment as an object such as a leaf or flower or another character in the scene), integrating subtle interactions to provide more autonomy and control over environment while still meeting relaxation goals. Gathering feedback from both healthcare clinicians and PC persons would be instrumental in assessing whether these additional features contribute to a more enriching and meaningful experience.

4.6 Part 2: Using generative tools to create VR prototype

4.6.1 Method in part 2

Before a video format was considered, there was exploration into using different generative AI platforms that would help speed up the prototyping process directly

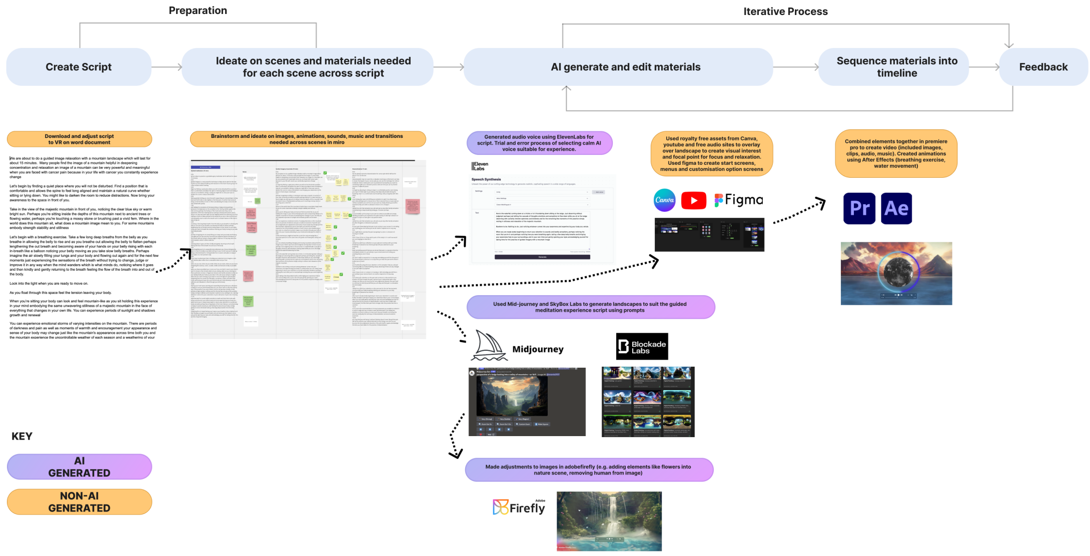

Figure 4.6: Workflow summary for video prototyping
Diagram summarising key workflow touch points translating mobile app to VR

in a development environment. However, upon assessment of these tools, they were deemed not feasible to use as they were mostly in beta and had limited functionality. One of the challenges was where platform could generate 3D models and environments, it was often limited to a small range of objects (furniture, shields, swords) which wasn't relevant to our project. Furthermore, most of these tools could generate 3D objects but didn't have in-built features like timelines, sound and audio support which is critical for conveying the VR experience. With all these considerations, we proceeded with video prototyping as the best format given it's advantages.

Figure 4.6 showcases a summary of all the generative AI and non-generative AI tools used in the workflow to create the video prototype. All generative AI tools accelerated the tasks of creating and editing materials that were critical in conveying the VR experience. These tasks included voice-over creation (ElevenLabs), generation of diverse mountain landscape images with varying camera angles, styles, and perspectives (Mid-journey), construction of 3D skybox environments (Blockade-Labs), modification of AI-generated images by adding or removing elements (Adobe Firefly), and the development of short prompt-based animations derived from AI-generated images (RunwayML).

While the generative AI platforms were responsible for creating the desired content, my main role in the creative process involved experimenting with prompts to iteratively shape the generative AI platform outputs and achieve my vision for the VR experience as a creator. In total, I generated 307 images in mid-journey, 30 skybox environments in Blockade Labs, 11 animation generations from static images in Runway ML between the months of July to September 2023 (see Appendix 1 for detailed outputs A).

The outputs from the generative AI platforms did not always align with my desired creative vision. To compensate, I used additional content manipulation and edit-

Figure 4.7: Adobe Firefly image manipulation
Image showing key aspects of image manipulated completed in Adobe Firefly post AI generation in Mid Journey

ing programs to refine and tailor the generated outputs. This refinement process involved using a generative AI tool called Adobe FireFly for static content manipulation and non-generative video editing platforms PremierePro and AfterEffects for editing animated content outputs. For example, one of the mountain landscape image prompts continued to generate a human in the foreground which wasn't part of my original prompt. I used Adobe Firefly to remove the human and replace the figure with natural elements in the scene such as rocks (see Figure 4.7). Another example was the image generation of a waterfall scene. The AI platform included a human figure which wasn't specified in my prompt and presented the scene from the perspective of being inside a cave, restricting the view of the waterfall. I used Adobe Firefly to remove the human, remove the cave elements to open up the scene and brightened up the scene by making the colours more vivid, and adding in additional elements such as flowers and butterflies (see Figure 4.7).

For animated content, Runway ML only generates 5 second clips. To extend the duration of the animation, I used animation programs like After Effects to loop out the animations to match the length of the audio content. However, due to challenges in perfectly executing the looping process, some animation clips exhibited a glitching effect. Given that the artefact was a prototype and the glitching effect did not detract from conveying the core parts of the VR experience, I decided to retain it in the final prototype.

The integration of Premiere Pro and After Effects into my workflow was essential for generating more complex animations beyond the capabilities of current generative AI platforms. Tasks such as creating the animation of the expanding ball for the breathing exercise and implementing subtle water movements in the opening scene were achieved using Adobe After Effects. Additionally, I incorporated royalty-free animation and video assets from Canva, overlaying them onto the AI-generated images in Premiere Pro. Through simple key framing and transparency adjustments, I was able to achieve my desired vision. This combination of generative and non-generative AI tools streamlined the creation process of the video prototype. See link to video prototype.

4.6.2 Reflection on part 2: develop knowledge about rapid video prototyping method for translating mobile app PC strategies to VR.

While generative AI tools significantly streamlined the process of creating the video prototype, several challenges were encountered:

- **Crafting right prompt to achieve desired art style**: Generating images or environments with tools like Mid-journey or Skybox Labs poses a challenge as the style can vary significantly based on the prompt used. You can retain similar styles within programs like Mid-journey as they have a concept called "seed generation," where a type of noise pattern is generated and can be re-used across future images. Skybox Blockade labs has different "styles." Choosing a similar style allows you to produce consistent image generation. However, as seen in figure 4.8, small variations in prompts can produce very different results. The process of achieving the desired style took a bit of time with experimenting with prompts.
- **Camera Angles**: Conveying different camera angles for VR in a video prototype is advantageous but challenging to describe in a prompt. Achieving the desired result required meticulous fine-tuning, as illustrated in figure 4.8
- **Lack of control over items generated in images**: Tools like Blockade Labs, Midjourney, and Runway ML offer varying levels of control in image, skybox and video generation. While Midjourney and Blockade Labs allow for negative prompts (excluding objects), Blockade Labs introduces a draw function for adding new elements in generated skybox scenes. However, this function can lead to substantial changes, potentially altering results more significantly than desired. Blockade Labs also lacks the ability to edit elements within a scene. For images generated in Midjourney, tools like Adobe Firefly provide granular control for editing, allowing the addition or removal of elements with precision using prompts (e.g., adding flowers in the background with a brush tool, removing unwanted elements such as human figures). Runway ML is effective in transforming static images into videos but lacks control over what elements are animated and the duration is capped at 5 seconds.

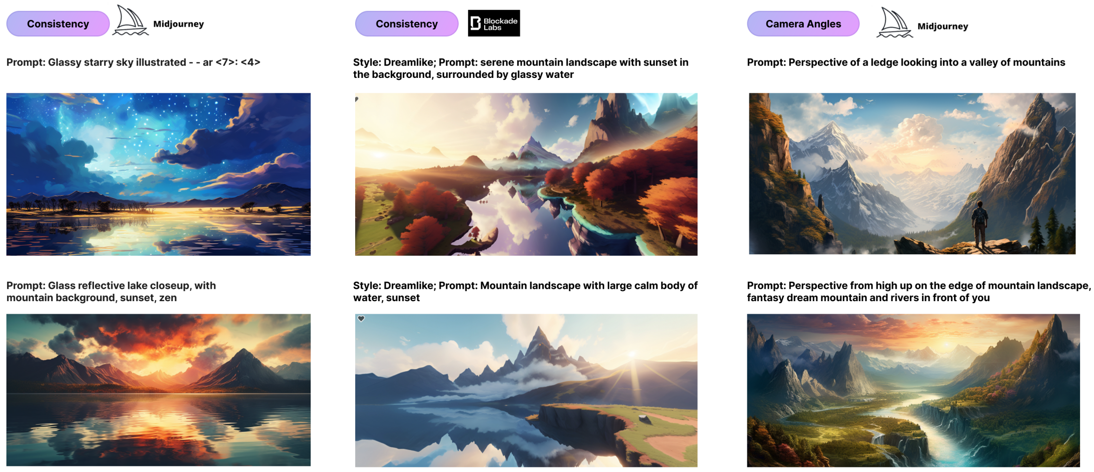

Figure 4.8: Outputs from AI generation
Image depicting challenges associated with consistency and camera angles with AI generative tools

In cases where finer control was needed for creating animated effects, After Effects was employed to generate desired animations over images.

- **Using multiple programs**: Managing multiple programs in the workflow posed another challenge, requiring careful tracking of materials generated across different tools. While platforms like Canva are beginning to integrate various capabilities into a single tool, the industry may witness convergence over time, simplifying the workflow and mitigating the challenge of juggling multiple tools and applications.

Overall despite the challenges posed from using generative AI tools to create a video prototype, the main benefits were being able to explore ideas without any technical constraints and create an artefact that can be easily shared and consumed by stakeholders for feedback. Without generative AI tools, creating backgrounds and animations for the video prototype would have been laborious and time consuming.

4.7 Part 3: Feedback iteration of video protoype

4.7.1 Method in part 3

The VR video prototype underwent feedback from a total of three researchers in the design team and three healthcare clinicians from HammondCare who are involved in our palliative care research project. The design feedback was collected in meetings with the design team and recorded through researchers notes and Miro board annotations. In total there was one feedback session with researchers from the design team and 2 feedback sessions with healthcare clinicians. Later a content analysis was conducted to summarise key themes from interviews.

In response to feedback from designers, an upfront explanation was incorporated into the video to establish context and set clear expectations regarding prototype fidelity. The healthcare clinicians were then emailed a link and instructed to watch

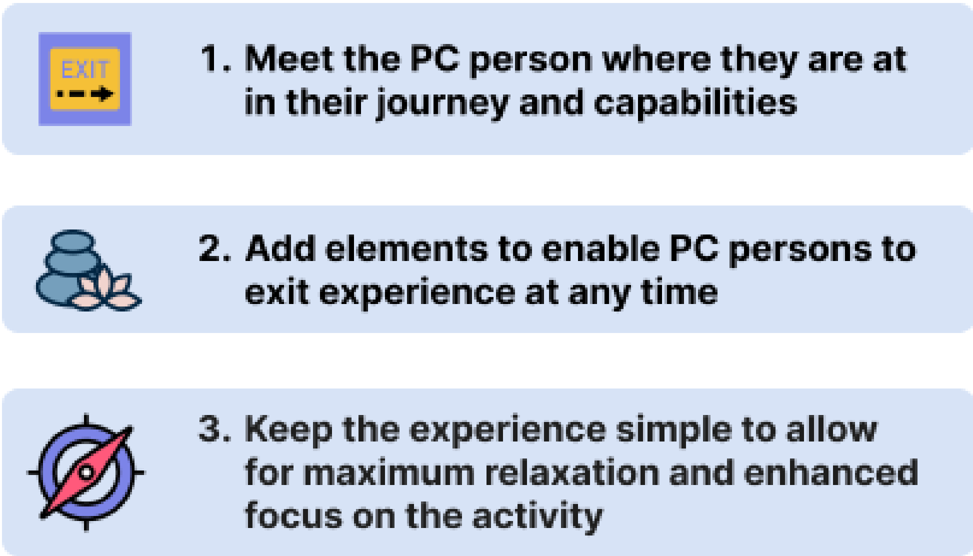

Figure 4.9: Themes from content analysis
Key themes from interviews with healthcare clinicians about VR prototype

the video at their convenience, and separate online sessions were scheduled for in-depth feedback through interviews. During the interview, I presented key scenes from the VR video prototype as static images on a miro board to facilitate detailed feedback. I first started by asking open feedback on the prototype before delving into receiving feedback about various aspects of the prototype which included: the interface design, customisation settings, content and animations, personalisation elements and overall visual aesthetics (see Appendix A). I used sticky notes to record verbatim points from clinicians for post-analysis. I extracted themes from verbatim points and grouped together similar themes and ideas (see Appendix A). Figure 4.9 highlights key themes from the analysis. After receiving feedback, I pinpointed the core aspects of the video prototype and engaged in iterations to develop a final MVP video prototype. This refined prototype serves as a crucial artefact for guiding Unity development or can be shared with developers for potential outsourcing of development. See link to final video and see figure 4.10 for iteration of changes made. I will cover the changes in detail in the next section below.

4.7.2 Reflection on part 3: iterate the video prototype based on a participatory collaboration with clinicians at Hammond Care and create a meaningful VR prototype that addresses needs of PC persons

The following key three themes arose from feedback with healthcare clinicians and how these suggestions were incorporated in the final iteration of the VR prototype as shown in Figure 4.10.

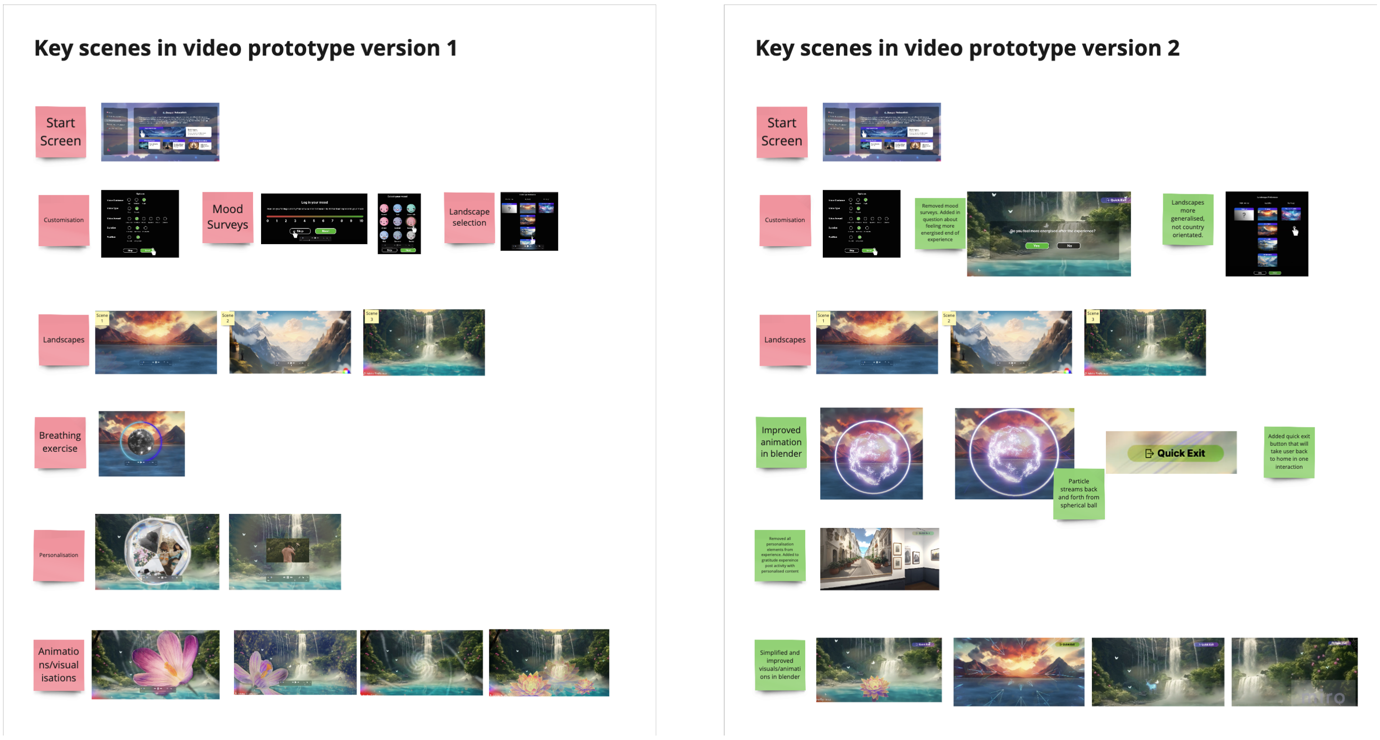

Figure 4.10: Key VR prototype changes
Figure depicts key changes from final round of feedback with clinicians

Meet the PC person where they are at in their journey and capabilities

Healthcare clinicians emphasised the importance of catering to the diverse needs of individuals in PC throughout their journey. While an average length of 6-10 minutes was recommended as suitable, there was a suggestion to also provide longer experiences for those who can engage for extended duration. The key consideration is to creating a state of flow, striking a balance between task engagement to create a sense of meaning and positive mood state while preventing low level self-referential thinking such as worrying [78, 79, 80] while being mindful of the fatigue and energy levels of PC persons.

In response to researcher recommendations, it was suggested to remove the mood self-report survey at the beginning of the experience. This adjustment aims to mitigate any potential impact on morale and engagement, recognizing that PC persons may find themselves consistently logging in with low moods. Instead, we incorporated one of the clinicians proposed suggestions to include a reflective question at the end of the experience, such as ”Do you feel more energised?” This question reflects the personal experiences of clinicians who have found that individuals in palliative care often feel less tired after engaging with the VR experience.

Add elements to enable PC persons to exit experience at any time

Clinicians acknowledged the helpfulness of the breathing exercise but expressed concern that PC persons might find it challenging to synchronise their breathing with the animation, particularly if they have breathing difficulties. One clinician noted, ”The timing of the expansion might be difficult to keep up with if they [PC persons] have breathing difficulties...It’s better to do it at their own rate.” To address this, clinicians recommended allowing individuals to proceed with the exercise at their own pace and suggested providing the option to exit the activity at any time if it became challenging. We included a safety exit button at the top right hand corner of the experience which would allow PC persons to exit directly into the headset's home screen. The aim of this feature was to help PC persons quickly distance themselves from potentially harmful or triggering content in one step. This is opposed to potentially struggling to press controller buttons to exit the VR experience or wait for external support to remove the headset and physically exit the experience.

Additionally, clinicians suggested starting the experience with more context, offering clear instructions and reducing the pressure for PC persons to keep with the breathing exercise. My new instructions were...."You are about to begin with a breathing exercise. You'll be guided through a calming breathing exercise where you will be focusing your attention on the gentle expansion and contraction of a ball of light in front of you. As you inhale, watch the ball expand, as you exhale, observe the ball gently shrinking. Remember there's no need to keep up with a specific rhythm. This exercise is about finding your own pace. There's no right or wrong and you can't fail. If at any point you wish to pause or leave the experience, simply click the safety exit on the top right hand corner of your screen and you'll be guided out of the app quickly. Find a comfortable position and let's begin…" For future iterations, clinicians recommended exploring potential feature to integrate into VR technology, such as microphones, to measure the user's breath and dynamically adjust the breathing rate. This could create a positive feedback loop, enhancing the overall effectiveness and personalisation of the breathing exercise.

Keep the experience simple to allow for maximum relaxation and enhanced focus on the activity

Healthcare clinicians recommended de-cluttering the virtual space by removing personalised images that may have associations and triggers, potentially distracting from the primary goals of relaxation and focus. They recommended exploring using personalised content and imagery outside of the guided imagery experience as a separate activity. One of the researchers suggested using a transition state after the guided meditation imagery exercise where PC persons would be transported into a post-activity space, containing a gallery to view images of objects, people, and places they consider important. Taking on this suggestion, the prototpye transported PC persons to the gallery space after completing the guided imagery activity, where they could view personalised images or objects chosen and uploade by the person prior to engaging in the VR experience (see timestamp 10 min: 48s in video link).

In addition to decluttering, we implemented clinician feedback on incorporating more subtle movements and placing greater emphasis on the sensory aspects of the environment, such as camera panning and zooming in on elements in the scene such as the glassy water. They also expressed a desire to integrate elements more seamlessly into the scene and reduce unnecessary noise, fostering a more serene and calming experience aligned with the intended goals of the activity.

Other improvement suggestions

Healthcare clinicians provided an additional suggestion to remove the concept of country-focused landscape choices and instead opt for more general landscapes (e.g., riverside mountain, fields with mountains). To implement this suggestion, we changed the labels of landscape names from countries such as ”Hawaii” to more generic naming conventions such as ”Tropical.” The rationale behind this recommendation is to offer broader and more universally relatable categories that PC persons can choose from, making the experience more inclusive and applicable to a wider population.

Furthermore, clinicians preferred the inclusion of a stream of particles flowing inside and outside of the spherical ball used in the breathing exercise to enhance the sensory experience (see timestamp 3min in video link). This addition aligns with the goal of making the activity more immersive and engaging for individuals. To address this suggestion, we overlaid a particle stream on a transparent spherical ball, created using Blender. This modification enhanced the visibility of the particle streams compared to the solid material used in version 1 of the VR prototype.

To address concerns about potential motion sickness, clinicians recommended maintaining a point of reference in each scene. This measure is intended to provide stability and orientation, minimising the risk of discomfort for individuals in palliative care. To achieve this, I reduced the number of points of reference in each scene, for example I reduced the number of lotus flower visual animations from 3 to 1. Future translation of the video prototype in a 3D environment must thoughtfully consider how specific visuals will be integrated into a 3D space and their potential impact on motion sickness.

4.8 Overall reflections

The VR video prototype proved to be a valuable artifact, particularly due to its ease of distribution. This proved crucial when collaborating with time-constrained healthcare clinicians and receiving feedback from different stakeholder groups. The advantages of the VR video prototype compared to other mediums (such as storyboards, sketches) is that it provides visual stimuli that is closely represented with the final VR experience (graphics, sound, music, pace, sequence), which provides a solid baseline for receiving feedback for iteration before moving into development. The next chapter will cover some of my reflections on the strengths and limitations of my approach.

Chapter 5

Discussion

5.1 Research Questions

Throughout my one-year research period, I investigated how to design meaningful VR experiences for adult PC persons. This involved completing a scoping review of existing literature to understand how HCI can embed better design strategies in VR to enable more enriching experiences for PC persons. From the design strategies identified in the scoping review, I then created a video prototype in collaboration with healthcare clinicians to develop a final MVP version. In this chapter, I discuss the implications of my findings with the two research questions outlined in Chapter 1, integrating wider literature along with the strengths, limitations and future directions for research.

5.1.1 How can we better understand current design strategies used in VR experiences for palliative care patients?

The scoping review played a crucial role in identifying a set of design strategies aimed at embedding enrichment for the development of more meaningful VR experiences for PC persons. While the design strategies helped provide guidance in making key decisions around VR prototype design, there were many challenges of applying these strategies in practice. Specifically, challenges arose in areas such as crafting skill-building activities that are meaningful for PC persons while tailored to their health needs, finding the right balance between active and passive participation, ensuring meaningful perspective-taking within the VR experience, providing a sense of agency to users, and incorporating a holistic notion of care. A discussion on each of these challenges is below.

Crafting meaningful skill building activities for PC persons

In the scoping review literature [13] many VR interventions designed for PC persons employed distraction strategies, often combined with features of deep relaxation or guided meditation. One study [50] used breathing exercises to teach relaxation skills to alleviate symptoms of pain, and this skill building was proven useful in various medical procedures such as medical scans (O'Gara et al., [50]). However, challenges were reported for PC individuals with conditions like lung tumors, as they often struggled with holding their breath for the required duration [50]. In our effort to translate the Cancer Pain mobile app's breathing exercise to VR, we encountered the challenge of designing a tailored exercise such as guided meditation suitable for a diverse range of PC needs. Our initial design used a simple expanding circle visualisation synchronised with audio cues. Through feedback, we iteratively improved the design by providing more context leading into the exercise, fostering reassurance and trust with PC users that they could not fail, and allowing them to go at their own pace. While these enhancements are incremental improvements on existing implementation of breathing exercises in VR, the solution still fails to cater to diverse abilities of PC persons. One potential future solution to explore is leveraging additional biosensory technologies to dynamically adjust visuals and acoustics in VR to match the PC person's physiological data such as breathing and skin wear. This approach gives full autonomy to PC persons and allows them to not only complete the breathing exercise at their own pace, but have full control over their environment. This has already shown great promise in the pulmanory rehabilitation [81] field. However, the implementation of these dynamic features in VR needs further research and calibration, and long-term evaluation even in adjacent fields such as cancer research has required significant development effort, time and cost [81].

Enabling greater autonomy through perspective taking and active interactions

The scoping review [13] highlighted the limited use of active interactions in VR for PC persons despite studies [5, 52, 6] demonstrating how active interactions with the environment can increase a sense of immersion, enhancing clinical and enrichment outcomes. Furthermore, most studies used first-person narratives with limited autonomy. Brungardt et al.'s study [45], highlighted PC individuals' desire for greater interactivity to gain more autonomy over the VR environment. Establishing this autonomy is especially critical for individuals in hospitals, who may lack control over their setting. However, enabling greater autonomy through increased interaction in the VR environment must be approached cautiously, as it may risk inducing fatigue in PC individuals, posing concerns for their health and safety. Furthermore, the practicality of including interactive experiences varies depending on the nature and goals of the activity. In the specific case of translating a guided meditation activity from mobile to VR, we opted for a passive experience, aligning with the passive nature of the audio content. Moreover, introducing interactive components during a guided meditation experience might potentially divert PC individuals from achieving their relaxation goals. Therefore, we made the decision to incorporate only passive interactions and first-person perspective narratives in the prototype. While this does not provide complete autonomy for PC persons to freely navigate the virtual world, we have sought to improve on previous VR experiences used in literature by allowing for greater customisation and personalisation of the environment. These options include selecting the duration time, gender of the voice, landscape, accent, and language. This customisation can enhance immersion and engagement, contributing to increased enrichment and improved symptom management [13].

It's noteworthy that certain meditation apps in the Oculus Store, like TRIPP (see

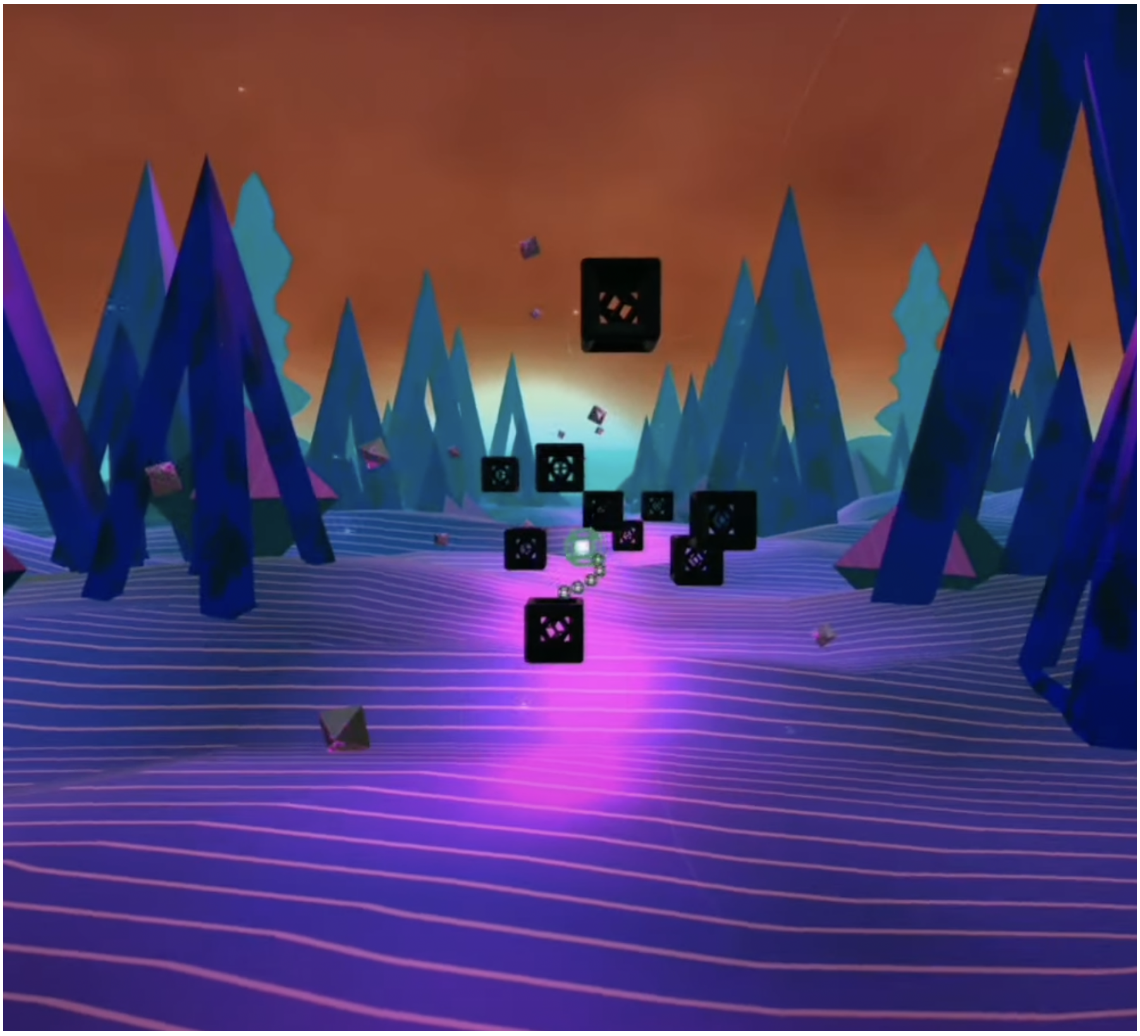

Figure 5.1: Screenshot from TRIPP meditation app of interactive activity
User using eye gaze to control ball around a field of cubes in VR environment

Figure 5.1), integrate interactive activities within their guided meditation experiences. These activities often involve using eye gaze interactions, such as navigating a kite or a ball through a field of blocks or popping balloons of the same color, all facilitated through eye-controlled interactions. However, the effectiveness of applying such interactions for PC persons and whether they enhance enrichment and relaxation outcomes requires further research.

Supporting a range of clinical and holistic care goals

The scoping review [13] revealed that studies had a notable gap in exploring how VR can serve as a tool to support holistic aspects of PC, such as the spiritual and social aspects of care [1]. Studies that incorporated these holistic models of care showed significantly greater and prolonged improvements in clinical symptoms and enrichment factors compared to typical meditation and relaxation-based approaches [68]. However, implementing holistic models of care in VR through a guided meditation activity poses challenges. Spiritual care for example, is deeply personal to each individual and it can be challenging to find visualisations that universally resonate. Using visualisations that fail to resonate with PC persons can detract away from the goals of relaxation. Future advancements in technology, such as generative AI, hold promise for addressing this challenge by creating personalised landscapes and visualisations tailored to individual care needs. While the prototype was not able to directly embed these holistic aspects of care, it did explore an avenue to incorporate more material elements important to each individual. This was done by introducing a photo gallery as an exit strategy from the guided meditation. The gallery featured images of objects, people, places, and pets that hold personal significance to the PC person and which they may not be physically access at present. Healthcare clinicians (HCPs) responded positively to this feature, aligning with Nikki et al.'s [7] previous exploration of visiting personal places of significance. However, the effectiveness of this exercise still requires validation with PC persons and healthcare clinicians through further research.

5.1.2 How do we create and prototype meaningful experiences in VR to support palliative care patients using a collaborative and participatory approach with clinicians?

The scoping review [13] revealed a significant gap in the literature concerning the involvement and consultation of adult PC persons in the design of VR experiences. Co-designing with adult PC persons poses challenges that are sometimes beyond the control of researchers. In our own project, we encountered these challenges early in the research process when attempting to recruit potential PC individuals for workshops. One individual faced language barriers that prevented their participation, while another preferred face-to-face interactions, which were restricted by ethics approvals to prevent the risk of infections. Although our project couldn't involve PC individuals directly for these reasons, we ensured that the prototype design and key decisions were shaped by PC healthcare clinicians who were embedded in the research team. This level of involvement and decision-making over key design aspects was lacking in the majority of papers [54, 53, 52, 6, 46, 47, 7, 48, 49, 51, 44, 5], included in our scoping review, where pre-built, out-of-the-box experiences were commonly employed, making it logistically challenging to involve healthcare clinicians to shape meaningful design for PC persons. There were two main areas where collaborating with healthcare clinicians led to more meaningful design, this included: creating a more engaging and tailored PC experience and improving accessibility and mobility of VR experiences.

Creating a more engaging and tailored PC experience

The scoping review highlighted opportunities to enhance the accessibility and mobility of VR tools for PC persons [13]. Sharing a VR video prototype with healthcare clinicians allowed for detailed feedback on how to implement these considerations, particularly tailored to the guided meditation experience. For instance, healthcare clinicians underscored the importance of addressing mood considerations for PC individuals interacting with VR experiences. While acknowledging that mood could impact engagement, clinicians raised concerns about the potential harm of asking PC individuals to fill out mood surveys before each VR exercise. Given the nature of their situation, where individuals may often feel low in mood, continuous selfreflection on a low mood could lead to psychological distress. In response, healthcare clinicians suggested an alternative approach: removing mood surveys until they are validated through research and posing a more general question at the end of the exercise, such as ”do you feel more energised?”. This shift turned mood tracking from a potentially harmful design choice into a more positive and meaningful experience for PC individuals. Collaboration with healthcare clinicians played a crucial role in shaping various design elements of the VR prototype. Their input led to meaningful decisions, such as providing additional context and instructions for the breathing exercise to address potential anxiety around keeping pace with the breathing exercise and incorporating a safety exit option for PC individuals to leave the experience at any time if they felt overwhelmed. The validation of design choices based on existing literature was another significant contribution by healthcare clinicians. This validation process included confirming the importance of offering options for experiencing VR either sitting up or lying down and emphasising the need for diverse duration options, with 6-10 minutes deemed ideal and longer sessions available for those who could endure them. This collaborative approach ensured that the VR prototype catered to the diverse accessibility and mobility needs and preferences of PC persons.

Improving accessibility and mobility

The sequencing of visuals, audio, and animations in the video prototype significantly enhanced the level of fidelity, enabling healthcare clinicians to provide detailed feedback and actively participate in the co-design process. This level of feedback would have been challenging to achieve with traditional 2D and static prototyping methods which are not able to capture the sensory and visual aspects of a final VR experience. For example, for the breathing exercise HCP were able to quickly identify desired visual improvements to make the activity more engaging. Rather than having the ball expand and deflate, they preferred to have particle streams going back and forth timed to the audio to help PC persons connect the exercise with the act of breathing. While they appreciated the variety of animations and visualisations, healthcare clinicians emphasised the importance of simplifying and reducing visual noise in scenes, particularly for the guided imagery exercise. Suggestions included slower movements, such as panning across sensory elements like water, and blending elements more naturally into the scene to minimise distractions and optimise relaxation. Additionally, healthcare clinicians recommended removing personalised images from the scene to avoid potential content triggers and maintain focus on relaxation. These collaborative contributions resulted in a more engaging prototype tailored to the specific needs of PC persons, aiming to maximise relaxation and focus. However, it’s essential to acknowledge a key limitation of the video prototype, as it could not fully convey certain aspects of 3D VR environments, such as scene transitions and depth. While this limitation was addressed upfront, some researchers expressed a preference for a more tangible version of the prototype in a coding environment to showcase these elements more effectively. Advancements in AI within the gaming and VR space may provide opportunities to expedite development and reach this desired development stage more efficiently.

5.2 Strengths, limitations and future work

The following section will highlight some of the strengths and limitations of this work, and opportunities to shape future work.

5.2.1 Scope of work

The scoping review contributed to meaningful development of a VR prototype for adult PC persons through the articulation of a set of design features that guided key decision making in executing critical design choices. Our study was motivated by a series of research questions as we continue an ongoing project in PC, part of which was previously published in a CHI paper [82]. In that participatory research, we identified directions through which VR can bring value to care practices in PC beyond the normative applications of VR for symptom management. This aligned well with the notions of enrichment [12] and countervention [39] to empower the status quo on what PC persons need and want. However, this study is limited in its scope as the findings apply to VR technology in an adult PC context. Future research may explore studies in the pediatric space and across technologies such as augmented reality (AR) and generally extended reality (XR) to grasp a wider range of possibilities for alleviating suffering as well as enhancing enrichment for PC. Additionally, the scoping review search protocol excluded any studies that did not specifically mention PC yet we encountered publications concerning the use of VR in cancer care, an area of care which overlaps with PC. To extend the findings, future research may widen the inclusion criteria.

5.2.2 Method

Participatory Approach

The scoping review findings clarified immense potential for diversifying design features while involving PC persons and their families in shaping the experiences that bring value to them. However, engaging vulnerable persons in PC in one of the most critical stages of life and should be carefully considered in terms of participant safety, dignity and well-being using approaches such as trauma-informed approaches in participatory design [83]. Future research should focus on improving methods for meaningful involvement of patients, families, and clinicians in research, particularly given the existing challenges in PC research, including and not limited to small and unrepresentative sample sizes and challenges of recruiting and working with vulnerable populations [84].

One of the limitations of our study was the absence of involvement of PC persons and families in the co-creation process. Furthermore, our process involved limited co-creation with clinicians. Due to time constraints of clinicians and scope of study, we largely co-created the experience within our research team and obtained feedback from clinicians post the creation process. There is a missed opportunity to engage in more meaningful participatory approaches with PC persons, their families and clinicians through co-creation workshops. There is also a missed opportunity to empower PC persons, families and clinicians to contribute to the ideation process and directly shape the VR experience design by using generative AI tools to create materials for input into the video prototype. Future studies should look to understanding the desirability and feasibility of using low tech generative AI platforms for co-design with PC persons, families and clinicians.

Future research holds the potential to address existing challenges in recruiting persons with disabilities (PC) for studies. The prevalent trend of favoring those with better health, English proficiency, daytime availability, and IT access, often recruited from existing patient or carer groups, inadvertently excludes those who do not meet these criteria. HCI can play a pivotal role in engaging diverse groups by establishing relationships with community partners who have direct connections with individual PC persons that larger community groups or organisations may not be able to access. Addressing practical constraints related to research participation could serve as a powerful incentive for broader engagement in research from PC persons and families. This involves providing greater flexibility in meeting times and venues, access to translators for non-english speaking PC persons, offering remote meeting alternatives for PC individuals unable to meet in person due to risk of infection, and offering professional support for technological or mobility challenges. Recognising potential fatigue created by in-person meetings, researchers should explore alternative methods like online forums, podcasts, or webinars, enabling PC persons to participate at their convenience [84].

In future studies, researchers should take a considered approach in tackling the ongoing challenge of balancing researcher, clinician and PC person perspectives in co-design. Our study, lacking PC representation, made critical design decisions, like removing personalisation and certain customisation features, based solely on researcher and clinician input. Chambers et al.[84] found persisting power imbalances in PC research, with academic knowledge often overshadowing patient experiences. While clinicians and researchers offer valuable insights, there's a recognition that assumptions may be at play, revealing power imbalances in research dynamics. It is critical to avoid tokenistic PC person involvement in research and empower PC persons to have a genuine voice in decision-making processes. Navigating the differences in perspectives is vital for equitable inclusion and, ultimately, co-designing more meaningful and inclusive VR experiences.

VR Video Prototyping Process

The integration of generative AI technology in the video prototyping process for VR offers a novel approach, enabling designers to quickly prototype concepts in the early stages with minimal technical constraints. AI significantly reduced the time required for generating illustrations, animations, and audio content, facilitating more efficient iterations after feedback with the research team and healthcare clinicians. The resulting video prototype served as an accessible artifact, easily shared with healthcare clinicians for remote consumption, contrasting with VR headset-based prototypes that demand additional context, setup assistance, and specialised VR devices. The incorporation of sounds, animations, images, and various camera angles in the video prototype effectively conveyed the sensory aspects of VR, enabling healthcare clinicians to provide detailed feedback which ultimately contributed to creating a more meaningful experience.

However, there are several limitations to our methodology in using video prototypes.

Firstly, video prototypes lacked the ability to capture intricate VR interactions, including eye tracking, locomotion, and hand gesturing. These aspects of the experience would require development in high tech authoring tools such as unity and are critical to showcasing the immersive interactions available in VR. Moreover while the video prototype incorporated design strategies to enable a more meaningful experience, the effectiveness of these design strategies in enabling enrichment for PC persons could not be validated without further research and testing with PC persons. This would have also enabled a more person-centred approach to design. Finally, the video prototyping in this study did not thoroughly consider and design for the potential impact of psychological harm. Woo and Lee [85] highlight how VR interventions have the potential to trigger maladaptive cognitions, leaving PC persons in a more vulnerable state (e.g., regret, hopelessness). They also cover how transitioning from the virtual to the real world may create difficulties in accepting one's status, particularly regarding physical limitations in reality compared to the virtual world. This may leave PC persons in a worse psychological state after using the VR experience. Future studies should implement psychological assessments before VR interventions to assess readiness and consider involving facilitators with psychological training backgrounds to minimise potential harm and enhance therapeutic benefits. Finally, the study didn't explore the potential of other complementary technologies, such as biosensory software, voice control, and real-time algorithms, to enhance personalized interactions for PC persons due to time constraints.

Another limitation of this study was the inability to quantify whether the use of video prototyping speeds up the process of moving from ideation to development stage compared to just using development tools for the prototyping process. This study benefited from using a baseline pre-clinically validated and desirable mobile app experience to translate into VR, bypassing the need to for developing content from scratch. Starting development of a VR experience from scratch may not be as straightfoward due to additional time needed for grater upfront research and validation processes. Subjectively, AI generative tools accelerated my video prototyping workflow, allowing me to focus on designing a more meaningful experience for PC persons and spend less time on intricate tasks like animation and detailed landscape illustration. This approach enabled me to create a high-fidelity video prototype in a short time. Future research should compare the effectiveness of AI-generated tools to high-tech coding tools in terms of time efficiency and suitability for co-design. Another limitation of using video prototyping is that ultimately, the artefact will need to undergo a process of development, necessitating low-tech creators like myself to either upskill in coding or collaborate with other skilled developers. Ongoing exploration of low-tech authoring tools to bridge the gap between the ideation and prototyping stage is vital for promoting equitable design.

Chapter 6

Conclusion

Current VR experiences have shown great promise in supporting aspects of a holistic model of care in adult PC populations. However, the benefits of VR as a unique immersive technological platform in supporting what Ahmadpour et al [2] described as "materiality of care" for adult PC populations, has not been fully realised. A move towards a more counterventionlist approach [39] in creating VR experiences is likely to foster enrichment and consider spiritual and social aspects of care that are valued in PC [2, 1]. Aspiring to change the language from patient- to person-centered care may be key in unlocking the potential that VR or other technologies can bring to PC. This shift compels us to renew our commitment to design justice for adult persons in PC as we seek to remove barriers to creating accessible, comfortable and safe virtual experiences for them. An upfront participatory design, devising more meaningful ways of engaging in remote co-design with PC persons, considering health risks, language barriers and other real-world constraints is needed to achieve such goals in HCI.

O'Gara et al. [50] urge us to investigate how to build bespoke experiences at a low cost to aid participatory design with PC persons and enable greater adoption of VR where it is valued. In line with this, our study identified time and skills-based gaps in creating VR prototypes for products, which acts as a barrier for creators to bring to life meaningful VR products for PC persons. The study therefore explored how generative AI tools can be used in conjunction with video prototyping to expedite the prototyping process, allowing low tech creators to ideate more efficiently and within constraints.

This methodology was used to create a video prototype that translated a mobile-based activity from the Cancer Pain mobile app to VR. The video prototype efficiently explored various possibilities for enhancing enrichment in PC persons, leveraging design strategies identified in the scoping review. This approach enabled the designer to flexibly explore ideas without technical constraints in early ideation stages of design. The video prototype also served as an easily shareable artifact, facilitating effective co-design with healthcare clinicians and providing a valuable tool for receiving feedback.

While bespoke and personalised experiences in VR have shown benefits in enabling greater symptom reduction, psychological well-being and general acceptance of VR, this can be costly and time-consuming to create [13]. Future studies should delve into possibilities for real-time personalisation based on user interactions in a virtual environment, leveraging advancements in generative AI tools. It's crucial to acknowledge the limitations of commercial AI models and generative platforms due to a lack of diversity in training data and the perspectives of the platform creators. Exploring these possibilities can inform discussions on balancing design strategies and industrial approaches for efficiency with opportunities for VR personalisation [86].

Finally, impactful innovation is an iterative process and creating meaningful VR experiences for PC persons takes time. The design strategies and artefacts developed in this study are intended to serve as provocations, sparking further research for ongoing exploration in the field.

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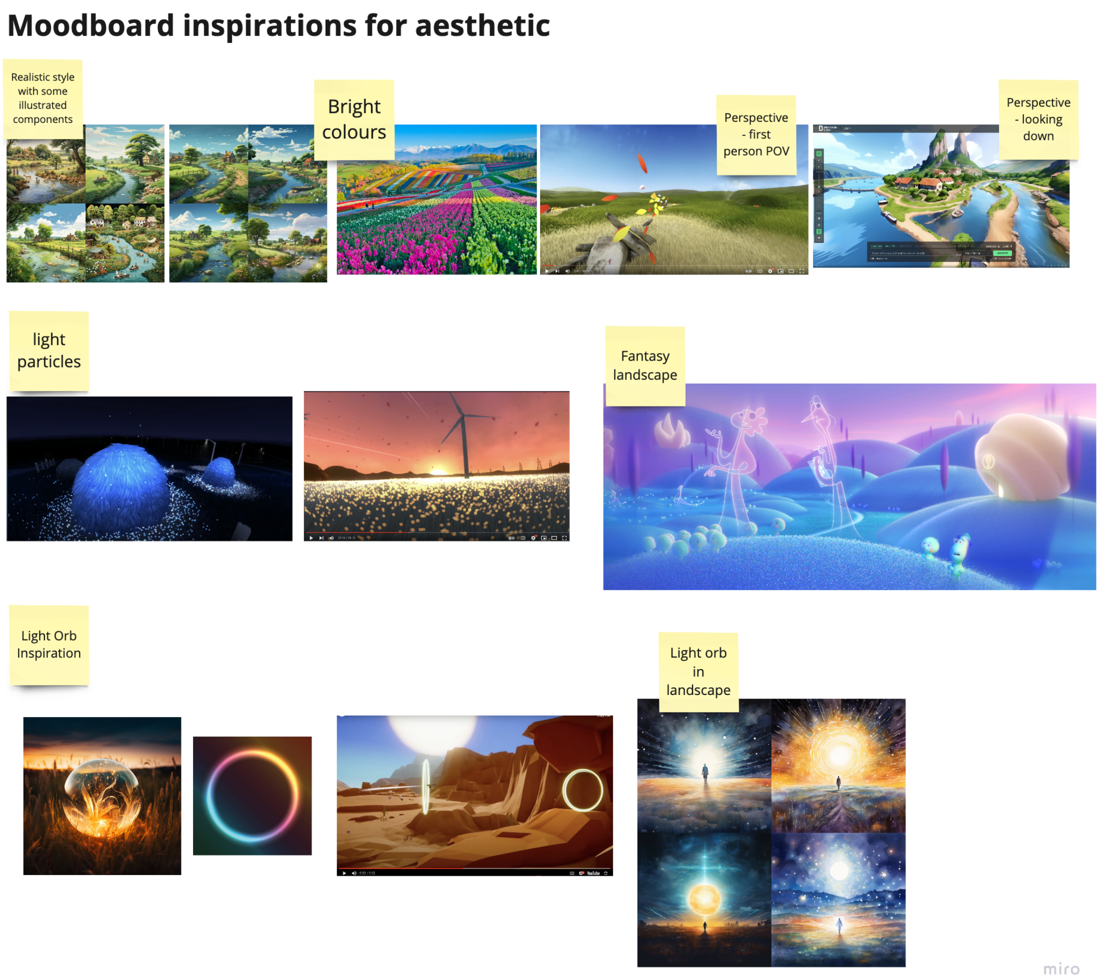
Appendix A

VR Design Process

All key parts of design process are mapped in Miro. See link.

A.1 Moodboard

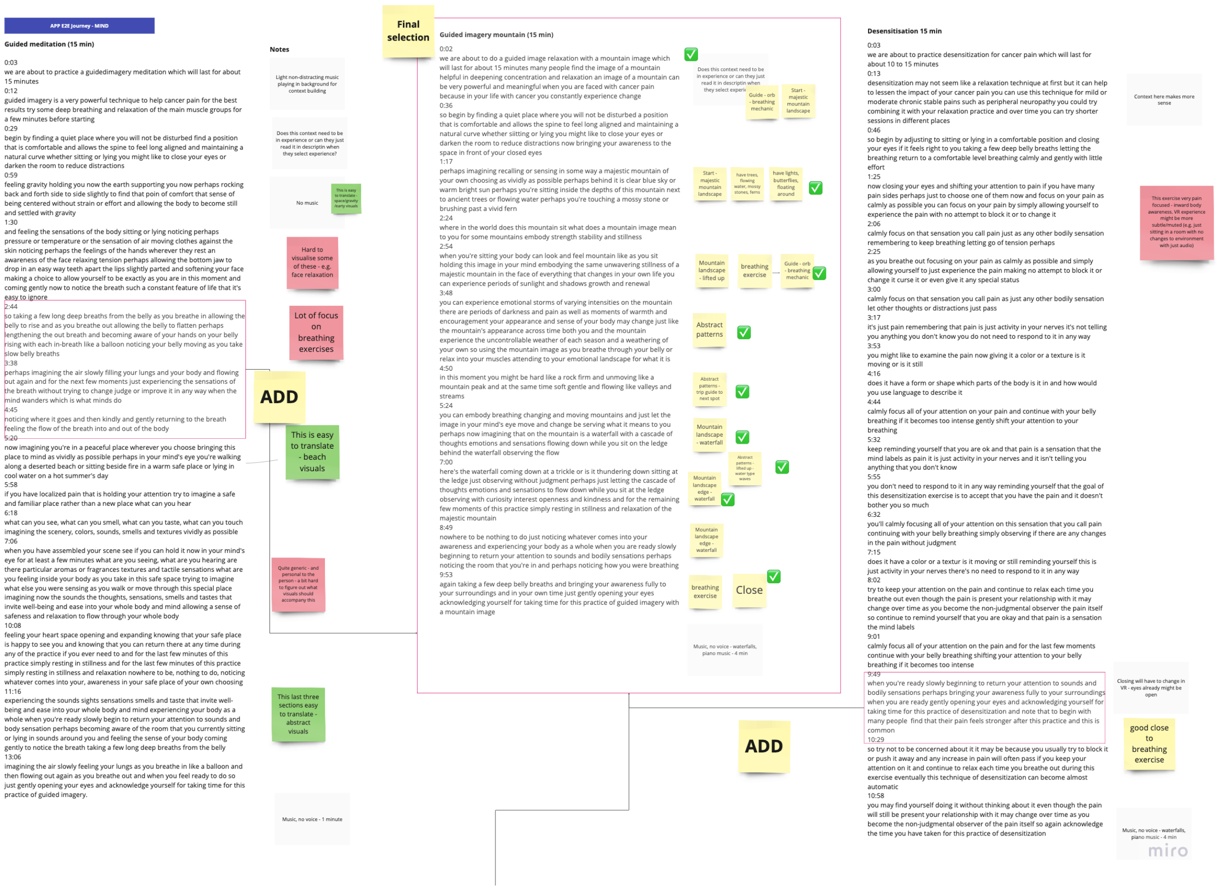
Collated images to serve as inspiration for the visual aesthetic of the VR prototype.



A.2 Script

A.2.1 Script Selection Process

Transcripts across the three most suitable Cancer Pain mobile app activities for VR translation which included: guided meditation exercise, guided imagery exercise (mountain) and the desensitisation exercise. I took notes across each experience which in combination with the criteria developed in 4 selected the guided imagery mountain exercise as my final activity. I edited the script, combining aspects of the other two scripts to create a final version.



A.2.2 Final Scripts

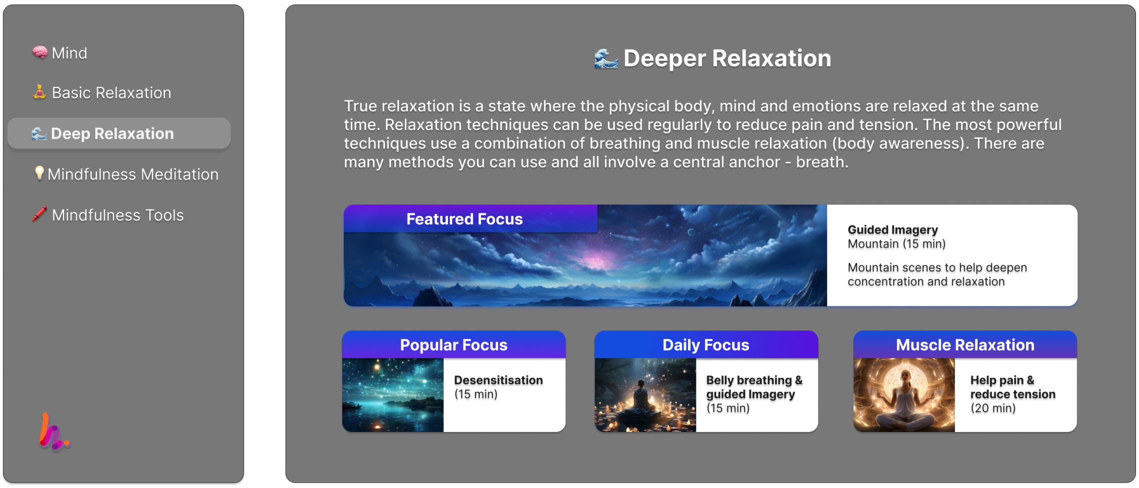
Link contains final script and revised script post clinician feedback.

A.3 User interface elements

Interactive interface elements used in the prototype (start screen, menu, surveys and customisation settings) were all designed in Figma. These screens were iterated post feedback from clinicians. See link to Figma file.

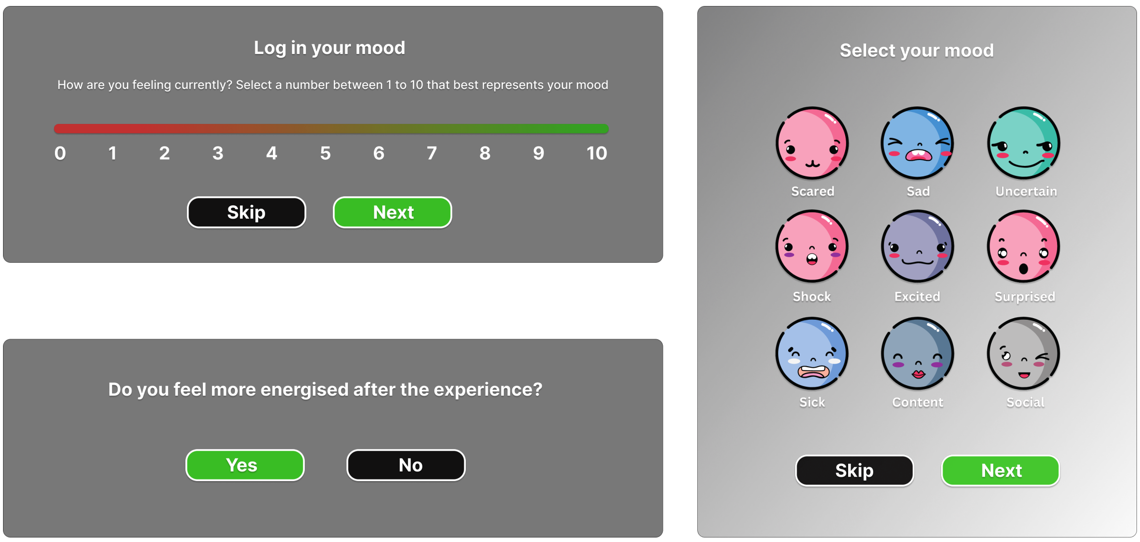
A.3.1 Menu

The menu was created to give an example of how the relaxation section of the mobile app would translate into a VR setting and how a PC person would navigate a VR space to select an activity.



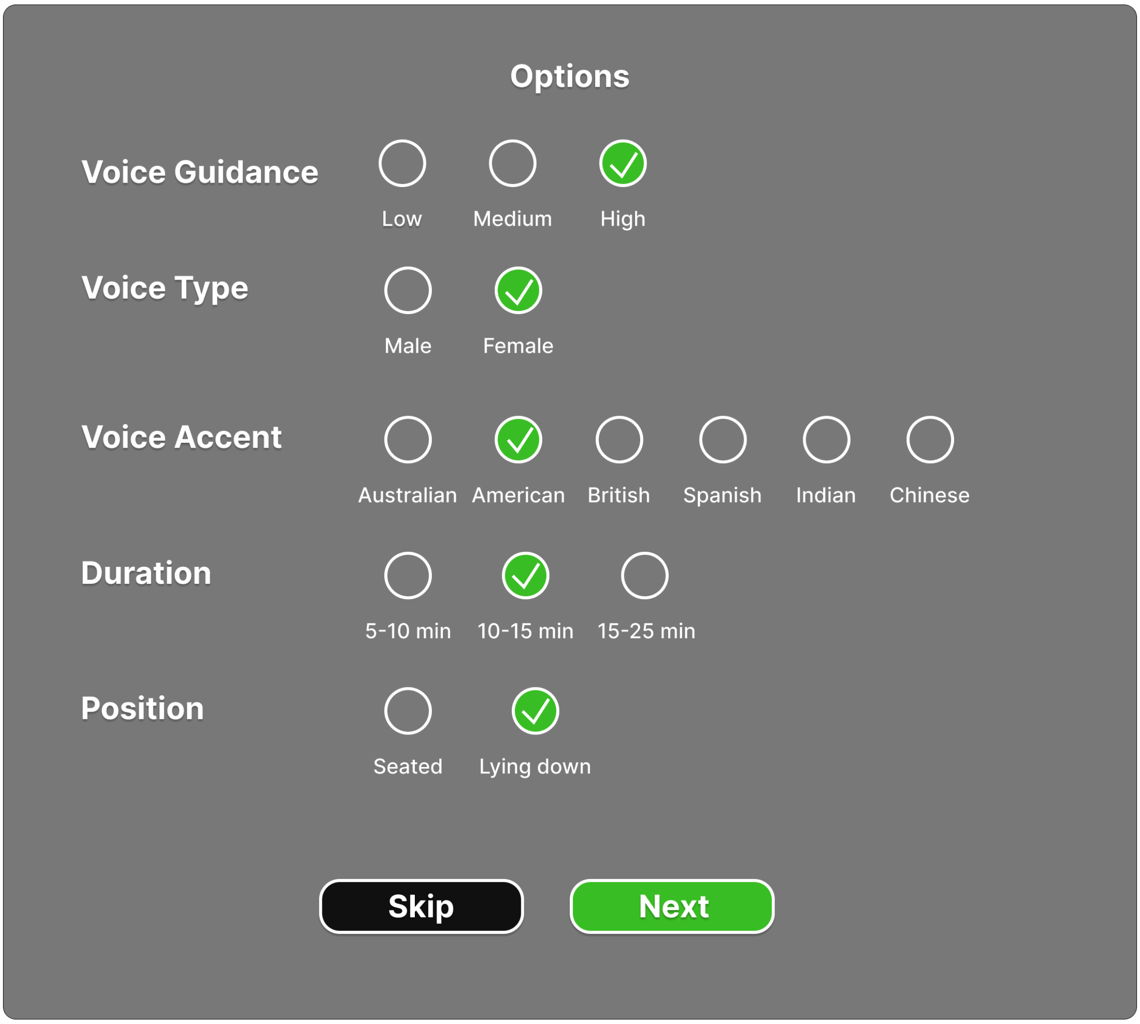
A.3.2 Mood Surveys

After feedback from clinicians, I removed ”Log in your mood” and ”Select your mood” surveys from the VR experience. I added post-activity question based on clinician feedback to ask whether PC persons felt more energised after completing the VR activity.



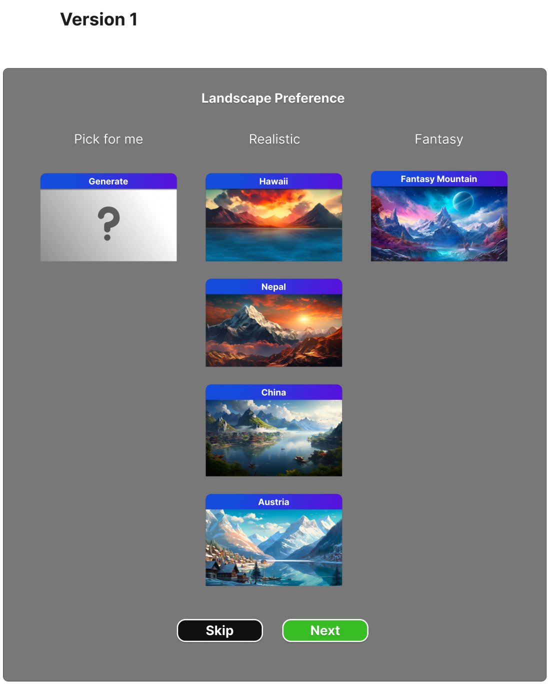
A.3.3 Customisation Settings

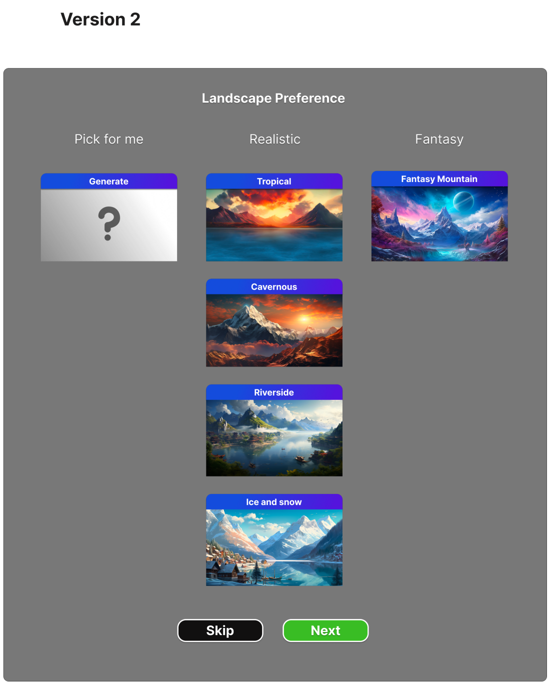
PC persons could select from a range of customisation settings to personalise the experience.



A.3.4 Landscape Customisation

Based on clinician feedback, we changed renamed the landscape options, changing them from country based descriptions to general environment based descriptions.



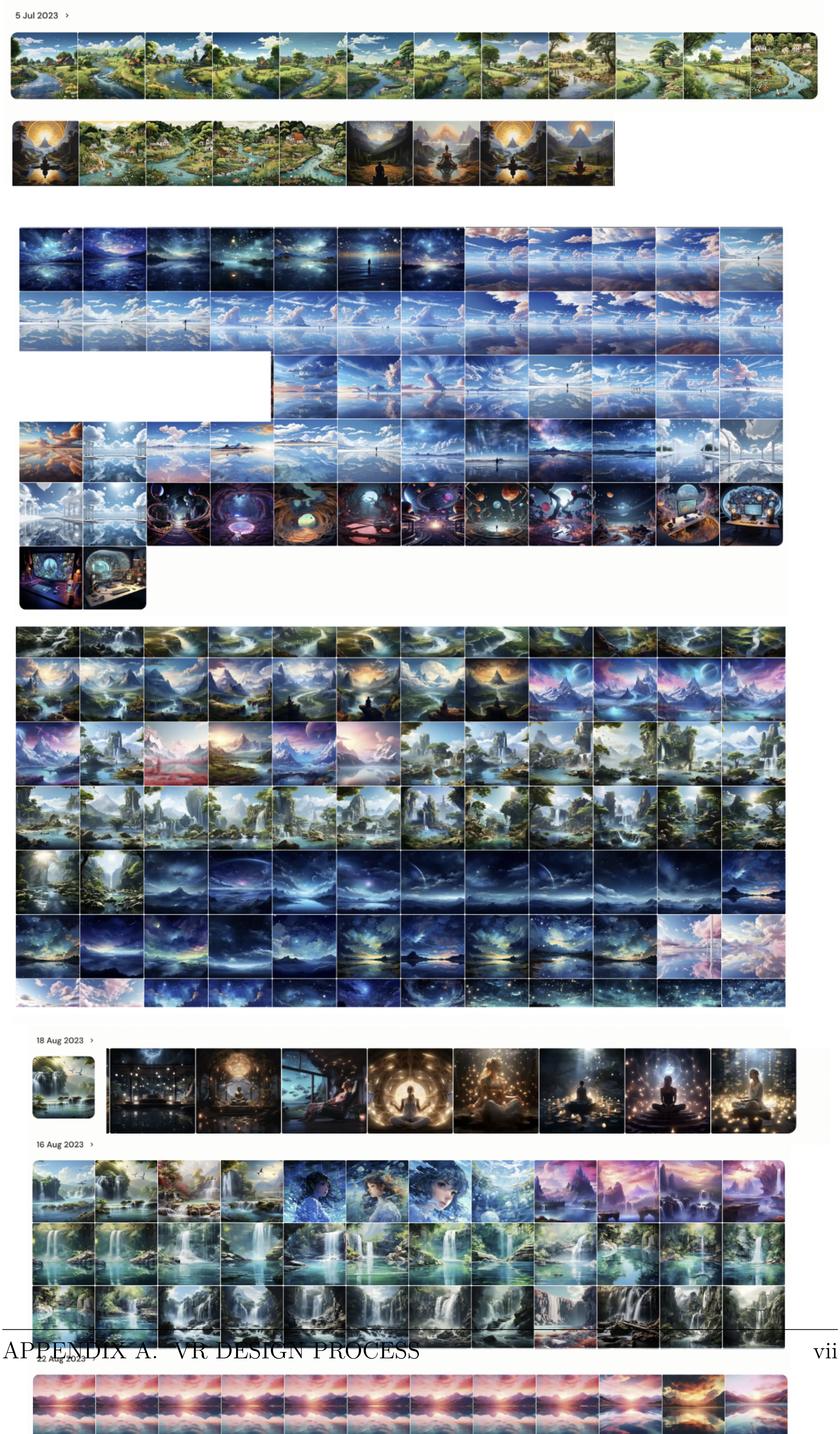


A.4 Generative AI tool outputs

A.4.1 Mid-Journey

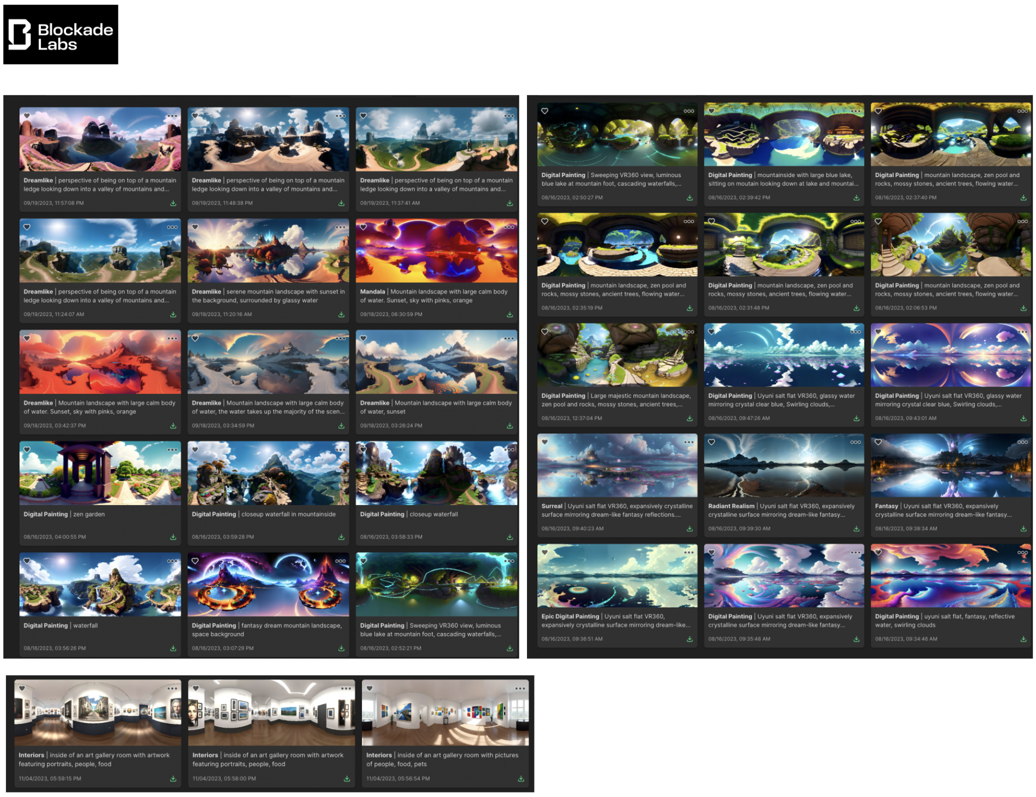
307 images generated from mid-journey. Some of these images were used in the landscape of the prototype as well as some of the menu screen elements.

Midjourney



A.4.2 Blockade Labs

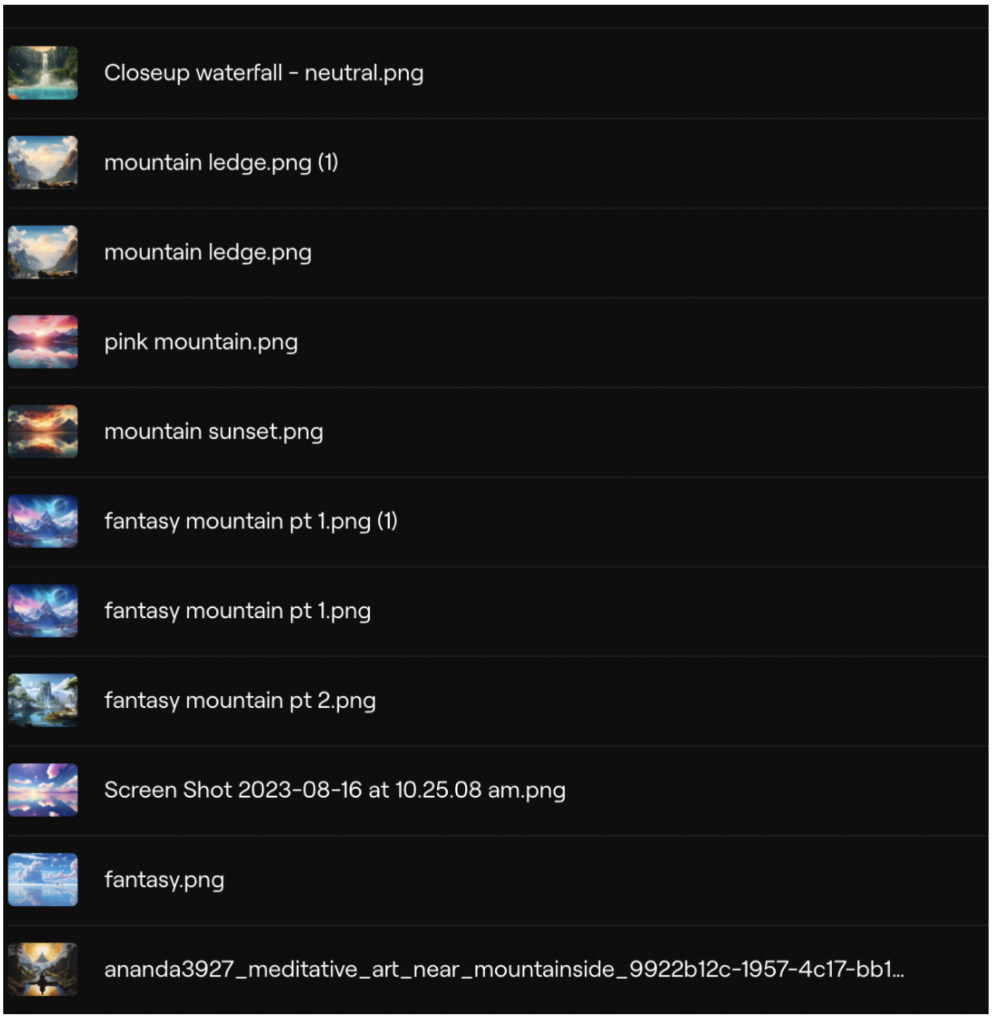
30 sky box environments generated in Sky Box Blockade Labs. Some of the 3D environments were incorporated into the video prototype by screen-recording the environment to create depth and movement.



A.4.3 ML Runway

Some of the static images generated in Mid-journey were put into ML Runway to create 5 second animation clips to be used in the video prototype.

runway



A.4.4 Feedback Sessions

The following questions are a loose guide to the structure of feedback sessions with researchers (1 session) and clinicians (2 sessions).

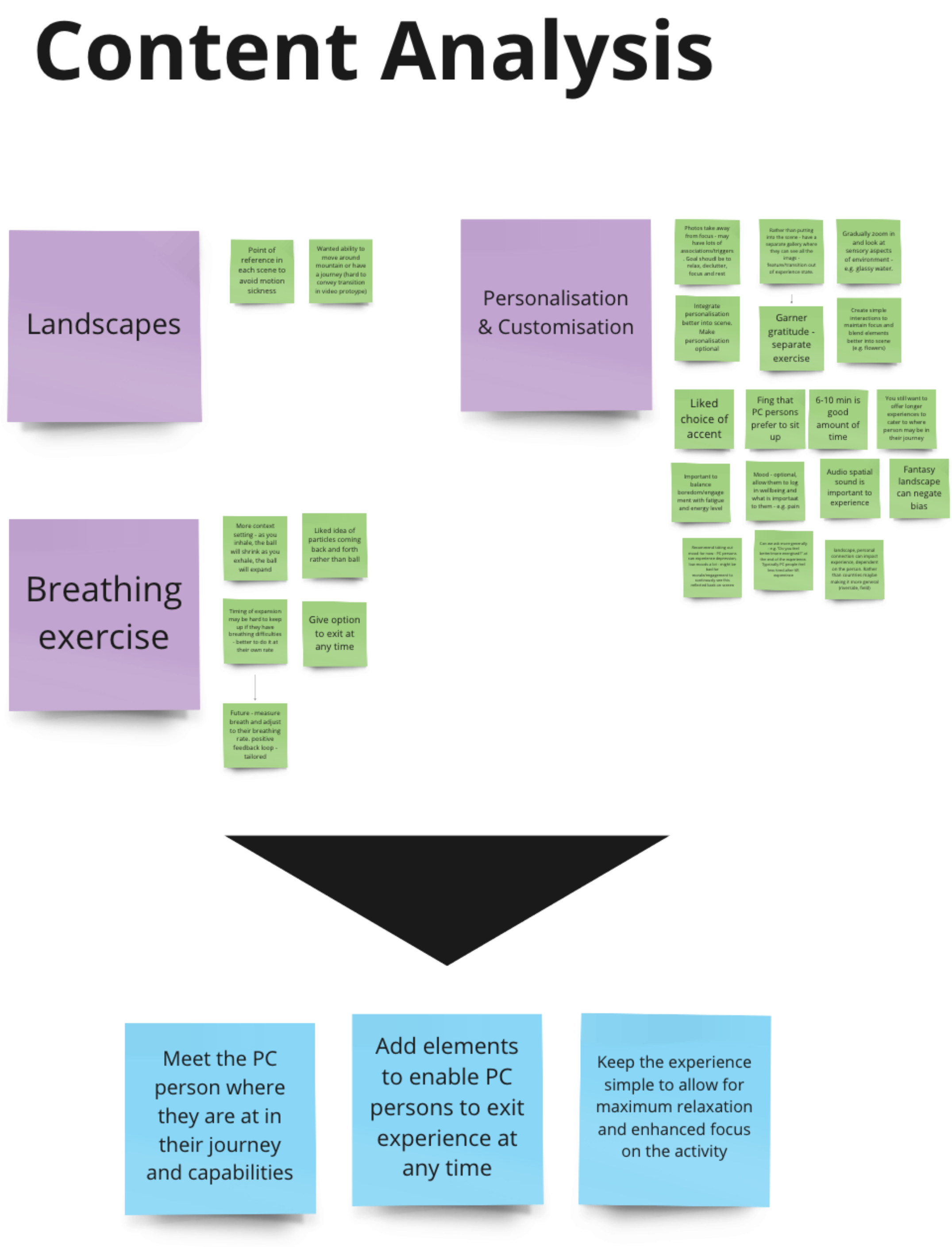
Questions:

- Overall thoughts on VR prototype?
- Any thoughts about start screen translation of app?
- How suitable are the customisation settings for PC persons?
    - In particular mood surveys
    - Landscape preference option
    - Customisation of voice, accent
    - Positioning
    - What is optimal duration?
- Feedback on design of landscape and animations
- Feedback on breathing exercise adaption
- Feedback on personalisation aspects
- Feedback on visual aesthetics, visualisations to match audio

During the feedback sessions, I recorded verbatim quotes and observations from researchers and clinicians about the VR prototype experience using sticky notes on a Miro board. I systematically went through key aspects of the prototype for feedback (such as personalisation, breathing exercise) with images from the prototype serving as supporting visual prompts to generate discussion. See record of feedback notes.

A.4.5 Content Analysis

I synthesised notes from the feedback sessions with researchers and clinicians to draw out key themes that would serve as areas to improve the VR video prototype for the next iteration.



A.4.6 Final Prototypes

Link to prototype 1 and link to prototype 2. Videos have been uploaded to YouTube.