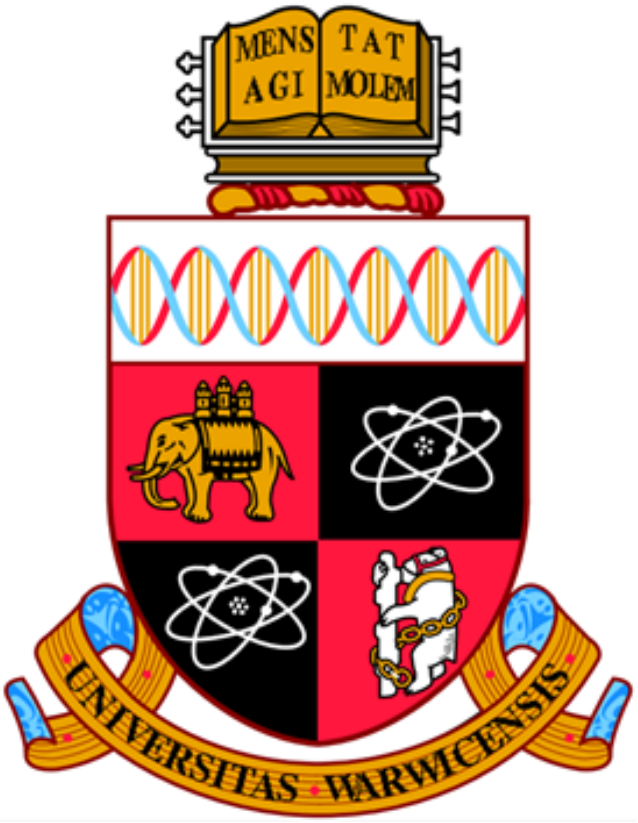
Using Virtual Experiences to Facilitate Refugees' Integration in Third Countries



by
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A thesis submitted to the University of Warwick
in accordance with the requirements for the
Doctor of Philosophy in Engineering

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Dedication

I dedicate my dissertation work to my family and many friends. A special word of gratitude to my loving parents, whose support, words of encouragement and push for tenacity ring in my ears every single day as I strive to be better. Dad, you sowed this seed in me all those many years ago and since the day I started I have prayed every day that you would live to see this day. To Sydney David Muggaga, thank you for what you have done to make my life easier as I studied. Thank you for taking care of the family.

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Declaration

AUTHOR: **Mark Patrick KIRYA**

DEGREE: **Doctor of Philosophy in Engineering**

TITLE: **Using Virtual Experiences to Facilitate Refugees' Integration in Third Countries**

DATE OF DEPOSIT: **12 September 2021**

I declare that some of the material contained in **Chapter Five** of this thesis, was also submitted as part of a journal article ("The Use of Virtual Environments to Facilitate Refugee Integration in Third Countries") which was submitted to a Virtual Reality Journal on 23rd July 2021.

The main author of the journal paper was **Mark Patrick Kirya** (also author of this thesis), with **Professor Alan Chalmers** and **Dr. Kurt Debattista**, both from the Warwick Manufacturing Group of the University of Warwick, as contributing authors.

I also declare that this thesis is my own work and has not been submitted for a degree at another university.

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Abstract

Virtual Experiences (VEs) have significant potential for a wide range of applications, including the potential to enrich the level of emotional interactions and socialisation, facilitate communication, treat phobias and PTSD, eliminate biases, deepen our understanding of ourselves and others, and enhance our appreciation of our environment. They also have the immense ability to elicit knowledge transfer and to change attitudes and behaviour. This research investigates whether VEs can play a key role in assisting refugees to learn how to navigate the complexities of the UK health system, a substantial stumbling block for their integration into society and for their own health and well-being. First, a pilot study involving University of Warwick students was conducted. During this study, the participants (N = 37) were exposed to material presented via three different media. The three media were descriptive text, a 360°video and a Virtual Environment (VE). All three media used in the experiment depicted a surgery in London. The experiment investigated whether any of the three media was superior in achieving knowledge transfer and whether there were specific attributes of the medium that could facilitate knowledge transfer. The results showed important tendencies and correlations between knowledge transfer and interactiveness of the media, with VE significantly superior across the four tested attributes. Furthermore, the results for the 360°video, demonstrated that the quality of the image was an important factor in achieving participants' appreciation of knowledge transfer. A second experiment build on these initial results. The participants (N=122) in this experiment were refugees in Senegal awaiting, what the UN Refugee Agency calls, "durable solutions" (repatriation to their country of origin, resettlement to third countries, or local integration in the country of asylum). They were exposed to material presented via three different media. These included a descriptive text, 360°images (superior to the previous 360°video) and a VE using a multi-factor approach where two of the three different media (360 and VE) were further sub-divided into six different factors. In both studies, we tested the hypothesis that interactive experiences have a greater propensity to elicit knowledge transfer because

of their psychological and physiological effect on areas of the brain, which are crucial for recollection-based memories, memory for spatial and episodic context, and scene perception. An assessment of participants appreciation of the information provided was done at the end of both experiments. The results show that interactive media, VE, was significantly better across all tested attributes. This suggests that VEs do indeed provide a far better understanding of a complex problem, such as navigating the UK health system. UNHCR is already looking at innovative ways to help refugees in their quest for durable solutions and future work will look to deploy such VEs at a number of UNHCR offices.

List of Abbreviations

2D	Two-Dimensional
3D	Three-Dimensional
360D	360°Images on a Desktop
360V	360°Images on an HTC Vive
360VD	360°Video on a Desktop
360VP	360°Images on an HTC Vive Pro
ANOVA	Analysis of Variance
AR	Augmented Reality
BSREC	Biomedical and Scientific Research Ethics Committee
CAMIL	Cognitive Affective Model of Immersive Learning
CAVE	CAVE Automatic Virtual Environment
CBT	Cognitive Behaviour Therapy
CPU	Central Processing Unit
CV1	Oculus Rift Consumer Version 1
GP	General Practitioner
HMD	Head Mounted Display
IN	Immersive Networking
IQR	Interquartile Ranges
IR	Inter-Reality
IT	Information Technology
ITQ	Immersive Tendencies Questionnaire
IVEs	Immersive Virtual Environments
IVR	Immersive Virtual Reality
LCD	Liquid-Crystal Display
LoR	Level of Realism
MANOVA	Multivariate Analysis of Variance
MCQs	Multi-Choice Questions
NHS	National Health Service
PQ	Presence Questionnaire
PSSUQ	Post-Scenario System Usability Questionnaire
PTSD	Post-Traumatic Stress Disorder
SID	Spatially Immersive Displays
SoP	Sense of Presence
SSQ	Simulator Sickness Questionnaire
UN	United Nations
UNHCR	United Nations High Commissioner for Refugees
USEQ	Usefulness Satisfaction and Ease of use Questionnaire

VE	Virtual Experience
VEC3D	Three-Dimensional Virtual English Classroom
VED	Virtual Experience on a Desktop
VEs	Virtual Experiences
VEV	Virtual Experience on an HTC Vive
VEVP	Virtual Experience on an HTC Vive Pro
VI	Virtual Instructor
VP	Virtual Patient
VPS	Virtual Patient System
VR	Virtual Reality
VW	Virtual World
VWs	Virtual Worlds
WEF	World Economic Forum

Chapter 1

Introduction

1.1 Introduction

Article 1(A)(2) of the United Nations 1951 Convention, and its 1967 Protocol, define a refugee as someone who "owing to a well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group or political opinion, is outside the country of his nationality and is unable or, owing to such fear, is unwilling to avail himself of the protection of that country; or who, not having a nationality and being outside the country of his former habitual residence, is unable or, owing to such fear, is unwilling to return to it" [133].

During displacement, refugees suffer a great deal of loss of family connections, livelihoods, homes, and possessions, which affects their ability to make socio-economic advancements. The United Nations Refugee Agency, in conjunction with the United Nations member states, has determined three disparate durable solutions for refugees. They include Repatriation to their country of origin, re-integration in their countries of asylum, and resettlement in third countries other than their countries of origin and the countries of asylum [74].

This research is focused on the integration of resettled refugees into their new environments in third countries, where very little attention is paid to the personal, cultural and

experiential factors of individual refugees, or other factors that influence integration [90].

Figure 1.1: A Refugee Woman in a Refugee Camp in the Democratic Republic of the Congo (DRC) - Photo by UNHCR (The UN Refugee Agency)

Phillimore (2008) [90] also highlights the integration challenges faced by refugees in the UK including the restrictionist stance on asylum adopted by immigration legislation and policy as well the more inclusive though less publicised, strand of policy developed around promoting the settlement and integration of refugees [90].

This study is focused on the use of Virtual Reality (VR) technology to make it easier for resettled refugees to integrate into UK society.

The power of VR lies in its innate ability to transform real-world environments with their complexities, into virtual worlds within which humans can perform as though they were in a real-world environment.

The efficacy of the VR technology on knowledge transfer is sustained by its ability to elicit fulsome engagement from users [59]. Human interactions and decision-making require understanding and management of emotions and responses [57]. Emotions govern

Figure 1.2: Refugee Women and Children in a Refugee Camp in the DRC - Photo by UNHCR

decision-making [117] and influence innovation, enterprise, empathy, or sympathy [54]. Although they are not directly responsible for knowledge/skills receptivity, they still contribute to "efficient and reproducible reasoning patterns" [54].

There is a correlation between the illusory appeal of VR or the sense of presence that people feel in a virtual world and the affective appeal of the overall experience and engagement [32]. Pain therapy for instance depends on the illusion of presence which facilitates the "clinical communication process" [42] and influences the interpretation of pain signals by use of psychological factors, which act as the gatekeepers to the levels of pain signals allowed into the brain's cortex [81].

According Linowes (2018) VR is a computer-generated simulation of a 3D environment, that appears real to the person experiencing it [70], because it elicits seemingly real, direct, and/or physical user interaction [28]. The end goal is to attain a strong sense of "being there" within this virtual environment. Key elements of a virtual reality experience include the virtual world, immersion, sensory feedback interactivity [106], the computer [91], and the users [11].

The HMD is VR's key visual display device in part because of its portrayal as a personal experience where interaction between the user and the virtual environment (VE) is as if it

were real in terms of day-to-day human actions such as "looking, pointing, walking, and physics" [65]. One of its key characteristics is its ability to isolate users and cut them off from the real world, which is important for minimisation of outside interferences and can therefore aid immersion. The images presented in HMDs are based on the user's current position and orientation and are measured by a tracking system [36]. According to Freitas (2018) [36] there are two types of HMDs: the opaque and the see-through HMDs. Opaque HMDs such as the Oculus Rift and the HTC Vive, completely immerse the user in the VE and "are used in applications that use their own virtual environment in which every asset of the environment is computer generated while see-through HMDs such as Google Glass, augment the real world with computer-generated data" [36]. There are other alternatives to the HMD such as walk-in spatially immersive displays (SID), which physically surround the viewer with a panorama of imagery, archetypally assembled by video projection. The CAVE (CAVE Automatic Virtual Environment) is one such example [64] of a SID that offers advantages over HMDs, including group viewing and interaction, wide field of view, high resolution, no cumbersome headgear, low user fatigue, and angular viewing without head rotation tracking and the related response time requirements. For purposes of this research, HMDs were chosen over SIDs to minimise interactivity (one of the key attributes of SIDs such as the CAVE is heightened interactivity and coordination among users) and to personalise the decision-making process. Issues around cost, size, special hardware/software requirements, and immersion also played a big part in the choice of HMDs.

1.1.1 The Choice of HMD

We evaluated several HMDs available to us based on resolution, the field of view, and weight. They included the Oculus Rift CV1 (see figure 1.3), the HTC Vive, the HTC Vive Pro and the Google Cardboard VR (See table 1.1).

We reviewed a study by Buck (2018) [12] and another by Borrego (2018) [8] and concluded that the HTC Vive , would better serve the purposes because of its large working range (7m) compared to the Oculus Rift (4.25m) [8]. Our decision was also based on the

Table 1.1: Device Specs for the various HMD systems available to us

Device	**Resolution**	**Diagonal FOV**	**Weight**
Oculus Rift CV1	2160 x 1200	110°	470g
HTC Vive	2160 x 1200	110°	555g
HTC Vive Pro	2880 x 1600	110°	555g
Google Cardboard VR	Depends on Smartphone	80°	96g

availability of both systems. We had more than one unit of the HTC Vive available but only one unit of the Oculus Rift. Based on the fact that there would be multiple users at a time, we decided to use the HTC Vive. The HTC Vive Pro was later added to the experiment because of its high resolution.

Figure 1.3: The Oculus Rift Head Mount Display

1.2 HMDs, Immersion and the Power of VR

The HMD has the ability to create an immersive virtual environment (IVE) by blocking off the user's audio and visual senses from the real world and discharging synthetic visual and auditory stimuli in their place [37].

These immersive tendencies give VR distinct innate "power" to draw users into the habitation of virtual situations which can lead to deeper than usual engagement and enhance learning. It offers a unique way to expose individuals to controlled social environments [128] in a safe manner and draw them into a level of interaction conducive to learning and exchange of knowledge.

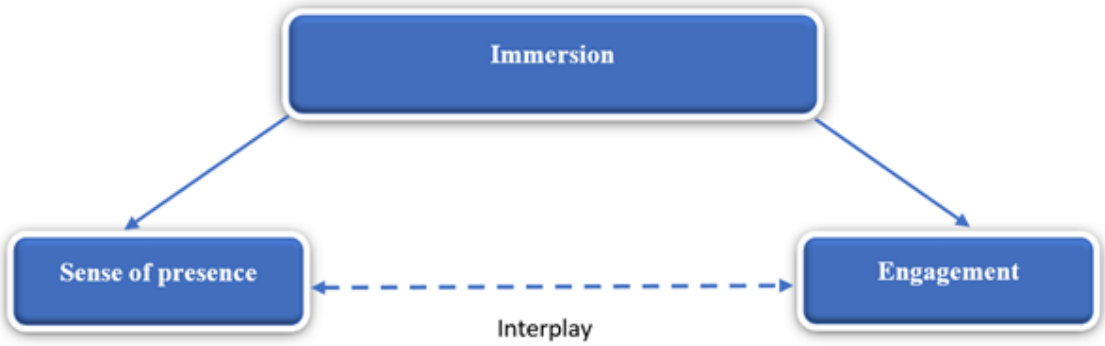


Figure 1.4: A simple taxonomy of immersion - derived from Mount, N. J, et al(2009) [84] that shows that immersion can result in a sense of presence ("being-there") on the one hand or engagement on the other, although there is an interplay between the presence and engagement, and the factors that are key to presence can also generate engagement.

VR thrives on transitioning between thresholds of what is familiar and what is strange and thus its success depends on these transitions being believed and accepted [25]. The research presented in this thesis explores the use of VR technology in transferring knowledge in order to effect cognitive, perceptual and behavioural change that can enable migrants to bed into their new environments more smoothly. It considers three disparate, but interdependent facets. Firstly, it reviews the use of VR technology (Virtual Experiences (VEs)) to enhance knowledge transfer and retention. It is based on the idea that most refugees suffer significant setbacks in their effort to integrate, in part because of a lack of knowledge of the cultural complexities of their country of settlement (*see Figure 1.5*), as well as language

obstacles [73]. Figures 1.1 and 1.2 show refugees in a refugee camp. One of the solutions for these refugees is to integrate them into third countries.

A further study revealed that most refugees suffer psychological distress, Post Traumatic Stress Disorder (PTSD), and other mental health problems as a result of migration (figure 1.2 shows migrants in flight with just a few of their belongings). The World Economic Forum (WEF) has ranked involuntary migration as the greatest risk to the global economic policy because of associated health risks [58]. In addition, from a host country's point of view, there is an argument to be made that stimulating collective/universal health security can only be achieved by establishing a health system that addresses the health needs of migrants.

Secondly, the research will compare VR as an effective medium of knowledge transfer compared to other media, including key variants that augment its power such as the Level of Realism (LoR), illusion of presence, and immersion/engagement. Cowan, et al (2015) [24] have defined knowledge transfer as the replication or repetition of "knowledge, skills and attitudes" attained through training in real environments at the end of such training; measured in both qualitative and quantitative terms [24].

Thirdly, the research investigates how VR technology can be related to behaviour change. Understanding this is central to designing an appropriate VR experiment that caters to the needs of target groups and enables the research to coalesce around envisaged outcomes. Studies indicate that when we undergo an experience, information gained from the experience is stored in the engram. The term memory engram refers to the theoretical means by which memories are stored as biophysical or biochemical changes in the brain in response to an experience. It is the "hypothetical learned information stored within the brain, which must be reactivated for recall" [99]. The retrieval of such a memory will invariably lead to a change or an adaptation of behaviour.

1.2.1 Hypothesis

The research is an experimental study to test the hypothesis that VR is the most efficient and effective means of knowledge transfer/acquisition because of its unique ability to aid

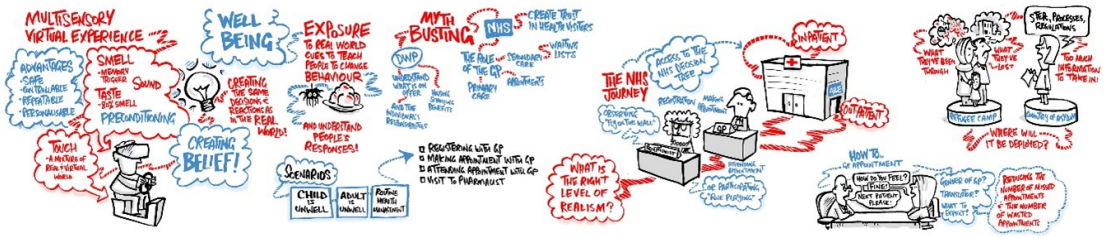


Figure 1.5: Developing the Problem and Hypothesis: The cartoon by Lance Bell, was drawn during the development of the hypothesis to demonstrate some of the difficulties faced by refugees in accessing the UK National Health Service due to social, cultural, economic and legal issues among other things.

in more effective storage of information gained from experiences. The end objective of the project is to use VR to aid behaviour change amongst refugees and ultimately facilitate their integration into third countries.

1.3 Migration and the Knowledge Gap

Migration and population mobility in Europe has increased the need for information dissemination and transfer of knowledge to new migrants to help them navigate socio-economic systems [10]. Elements of Europe's socio-economic architecture are new to most migrants who have limited knowledge of how to navigate these systems. To date, the most common and perhaps easiest way of enhancing their knowledge is by providing guidance in the form of texts on select websites [66]. However, there is a dearth of resources to deliver an interpretation of the different language combinations that are contextually relevant for migrants which inhibits their ability to integrate smoothly into UK society and enjoy its benefits [10]. VR has however proved particularly well suited to facilitate this transfer of knowledge because of its ability to open gateways for independent, experiential learning [51]. It is also able to transcend fixtures implying that such migrants can experience where they need to be without having to physically travel to these sites. Moreover, across the globe, VR is increasingly becoming more familiar to users, which offers real potential for its use as a knowledge transfer platform.

1.3.1 Knowledge Transfer Defined

Cowan (2015) [24] defines the integration of skills acquired during an experience into daily practice at a time after the experience. Contextualising this transfer to intersect with actual practice achieves better outcomes and this is what gives rise to the need for appropriate media for knowledge transfer. The introduction of user-friendly technology in the knowledge transfer processes is an innovative strategy that would enhance current traditional methodologies with their numerous limitations. VR not only espouses those qualities but adds timelessness, a high level of interaction, and the adaptability of technology to the learning environment. Research shows that interactive and collaborative forms of knowledge transfer are more effective in inducing changes in application or behaviour change than existing models such as the use of text on a website [24]. According to Gantt (2011), we have a short-term retention capacity of 20% of auditory information, 40% of audio-visual information, and 75% of interactive information. This is in part because, according to the sensory integration model, the central nervous system integrates various sensory inputs in order to arrive at a coherent representation of an experience [125].

1.3.2 How Knowledge is Conveyed

Although there are numerous variants of representations, there are only two basic forms by which knowledge is conveyed - descriptions and depictions. Texts are the most common kind of descriptions, while pictures are depictive representations [105].
Descriptive representations rely heavily on previous experiences for the formation of mental models, while visual models require an analog structure mapping based on perception and thematic selection [105].

VR is an enhanced and interactive form of depictive representation. This interactiveness offers easily repeatable experiences. It is therefore effective in its enhancement of knowledge construction and transfer because of its ability to replicate and repeat key concepts [21]. It elicits more engagement and helps learners to better appreciate contextual applications of what they have learned. It also simplifies learning complex skills because

it represents the problems and complex set of challenges in ways that can be more easily understood than if instructions were delivered verbally. Indeed, previous studies on video-based instruction by Herron, et al (1995), and Shyu and Simpson, et al (2000) indicate that learners are more appreciative of video-based instruction, thus corroborating the above assertion [49], [107]. Learners with no prior knowledge or experience do not have to formulate abstract perceptions because they are able to benefit from the visual technological systems as they better enhance their understanding. It is also codified into memory in ways that are superior to rich text that is easily altered with new experiences.

During the experiments, we found that the effect of the visual fidelity of an experience is important in allowing participants to relate their virtual experiences to real-world applications. We also discovered that the effect of visual fidelity on the transfer, retention and replication of knowledge largely depends on the kind of task at hand and requires value or orientation judgement to recall the task. For instance, how many doors does the surgery have and where are they? On the other hand, a greater level of fidelity will be required if greater visual detail is required to recall the task. For instance, what is written on each door?

1.3.3 Memory

One of our findings was that memory and knowledge are indeed linked because memory operates on the basis of knowledge. It is a retention of experience created through "internal neuronal representations," over a period of time and results in behaviour change [94]. It also heavily depends on information that is "encoded in the neuronal substrate" but articulated in the form of behavioural patterns [94]. However, in view of the fact that it is expressed in the form of thought or behavioural patterns, it does not exist until it is retrieved [118]. That is why memory encoding is important.

1.3.4 Memory Encoding

Encoding is the process by which an experience alters knowledge. What you knew before the experience becomes irrelevant to the extent that the experience changes the knowledge that you now have. Coding is the manner in which a particular experience is conveyed to the brain. Coding is done so that such an experience can be retrieved later. Coding therefore generally results in an adaptive change [94].

The question for us in this research was how the three media used could effectively facilitate coding in order to result in the required adaptive change. Based on the study by Roediger (2007), we surmised that effective coding would depend on the quality of the experience (denoted as "X" below). The experience once encoded and retrieved becomes X*. However, during retrieval, it goes through a second experience of re-consolidation and emerges as X**. Below is a representation of the coding (X), consolidation (X*) and re-consolidation process (X**) [94]. The simple equation 1.1 below is the basis of the study in chapter six which highlights the importance of memory consolidation in the knowledge transfer process.

$$X + X* \Rightarrow X* + X** \tag{1.1}$$

1.3.5 The Process of Knowledge Transfer

Based on the Ruggeroni study (2001), knowledge transfer refers to the effects of experience on one task on the performance of a subsequent task [98]. The transfer must be considered relative to an appropriate control condition in which the initial task of interest is not practiced before performance of the subsequent task [94]. If the first task enhances performance on the second task relative to the control condition, then the situation is one of positive transfer; conversely, if the first task impairs the performance of the second task, negative transfer has occurred [94]. This, therefore, implies that the "experience" will alter whatever internal representations will have been formed over the long term.

Therefore, the concepts of encoding and consolidation are relevant to transfer. First, we go through an experience or perform an initial task which is coded in the engram. We then perform the task again which results in consolidation and reconsolidation. And so memory encoding does not come to an end the first time. Rather, it proceeds afterwards, culminating in a stabilised trace [94]. In the course of this process, the newly acquired information will integrate with existing bodies of knowledge in the brain, resulting not only in the long-term representation of the new information but also in the alteration of existing knowledge [94].

Given that this research study was about the efficacy of a VE in achieving knowledge transfer, it was important for us to understand the knowledge transfer process. This process as highlighted above involved coding of the initial experience, and consolidation and reconsolidation of the memory. In asking the key research question about which medium was most effective in the transfer of knowledge, the incidental question was, which medium was the most effective in the coding of a memory. We, however, underline that the current study is not about memory formulation and thus limited itself to knowledge transfer through the performance of the first task. There was no second (criterial) task and that is why the concept of memory is not discussed further in any detail.

1.4 Structure of Thesis

The rest of the thesis is structured as follows:

1. **Chapter 2: Background**

   Chapter 2 presents previous work and key concepts related to the research. They include virtual reality technology and knowledge transfer. It also discusses knowledge retention and design features such as fidelity or the level of realism, and key outcomes of these features such as the sense of presence and immersion. The chapter also considers issues related to migration and refugee integration. Finally, this chapter conducts a systematic evaluation of the applicability of VR environments in

knowledge transfer.

2. **Chapter 3: Research Methodology**

   Chapter 3 describes the scope of the investigation, the key research questions, the experiment procedure and design, measurements and analysis, the method of analysis, and the research protocol. The chapter also discusses the hypothesis and the scope of the research.

3. **Chapter 4: Pilot Study**

   Chapter 4 outlines the pilot study which was primarily focused on identifying design challenges as well as other issues that might negatively or positively affect key outcomes. The study used University students who were not the target population for this research.

4. **Chapter 5: The Use of Virtual Environments to Facilitate Refugees' Integration in Third Countries**

   Chapter 5 evaluates the three media of knowledge transfer and the variations made to the 360°images as well as the Virtual Experience. It highlights findings on the experience of participants, the sense of presence, the usability of the different media and the results of the two assessment tests.

5. **Chapter 6: Longitudinal Study**

   Chapter 6 highlights the results of a longitudinal study aimed at ascertaining the efficacy of the media in triggering knowledge retention. The study involved 89 participants.

6. **Chapter 7: Thesis Discussion**

   Chapter 7 outlines the broad findings of the study, its impact, and its limitations.

7. **Chapter 8: Conclusion and Future Work** Chapter 8 concludes the research, outlines its contribution to knowledge, the lessons learned, and makes recommendations for future work.

1.5 Summary

In this chapter, we discuss the definition of a refugee based on Article 1 (A)(2) of the UN 1951 Convention and its 1967 Protocol. We also discuss why refugees are a unique population cohort because of the loss they suffer during migration, and the migration knowledge gap, which sets the stage for why knowledge transfer would be central to integration. Some of this loss is depicted photographically through figures 1.1 and 2.6 showing life in a refugee camp including shelters made of plastic sheeting provided by the UN Refugee Agency. This is why it is important that there are concerted efforts towards finding solutions for them that are quick but sustainable. One of such solutions is integration into what we refer to as third countries. A third country is also referred to as the country of resettlement, with the first and second countries being the country of origin and country of asylum respectively. We then turn to VR highlighting why we chose one VR system (HMDs) over another (SIDs) and why we selected a particular set of HMDs (the HTC Vive and the HTC Vive Pro). Figure 1.5 shows how the hypothesis was methodically developed and this is discussed further in subsection 1.2.1. We then discuss the concept of knowledge transfer, how knowledge is conveyed, and how a memory is created and retained. Finally, we outline the structure of the thesis.

Chapter 2

Background

VR has proven effective in its ability to transform real-world environments with their complexities into virtual worlds within which humans can perform as though they were in a real-world environment. Given this capacity, Virtual Experiences (VEs) can be crucial to the coding process described in subsections 1.2.4 and 1.2.5 in Chapter 1 and can form the basis for the effective impartation of knowledge and skills [35]. They provide a unique and often under-utilised opportunity for constructing "attention learning" [35], but in order to attain the best possible effect, must be underpinned by a naturalness (realism); a believable resemblance that the user is interacting with the real world including the use of virtual characters that possess artificial intelligence and are able to provide actionable feedback [87].

2.1 Immersion and Presence

According to Slater (2016) [113], immersion is determined by information processed by our sensory systems (sight, sound, smell, taste, force, and touch) within a virtual environment, combined with data gleaned from previous real-world experiences. It is this combination of the virtual experience and the real experience, that makes VR work [119] because its underlying goal is to replace real sense perceptions with the computer-generated ones combined with changes triggered by the involvement of the user (there is a positive correlation between the user's ability to modify a VE and the degree of immersion

implying the greater the extent to which a participant can modify a VE the greater the degree of immersion [113]). Accordingly, immersion occurs when sensory perceptions are effectively replaced by mental models created by the brain once data is received from a VE. At this point, the consciousness of the real world is transmuted to a greater awareness of the VE rather than the real world despite the user's absolute awareness what they perceive is not real. Factors central to this transmutation include "wide field-of-view vision, head tracking, low-latency from head move to display, high-resolution", and multi-sensory virtual experiences [113]. As such, the user's ability to perceive is determined by the use of their senses and their bodies in a natural way (natural body and visual movements such as turning, bending, moving, looking, viewing, touching, push and pull, etc), which means that for immersion to occur there has to be a linkage between the user's proprioceptive feedback in relation to the natural body movements, and the information/data displayed or received. For instance, head movement should trigger a corresponding change to the visual display. An immersive VR system is therefore one that "delivers the ability to perceive through natural sensorimotor contingencies" [113] and therefore describes the technical capabilities of a system. Immersion as a function of those capabilities is an objective measure of the richness of the system, and its ability to shut out the outside world. The degree of immersion varies based on the number of senses stimulated by the system and the quality of the hardware and virtual experience accessed within the system [77].

2.1.1 Presence

A subjective associate of immersion is presence, which is the consciousness of being in the VE, and the corresponding modes of behaviour" [112]. If a user for instance turns their head in a VE, and there is a change in the information displayed, then the user's perceptual system infers that what is being displayed is the actual surrounding. This triggers the subjective illusion called "presence" or the illusion of "being there" in the VE even if you know for certain that you are not actually there [111]. It is the real-time changes in sensory perceptions triggered by natural movement that in turn bring about the sense of presence or the "illusion of being there" in the VE [100]. Users who attain a high level of presence

within the VE, should find the VE more engaging (see figure1.4) than the surrounding world, and consider the environment specified by the displays as sites being visited rather than just images being seen. Behaviours in the VE should be consistent with behaviours that would have occurred in everyday reality in similar circumstances [111]. Immersions, therefore, refer to the descriptive factors that can be used to characterise a VR system, while presence are the psychological and behavioural responses.

There is a triangulation between the illusory appeal of virtual reality or the sense of presence that people feel in a virtual world, the affective appeal of the overall experience and engagement [32]. This illusory appeal oftentimes referred to as the illusion of presence, helps to achieve very high levels of interaction and immersion and to provide real-time feedback between the real world and the virtual world by which individuals' VEs are influenced by their physical experience.

Pain therapy for instance depends on this "illusion", which facilitates the "clinical communication process" and influences the interpretation of pain signals by use of psychological factors, which act as the gatekeepers to the levels of pain signals allowed into the brain's cortex [81].

The Head Mounted Display (*see Figure 2.1*) creates an immersive virtual environment (IVE) by blocking off the users' audio and visual senses from the real world and discharging synthetic visual and auditory stimuli in their place [37]. This innate "power" of VR to draw humans into habitation of virtual situations is what leads to deeper than usual engagement and enhances knowledge transfer. It offers a unique way to expose individuals to controlled social environments [128] and to draw them into a level of interaction conducive to learning and exchange of knowledge.

Indeed Ruggeroni (2001) finds that even a low level of interaction can significantly affect the transfer of knowledge [98].

Figure 2.1: The HTC Vive Pro Head Mounted Display and Handheld Controllers

2.2 Knowledge Transfer, Memory Retrieval and the Level of Realism

Although the effect of VR on knowledge transfer has been widely researched, this research specifically focuses on the use of VR to transfer knowledge to refugees for purposes of integration into third countries.

According to Dohn (2020) [29] transfer occurs when a person or a group of people put "something that has been learned in one context to use in another."

Cowan, et al (2015) define knowledge transfer as the application of knowledge after the transfer [24]. It is generally assumed that contextualising the transfer of knowledge to intersect with actual practice achieves better outcomes. Therefore virtual simulations typically strive for high levels of realism. However, how close the "virtuality" should match the real environment remains a matter for debate and perhaps further study. For instance, as partly highlighted in the research questions, (1) what level of realism would be required to maximise knowledge transfer, retention, and later the application outlined in the Cowan (2015) study (*see Figure 2.3*)? (2) What level of realism would maximise coding and memory consolidation/reconsolidation and diminish the negative impacts of "knowledge-transfer loss? This is particularly important since John et al (2016) found that high fidelity was not a factor in performance improvement [55]. This outcome is supported by an earlier study by Tan et al (2012) [124]. (3) How can transfer be achieved? (4) Can it be achieved differently for different types of knowledge? Answers to these questions are

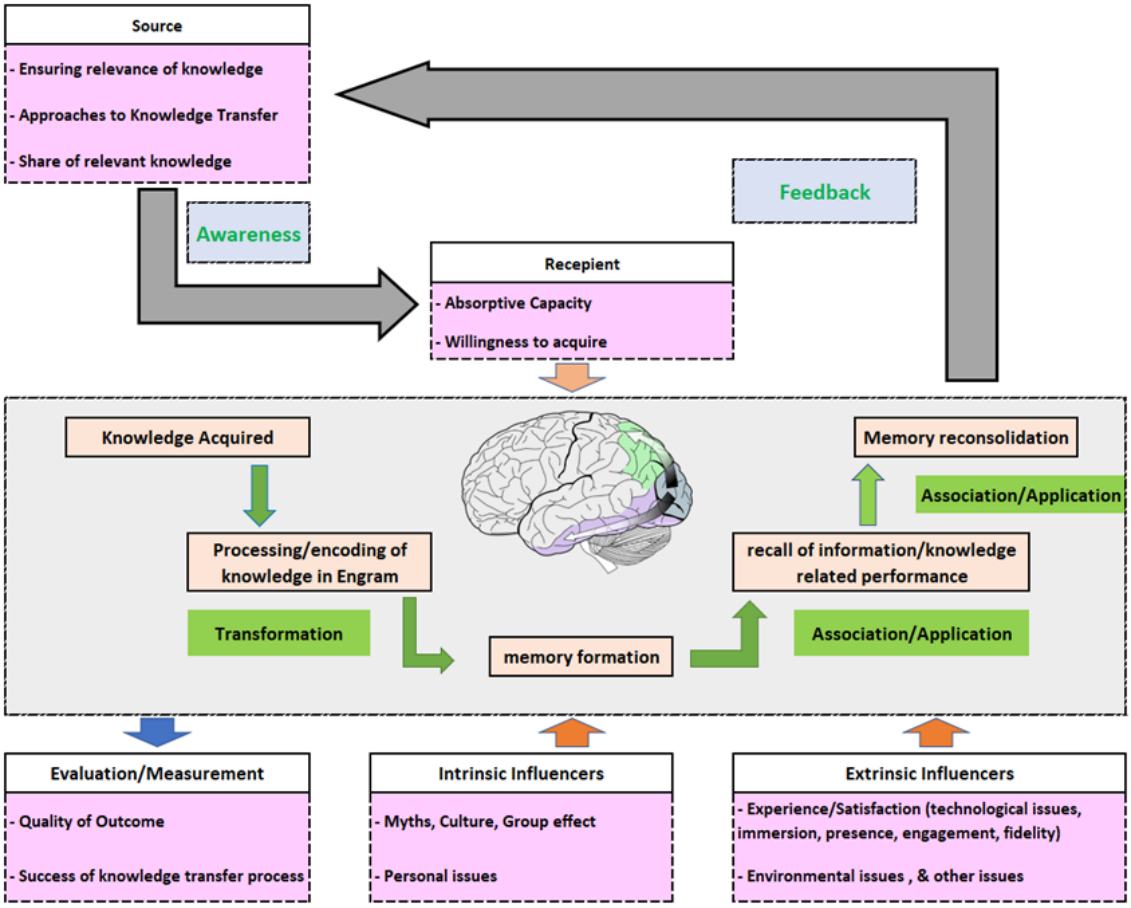


Figure 2.2: Relationship between knowledge transfer, memory formulation, consolidation and reconsolidation, and the role of influencers such as experience and myths. Adopted from Liyanage et al (2009) [72]

pertinent because they impact the approach, the device design, the content, and the level of accuracy.

2.3 Approaches to Knowledge Transfer

Dohn et al (2021) and Spector et al (2014) name five approaches of knowledge transfer, differentiating between "situations" and the content of "the move" [29]. These approaches include the **behaviourist approach** which defines transfer as "retention of knowledge across situations" and focuses on knowledge transferred to elicit certain behaviours linked to specific situations (this was specifically the focus of this study [116], [29]). The **cognitive approach** focuses on internal processing which allows the learning to put the knowledge to use in different situations but "where the different situations are recognized

as sharing structure. The **participationist approach** is similar to the cognitive approach but there are differences in focus between the two approaches, with the cognitive approach focusing on cognition of the situation and the participationist approach defining the learner in terms of the social setting, where transfer concerns patterns of participation and how participants can engage with their social conditions even in new situations. Other approaches highlighted by Dohn et al and Spector et al (2014) include the **situated cognition approach** and the **developmental practices approach**. These approaches have several features in common and that is why Spector et al (2014) and Dohn et al (2020) advocate for the scalability of different approaches and designs.

Figure 2.3: The cartoon drawing (designed during the scenario setting in order to more accurately design the experiment) focuses on the level of realism required to ensure a transfer of knowledge to refugees in order to facilitate their access to the NHS through four specific levels (the receptionist/entry point, the GP, hospital in-patients and out patients) - Cartoon by Lance Bell

2.4 Interactivity

Instructional and interactive media are effective in the enhancement of knowledge construction and transfer because of their ability to replicate and repeat key concepts. They have

the ability to portray settings, characters and actions in a way that captures the attention of the user, while at the same time simplifying contextual complexities and challenges [21]. They create more satisfaction (an unforgettable experience) and enable users to understand, retain and where necessary more ably replicate the knowledge gained. This is in part because they are more engaging and can help users to better contextualise the knowledge gained. It also simplifies learning complex skills because it represents the problems and complex set of challenges in ways that can be more easily understood. This position is supported by Herron, et al (1995) [49] , Shyu (2000) [107] and Simpson, et al (2004) [109] who postulate that learners are more appreciative of video-based instruction.

2.5 The Role of Familiarity in Knowledge Transfer

Optimal transfer of knowledge in a virtual setting can be achieved if individuals have the appropriate skills and competencies, especially in cases where the requisite transfer of knowledge cannot be specified beforehand, or the knowledge is emergent, or if it transcends from implicit (experience-based) to explicit (codified) knowledge [131]. Individual competencies help to navigate challenges and surmount obstacles related to knowledge impartation, especially when faced with new or unfamiliar circumstances. They also help to clarify communication, which is vital to the success of VR navigation [131].

2.6 The Link between Knowledge Transfer and Knowledge Retention

Knowledge Transfer and memory are linked because the existence of a memory is predicated on the existence of knowledge. Memory is structured knowledge that grows with time. It is also a retention of an experience created through "internal neuronal representations," over a period of time and results in behaviour change [94]. It heavily depends on information that is "encoded in the neuronal substrate" but enunciated in the form of tweaking behavioural patterns. Indeed because memory is expressed in the form of thought

or behavioural patterns, it does not exist until it is retrieved [94]. Thus, as discussed in Chapter 1 of this study, when a person goes through an experience, it is initially encoded in order to facilitate its retrieval later. Once it is retrieved, it is encoded again (consolidation and reconsolidation). This entire process generally results in an adaptive change which signifies that a transfer of knowledge has taken place.

2.7 Knowledge Transfer as a Function of Experience

Based on the discussion in Chapter 1 and in subsection 2.4, the centrality of experience (satisfaction) to knowledge transfer and retention is key. Experience occurs at the initial task performance stage and at every time that the memory is retrieved (consolidation and reconsolidation). Once a memory has been retrieved there is a high likelihood that it will not remain the same. Changes take place from the initial experience (X), which undergoes coding, to when that coded memory (X) is retrieved as X^*. Once X^* is retrieved, it goes through a second experience of re-consolidation and emerges as X^{**}.

Souza et al. (2020) highlight the potential for "remote VR" for knowledge transfer and retention particularly in cases where there was no previous knowledge on the topic. They investigated knowledge transfer in group-based learning for neuroanatomy students, using serious games focusing specifically on knowledge transferred by use of physical and virtual models of the human brain. They found significant differences in the knowledge transferred and retained for the virtual brain model, highlighting the importance of immersive VR as preferred by users. It also improved performance, when compared to traditional learning methods. They also point to the effect of collaborative learning on knowledge retention [115]. Based on the findings of Murcia et al (2018) however, there is no resounding consensus on the superiority of VR over physical training for knowledge transfer, although one of the stated weaknesses of their study was that there was no interaction in the virtual environment [85]. One of their other findings was that knowledge retention was low due to the complexity of the task, which perhaps supports Souza et al (2020) assertion that the "nature of task, the virtual environment and VR system setup" can affect outcomes [115].

Palanica et al.(2019) studied the use of VR in helping patients to understand treatment

information by use of VR technology designed to help facilitate this knowledge transfer between physicians and patients and found that because the experience was engaging, it helped patients to learn about complicated medical information in part because it allowed them to interact with representations of their own anatomy and procedural findings, rather than being passively told about their operation. Importantly, this experience helped patients visualise and better understand their disease [88].

The Alfalah et al. (2019) study on the use of VR as a medical training tool to improve the quality of medical skills of medical students, specifically on heart anatomy also supported this view. Their focus was on a comparative study between traditional medical teaching modalities and VR technology, and they found that VR enhanced experiences and improved the medical students' understanding of heart anatomy. According to the study, there was a higher satisfaction rate for VR in relation to structure and visualisation [3].

2.8 Refugees Integration and the Knowledge Gap

Loss of social capital and other forms of resources during migration is a major destabilising factor for migrants because of the importance of resources to integration [41].

According to the UK Home Office integration happens "when refugees are empowered to achieve their full potential as members of British society, to contribute to the community and to become fully able to exercise the rights and responsibilities that they share with other residents" [48]. Yet, many refugees when they arrive in the UK and other resettlement countries, are oblivious of their host country's culture. This can affect their ability to "achieve their full potential" in their new country, curtail social and economic integration, and can result in the formation of immigrant enclaves divorced from the overall social-economic construct of the host country including labour markets [19].

Isolation and the lack of social networks can negatively impact the mental health and well-being of refugees. It can also negatively impact their ability to integrate smoothly into new environments especially as social capital is critical to the acquisition of other

forms of capital and to integration in general. Myth-busting (*see Figure 2.4*) and equipping migrants with knowledge on how to navigate the system, therefore, is a building block to integration.

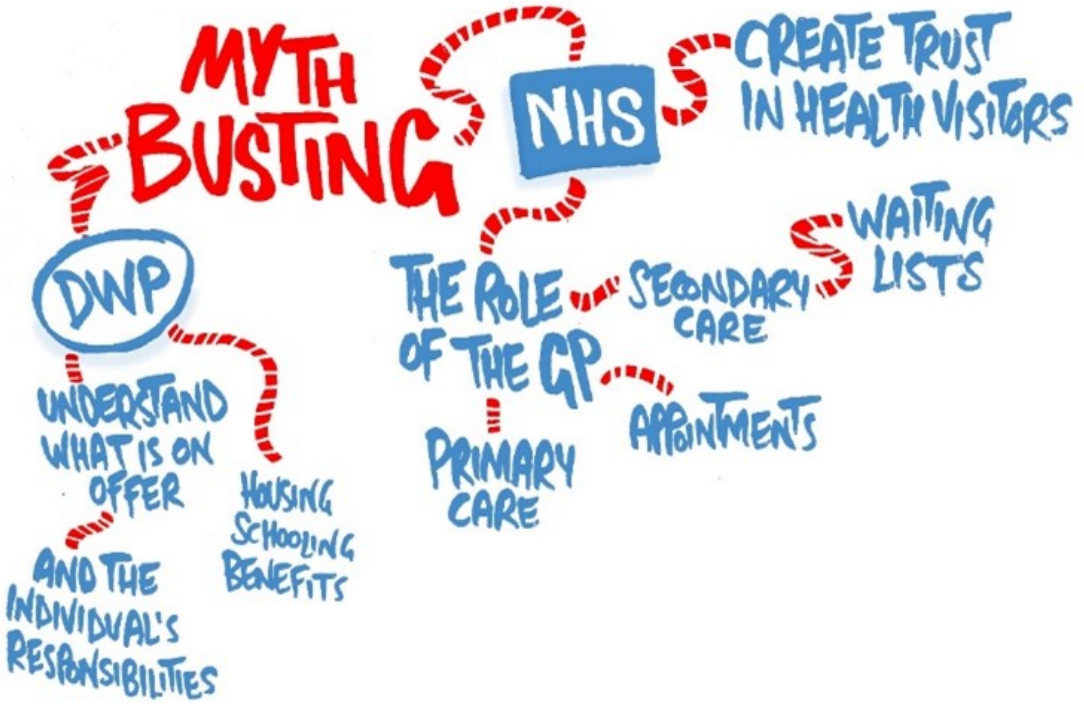


Figure 2.4: Myth-Busting is an important element of Knowledge Transfer among refugees. Myths linked to past experiences, cultural norms and fear of the unknown among other things, sometimes affect refugees' ability to fully access services such as the NHS - Cartoon by Lance Bell

2.9 The Value of this Research

The work presented in this study here posits that the use of VR, can positively impact the well-being of refugees [114] by among other things, myth-busting (*see Figure 2.4*), helping them to gain a better understanding of their new society and supplanting the challenges imposed on them by language limitations and the feeling of powerlessness when faced with obstacles such as navigating the NHS.

Figure 2.5: Virtual Images of the Glebe Road Surgery created through photogrammetry and laser scanning

2.10 VR and Memory Retention

VR's ability to simulate the complexity of real-world environments makes it usable in neuropsychological assessments [83]. This means that human performance within a virtual environment can be investigated because of the interconnectedness amongst emotions, cognition, learning, and behaviour.

In keeping with this argument, Pimentel et al (1993) [91], focus on the immersive VR interactive experience, in which the actual technology is completely forgotten, and the person becomes "the ghost in the machine" allowing VR to give the user a "sensory-rich interactive experience", which impacts their uptake of information [91]. Sauzéon et al. (2012) [102] also argues that being able to navigate in VR has an effect on memory and ensures better memory retrieval as discussed in Chapter 1 and previously in this Chapter. Memory depends heavily on information that is "encoded in the neuronal substrate" but articulated in the form of behavioural patterns and so it does not exist until it is retrieved. This is what makes the medium of knowledge transfer all the more important because it is essential to encoding and the experience attained from it will alter knowledge [94].

2.11 Motivation behind this Research

Migration and population mobility in Europe have increased the need for information dissemination and transfer of knowledge to new migrants to help them navigate socio-economic systems(Braun 2013) [10] and thereby more easily integrate into their new host environment. Elements of Europe's socio-economic systems are novel to most migrants. As such, they have limited knowledge on how to navigate them. One of the harder challenges is access to the healthcare systems of such countries (Kang 2019) [56].

Figure 2.6: Migrants on the move - Photo by Roger Arnold (UNHCR)

Traditionally, a common way of enhancing their knowledge is through descriptive text and image depictions, for example via specific websites. However, it is not yet clear how best to provide the refugees with the information they both need, and that is fully actionable.

This research is focused on how to transfer knowledge to migrants destined to the UK. It investigated alternative means, around digital media, particularly VR, that can be used to transfer knowledge to refugees, and ascertain which one was best suited to enhance knowledge understanding and retention before they travel to the UK.

A key goal of the research presented was to explore the efficacy of VR technology in

the transfer to, and retention of knowledge by refugees based on the hypothesis that VR is the most efficient and effective means of knowledge transfer/acquisition because of its unique ability to aid more effective storage of information gained from experiences.

It is based on the same understanding as Achuthan (2017) who held that interactive and collaborative forms of knowledge transfer are more effective in inducing changes in knowledge application [1].

2.12 Ethical Approval

This study was approved by the Biomedical and Scientific Research Ethics Committee (BSREC) of the University of Warwick on 08 January 2019 under ethical approval number REGO-2018-2308.

2.13 Contributions to Knowledge

There were a number of key lessons learned on the efficacy of VEs in knowledge transfer, mostly from the experimental findings on the effect of a number of mediating factors on knowledge transfer.

2.13.1 The Experimental Design

The use of the three media as outlined above was novel and it suggests a new research approach to relatively novel phenomena (knowledge transfer amongst refugees). As discussed in this thesis, descriptive text is the most commonly used method of knowledge transfer to refugees while the use of 360°video and images has only recently been introduced for purposes of knowledge transfer but is not widely used. The third element, VEs would be new.

This study has also introduced a more malleable but advanced method for knowledge transfer amongst refugees with a high-quality interactive and immersive system. It has also provided forms of measurement for knowledge transfer and memory. Although issues around memory formulation and consolidation were not necessarily a subject of this research, the experimental studies conducted clearly demonstrated the possibility of enhancing memory consolidation.

2.13.2 The Impact of Fidelity, Sense of Presence and Experience on Knowledge Transfer

There are important predispositions laid out by this study demonstrating the impact of a medium on experience which is in turn impacted significantly by the level of realism and the sense of presence. The study also provided important insights on usability. The correlation between experience, presence, knowledge attained and the ability to form an accurate memory (knowledge retention) was established. All these pointed to the superiority of high-quality VEs.

It is self-evident that the success of Virtual Reality experiences in terms of learning and knowledge transfer to a great extent depends on its illusory appeal. This is supported by Marlyn Kemper Littman (1996) who suggested the importance of virtual reality was founded on believability in order to stimulate "productivity and creativity" [71].

2.13.3 Usability of a medium and its impact on Knowledge Transfer and Retention

Although participants found the VEs not highly user friendly for instance, it did not affect the knowledge gained. One important lesson learned during the pilot study however was that usability only played a key role if it was linked to design features, the easiness of

navigation and fidelity or the ability of the user to relate to the medium.

2.13.4 The Import of Fidelity

The significant difference in the performance of VEV and VEVP can be surmised as the importance of fidelity or level of realism and its effect on the level of engagement. The effect of fidelity and interaction can also be seen in how 360VP outperformed 360V and 360 and VED on some occasions. This in turn affected the development of spatial and interface knowledge, which in our estimation, affected the attainment and retention of knowledge.

It was also evident that the effect of the visual fidelity of an experience on the transfer, retention and replication of knowledge was directly related to whether the task at hand required value or orientation judgment to recall the task and because for the most part the tasks presented required orientation judgment, it was surmised that interaction and level of realism were key to performing the orientation judgment and to thus more accurately recall the task.

2.13.5 The Power of VEs in Knowledge Transfer Amongst Refugees

All the 122 refugees that took part in the study knew nothing about the subject matter (the UK NHS). However, those that used VR were able to achieve a significantly higher mean score when compared to the others. They also suffered lesser knowledge loss when compared to those that used other media. The mean scores for the three media demonstrated the efficacy of VEs (see table 2.1).

On the flip side it meant that for refugees to better comprehend the descriptive text, and to appropriately apply that knowledge, they would have needed to have had a previous experience with the subject matter and thus prior knowledge of the NHS or the Glebe Road

Table 2.1: Mean scores for the three media demonstrating efficacy of VEs

Assessment Test	**Text (μ)**	**Text (σ)**	**360°Images (μ)**	**360°Images (σ)**	**VEs (μ)**	**VEs (σ)**
Test1	43.84	6.002	42.70	7.916	57.97	8.542
Test2	30.26	4.318	37.70	8.970	54.45	7.945
Test3	12.32	1.701	22.19	6.956	46.36	8.799

Surgery. This would have helped them to formulate mental models of what they were being asked to internalise. The same applies to the 360°images, where additional images would have been required to provide a more wholesome story, and potentially fill "information gaps". The general lack of prior knowledge meant that participants who were exposed to the text and 360°images, possessed a poorer internal source of information which then made mental model construction from the information provided, relatively more difficult. On the other hand, the VE offered alternative routes for mental model construction. In particular, it did this through its interactive-ness and its ability to allow participants to revisit scenes and thus allow for memory consolidation.

2.14 Publications

A related study was submitted to and accepted for printing by the Virtual Reality Journal (DOI - 10.1007/s10055-022-00659-x). The journal paper shows important tendencies that knowledge transfer, experience, usability and presence were strongly impacted by the type of medium used and the level of realism presented.

It also showed that on average, VR outperformed all the other selected media of knowledge transfer most likely due to its immersive tendencies, its ability to induce the illusion of presence, as well as its inherent capabilities to enhance interaction and engagement.

The 360°environment came second and the text variation, third. The significant difference in the performance of VEV and VEVP was surmised as the import of fidelity and its effect on the level of engagement. The effect of fidelity and interaction was also

seen in how 360VP consistently outperformed 360V and 360 and VED on some occasions. Overall, it was argued that a lower level of engagement and the "interactive-ness" of the text and 360°images may have had the biggest impact on their relatively lower scores on memory processing.

The work revealed that the use of virtual experiences offers the potential as an important knowledge acquisition tool for refugee integration. The obtained results indicated clearly that the VR could be used as a powerful knowledge transfer tool because of its superior ability to elicit the formation of a memory.

2.15 Novelty of this work

The current research stands out as novel, because of its focus on the specific use of VR as an effective tool for integrating refugees and asylum seekers into third countries. Very little attention in terms of research or policy decisions, is focused on exploring the circumstances in which refugee integration occurs, experiences that influence refugee arrival and settlement in new countries and how those experiences cause psychosocial stress which could ultimately impact upon refugees' pathways towards, or away from, integration. Indeed, because of their unique circumstances, refugees are negatively affected by upheaval, a general lack of support, pressure to adapt too quickly or an inability to follow the desired strategy which can all result in integration stress, and even mental illness [41].

They also suffer a significant loss before, during and after migration, including loss of social capital, family connections, livelihoods, homes, possessions, and other resources, all of which are a major destabilising factor because of their importance to integration [41]. They are unique in their isolation and the lack of social networks, both of which can negatively impact their mental health and well-being. They are also unable to build relationships with people for a variety of reasons including the lack of employment opportunities, lack of secure housing, Post Traumatic Stress Disorders (PTSD), lack of access to services such as healthcare and a sheer lack of understanding of how the service sector works [41].

In many cases, they lack choice or agency, which makes them vulnerable to psychosocial stress and integration challenges and obstacles. PTSD is particularly exhibited by a large proportion of refugees and asylum seekers, largely because of their having experienced traumatic situations [89]. This high risk of PTSD is because of direct exposure to often malicious violence, associated loss events as highlighted above, and an 'existential dilemma' caused in part by their core beliefs being seriously challenged [127]. Gorst (1998) highlights the significance of the relationship between social factors in third countries (such as access to services), and the severity of both PTSD and depression [43].

The UK Home Office posits that integration is significantly helped by empowering refugees to become fully able to exercise their rights and responsibilities [48] and knowledge acquisition central to empowerment and integration [104].

VR can be central to empowerment through knowledge transfer because it can naturally permit users to experience real-world environments, with their complexities, within virtual worlds where they can perform real-world activities in a safe, controlled and repeatable manner [57]. Presenting information in an interactive manner can result in a more fulsome and efficient use of memory [87].

VR can draw users into habitation of virtual situations that leads to deeper than usual engagement and enhances their ability to remember and therefore replicate the knowledge attained. It offers a unique way to expose individuals to controlled social environments [128] and involve them in a level of interaction conducive to learning and exchange of knowledge. Indeed because it thrives on transitioning between thresholds of what is familiar and what is strange [25], if well applied, it can help refugees transition from what was, to what is, without even being "there".

2.16 Summary

In this chapter, we outline the linkages between immersion and presence and how the two influenced the research design. We introduce the concept of knowledge transfer, linking it with memory and fidelity (as highlighted in figure 2.3 which was used to set the scenario), and also discuss the importance or lack thereof (as highlighted by John et al [55]), of fidelity in achieving a knowledge transfer. We also discuss the different approaches to knowledge transfer (highlighting five different approaches - the behaviourist, cognitive, participationist, situated cognition and the developmental practices approaches) and the centrality of interactivity which although not fully exploited, was key to the design of experiments. Also highlighted, are reasons why it was important that the impact of familiarity be minimised because of how it would have biased the results of the experiment. By so doing, we showed why it was important that the refugees who were the center of our study, have no prior knowledge of the NHS and its processes or the specific surgery that was to create the environment upon which the experiment was based. We also discuss the importance of the participants' "experience" to knowledge transfer, a term we interchangeably use with satisfaction throughout the thesis. We also briefly show the process of knowledge transfer and how a memory is formed, consolidated and reconsolidated and how VR could impact the formation of a memory. Having discussed the central elements of the media of knowledge transfer, we turn our attention to the phenomenon of forced displacement and its impact on refugees in particular. Why also discuss why they are different from other population cohorts, highlighting the importance of aligning perceptions to reality, or myth-busting (see figure 2.4). Finally, highlight the fact that the research is backed by ethical approval from the University of Warwick BSREC, and also discuss the motivation behind, and value of the research. We outline the research's contribution to knowledge, its novelty and publications.

Chapter 3

Research Methodology

Goodard (2004) defines research as the process of "answering unanswered questions" or creating that which does not currently exist or creation of knowledge [40]. Singh (2008) adds dependability to the definition by defining research as a quest to answer yet unanswered questions or a process of attaining a reliable solution to a challenge through "planned and systematic" data collection analysis and interpretation [110].

This chapter outlines the research process, the scope, the design of the experiment, materials, measurements, and the analysis process.

3.1 The Scope of Investigation

Several studies, already highlighted in chapters 1 and 2, have been carried out to demonstrate the efficacy of virtual reality systems in transferring knowledge. They include Wallet et al. (2008) for instance investigated the impact of passive and active exploration mode on quality of transfer in three different spatial recall tasks and found that VE induced better performances than the passive conditions in complex exercises for two out of three of the tasks [130]. Makransky (2021), investigated the effect of immersive virtual reality (IVR) in education and training and highlighted the importance of using learning theories. Their research was based on the Cognitive Affective Model of Immersive Learning (CAMIL) and

focused on six affective and cognitive factors (interest, motivation, self-efficacy, embodiment, cognitive load, and self-regulation) that can lead to IVR-based learning outcomes [77]. Alfalah (2019) [3], compared traditional medical teaching modalities to virtual reality technology and found that superior outcomes for the latter, including higher satisfaction among users in the system particularly on "structure and visualisation". Palanica (2019) denoted the usefulness of the knowledge transferred through VR in providing patients, including child patients, with a better understanding of their medical conditions as it empowers them to become more active in sustaining their own health while also giving medical practitioners the tools to better care for individuals [88]. Fetaji (2020), found that merging immersive 3D VR and AR improved students' ability to understand and significantly increased the knowledge transfer among students [34].

None of the studies, however, covers the use of virtual reality in helping refugees integrate in third countries. Exploring the potential of virtual reality for this purpose is particularly important in the face of increased migration and the resulting need to enhance the socio-economic inclusion of refugees in their new host countries. Elements of Europe's socio-economic systems are novel to many of the refugees, and they have limited knowledge of how to navigate them. One of the challenges they face is access to the healthcare systems of European countries [56].

Traditionally, passing on information to refugees to help them integrate has been through descriptive text and image depictions, for example via specific websites. More recently, the UNHCR and several European governments are using 360°images as well as 2D mixed reality to provide refugees with specific information on how to access goods and services. However, it is not yet clear how best to provide refugees with the information they need and ensure that they can act upon it.

Accordingly, this work investigates how digital media, particularly VR, can be used to transfer knowledge to refugees. By evaluating and comparing individuals' experiences with the three different forms of media (descriptive texts, 360°images and Virtual Reality),

and their subsequent ability to remember the information provided, the study attempts to ascertain which method of knowledge transfer is best to ensure that refugees understand the information given to them.

3.2 Research Aims

The research aimed at ascertaining whether VR, compared to other media, was the most efficacious in attaining knowledge transfer, and retention. The basic premise of this objective was that "new" knowledge can elicit a change in perceptions, cognition, beliefs, and attitudes. It can also trigger a change in performance and decision-making, particularly among refugees, given their new realities when they settle in "third countries".

Accordingly, the study set out to do the following:

1. Identify and examine the most commonly used media for knowledge transfer particularly among refugees (as previously stated three media types were selected).
2. Develop a knowledge transfer experimental model.
3. Identify the target population and their perspective on the model to be used.
4. Identify the relations between the media and knowledge transfer and retention.
5. Identify the effect of the level of realism, and engagement and their correlation to knowledge transfer and retention.

To achieve these research aims, the following research questions were formulated to define the scope of investigation for this research.

3.2.1 Key Research Questions

To establish the relationship between the three selected media and knowledge transfer-retention, the following questions guided the research:

1. Whether the benefit from a VE is linked to the level of realism or whether there are other important factors that determine the level of effect of a given VE.

2. Whether the benefit derived from experiencing a VE defers in the main, from the benefit derived from conventional media of knowledge transfer and retention.

3. To what extent are the knowledge and skills gained after exposure to three selected media transferable to real-world experiences, outside of the time confines of the exposure.

4. Whether there is a correlation between engagement and aftermath-performance; and whether that relationship is congruent or whether it leans toward one or two of the independent variables.

5. How can we distinguish between familiarity and actual new knowledge attained?

3.3 User Evaluation

The key requirement for the study was to create a level of realism that would trigger engagement and enhance interactivity. The goal was to ensure that participants would find similarities between what they were seeing in the virtual world and the 360°video and images on the one hand, and the real world on the other. There was a recognition that in order to appropriately design the experiment, a form of user evaluation would have to be injected into the process. As such, addressing issues related to the robustness of the system, how the transfer process would be triggered and assisted to its logical conclusion, testing the LoR and in many respects comparing the experiment with the real world. This led us to define outcomes around the following key questions:

1. Does the system's design comport with the skills set of the target population?

2. Is the system well designed to trigger knowledge transfer and to as smoothly as possible aid the knowledge transfer process?

3. How can the system be designed to enhance the experience and level of satisfaction of users?

4. How can the illusion, interactivity, and engagement be enhanced (these terms are used interchangeably even though one does not necessarily equal the other)?

These and other factors were identified as enhancing the appropriateness of the system for the study. These factors are further addressed in Chapters 4 and 5 of this study.

3.4 Knowledge Transfer and the Level of Realism

As discussed at length in Chapters 1 and 2, a high level of realism is essential to ensuring the suspension of disbelief and engaging with a Virtual Reality system, taking advantage of its immersive tendencies. Chalmers, et al (2007) however argue that while the concept of "There-reality" (environments that evoke the same perceptual response from a viewer as if they were actually present, or there) is appealing and even attainable, its requirements pose a major impediment. They however posited that the interactive nature of the virtual environments could make up for the lower levels of realism [16]. Therefore, although achieving the highest possible LoR was seen as essential, it was deemed necessary to also aim at achieving the best possible levels of interaction in order to inject in the system repeat measures that would enable users to encode memory (see Section 2.2), consolidate it and re-consolidate within the experiment in order to enhance knowledge retention. As such, simplified research questions were designed along the following lines:

1. How would participants be affected by changes in the level of realism?

2. What level of detail would be required to ensure that there was enough LoR to match a real-world experience?

Some of these issues are addressed in Chapters 4 and 5 of this study where a comparison between different levels of realism in the pilot and second experiment is outlined.

3.5 Selective Rendering

As previously discussed, an important factor going into this research was an attempt to appropriately respond to questions of Realism since the entire process was about computing images for refugees to look at and appreciate. Rendering high-fidelity images in reasonable or real-time is highly challenging given the complexity of modelling a real scene. However, understanding the human visual system makes it possible to render images selectively (selective rendering) to capture the human visual attention which moves rapidly between fixation points in the scene [75].

It makes it possible to overcome issues related to LoR because of humans' visual selective attention. Understanding human perceptions (what they see and do not see) is therefore central to enabling us to both target areas of high perceptual importance while maintaining the perceptual quality of the subsequent image [15]. Using these methods has the real possibility of attaining high fidelity graphics at real-time interactive rates. They would make it possible to concentrate user on areas of high perceptual importance while ignoring details that would not be perceived by the user and at the same time achieving more real-time interactive rates, particularly because virtual reality environments are mostly about perceptual responses of users being the same as responses in a real-world environment.

Selective rendering is applied in three ways: adaptive techniques, incremental techniques, and component-based approaches [16]. Adaptive techniques focus on areas of the image that are deemed most important based on identified criteria, while incremental techniques, gradually improve the image until a specific condition is satisfied. Component-based techniques on the other hand "allow the system to control rendering at the component level" [15]. The three techniques require conditions on the rendering quality to have been set prior to, or during the computation of the images of frames [27].

3.6 Sense of Presence, Immersion and the Importance of Experience

Based on the conclusion by the Chalmers et al (2007) and other studies in the area of LoR and related challenges, it was determined that attaining a level of immersion that would enhance participants satisfaction (experience) with the system was essential. Indeed Chalmers et al (2007) proposed enhancing interactivity. There is however a strong correlation between immersion and the sense of presence (Mestre, 2006) [82] although some argue that the correlation is over exaggerated because these concepts depend on the characteristics of users as determined by Krijn et al (2004) [60] and Bullinger and Riva (2005) [13].

Our study, therefore, did not deem the relationship between these concepts as linear but nonetheless determined that they were essential to enhancing the experience of the participants and hence defined the following key questions:

1. What would be the key tenets of user satisfaction in relation to a VR system?

2. How would different levels of immersion affect knowledge transfer?

3. What would be the key tenets of an immersive VE and what would make such an experience fully, semi or non-immersive?

We delve into these concepts further in chapters 4 and 5, as well as Chapter 7 of this study.

3.7 Participants

The selection of participants for the pilot and second experiment at outlined in Chapters 4 and 5. This is because the selection and outreach to participants were different in the two experiments. Also, the number of participants in the two experiments was different (N =

37 for the pilot and N = 122 for the second experiment). Furthermore, there were a few differences in the characteristics of the participants in the two experiments.

3.8 Method

Broadly, the study investigated the use of three different media of knowledge transfer, with the aim of ascertaining which one of the media could best assist participants to apply the knowledge that they had attained.

Guided experiments and questionnaires were utilised and conducted. Further details on the methods used are contained in Chapters 4, 5 and 6.

3.9 Research Design

Underlying the research design was the need to arrive at which one of the three media of knowledge transfer was best suited to enable the transfer of knowledge and retention. Details of the research are outlined in Chapters 4 (Pilot Study), 5 (Second Experiment), and 6 (Longitudinal Study). Several observations were used to assess sequence effects for the knowledge assessment (Test 1). The study also compared the different validated self-reports on Presence, Experience and Usability. Responses were simultaneously collated thus reducing the sequential effects.

Based on the lessons attained from the pilot experiment, the researchers used the Between Groups Design in addition to the Repeated Measures Design to compare the effect of and redesign the media both within the groups and between the different groups, in relation to the five dependent variables (Experience, Presence, Test1, Test2 and Usability and later, Test3).

3.10 Defining Dependent and Independent Variables

This research was intended to evaluate the efficacy of three media of knowledge transfer in fostering knowledge transfer and retention. Incidental to this outcome were other factors such as the sense of presence, immersive tendencies, the level of realism and ultimately the experience of participants (satisfaction derived from experiencing the three identified media of knowledge transfer).

The level of knowledge transferred would be measured through an assessment test (or assessment tests). In addition, questionnaires were given to participants to measure the other factors (experience, sense of presence, and usability of each of the three media). The data derived from these measurements was quantitatively statistically analysed as detailed in Chapters 5 and 6. More details on the delineation of variables can be found in chapters 5 and 6.

3.11 Determining the Assessment Method

One of the major reasons for assessment is to be able to report on the knowledge transferred/gained and retained. There are different kinds of assessments, and some are opposed to each other but what unites them is the end objective of ascertaining whether knowledge was gained. Indeed, according to Harlen (2008), the overarching criteria for selecting a method should be the impact on learning. In this research, we attempted to test participants' cognition rather than just their knowledge gained on simple factual elements of the study [47]. Assessment is important to ascertain that knowledge has been gained and that it can be recalled and reused appropriately [17].

Leung (2008) highlighted a number of assessment methods. They include **work sampling**, which collects data on observed behaviour during the performance of a task by using multiple observers and occasions. **Checklists** also capture observed behaviour while **peer to peer assessments** focus on habits, teamwork, and interpersonal sensitivities. The **Logbook** method focuses on the experience of the learner while skill-based assessments

"measure the knowledge, skills, and judgment required for competency in a given domain". The objective of **competence testing** is to ensure *bonafide* qualifications to practice in a specific domain. **Multi-Choice Questions (MCQs)**, **essays**, and **oral examinations** focus on factual recall and applied knowledge, while **structured tests** measure outcomes. Other assessment methods include the **oral testing or the viva** where the overall behaviour of the learner is examined [67], the in-**depth interview**, and **focus group discussions**. This list is by no means exhaustive. Chen (2005) also named other assessment methods including **pop quizzes**, **recitals**, and **competitions** [17].

In selecting the form of assessment to use, we focused primarily on what we wanted to measure, the cost of the assessment (both in terms of resources and time) and the validity of the results as a true reflection of the knowledge transferred and retained and the need to provide valid, usable, reliable and generalisable data. We also took note of the need to avoid interviewer bias. Furthermore, we considered the existing knowledge base of the participants, future needs, and priority areas that needed to be addressed. We also felt that a standardised approach would facilitate data analysis and be more useful for future research. We wanted to avoid challenges such as participants feeling frustrated due to failure to respond to certain questions, which would have posed analysis challenges.

Aware of the importance of using multiple assessment methods, we selected a mixture of open-ended and closed-ended questions and endeavoured to make the questionnaire as short as possible in order to mitigate the negative impact of long questionnaires on the quality of responses [18].

3.12 Developing the Experiment

3.12.1 The Virtual Environment and the 360°Video

The experiments was developed using Photogrammetry and high-quality 3D laser scanning for the VR (see figure 3.1), a 360°video camera (see figure 4.1)for the pilot experiment and a 360°SpheronLite camera (see figure 3.2) during the second experiment. Details of how the rendering was done are contained in Chapters 4 and 5.

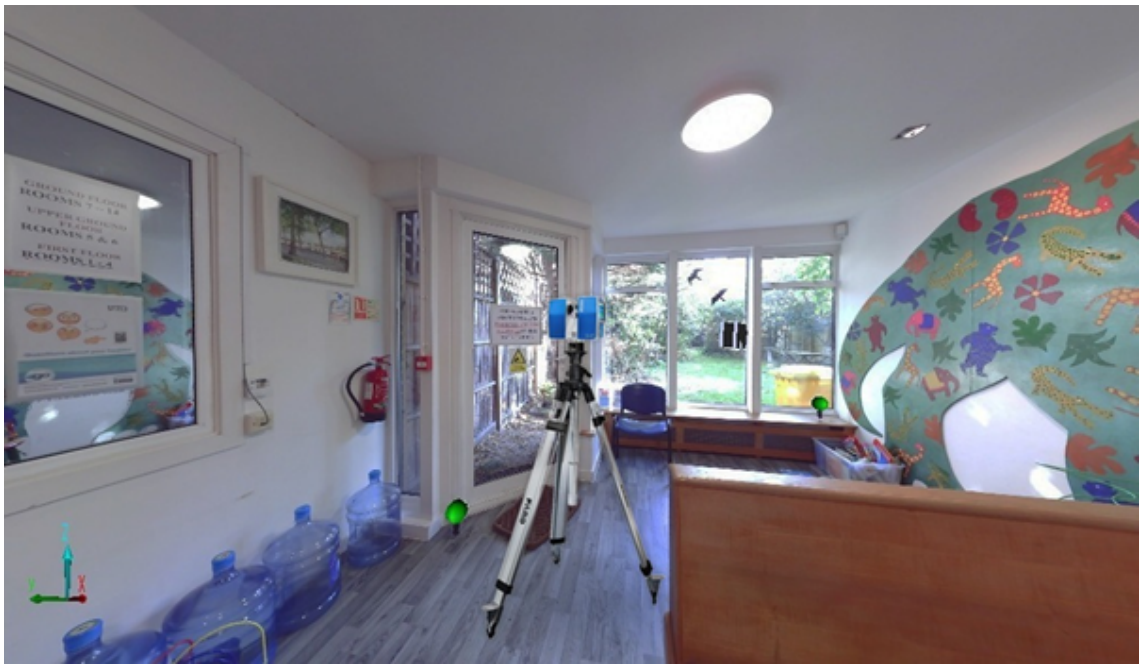


Figure 3.1: FARO Laser Scanner used for high quality laser scanning

3.12.2 The Descriptive Text

A text description of the surgery was developed on an A4-sized paper. The text method was selected because it is currently the most commonly used method to provide information to refugees.

3.13 Control Mechanisms

Three different media of knowledge transfer were identified for both the first and the second experiments. In the second experiment, however, the three media were varied into seven different types based on fidelity were used.

Further details on how the pilot, second and longitudinal study were conducted, the delineation of the dependent and independent variables, measurement of dependent variables, experimental procedures, and what was done for each of the experiments can be found in Chapters 4, 5 and 6.

Figure 3.2: Spheron 360 HD Camera

3.14 Hardware and System Architectures

The study aimed to deliver a high-quality interactive and immersive VEs in order to meet the overarching objectives of the study. In order to do so, there was a commensurate need for high-quality hardware to achieve the expected outcomes.

As such, two parallel systems (see figure 3.3) were built for 360°Video and Images, in a manner that would allow the study to fulfil the different research aims.

The pilot study required a system to obtain basic feedback on both the system design, information, and service quality, as well as the delivery. We determined that this information would be gleaned from participants' objective responses, our own observations, as well as the extent to which we determined that the objectives of the study were being met.

In order to deliver quality output, to participants during the first experiment, two 55" LCD monitors were provided for both the VE and the 360°Video. In addition, we also provided two PCs (Intel Q6600 2.4GhZ core 2 Quad processor and Nvidia Geforce 8800

GTX with 768 MB of RAM) to run both the VE and the 360°video. In addition, an HMD was provided for the VE (but not for the 360°video). This was rectified in the second experiment. More details about the hardware is contained in Chapters 4 and 5.

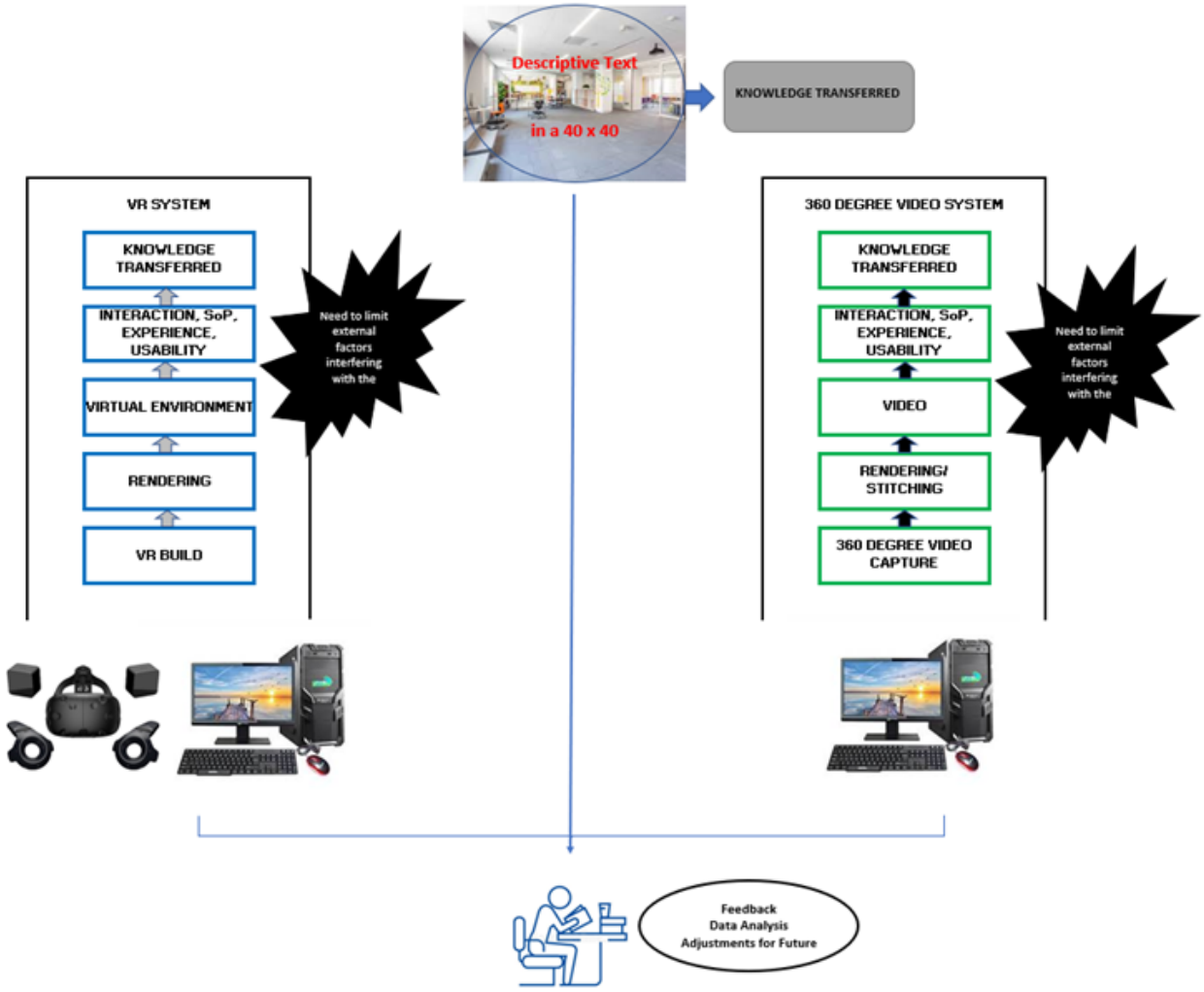


Figure 3.3: Hardware and System Architecture

3.15 Measurements of Knowledge Transfer

Measuring knowledge transfer is complex and methodological because knowledge transfer is often associated with multiple channels and stages as highlighted in Chapters 1 and 2 where we discussed the value of an experience in encoding, the effect of coding on memory retrieval, and the circular effects of consolidation and re-consolidation. All these processes have "complex interrelationships" as exemplified by figure 3.4 [46].

Several studies have attempted to find appropriate methods for measuring knowledge transfer. Halonen (2008) [46] discuss knowledge as a set of hierarchical concepts of data, information and knowledge, while acknowledging its ambiguous nature. They conducted a qualitative study on knowledge transferred in virtual learning environments and used a questionnaire to determine success in knowledge transfer. Their evaluation model however postulates that several factors such as the system design, the quality of information, quality of service delivery mechanisms and user satisfaction affect outcomes.

This research relied on the collection of empirical material and the use of questionnaires that were carefully addressed to the groups drawn along the lines of the dependent variables. The questionnaires included both closed questions and open questions. In particular, an assessment test was used to ascertain whether indeed participants had acquired new knowledge. As with the [46] evaluation model (see figure 3.4), assessments were linked to the system's design (presentation of the information, "Usability" of the medium, interaction and engagement as denoted by "Presence"), and systems delivery ("Experience") which affected the key outcomes as epitomised by the assessment results (Test1, Test2 and Test3).

Previous research has relied on a number of different types of measurement to assess knowledge transfer including assessment tests, communication between/among participants and observation of performative actions. Following this, this research used three tests (Test1, Test2 and Test3) to ascertain whether knowledge transfer had occurred [46].

3.16 Designing the Questionnaires

Questionnaires were used based on the understanding that they are among the most common research tools in virtual reality (VR) user studies [2] because they are able to gather participants' subjective experiences [5], but also because of they are ideal for predictive and analytical research, aimed at understanding correlations between variables [96].

The questionnaires used, were focused on the three basic criteria outlined in how the

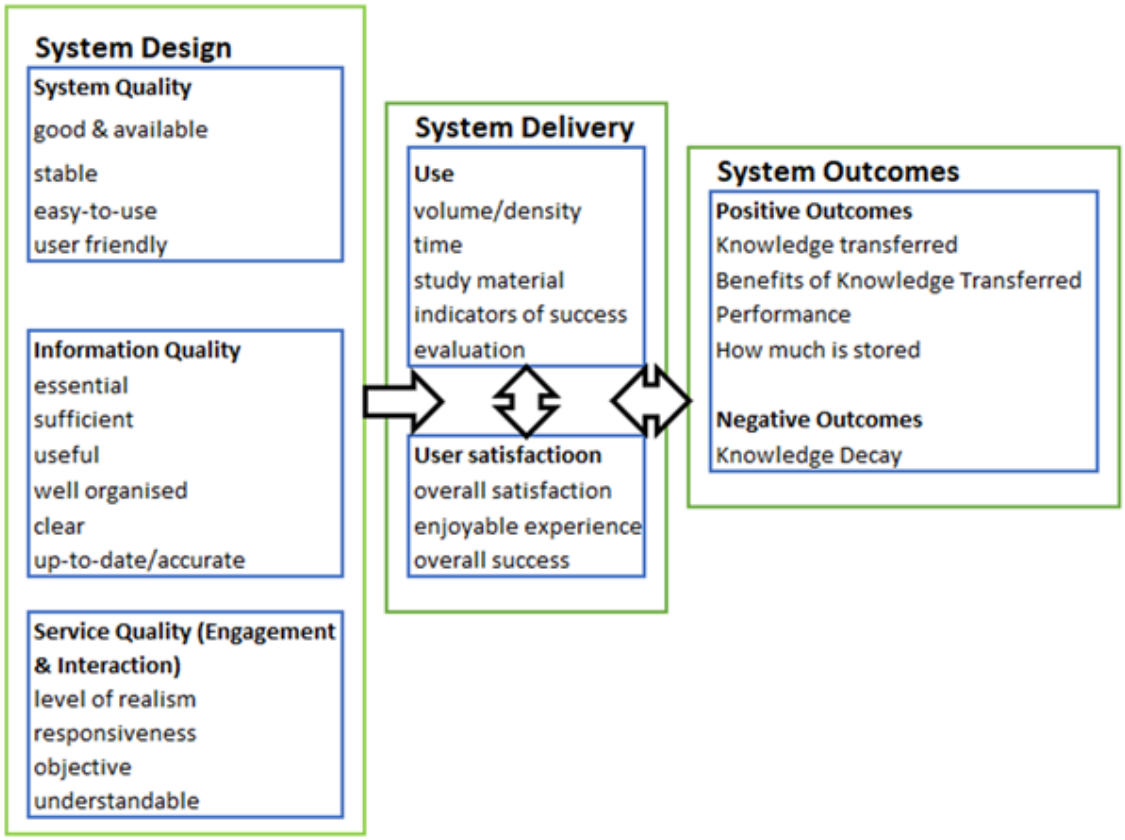


Figure 3.4: Knowledge Transfer Evaluation Model derived from Halonen and Thomander (2008) [46]

scenario was set (see figure 2.3). The scenario was focused on the initial access to the NHS (or GP surgery), the in-between process (waiting), and accessing the General Practitioner (GP).

The questionnaires included both structure (to allow for classification of responses) and unstructured questions (to allow participants to respond more freely) and were written on A4 pieces of paper and distributed to participants (respondents) in person. They were designed in such a manner as to help the investigator to analyse the data quantitatively, and to ascertain the frequency of occurrence of opinions, attitudes, and/or experiences.

The first part of the questions was used to establish whether the participants understood key facts about how to access the NHS or a surgery. The second part of the questions was geared towards establishing the participants' appreciation of the environment either as described in the descriptive text, or as depicted in the 360°video/images and the virtual environment. The third part of the questions was about accessing the GP. The three

elements outlined above were highlighted in the descriptive text and depicted in the 360°video/images and in the virtual environment.

The questions were written by the investigator and reviewed by visualisation and VR experts (Professors Alan Chalmers and Kurt Debattista), Professor Caroline Meyer an expert in clinical psychology, and NHS practitioners such as Professor Peter Bazira (Professor of Clinical Anatomy and Medical Education, Hull York Medical School), and General Practitioners in the NHS (Dr. Kate Barusya Mwesigwa, and Dr. Arthur Iga).

The questions on experience and sense of presence were derived from the Presence and the Immersive Tendencies Questionnaires [132], while the usability questions were derived from the Post-Scenario System Usability Questionnaire (PSSUQ) [68] and Lund's Usefulness, Satisfaction, and Ease of use Questionnaire (USEQ) [76].

3.17 Summary

In this chapter we have presented work related to the research methodology and how we intended to prove the research hypothesis. We began by defining the scope of our investigation as the juxtaposition of digital media (particularly VR), against other commonly used media types, such as the descriptive text, to transfer knowledge to refugees. The decision to identify the three media was based on three basic criteria. First, we selected VR based on the hypothesis that VR is the most efficient and effective means of knowledge transfer/acquisition among refugees. The second criterion was to select emergent media variations currently in use such as the 360°video and 360°images which have been used in several refugee-hosting countries in Europe and across the world for immersive story telling [38]. Third, we sought the most commonly used medium of knowledge transfer among refugees, which is the descriptive text. We deliberately left out the use of a website in part because it did not fit any of the three criteria highlighted above but also because adding a fourth element to the experimental design would have made the experiment far too complicated. We also surmised that websites depend on the availability of internet connectivity and sometimes a fairly sizeable bandwidth, which many refugees may not have access to. We however intend to explore the use of websites with a mixture of text

and hyperlinks to 2D or 3D videos and information useful to refugees, in further research so that we can compare three different technology-based scenarios.

The three selected media highlighted above were validated by Professor Alan Chalmers (Professor of Visualisation at the University of Warwick) Professor Kurt Debattista, and Professor Caroline Meyer (Pro-Vice-Chancellor Research at the University of Warwick).

In developing the experimental design, we sought to use a single UK Surgery as a microcosm of the UK National Health Service (NHS), focusing on three basic levels of entry. The first level of entry was the reception (determining what happens on arrival or on first contact with the NHS). The second level of entry was the waiting process and the third was accessing a General Practitioner. The scenarios in the three media were limited to the three highlighted above in part because of the complexity of both capturing and rendering high-resolution scenes of the 360°videos and images, as well as the virtual environment.

We then focused on how the three media, and in particular VR could be used to transfer knowledge and the vectors for evaluation we would use. Accordingly, we arrived at different conditions of measurement. They included the experience of the user with the media (or a measure of the satisfaction of the user), the feeling of being there (sense of presence or illusion of presence) and the ability to gain, retain and remember as measured through the same assessment test conducted three separate times (test1, test2 and test3). The key research questions were in the main centred on establishing whether there were significantly more benefits of using one of three media types over the other two, based again on the level of realism, the experience of the user, engagement, and knowledge attained and retained. The strategic outcomes were focused on first having a system that was designed well enough for participants to navigate it, and importantly ensuring that their experience or level of satisfaction facilitated the knowledge transfer and retention process.

Considering the complexity of attaining a sufficient level of realism to enhance the experience of the users, we planned to use selective rendering to make it possible for users to experience real-time interactivity. This was however set aside for future research because of the central tenet of using selective rendering which is understanding the visual perceptions of the participants. It would have required us to invest a lot more time in developing this level of understanding.

We also focused on the correlation between the concepts of "illusion of presence", "immersion" and the "experience of the user" with the media used on the one hand, and how to introduce these key concepts into the experimental design. Three key questions were defined. The first was about the key parameters of user satisfaction in the VR system to be designed. The second focused on determining how the illusion of presence and different levels of immersion would affect knowledge transfer. The third was centred on defining the essential elements of an immersive VE in order to more aptly design the system for the purposes of the experiment. Having discussed issues around systems design we then turned the focus to selecting participants. The basic criteria used in this selection were their level of education (criterion used in the first and second experiment, as well as the longitudinal study) and their status as refugees (criterion used in the second experiment, and the longitudinal study).

Having determined that the media types would be the independent variables, we defined the dependent variables based on factors that in our determination, were incidental to knowledge transfer and retention such as the sense of presence, immersive tendencies, the level of realism and the experience of the participants. We then discussed how the experiment was developed, including the identification of the hardware, and designing the system architecture in addition to establishing control mechanisms. The final part of this chapter was centred on how we went about developing measures of evaluating the knowledge transferred and retained. This involved the use of observation, and both closed and opened ended questions contained in four different sets of questionnaires (on

experience, usability, sense of presence and assessment of knowledge transferred and retained), which could be further developed in future research.

Chapter 4

Pilot Study

During the early stages of the research, it was determined that a preliminary study would be necessary to inform later studies. It was surmised that a pilot would help explore participants' experiences, help in resolving any design issues and highlight practical recommendations that could be used subsequently.

4.1 The Objectives of the Pilot Study

The aim of this study was to establish the suitability of Virtual Reality in knowledge transfer and whether virtual reality could aid retention of knowledge for potential users. The pilot study was designed to acquire a basic set of data from participants' responses during their exposure to VR and other media of knowledge transfer. It measured an array of dependent variables including participants' experiences, to what extent they felt engaged with the media and the information being delivered to them, and based on this, how well they could remember the information passed on to them. The measure of these variables was assessed through semi-structured questionnaires.

We determined that outside of a well-designed simulation, it was important to evaluate users to ascertain familiarity with the NHS, VR systems, and simulation sickness, to ensure that performance of the experiment was not negatively impacted. We thus formulated the following questions:

1. How well does the VR simulation in particular fit the needs of the users?

2. How well are the users able to navigate the system, either based on familiarity or on quick learning?

3. How familiar are the users with the inner working of the NHS?

4. How well are users able to navigate any one of the three selected media?

These considerations were intended to ascertain the usability of each of the three selected media.

4.2 Method

The experiment investigated the use of three different media of knowledge transfer, with the aim of ascertaining which one of the media could best assist participants to apply the knowledge that they had attained. Guided experiments and questionnaires were utilised and conducted on a group of 37 voluntary participants. The experiments were based on three media of knowledge transfer namely:

- Virtual Reality (VR)
- 360°video
- The use of text

4.3 Defining Dependant and Independent Variables

The purpose of this research was to ascertain whether VR, rather than any other medium, was the most efficacious in attaining knowledge transfer, and retention (to the extent possible minimising memory decay).

The media of knowledge transfer (text, 360°video and VE) were designated as the independent variables and were compared to eventual outcomes using quantitative analysis deployed variously to establish a baseline condition for comparison.

Dependent variables were linked to outcomes that would be determined through observatory, verbal and textual assessments. They were derived from individuals' responses,

linked to participants' "Experience", the "Usability" of the different media, measure of "Presence", and their ability to remember as measured through an assessment test ("Test1"). These were all measured by administering assessment questions. The measured data were reproduced to comparable variables for quantitative analysis.

4.4 Materials and Tasks

All participants were provided with information, video or a virtual environment relating to the subject matter under investigation for purposes of knowledge transfer. The information/data contained in all three components was identical for all participants.

Participants navigated the three sets of experimental material following a clearly defined set of directions.

The text component was administered using A4 pieces of paper on which a description of the Glebe Road Surgery was written.

Regarding the VE, a Head Mounted Display was used as a visual means to transfer knowledge/information to the brain. The HMD was connected to a CPU and monitor so that we were able to see the same virtual environment that the participants saw. The HMD was self-sufficient and was able to collect and display the input received from the CPU. The HMDs used (HTC Vive and HTC Vive Pro) had high display resolution and pixel density, and a stable tracking system.

The environment consisted of a 3D representation of a London-based Surgery (the Glebe Road Surgery - see figure 2.5 in chapter 2) created using commercial 3D modelling software (Maya 8.0) and Photogrammetry and Laser Scanning (using the FARO Laser Scanner - see figure 3.1). Photogrammetry and high-quality 3D laser scanning were used to obtain relevant information about the interior of the Glebe Road Surgery.

The laser scan point cloud and photographs were used to create the environment with millimeter accuracy. The images were used to create physical based render textures, to accurately recreate the environment and lighting conditions. The models were done in Autodesk Maya, and the Unity 2018.4 engine was used to create a VR build of the surgery using the SteamVR plugin. The build was tested and ran flawlessly on the HTC Vive and HTC Vive Pro headsets.

The 360°video was captured using a Samsung Gear 360 High Resolution VR Camera (see figure 4.1) with a video of 4096 $\times$ 2048 and 24 FPS. Further details about the VR build and the 360°video capture are provided in sections 4.5.2 and 4.5.3 respectively.

Figure 4.1: Samsung Gear 360 (2016)

4.5 Research Design

The overarching objective of the experiment was to ascertain which one of the three media of knowledge transfer was best suited to enable transfer of knowledge resulting in a behavioural change as outlined in the previous sections. To achieve this, a text representation, 360°images of the Glebe Road Surgery (London, United Kingdom) and a Virtual Environment of the same surgery (the Glebe Road Surgery) were developed. Participants were randomly divided into three groups (Group 0 - text, group 1 – 360°video or images, and group 2 – Virtual Environment). They were selected using simple randomisation as highlighted in section 4.9 on control mechanisms. Two separate sets of experiments (a pilot and a second experiment) were conducted within eight months of each other. During the pilot, the research leaned on both the Within Subjects Model (or Repeated Measures Design) to compare the effect of the independent variables (media types i.e. the descriptive text, the 360 video and Virtual Reality) on each participant. This was done to minimise error variance related to individual differences [92]. Participants were therefore allowed to participate in the three different experimental variations after they had done the assessment test to establish whether knowledge had been transferred. To eliminate any practice or sequence effects, the assessment test was administered immediately following participants' exposure to only one medium.

Several observations were used to assess sequence effects for the knowledge assessment (Test 1). The study also compared the different validated self-reports on Presence, Experience and Usability. Responses were simultaneously collated thus reducing the sequential effects.

4.6 The Choice of the Glebe Road Surgery and Content of the Environment

The environment rendered and described in the descriptive text was the reception area, the waiting area (including a children's play area) and the access to the GP's room at the Glebe Road Surgery. The material provided for each of the media types was fairly the same and there were no major overlaps or omissions. Nonetheless, there were some information in the text description that could not have been captured in the 360°or the Virtual Environments. A number of descriptions highlighted in the Text were not depicted in the 360°and the virtual environments. For instance, the Text used during the pilot experiment, contained a brief description of the loss suffered by refugees and the justification for knowledge transfer that would facilitate access to services in their countries of asylum or countries of resettlement. It also contained a brief discussion on the Focus Group Discussion of 28 March 2017 during which the problem statement was formulated. The Text also contained a description of access to the NHS which was not depicted in the 360°or the Virtual environments. These elements were however removed from the text description used in the main (second) experiment. That notwithstanding, in both the pilot and second experiments, there were descriptions made in the Text, which could have been subjectively perceived differently by participants. For instance, mentioning that the desk at the reception area "is quite big and can accommodate at least three reception staff during peak usage" could, to a subjective viewer, be interpreted differently because it does not mention the size of people in question or the actual size of area being described, which are both factual accounts of the environment. We also described the size of seats (7-seater, 12-seater, and another 7-seater) to the right of the reception area, directly in front of the reception area, and to the left the reception area respectively. There was also a description of "toilet facilities and facilities for nappy-changing, bottle-feeding and breast-feeding", contained in the Text, but not in the other two environments.

Aside from the other reasons advanced in this paper, a single surgery was ultimately

selected because of difficulties in getting permissions to access other surgeries in part due to the data protection and privacy issues that most of the surgeries felt might be violated if access was given. Several surgeries were approached for permissions to capture the environment or even just take measurements, but the requests were rejected. Moreover, we faced long waiting periods between initial contact with the surgery and eventual the responses, which were for the most part negative and delayed the commencement of the study. We were almost at the point of constructing an abstract surgery when the Glebe Road Surgery accepted our request. Several trips were made to the London based surgery to capture the images using various equipment such as the 360°camera (to capture a video of the interior of the surgery), the 360°SpheronLite camera (see figure 3.2), the FARO laser scanner (see 3.1, and in some cases mobile phones to capture details that we were not sure had been well captured by the equipment used. Although we wanted to access more than one surgery, another reason why we settled on just the one was because surgeries are the gatekeepers for access to specialised health care in the UK. Having observed a number of surgeries including the University of Warwick Health Centre, the Abbey Medical Centre in Kenilworth, the Waterside Medical Centre (Leamington Spa), the Sherbourne Medical Centre (Leamington Spa) and the Glebe Road Surgery in London, we determined that the key common features for each of those surgeries were the reception area, the waiting area and access to the GP's room. Each of the surgeries also had a visible record keeping area and details such as posters and information boards which we attempted to capture in the three media used. In terms of the value added of each medium, the visualisation media (360°video, 360°images and the virtual environment) had the ability to incorporate large volumes of data and enable improved presentation [23] as well as navigation of the environment for purposes of attaining the details that had been outlined in the descriptive text. The other value of the visualisation media which the descriptive text lacked, was the ability to elicit a sense of presence. Virtual reality was advantageous because of its almost limitless scalability in terms of level of realism, sense of presence, the experience of the participants, and its interactivity. Based on the findings of Roch et al (2012) [93], the value added of the descriptive text was its ability to elicit a verbal memory that participants

would be able to call upon when recall was required.

4.7 Rendering

Following the decision to use the Glebe Road surgery as the environment that would be displayed to participants, sensory images were created to depict the environment. The sub sections below highlight how the chosen representations were implemented.

4.7.1 Photogrammetry and Laser Scanning

Photogrammetry ("the science of measuring in photos" [69]) and high-quality 3D laser scanning was used to obtain relevant information about the interior of the Glebe Road Surgery. The 3D laser scanner used (see figure 3.1) obtained highly accurate data (to the millimetre) about the properties of the surfaces and objects by capturing patterns in the form of photographic images [103]and 3D digital models. The scanner collected all the geometric parameters of the environment, measured in micrometres (μm) and then constructed three dimensional coordinates of the surfaces and objects, creating points clouds of data from the surfaces of the surgery and thus capturing the exact size and shape of the objects as three-dimensional representations. These data points were used to recreate virtual images of the surgery which were subsequently displayed on the Head Mounted Display.

For purposes of rendering, we developed the experimental design based on a UK Surgery (the Glebe Road Surgery) capturing three basic but key elements of the process of accessing healthcare in the UK in general (the reception, the waiting and access to the GP) which we surmised would be representative features common to several NHS institutions. The rendered scenes were limited to these three elements of access to healthcare levels of entry partly because of the complexity of both capturing and rendering high resolution scenes of the 360°videos and images, as well as the virtual environment. A GP surgery was chosen because of the introduction of autonomous health service management by the

UK in the late 1990s and early 2000s. These reforms introduced the concept of patient choice of health service for elective care and the General Practitioner (GP), which is the UK Healthcare system's first point of contact for the medical needs. GP's as part of the primary care system play a gatekeeping role in determining access to more specialised health care services within the NHS [9].

4.7.2 Capturing 360°Video

A 360°video was captured using a Samsung Gear 360 High Resolution VR Camera with a video of 4096 $\times$ 2048 and 24 FPS (see figure 4.1). The videos were rendered using the Gear 360 Action Director software and the video quality set to MPEG-4 4K 3840 $\times$ 1920 / 25p (50 Mbps). The images were then uploaded on a desktop and displayed on a 4K high Definition 55" screen for maximum high-definition effect.

4.7.3 Developing the Text

A text description of the surgery was developed mirroring the 360°video and the virtual environment. The text was developed and printed on an A4-sized paper (with a copy printed for each individual participant). It was written by the investigator based on the scenes captured in the 360°video and the Virtual Environment. It was then reviewed by Professors, Alan Chalmers, Caroline Meyer and Kurt Debattista, as well as experts within the NHS such Professor Peter Bazira (Professor of Clinical Anatomy and Medical Education, Hull York Medical School) and Dr. Kate Barusya Mwesigwa, a General Practitioner in the NHS. In terms of the content of the text, it described key aspects of access to the NHS, how the research concept had been developed, and the features contained in the 360°video and the virtual environment. These features included accessing the surgery through a reception area, a description of the waiting areas including the waiting area, a mention of key fixtures such as the monitor and posters, a description of the children's play area and a description of how to access the GP's room.

4.7.4 Participants' Tasks

The participants who were assigned to the "descriptive text" component, were asked to read through the text describing the Glebe Road surgery. The participants assigned to the 360°video representation of Surgery and those assigned to the VR representation of the surgery were tasked with spatially navigating the respective environments. The 360°video environment was displayed on a high definition 55" TV screen connected to a desktop while the Virtual environment was displayed on both the high definition 55" TV screen and an HTC Vive HMD. Participants used handheld controllers to navigate the VE while only using a mouse to navigate the 360°environment.

In terms of the knowledge to be transferred, the Text participants were expected to read the text description of the three concepts described above and hopefully attain a verbal memory of what had been read. The 360°and the VR participants were expected to spatially navigate the respective environments and using cognition, internalise what they had spatially navigated. There was no interaction with objects, animated content or selective rendering that would have highlighted specific areas over others in the 360°and Virtual environments because of the reasons highlighted in section 3.6 on selective rendering. However, participants could zoom in and out of specific spaces, and acquire more detail on objects and items such as posters.

4.8 Measurement

The efficacy of the three media was measured using various tests on the independent variables. Participants were selected and randomly assigned to three different groups using simple randomisation [4] once they had registered. The groups were classed according to the different media (text, 360°video and VE). Table 4.1 shows the demographics of the participants. They responded to a 21 – question questionnaire immediately following their exposure to the medium to which they had been assigned.

They were encouraged to respond objectively to the 21 questions. The design of the

questions gave participants the chance to answer the questions first objectively and then subjectively (in their own words). The questions were targeted to find evidence that a transfer of knowledge had occurred. This meant assessing whether interactions with the text, the 360°Video or the VE had caused a transfer of knowledge. It was supposed that if transfer had occurred, the participants would be able to demonstrate what they had processed about the experience by correctly responding to the assessment questions.

Thereafter, they were allowed to experience the other two media following which, they answered a 32 – question questionnaire from Witmer and singer [132] on the "measure of presence" that participants felt during the experiment. Finally, they were asked to judge between the three media based on their experience of each, through a six–question questionnaire which was administered on their experience and the usability of the medium of knowledge transfer experienced. The questions on experience were derived from the Presence and the Immersive Tendencies Questionnaires (ITQ) [132], while the usability questions were derived from the Post-Scenario System Usability Questionnaire [68] and Lund's Usefulness, Satisfaction, and Ease of use Questionnaire [76]. As shown in figure 4.2 below, their specific responses, as well as the observations of the investigators, led to a redesign of the experiment and specifically the assessment questionnaire.

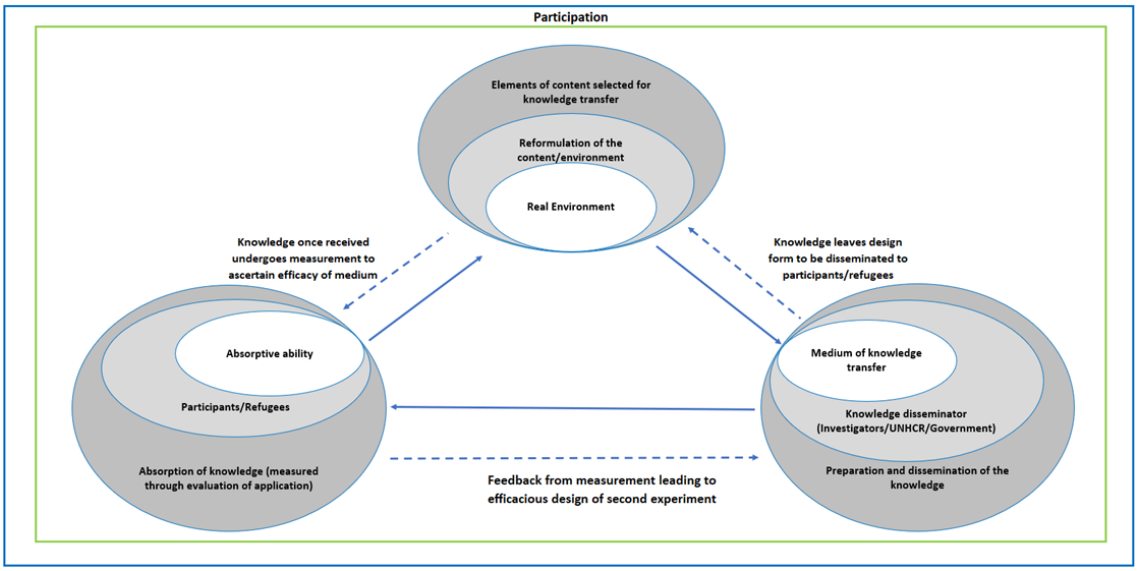


Figure 4.2: Showing measurement of Knowledge Transferred leading to design of second experiment (adapted from Verena Christiane Eckl's Barriers of Knowledge Transfer) [30]

Previous work had shown the influence of barriers such as skills, previous experiences, culture, design (in this case issues around level of realism, and interactive-ness of medium), to achieving knowledge transfer.

4.9 Participants

4.9.1 Selection of Participants

Adverts were posted all over the University of Warwick campus with a view to getting as many potentially eligible participants as possible. The participants had to, at the very least, be undergraduate students and have basic IT skills. This was done in order to arrive at a group of participants who would best provide the information that would help us to succeed in the research objectives [31]. Other participants were recruited through person-to-person contact. All participants were informed of the purpose of the experiments, the time when, and the location where they would take place. They were also provided with a summary of the study, information on what was required of the participants, and contact information if they had any questions.

Given the difficulty involved in recruiting participants at the University, both the snowball sampling and horizontal networking [39] were used to recruit participants.

Ten participants were recruited using the judgment sampling method [31]. They then passed on the word to fellow students and acquaintances (snowball sample). This method focused on the most accessible participants in part because of the difficulty involved in recruiting university students [79]. This method was cheap and convenient in terms of cost, time, and effort [79]. It was important to arrive at a relatively representative sample of participants who met the criteria for using the intervention. Key among these criteria was ensuring that the sample used for the study was the most productive to respond to the questionnaires [31], [79]. The aim of the pilot study was to evaluate how useable the system was, to identify potential barriers to using the three media, and to explore whether

this experience was useful to participants in relation to gaining a better understanding of the subject matter (navigating the NHS). Therefore, snowballing was deemed appropriate. It was also deemed that the number of participants (N = 37) was large enough to identify a large cross-section of problems with the system in general.

Although according to [126] "most usability problems are detected with the first three to five subjects," a bigger sample is unlikely to reveal further information (usability problem discovery method). Blair (2006) [6] postulated that there was a greater likelihood of identifying exceptional problems, with larger samples. A mixture of qualitative and quantitative approaches was used to obtain the perspectives of participants on the three media used. We surmised that 10 participants per media would help us to establish the feasibility of the system and to identify any problems with the system if they existed.

Based on this assessment, thirty-seven University of Warwick students and employees between the ages of 20 and 35 were recruited on voluntary terms. The average and median groups of the participants were between 21 - 25 years. Four of the participants did not register their age groups. All participants had basic IT knowledge with at least 10 of them (about 27%) of them having basic knowledge of VR. All participants had no prior knowledge of the subject matter (the Glebe Road Surgery) being investigated for purposes of the experiment.

Although all participants undertook all three components of the experiment, 12 did the text component first and were immediately assessed after their involvement. Another twelve participated in the 360°component and were assessed immediately afterwards. The final group was composed of those that participated in the VR component of the experiment. They too were assessed immediately following their participation in the VR component of the experiment. After the respective assessments, participants were allowed to take part in the other two components of the experiments.

4.9.2 Characteristics of Participants

Although most of the participants were skilled in the use of computers only a few (10) were well versed with virtual reality. Table 4.1 shows the characteristics of participants.

The participants were evenly split among males (18) and females (19) and were from several ethnic backgrounds/countries as highlighted in the table. Their ages ranged from 21 – 35 and most of them were postgraduate students with only 15 at the undergraduate level. The average age of the ethnic background was three males and three females, aged from 22 to 27.

Table 4.1: Characteristics of Participants

Characteristics of the Participants					
Unique Identifier	Gender	Age	COO	Education Level	PEVR
1707191	Female	31 - 35	Germany	PG	YES
1707192	Female	21 - 25	China	UG	NO
1707193	Female	31 - 35	Netherlands	PG	YES
1707194	Female	31 - 35	UK	PG	NO
1707195	Male	26 - 30	UK	PG	YES
1707196	Female	26 - 30	China	PG	YES
1707197	Female	21 - 25	China	PG	NO
1707198	Female	26 – 30	China	PG	YES
1707199	Female	21 – 25	Korea	UG	NO
1707200	Female	26 - 30	UK	PG	NO
1707201	Male	21 – 25	UK	UG	NO
1707202	Male	21 - 25	UK	PG	NO
1707203	Female	21 - 25	Germany	UG	NO
1707204	Male	25 - 30	China	UG	YES
1707205	Female	21 - 25	China	UG	NO
1707206	Female	21 - 25	China	UG	NO

Continuation of Table 4.1

Unique Identifier	Gender	Age	COO	Education Level	PEVR
1707207	Male	26 – 30	China	PG	YES
1707208	Male	21 - 25	UK	UG	NO
1707209	Female	21 - 25	UK	UG	NO
1707210	Female	26 - 30	Netherlands	PG	NO
1707211	Female	21 - 25	Nigeria	PG	NO
1707212	Male	21 - 25	Italy	UG	NO
1707213	Male	31 - 35	UK	PG	YES
1707214	Male	21 - 25	China	UG	YES
1707215	Male	26 – 30	China	PG	YES
1707216	Female	21 - 25	India	UG	NO
1707217	Male	21 – 25	Italy	PG	NO
1707218	Female	21 - 25	Austria	PG	NO
1707219	Male	26 - 30	USA	PG	YES
1707220	Female	21 - 25	USA	UG	NO
1707221	Male	31 - 35	Nigeria	PG	NO
1707222	Male	26 - 30	Singapore	PG	NO
1707223	Male	31 - 35	Nigeria	PG	YES
1707224	Female	21 - 25	Korea	UG	NO
1707225	Male	21 - 25	China	UG	YES
1707226	Male	26 - 30	Netherlands	PG	NO
1707227	Male	31 - 35	Greece	PG	YES

**PEVR – Previous Experience with Virtually Reality, PG – Postgraduate, UG – Undergraduate, COO – Country of Origin*

Importantly only 22% (8 out of the 37) of the participants were from the UK and based

on that, it was assumed that at least 70% of the participants knew little or nothing of how to navigate the NHS.

All participants had basic IT knowledge with at least 25% of them having basic knowledge of VR.

4.10 The Experimental Procedure

Participants were contacted by email at least one week prior to the experiment. Upon arrival, they were asked to read a participant information leaflet describing general aspects of the study before being given a verbal explanation of what the experiment was about. At this stage, they were requested to complete and sign consent and demographic data forms and then assessed for IT and VR knowledge. After that, we ran a brief tutorial of the VR and the 360°video to achieve the minimum expertise to move and interact within the environment. After the initial tutorial, they were allowed to engage with each component of the experiment for between 20 – 30 minutes. The two components (VR and the 360°video environment) required the participants to internalise how to navigate the Glebe Road Surgery either by reading the text, by engaging with the 360°video or engaging with the virtual environment.

The experiment was conducted in three separate rooms of 40 $\times$ 40 metres, which allowed those using the Head-Mounted Displays (HMDs) to navigate with ease. "Text" participants then went on to take part in the experiment while the other two sets of participants received an explanation of how to navigate 360°video on the desktop and the virtual environment on the Head Mounted Display.

Thereafter, they were allowed to take part in the experiment and were subsequently asked to respond objectively to the 21-question questionnaire. The questions gave participants the chance to respond in their own words and were designed to find evidence that a transfer of knowledge had occurred. This meant assessing whether interactions with the text, the 360°or the VE had caused a transfer of knowledge. It was surmised that if transfer had occurred, the participants would be able to respond correctly to the questions based on

what they had experienced.

Following the assessment test, all three groups of participants took part in the other two components of the experiment. When all participants had completed all three components of the experiment, they were asked to respond to questions on their experience with the media, as well as its usability of the media. Finally, they were requested to respond to "Presence" and "Immersive Tendencies" Questionnaires. All questionnaires were based on a 7-point scale.

In terms of the amount of time taken to complete each component of the experiment (including the time taken to respond to the assessment questions, which were administered immediately following the experiment), the text component lasted about 45 minutes while navigating the 360°video lasted about 15 minutes. Participants seemed fascinated by the VE and lasted between 40 – 50 minutes on average in the VE and responding to the assessment questions).

4.11 Control Mechanisms

A non-probability sampling method was used to determine a sample size of N = 37. Different participants were initially exposed to the medium to which they had been assigned. However, it was deemed necessary to expose them to the other two in order to more appropriately respond to the presence and immersive tendencies questionnaires. This was done using simple randomisation [4]by first assigning them numbers between 0 - 43 (forty-four participants had registered to participate in the experiments, but 37 showed up on the day). The three media were classified into the three groups highlighted above (Group 0- text, group 1 – 360°video or images, and group 2 – Virtual Environment). The participants numbers (0 - 43), and the media group numbers (0, 1, and 2), were written on pieces of paper and placed in two separate opaque plastic containers (one for the participants and the other for the media). The numbers (0 - 43) were then randomly selected from the plastic container assigned to participants numbers and paired with a group number also randomly picked out of the other plastic container. The selection (minus

Table 4.2: Sequencing of Assessments During the Pilot Study

First Seq		
Group Name	No. of Participants	Measurement (Knowledge)
Text	11	21-Question Assessment Test
360VD	12	21-Question Assessment Test
VEV	14	21-Question Assessment Test
Second Sequence (2a)		
Group Name	No. of Participants	Measurement (Presence)
Text (360VD in First)	12	32-Question Presence Test
360VD (VEV in First)	14	32-Question Presence Test
VEV (Text in First)	11	32-Question Presence Test
Second Sequence (2b)		
Group Name	No. of Participants	Measurement (Presence)
Text (VEV in First)	14	32-Question Presence Test
360VD (Text in First)	11	32-Question Presence Test
VEV (360VD in First)	12	32-Question Presence Test
Third Sequence (3a)		
Group Name	No. of Participants	Measurement (Experience)
Text	11	6-Question Presence Test
360VD	12	6-Question Presence Test
VEV	14	6-Question Presence Test
Third Sequence (3b)		
Group Name	No. of Participants	Measurement (Usability)
Text	11	6-Question Presence Test
360VD	12	6-Question Presence Test
VEV	14	6-Question Presence Test

those that did not show up on the day) turned out as follows:

1. Text: N = 11

2. 360°Video on a Desktop (360D): N = 12

3. VE on the HTC Vive (VEV): N = 14

After initial exposure to the specific medium to which they were initially assigned, a 21-question assessment test was administered to the participants to assess the level of knowledge attained during the experiment. Participants were then allowed to experience the other two media in order to answer the "Presence" and "Immersive Tendencies" questionnaires.

All the participants received the same instructions, including specifically being instructed not to confer with each about any aspect of the experiment. They all came into the experiment with the same level of knowledge of the experiment as represented in the Participants Information Leaflet (PIL).

At the end of each session, participants were informed of how the results from the experiment would be used. They were also debriefed specifically to ascertain if they experienced any harm or discomfort during the experiment, informed about the expected outcomes of the research, and briefed on how these outcomes would be deployed. Finally, the investigator asked them if they had any questions that they would like answered. A few of the participants were keen to know how the results of the experiments would be deployed.

4.12 Results

In order to analyse the effect of the media on knowledge transfer and retention, the results of the three media were evaluated based on the three different groups of participants, each of which was exposed to all the three media as explained in section 4.6 above.

4.12.1 Multivariate Analysis

A MANOVA was performed to analyse the results of the four DVs (Experience, presence, usability, and assessment test1). Using Pillai's trace, we found that the group main effect was significant, F (8,64) = 7.195, $p < 0.001$, (where the F is the ratio of the variation between sample to the variation within samples and the p-value measured statistically significant difference between the means of the seven groups and was used to reject the null hypothesis (H0) by concluding that there was a statistically significant difference between the means of the seven groups). The η_p^2 was 0.474 implying a large effect size or a slightly under 50% chance that the media would have an independent effect on dependent variables. We thus rejected H0 and accepted H1. Due to the multifactorial nature of the

analysis, univariate ANOVA was conducted.

4.12.2 Univariate Analysis

An in-depth univariate analysis for the four DVs was then conducted in addition to pairwise comparisons amongst the factors.

4.12.3 Experience

A one-way ANOVA was used to test the results of how participants experienced the Text component of the experiment. The main effect of "experience with the media" was significant, F (2,34) = 13.188, $p < 0.005$. On average, across all groups, $\mu = 4.27$ with $\sigma = 1.427$. Table 4.3 shows the individual scores for the Mean (μ), Standard Deviation (σ), Median ($\tilde{x}$), Range (R) and Interquartile Range (IQR). The η_p^2 of 0.437 was similar to that achieved using the MANOVA, implying a large effect size (over 40%) of the media on experience of participants.

Table 4.3: Results showing correlation between media type and "Experience"

Medium	μ	σ	$\tilde{x}$	**R**	**IQR**
Text	3.270	1.104	3.00	3.00	2.00
360VD	3.830	0.835	4.00	2.00	2.00
VEV	5.430	1.284	5.50	3.00	3.00

Figure 4.3 shows box plots of the data on participants' experience with the selected media of knowledge transfer, based on a 95% confidence interval. Examination of the figure readily suggests a positive association between the type of medium used and the satisfaction (experience) of the participants. The boxes shift upward with the different media pointing to the relative superiority of the VEV. The median for Text is 3 while that for 360VD is 4 and that for VEV is about 5.5. The median line of the VEV lies outside of the Text and 360VD suggesting a significant difference between participants' experience with the VEV as compared to the 360VD and the Text. Comparing the interquartile ranges (IQR) to examine how the scores for each of the media are dispersed, shows that

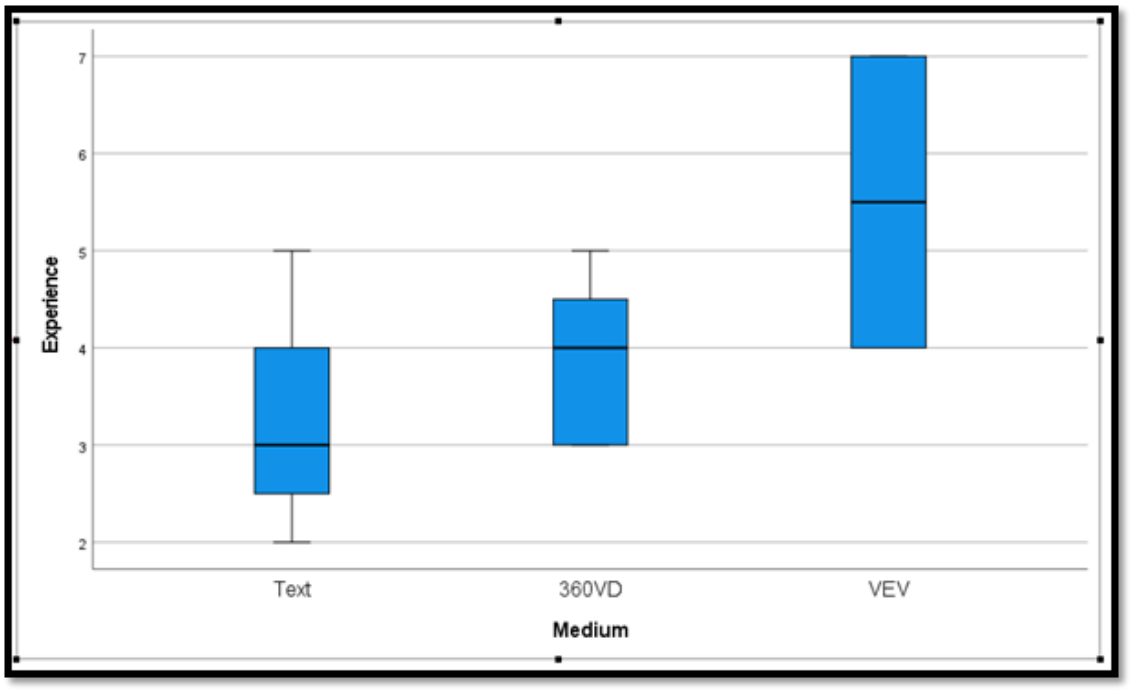
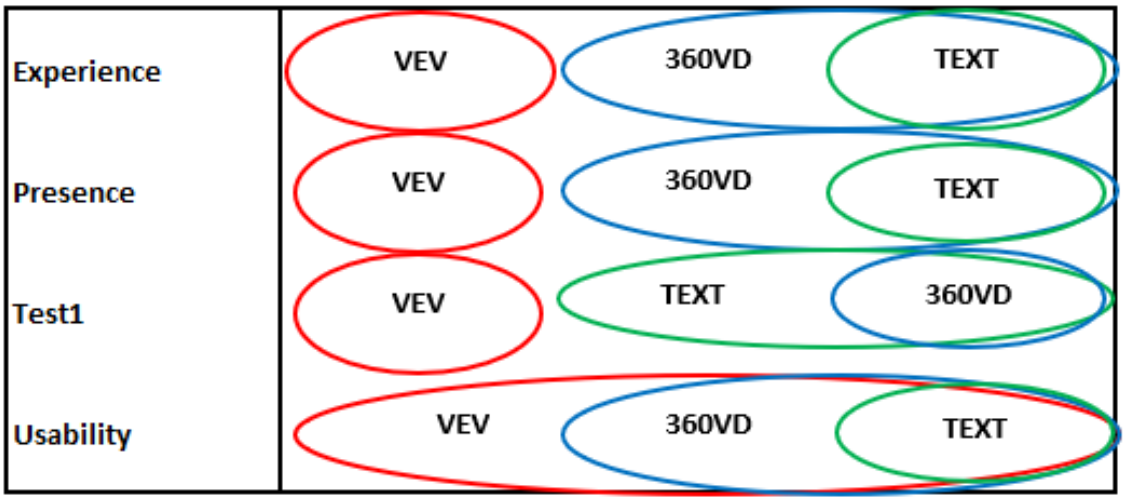


Figure 4.3: Boxplot for Medium v Experience

VEV scores are more dispersed than the Text and the 360VD although the overall spread as shown by the extreme values at the end of the whiskers is smaller for the VEV and largest with the Text. This demonstrates that overall, VEV participants agreed on the illusion of presence being high, and also had a higher level of satisfaction (experience), than participants that used the other two media. The Text however had the widest spread essential demonstrating that while participants who used the VEV thought the experience was good to excellent overall, 25% of the Text participants (in the lower quartile – Q1) thought it was "average" to "not good at all". The majority of the Text participants as represented by IQR = 2, thought it was somewhere between "not good" to just above average (fairly good). The 360VD was the least dispersed of the three with a spread of R = 2 and IQR = 2, and most participants scored it between average (more or less good) and just above average (fairly good). The distribution for the VEV was also perfectly symmetrical while that for the Text was right-skewed meaning most people scored it between not good and average. The 360VD on the other hand was left-skewed implying that most of the 360VD participants rated it between average and good.

Pairwise comparisons with Bonferroni corrections are shown in figure 4.4. The figure presents pairwise comparisons for all DVs. The factors are sorted by their means (where the leftmost factor has the best mean for that DV). The colour groupings demonstrate a lack of statistically significant difference in the pairwise comparisons. The pairwise comparisons for Experience show no statistically significant difference between the "Text" and the 360VD, but a statistically significant difference between the VEV on the one hand and the Text and 360VD on the other. The means plots and pairwise comparisons showed a significantly superior mean for the VEV, when individually compared to both the 360VD and the Text but no statistical significance when comparing the Text and 360 VD to each other ($p > .001$).

Table 4.4: Pairwise comparisons, with Bonferroni corrections, between the different factors for all DVs. All factors are sorted left to right by mean. Coloured groupings denote no significant difference amongst factors in a group. There is clear preference for the virtual reality medium.



4.12.4 Presence

The main effect of Presence was significant, $F(2,34) = 81.18$, $p < 0.001$. The group mean score was $\mu = 122.78$ and $\sigma = 31.977$ and the individual scores for μ, σ, $\tilde{x}$, R, and the IQR are highlighted in table 4.5.

Table 4.5: Results showing correlation between media and "sense of presence" during the pilot study

Medium	μ	σ	$\tilde{x}$	**R**	**IQR**
Text	98.550	15.616	97.50	55.00	23.00
360VD	102.170	15.326	105.50	44.00	30.00
VEV	159.500	10.196	160	39.00	13.00

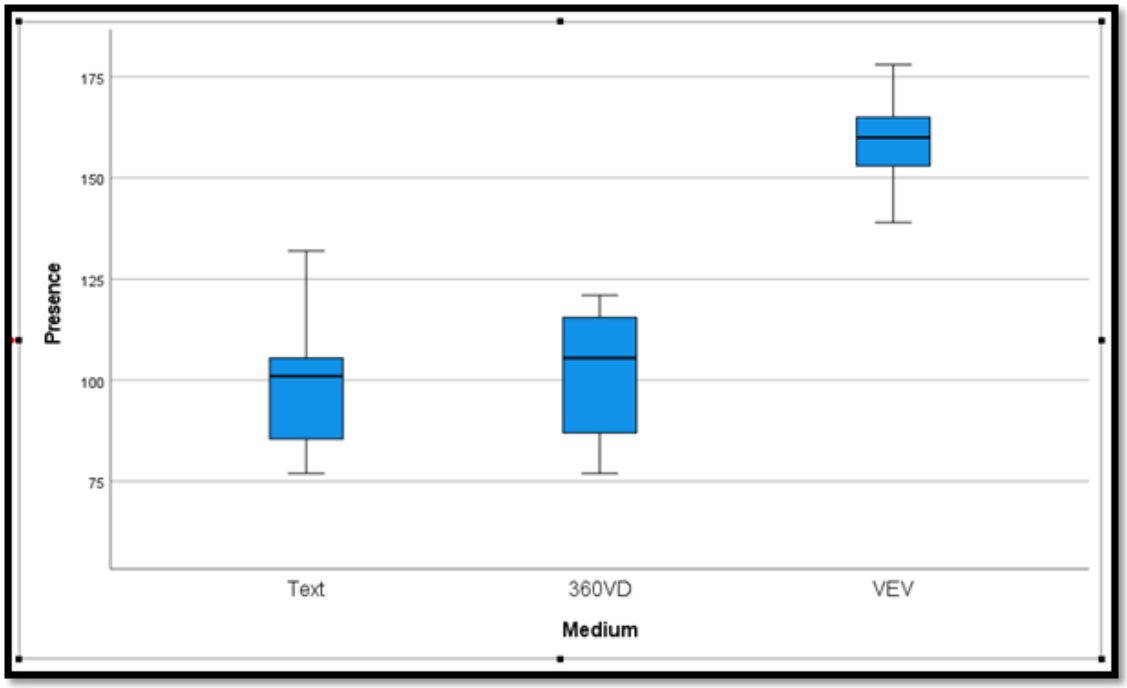


Figure 4.4: Boxplot examining sense of presence felt by participants while using the three media

Figure 4.4 shows box plots of the data on participants' illusion of presence when using the three media of knowledge transfer, based on a 95% confidence interval for the mean. An analysis of the figure shows a positive correlation between the type of medium used and the illusion of presence. It points to the relative superiority of the VEV's illusory appeal when compared to the Text and the 360VD which are not statistically significantly different given their median values of $\tilde{x}$ = 101 (Text), and $\tilde{x}$ = 105.5 (360VD). The median value of the VEV on the other hand is significantly different at $\tilde{x}$ = 160. The median line of the VEV lies far above that of the Text and 360VD suggesting a significant difference between participants' illusion of presence while using the VEV as compared to the 360VD and the Text. Comparing the interquartile ranges (IQR) to examine how the scores for each of the media are dispersed, shows that VEV scores are less dispersed than the Text

and the 360VD. The overall spread as shown by the extreme values at the end of the whiskers is largest for the Text (R = 55) and smallest for the VEV (R = 39). There is a general agreement based on the scores, among the VEV participants of its overriding superiority as demonstrated by the low IQR = 13. The IQR for the 360VD was highest at 30 signifying a general lack of consensus on its illusory appeal. Indeed, the boxplots suggest an insignificant difference between the Text and the 360VD.

Pairwise comparisons can be seen in figure 4.4. The results show that the Text and the 360VD had no statistically significant difference (p value was 1.000). However, there was a statistical difference (p value 0.000) between the VEV and the other two media (360VD and Text) as it recorded a higher level of presence based on participants' scores.

4.12.5 Test1

The univariate one-way ANOVA of Test1 assessed the effect of the medium on the participants' ability to attain the information/knowledge provided through the experiment.

The main effect of "Test1" was statistically significant, F (2,34) = 5.777, $p < 0.001$. The group mean score was μ = 78.84 and σ = 26.35 and individual scores for μ, σ, $\tilde{x}$, R, and the IQR are highlighted in table 4.6. There is a relative stability around the standard deviation although it falls as we gravitate towards depictive (as opposed to descriptive) media.

Table 4.6: Results showing correlation between the three media and assessment Test1 during the pilot study

Medium	μ	σ	$\tilde{x}$	**R**	**IQR**
Text	69.910	25.300	70.00	50.00	26.00
360VD	67.500	23.103	66.50	80.00	29.00
VEV	95.570	22.159	103.500	70.00	38.00

Figure 4.5 shows box plots of the data on participants scores on the assessment test administered immediately following the experiment to assess the correlation between the media and the knowledge transferred. An analysis of the figure shows a positive correlation between the media type and the test scores. It also shows that the Text performed better

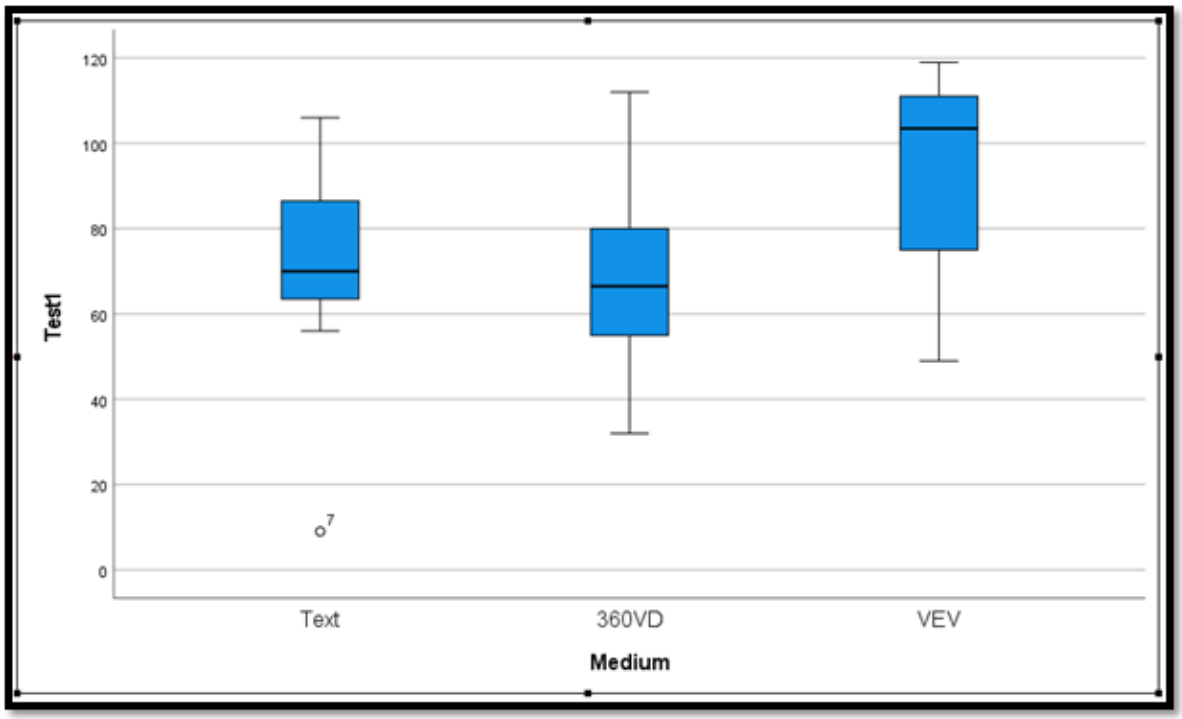


Figure 4.5: Boxplot for Medium v Test1 for the three media

than the 360VD. The VEV on the other had showed its superiority both based on the fact that its median (103.50) is close enough to the maximum values of the Text (106) and the 360VD (112), and on the significant difference between its median and that of both the Text (70) and the 360VD (66.50).

The VEV also has the lowest range (70), compared to the Text which has the highest range (97) and the 360VD (80). The IQR of the VEV is 38, while that of the 360VD is lower at 29 and that of the Text is even lower at 25. Based on the IQR, it can be surmised that the there was a general consensus based on the scores of the participants that the VEV provided the best platform for knowledge transfer, followed by the Text and the 360VD. The distribution for the VEV was also left skewed implying that most people scored highly in the test results. Although the 360VD performed the poorest, its distribution was symmetrical. The Text on the other hand was right skewed with most participants scoring between 63 and 88.

Pairwise comparisons with Bonferroni corrections can be seen in the Test1 row of table 4.4. Based on the Bonferroni correction, η_p^2 was 0.474 implying a slightly under 50% chance that the media would have an independent effect on knowledge attainment. The

results also demonstrated the superiority of VE on the knowledge attainment test. The standard deviations were also relatively stable with Text returning σ = 7.063 demonstrating slightly more volatility with the descriptive medium as opposed to the depictive media which were relatively more evenly matched at σ = 6.762 (360VD) and σ = 6.260 (VEV). There was however a relative stability of the results which signified the superiority of Virtual Reality in knowledge transfer.

4.12.6 Usability

Univariate Analysis on usability and its correlation with the different factors of the IV was statistically insignificant with an F value of F (2,34) = 0.176, p $>$ 0.001 (p value was 0.839). Individually, the scores of the three media in terms of μ, σ, $\tilde{x}$, R, and the IQR, are highlighted in table 4.7. Based on the Bonferroni correction, η_p^2 was 0.010 and the three media were evenly matched in terms of usability (p Value of 1.000).

Table 4.7: Results showing participants usability rating for each one of the three media used during the pilot study

Medium	μ	σ	$\tilde{x}$	**R**	**IQR**
Text	3.730	1.191	4.00	3.00	2.00
360VD	3.830	0.937	4.00	3.00	2.00
VEV	4.000	1.251	3.50	4.00	2.00

Based on figure 4.6 and table 4.7, VEV scored the lowest of the three media while the Text and the 360VD were evenly matched. The distribution for the Text was perfectly symmetrical while that for the VEV was right skewed implying that most of the participants scored it below average for usability. The 360VD on the other hand was left skewed implying that most of the participants scored it between "fairly good" to "good" on usability.

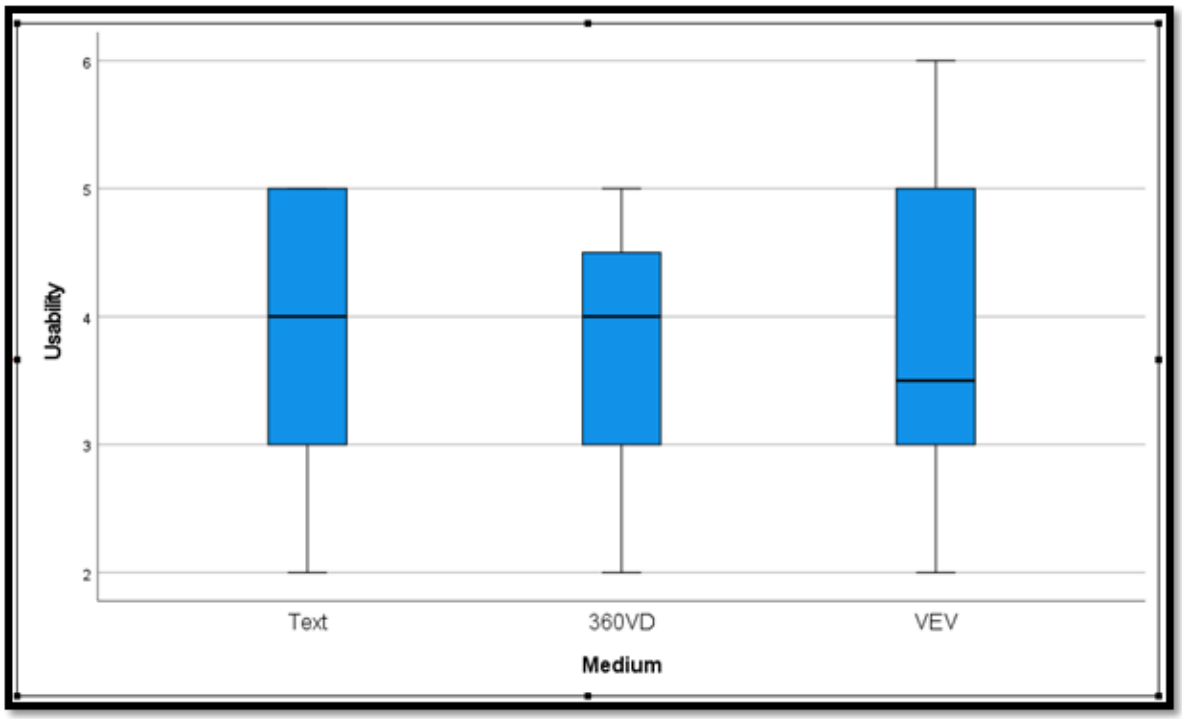


Figure 4.6: Boxplot for Medium v Usability for the three media

4.13 Discussion

The pilot study showed important but, in many respects, non-conclusive trends between the dependent variables and their impact on knowledge transfer. It showed a link between the experience, presence, and VE in terms of its knowledge transfer related performance, evidenced by its strong showing in test1. The import of fidelity was evident in terms of how the VEV outperformed the Text and the 360VD, but in particular, the poor showing of the 360VD (360VD was of a poorer quality). The VE provided a greater level of engagement and interactiveness than the text and 360VD which may have impacted the test1 results. It showed the power of depictive representations but only if well represented (a combination of fidelity and interactiveness) given the superior scores of the VE contrasted against the relatively poor showing of 360VD that was only marginally better than the text and in fact poorer when it came to knowledge transfer. On the usability scores, although participants spent a longer time in the VE perhaps demonstrating a fascination with it, but also its ability to draw them in and engage them more powerfully, it was only marginally better

than the other two media.

An important import from the pilot study was that far less time was spent on the 360VD than the other two media (text and VE) and this was deemed to be partly because of its poorer quality. It was therefore surmised that better quality 360VD might give better results.

4.14 Summary

The pilot study revealed the potential of VEs as an important knowledge acquisition tool particularly given its superior results. It also revealed the need to invest in a further study with greater fidelity for both the VE and the 360°video/images. It was also determined that in order to better understand the power of the two media, both the input and output mechanisms would have to be similar (i.e. the depictive representations would have to be similar and the output used such as desktop and the head mounted display would have to be the same). It was decided that a second study focusing on fidelity of the two media, as well as their ability to elicit engagement and thus a memory imprint would be an important new addition to the experimental design. Finally, the pilot study made clear that further development was necessary in order to attain more precise data.

Chapter 5

The Use of Virtual Environments to Facilitate Refugees' Integration in Third Countries

This chapter focus in part on the challenges faced by refugees as they navigate national services systems in countries of resettlement. It builds on Chapter 4 in assessing the case of UK-bound refugees, access to the UK's National Health Service (NHS) and how VR can be used to make their integration easier. It attempts to clarify how best to provide the refugees with the information they both need, and that is fully actionable.

It is an outgrowth of the pilot experiment in so far as the experimental design and procedures outlined in this chapter were largely based on the experiences with the pilot study. These changes included increasing the number of participants (N = 122) and making slight variations to the Independent Variables. Indeed, the three different media (Text, 360°Video, and VE) were varied into seven multifactors in order to assess the effect of fidelity on perception. The seven different variations of the three media were designated as follows:

1. Text (Text)
2. 360°image mounted on a desktop (360D)
3. 360°image mounted on HTC Vive (360V)

4. 360°image mounted on HTC Vive Pro (360VP) - introduced for its higher resolution displays

5. Virtual Environment mounted on a desktop (VED)

6. Virtual Environment mounted on HTC Vive (VEV)

7. Virtual Environment mounted on HTC Vive Pro (VEVP)

In addition to the above-mentioned variations, this experiment was conducted with refugee participants who were yet to arrive in the UK and knew nothing about the UK healthcare system.

5.1 Participants

5.1.1 Number of Participants

The study was ethically reviewed and approved by the Biomedical and Scientific Research Ethics Committee (BSREC) of the University of Warwick as highlighted in section 2.11. Based on the approval, 122 refugees, mostly between the ages of 20 and 30 were recruited on voluntary terms. Although all participants had basic IT knowledge, none of them had any knowledge whatsoever of Virtual Reality.

In addition, none of the participants had any prior knowledge of the subject matter (access to the NHS or the Glebe Road Surgery) being investigated for purposes of the experiment. Participants were also screened for motion sickness as highlighted in sub-section 5.1.2.

5.1.2 Selection of Participants

Participants were recruited on voluntary terms through emails, posters, online banners and through word of mouth, over the course of six months. Initially, leaflets were printed

out and handed to refugee leaders. They were also given the Participant's Information Leaflet (PIL) beforehand and requested to read through it as part of the preparation for the experiment. They were also given copies of the consent form before being requested to pass the word around. Several participants responded and were subsequently formally invited by email.

Participants were informed that the study was entirely voluntary and that refusal to participate would not affect them in any way. They were also informed that if they agreed to take part in the study, they would have to sign a consent form, signalling that they were participating of their own free will. They were nonetheless notified of their right to withdraw from the study at any time, that they had the right to withdraw from the study completely and their right to decline any further contact in the event of withdrawal. The participants were, however, informed that once the data had been collected, it could not be withdrawn from the study after it had been processed for analysis and that they would accordingly have up to 48 hours after completion of the experiment within which to withdraw their data. Finally, they were also warned that there was a possibility that the head-mounted displays might cause simulator sickness and that they should pay attention to any such signs and notify the investigator if they felt unwell.

A non-probability sampling method was used to determine the sample size for the study. The sampling frame for this study was refugees with university-level education and with basic IT knowledge. This was to ensure that the sample used for the study was the most productive to respond to the questionnaires [31]. The participants had never experienced Virtual Reality and knew nothing about the National Health Service System of the UK. Some 122 refugees were recruited following the "central limit theorem (σ2/n where the variance is the standard deviation [σ] squared divided by the sample size [n])" by which it was assumed that the sample means of the 122 and the means of the seven independent factors would be evenly distributed and that in each case "N" would be greater or equal to the sample size (Rosenblatt 1956) [95] and (Stephens, 2006) [120]. To increase

the validity of the results, a "within-groups design" model was used, which allowed us to correlate the results from participants using the different "knowledge transfer" media variations. All 122 participants were exposed to just one of the seven different "knowledge transfer" media variations, resulting in 122 different results.

5.1.3 Characteristics of Participants

Some 122 participants (49 female and 73 male) were recruited for the experiment. Over 95% of the participants were between the ages of 21 and 30 years and of African origin. They were from six different African countries (Central African Republic, the Democratic Republic of the Congo, the Republic of Congo, Gabon, Cameroon and Cote d'Ivoire). They were divided into seven different groups corresponding to the different media variations that had been determined. Table 5.1 below shows the sample sizes per media variation.

Table 5.1: Sample size of different media variations

No.	Medium of Knowledge Transfer	Sample Size
1.	Text	28
2.	360D	14
3.	360V	14
4.	360VP	19
5.	VED	14
6.	VEV	14
7.	VEVP	19
8.	Total (N)	122

All the participants had not previously experienced the use of VR or HMDs and so through the experiment were able to experience navigating a virtual world for the first time.

A key goal of the experiment was to further test the hypothesis that VR technology was more effective than the 360°medium and the descriptive text, in achieving knowledge transfer and retention.

5.2 Method

The experiment compared three methods of presenting the information: text, 360°images and VR.

5.2.1 Design

The overarching objective of the experiment was to ascertain how media impacts knowledge transfer and retention. To achieve this, a descriptive text of a surgery (Glebe Road Surgery in London, UK - Figure 5.1) was presented on an A4 piece of paper. In addition, 360°images and a virtual representation of the same surgery were captured and created, respectively. Participants were randomly divided into seven groups based on the different media variations outlined in table 5.1 above. The three media (text, 360°images, and Virtual Environment) had been varied based on fidelity. The rendered material would be cast onto a desktop, an HTC Vive HMD, and the HTC Vive Pro HMD for both the 360°images and the VR build.

As highlighted above, the choice of media was a between-participants independent variable for the experiment (see table5.2).

The media were disaggregated into seven different variations as follows, where the term in brackets denotes how the factors will be referred to in the rest of the thesis:

Table 5.2: Media variations and acronyms used in this study

Media	Variation and Usage in this Study
Descriptive Text	Text
360°Images on Desktop	360D
360°Images on HTC Vive	360V
360°Images on HTC Vive Pro	360VP
VE on Desktop	VED
VE on HTC Vive	VEV
VE on HTC Vive Pro	VEVP

The dependent variables were:

Figure 5.1: A Photo of the Glebe Road Surgery (1 Glebe Rd, London SW13 0DR)

Initially, three different sets of questionnaires (on Experience, Presence and Usability), were administered for each of the dependent variables and were based on a multi-item scale where one was the lowest score and seven, was the highest score. Participants were asked to fill out which scale best comported with their own experience. There were 32 questions on ”Presence” and six questions each on ”Experience” and ”Usability”.

Participants were exposed to the experiment and then asked to complete the assessment questions from which their responses were evaluated (Test1 and Test2). The assessment questions, reviewed by experts in the psychology and medical field, included a 14 - question test on the subject matter (access to the Glebe Road Surgery), five of which were

Table 5.3: Outline of Dependent Variables

Experience	Denoting participants' experience (satisfaction) with the media variation they were exposed to
Presence (Measure of Presence)	The extent to which participants felt the illusory sense of presence while using the medium
Test1	Assessment test for knowledge transferred administered immediately after the experiment
Test2	Knowledge retention assessment test administered between 10 - 14 days after Test1, using the same questions (translated into French because most of the participants were Francophone)
Usability	Denoting participants' views on the how easy to use the specific media variation was

aimed at testing their application of the knowledge (navigation of the surgery). These were also marked out of seven (with one as the lowest score and seven as the highest). Participants were scored based on their grasp of the concepts presented.

The participants were then asked to return 10 - 14 days after completing the experiment and take the 14-question assessment test a second time (Test2) to assess their memory retention.

5.2.2 Materials

All participants were provided with similar information on the Glebe Road Surgery either through a descriptive text, a 360°image, or a virtual environment. The information/data contained in all three components were identical for all participants. They were initially provided with a Participants Information Leaflet (PIL) containing the objectives of the experiment and how it would be conducted. They were also requested to consent to the following by signing a consent form.

1. That they had read and understood the PIL.
2. That they had been given the opportunity to consider the information, ask questions and that any questions asked had been satisfactorily answered.

3. That they were fully cognizant of the fact that their participation was voluntary and that they were free to withdraw at any time without giving any reason.

4. That they understood that eye-tracking data and demographic data would be collected during the study and anonymised.

5. That they understood that relevant sections of data collected during the study, could be looked at by individuals from The University of Warwick and from regulatory authorities. Accordingly, that by signing the consent form, they would be granting permission for these individuals to have access to data collected from the study.

They were then allowed to take the experiment. Table 5.4 shows the materials used during the experiment.

Table 5.4: Materials used during the experiment

Materials		
No.	Medium	Materials
1	TEXT	Sheets of Paper (A4 Printed in Colour)
2.	360D	55" Smart, 3D Compatible HD and 4K Screen connected to HP Pavillion Desktop – TP01 – 0118in. Navigation was done using a computer keyboard
3.	360V	HMD (HTC Vive) Connected to HP Pavillion Desktop – TP01 – 0118in. HTC Vive handheld controllers were also used to navigate
4.	360VP	HMD (HTC Vive Pro) Connected to HP Pavillion Desktop – TP01 – 0118in. HTC Vive Pro handheld controllers were also used to navigate
5.	VED	55" Smart, 3D Compatible HD and 4K Screen connected to HP Pavillion Desktop – TP01 – 0118in. Navigation was done using a computer keyboard
6.	VEV	HMD (HTC Vive) Connected to HP Pavillion Desktop – TP01 – 0118in. HTC Vive handheld controllers were also used to navigate
7.	VEVP	HMD (HTC Vive Pro) Connected to HP Pavillion Desktop – TP01 – 0118in. HTC Vive Pro handheld controllers were also used to navigate

5.3 Rendering

This section discusses in detail how the graphical representations were rendered.

5.3.1 Photogrammetry and Laser Scanning

Based on the experiences and results of the pilot study, new models of the Glebe Road Surgery were created using photogrammetry and high-quality 3D laser scanning (see figures 5.2, 5.3 and 5.4).

The 3D models from the laser scanner were used to create the environment with millimeter accuracy. They were used to create physical-based render textures, to accurately recreate the environment and lighting conditions. They were done in Autodesk Maya, and the Unity 2018.4 engine was used to create a VR build of the surgery using the SteamVR plugin.The build was tested and ran flawlessly on the HTC Vive and HTC Vive Pro headsets. All images (real or virtual) are related to the Glebe Road surgery at *1 Glebe Rd, London SW13 0DR, United Kingdom*.

Figure 5.2: Virtual image of access to the children's play area at the Glebe Road Surgery (1 Glebe Rd, London SW13 0DR)

Figure 5.3: Virtual image of entrance to GP's room at the Glebe Road Surgery (1 Glebe Rd, London SW13 0DR)

Figure 5.4: Virtual image of reception area and waiting area at the Glebe Road Surgery (1 Glebe Rd, London SW13 0DR)

5.3.2 Capturing 360°Images

360°images (see figures 5.5, 5.6, and 5.7) at a high High Dynamic Range image quality were captured using a SpheronLite 360°camera. They were processed using SpheronLite software, uploaded on a desktop and displayed on a HTC Vive and the HTC Vive Pro Head Mounted Displays. The quality levels of both the VR and the 360°images were high. The images were displayed on a computer monitor in order to make a distinction with the display on the HMDs in terms of quality, and the ability to heighten participants' level of engagement. The HTC Vive Pro displayed a superior quality of images with a screen resolution of 1440 × 1600 pixels per eye (or combined resolution of 2880 × 1600 pixels) compared to the HTC Vive screen resolution of 1080 × 1200 pixels per eye (and combined resolution of 2160 × 1200 pixels).

Figure 5.5: Virtual image of access to the children's play area at the Glebe Road Surgery (1 Glebe Rd, London SW13 0DR)

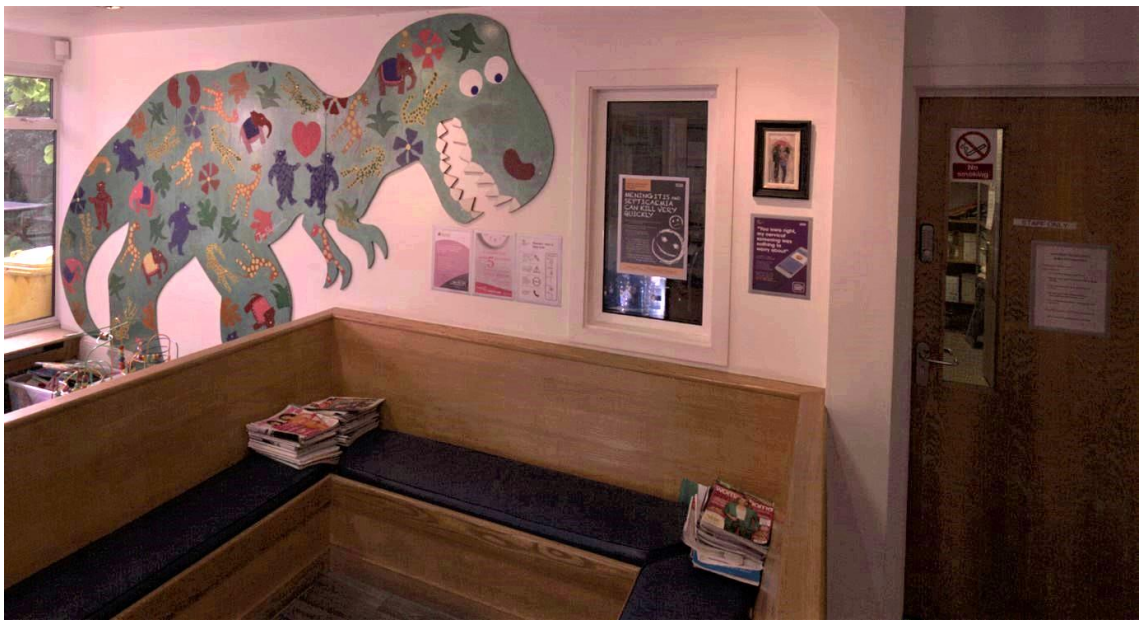


Figure 5.6: 360°image taken at the Glebe Road Surgery children's play area (1 Glebe Rd, London SW13 0DR)

Figure 5.7: 360°image taken at the Glebe Road Surgery waiting area (1 Glebe Rd, London SW13 0DR)

5.4 Experimental Details

Administration of the experiment was done by text, 360°images and VR. The text component of the experiment was administered using A4 pieces of paper on which a description of the Glebe Road Surgery was provided. The text was reviewed once again by Professors Alan Chalmers, Kurt Debattista, Caroline Meyer, and Peter Bazira and they recommended that some of the details, especially those that had not been represented in the 360°and the virtual environment be excluded. These details were on migration and the loss suffered by refugees (represented in Chapter 1 of this research). Other details excluded were the discussion on the focus group discussion held on 28 March 2017, which was antecedent to the study. Finally, the introduction on access to the NHS, in general, was deemed unnecessary as it had also not been represented in the 360°and Virtual environments. These details were removed to ensure to the extent possible, similarities with the detail in the 360°and the virtual environments. Participants were asked to read the text and respond to related questions thereafter (prepared in french since most of the participants were francophone).

The 360°and VR components were administered using three different media differentiated based on the fidelity including a desktop computer connected to a 4K high Definition 55" screen for maximum high-definition effect, an HTC Vive HMD (see figure 5.8 with handheld controllers, and an HTC Vive Pro to inject the visual and hand-controlled effects (see table 5.2).

5.4.1 Procedure

As a control measure, participants were assigned numbers (0 - 121) before arrival, and the numbers were randomly assigned to the seven different media variations. Upon arrival, each participant was advised on which of the seven media variations they had been assigned to for the experiment. To minimise "practice effect" and risks related to the COVID – 19 pandemic, participants were contacted at least three days prior to the experiment and asked to arrive within a specific time slot. On arrival, they were taken through the COVID-19

protocols which included testing their temperature, sanitising their hands and handing them a pair of surgical gloves to use while manipulating the equipment and to ensure safety in the event of contact with any materials or fixtures inside the room where the experiments were conducted.They were also instructed to hand over the HMD and handheld controls to the investigator for sanitising immediately after use. At this point participants were assigned the media variations that had been randomly preselected for them prior to their arrival. The experiment was conducted in three separate rooms of 20 $\times$ 20 metres for those using the HMDs, and 5 $\times$ 5 metres each for those using the desktop computer and reading the descriptive text.

The participants who took the text component of the experiment were allowed to read through the descriptive text and thereafter respond to the assessment questions (prepared in French). The remaining participants had to go through a five-minute trial of the 360°images and the virtual environment on a desktop and using the HMDs. They were then exposed to a 15 to 20-minute experience of the 360°images and virtual environment of the Glebe Road surgery.

The 360°images and virtual environment were displayed on a desktop computer, and the HTC Vive and HTC Vive Pro HMDs as previously mentioned. They were then given a 10-minute reorientation break before responding to the 14-question assessment to test their knowledge attainment. After a 10-14-day period, the second knowledge retention

Figure 5.8: Participants navigate using the HTC Vive and the HTC Vive Pro

test was administered without recourse to the material provided previously to assess the participants' ability to remember what they had been shown.

Participants were encouraged to respond objectively to all questions, which were designed to give them the opportunity to answer the questions in their own words. The questions were designed to find evidence that on the one hand, a transfer of knowledge had occurred, and on the other, there had been knowledge retention. The Presence and the Immersive Tendencies Questionnaires (Witmer 1998) [132] tested their level of engagement and ascertained what was responsible for that level of engagement and the quality of their experience.

The two questionnaires were based on a 7-point Likert scale to measure the immersive and engagement potential of each individual and the degree to which individuals were able to ignore outside distractions. The intention here was to analyse engagement/immersion as a subjective tendency in relation to the transfer and retention of knowledge.

5.4.2 The Experiment

The entire experiment took between 90 and 120 minutes to complete. There was then a 20-minute break to sanitise all equipment and fixtures before the next group of participants was allowed in. The arrival of participants was carefully choreographed by inserting a 15-minute interval between groups, to minimise contact between the outgoing and incoming participants.

At the end of each session, participants were requested not to discuss any element of the experiment amongst themselves and to return in 14 days to take the "knowledge retention test". They were also debriefed to ascertain if they experienced any harm or discomfort during the experiment, to discuss the expected outcomes of the research and how they would be deployed, and to answer any questions they might have.

5.5 Results

In order to analyse the effect of the media on knowledge transfer and retention, the results of the seven factors were evaluated based on the seven different groups of participants, each of which was exposed to only one factor of the experiment. Considering the sample size (N = 122) and therefore the size of data to be manipulated, we decided to use parametric tests. We also chose the parametric tests because of their higher statistical power over the non-parametric tests, which made it more likely to avoid a type 2 error result [45].

5.5.1 Multivariate Analysis

Initially, a MANOVA was conducted to analyse the results across all DVs. Using Pillai's trace, we found that the group's main effect was significant, F(30,575) = 8.834, $p < 0.001$. The η_p^2 (partial eta squared) was 0.315 implying a large effect size or a greater than 30% chance that the media would have an independent effect on dependent variables. We thus rejected H0 and accepted H1. Due to the multifactorial nature of the analysis, univariate ANOVA for the five DVs was conducted.

5.5.2 Univariate Analysis

This section outlines a more in-depth univariate analysis of the five dependent variables and pairwise comparisons amongst the factors.

5.5.3 Experience

A one-way ANOVA was used to test Experience. The main effect of Experience was significant, F(6,115) = 42.56, $p < 0.001$. On average, across all groups, $\mu = 5.14$ with $\sigma = 1.501$. Individually, the scores of the seven factors in terms of μ, σ, $\tilde{x}$, R, and IQR, are represented in table 5.5.

Pairwise comparisons with Bonferroni corrections are shown in Table 5.8. The table presents pairwise comparisons for all DVs. The factors are sorted by their means (where the leftmost factor has the best mean for that DV). The colour groupings demonstrate a lack of

Table 5.5: Results for "Experience" with each of the media variation used in the main study

Medium	μ	σ	$\tilde{x}$	**R**	**IQR**
Text	3.11	1.370	3.00	5.00	2.00
360D	5.00	0.679	5.00	2.00	1.00
360V	5.71	0.825	6.00	3.00	1.00
360VP	5.74	0.991	6.00	3.00	2.00
VED	5.50	0.650	5.00	2.00	1.00
VEV	6.07	0.514	6.00	2.00	2.00
VEVP	6.26	0.315	6.00	2.00	1.00

significance in the pairwise comparisons. The pairwise comparisons for Experience show quite a complex relationship across the DVs and serve to illustrate how this presentation works. In the case of Experience, there is no statistically significant difference between VEVP and VEV. Furthermore, no statistically significant difference is seen across VEV, 360VP, VED, 360V and 360D. All are statistically better than Text.

The means plots and pairwise comparisons showed a significantly superior mean for the VEVP, with a close match with VEV, which is itself close to the rest of the digital media. The display on HMDs seems to dominate, with 360VP having a higher mean than VED too, albeit with no significant differences shown.

Figure 5.9 shows box plots of the data on participants' experience with the seven media variations, based on a 95% confidence interval. There is a positive correlation between the type of medium used and the satisfaction (experience) of the participants. The boxes shift upward with the media variations pointing to the relative superiority of the VEVP. Based on the range and the IQR, VEVP was superior with an IQR of 1. Accordingly, most participants felt a high level of satisfaction with the VEVP (Range = 5 with the minimum score at 5 and maximum score at 7). Indeed most VEVP participants felt that their experience with the VEVP was either "very good" or "excellent" while the responses from the VEV participants show that their experience was marginally less satisfactory (between "good" and "excellent" but with a wider spread based on an IQR of 2). The 360VP was ranked third with the 360D, the 360V, and the VED all being equally matched. The responses of the Text Participants showed that it was the least preferred medium with

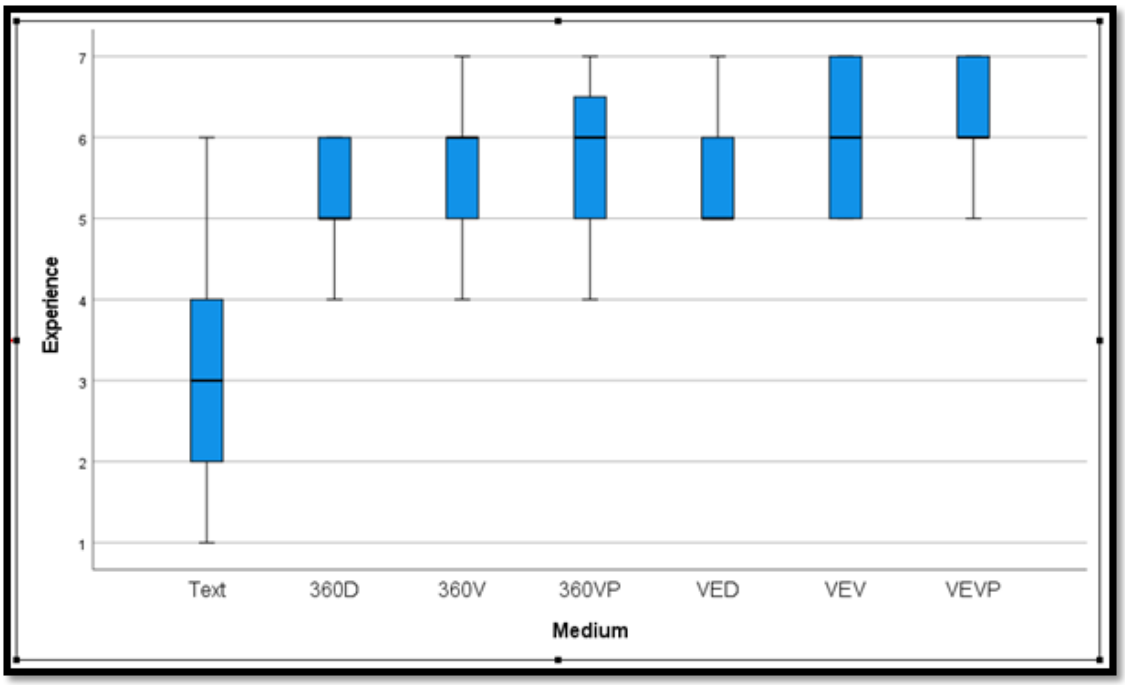


Figure 5.9: Boxplot Showing Participants Experience with the different media variations

most TEXT participants' responses revealing that their experience was either "poor", or just "above average".

5.5.4 Presence

The main effect or Presence was significant, F (5,88) = 25.57, $p < 0.001$. The group mean score was μ = 122.47 and σ = 53.14 and the individual scores for the seven factors in terms of μ, σ, $\tilde{x}$, R, and IQR, are represented in table 5.6.

Table 5.6: Results for "sense of presence" from the main study

Medium	μ	σ	$\tilde{x}$	**R**	**IQR**
360D	137.43	14.463	134.5	33	16
360V	135.50	13.426	133	53	17
360VP	152.05	11.974	153	37	23
VED	145.00	18.000	149.5	62	30
VEV	172.21	21.906	156.5	68	32
VEVP	183.87	13.019	167	29	18

Pairwise comparisons can be seen in Table 5.8 Results show VEVP and VEV elicited a higher level of presence than the rest of the media variations. There was no significant difference between the rest of the media variations.

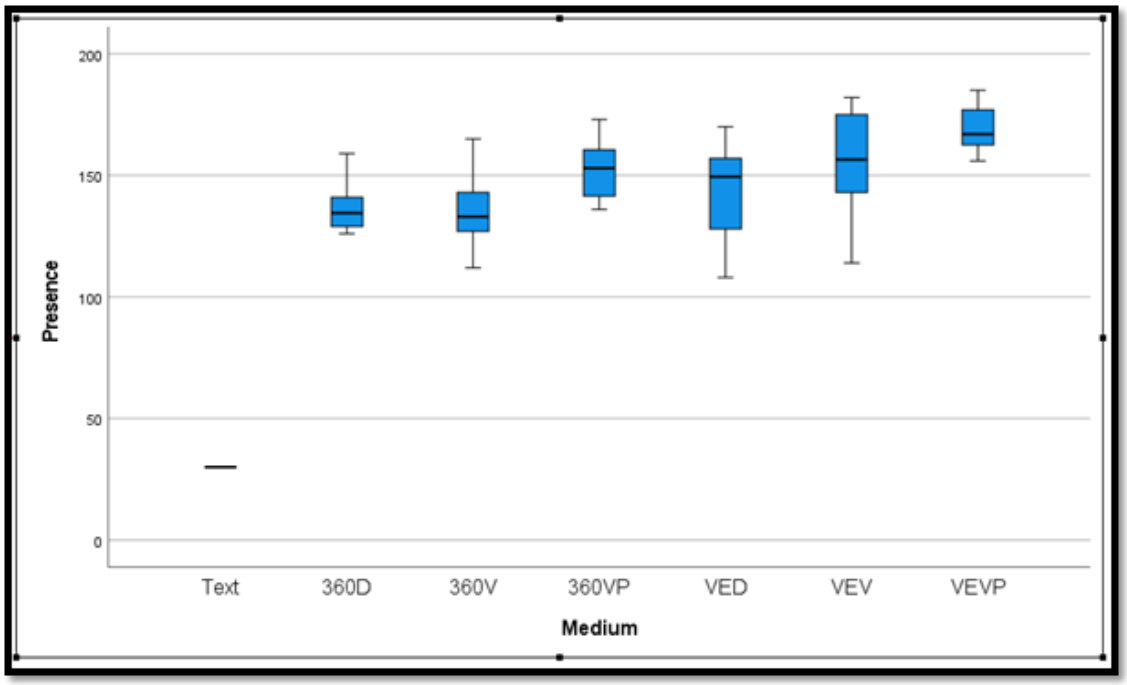


Figure 5.10: Boxplot showing the correlation between the seven media variations and the *"illusion of presence"*

An analysis of figure 5.10 shows a positive correlation between the type of medium used and the illusion of presence. Based on the responses from the VEVP participants, they illusion of presence was highest with the VEVP (see table 5.6 and figure 5.10 for $\tilde{x}$, R and IQR) The VEVP was also right-skewed implying that most participants scored it above 167 which was between "good" and "very good". The VEV had a symmetrical distribution with a wider spread (see table 5.10 showing the results for $\tilde{x}$, R and IQR) and participants rated it as having a less "illusion of presence" than the VEVP. The 360VP was rated marginally better than the VED while the 360 D and the 360 V were not significantly different.

5.5.5 Test1

The univariate one-way ANOVA of Test1 assessed the effect of the medium on the attainment of information/knowledge from the experiment.

The main effect of *"Test1"* was statistically significant, F (6,115) = 31.78, $p < 0.001$. Figure 6 shows the mean scores across Test1. The group mean score was $\mu = 48.33$ and $\sigma = 10.240$ and the individual scores for the seven factors in terms of μ, σ, $\tilde{x}$, R, and IQR,

are represented in table 5.7.

Table 5.7: Results for Test1 from the main study

Medium	μ	σ	$\tilde{x}$	**R**	**IQR**
Text	42.68	7.626	42	36	9
360D	39.86	6.371	41	18	10
360V	43.14	7.210	42	25	13
360VP	45.16	7.366	46	24	15
VED	53.07	5.181	53.5	21	6
VEV	57.57	4.845	57.5	15	7
VEVP	59.58	11.549	58	30	13

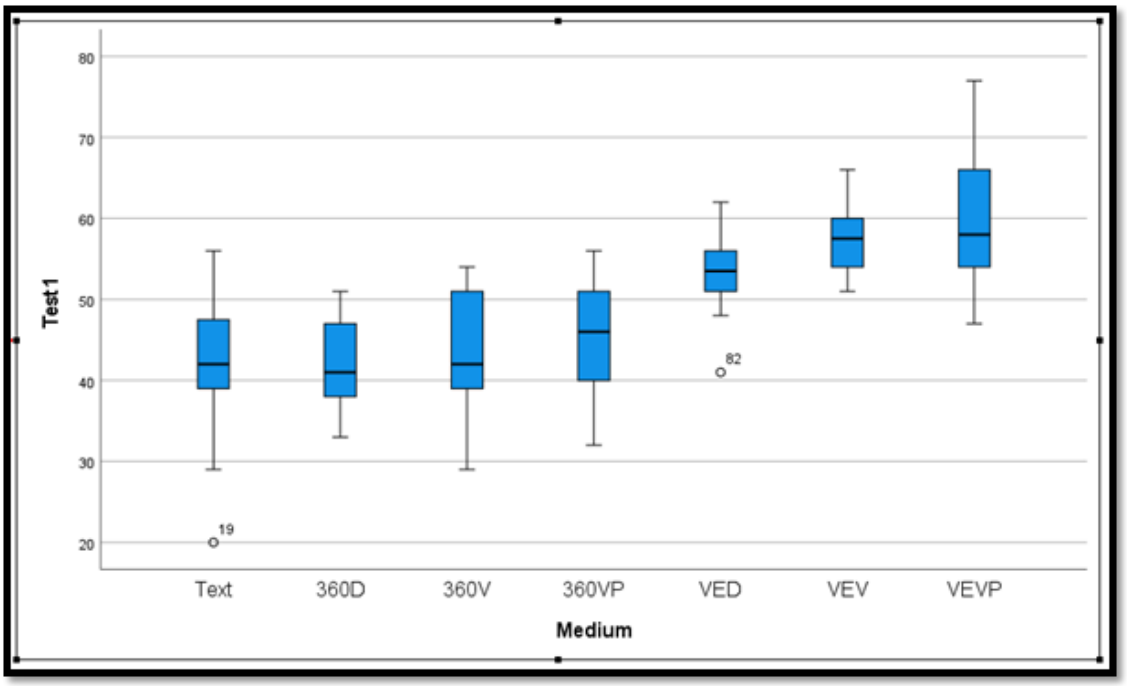


Figure 5.11: Boxplot highlighting correlation between media variations and participants' performance in Test1 (knowledge transferred)

Figure 5.11 shows how participants scored on the assessment Test1, which was administered immediately following the experiment to assess the correlation between the media variations and the knowledge transferred. Based on an analysis of the data, the VEVP ($\tilde{x}$ = 58) although having a marginally superior median than the VEV ($\tilde{x}$ = 57.50), had a much better showing on knowledge transfer based on its right skewed-ness showing that most participants scored above the $\tilde{x}$ = 58. The VEV had a symmetrical distribution meaning that within the IQR (the middle 50% of the participants), as many participants scored below the median as those that scored above it. The Text (see table 5.7 and figure 5.11 for $\tilde{x}$ and

IQR), the 360D and the 360V were more evenly matched. The 360VP scored marginally better than the Text, the 360D and the 360V. The results show the relative superiority of VR with even the VED scoring significantly higher than the Text, the 360D, the 360V and the 360VP.

Pairwise comparisons with Bonferroni corrections can be seen in the Test1 row of Table 5.8. These results demonstrate the superiority of VE on the knowledge attainment test. However, VED and VEV have lower standard deviations than VEVP and the other factors (Text, 360D, 360V, and 360VP as represented in table 5.7) demonstrating the relative stability of the results and therefore a superiority of Virtual Reality.

Table 5.8: Pairwise comparisons, with Bonferroni corrections, between the different factors for all DVs. All factors are sorted left to right by mean. Coloured groupings denote no significant difference amongst factors in a group. A clear, significant, preference for virtual reality emerges.

Experience	VEVP	VEV	360VP	VED	360V	360D	Text
Presence	VEVP	VEV	360VP	VED	360V	360D	
Test1	VEVP	VEV	VED	360VP	360V	Text	360D
Test2	VEVP	VEV	VED	360VP	360V	360D	Text
Usability	VEVP	VEV	360V	VED	360VP	360D	Text

5.5.6 Test2

A one-way ANOVA was conducted for Test2. The main effect was statistically significant, F (6,115) = 61.84, $p < 0.001$. The group mean score was $\mu = 41.8$ and $\sigma = 12.191$ and the individual scores for the seven factors in terms of μ, σ, $\tilde{x}$, R, and IQR,are represented in table 5.9.

Pairwise comparisons are shown in Table 5.8. The mean scores on the knowledge retention/memory test demonstrated the superiority of VE. As with Test1, the lowest SD related to VEV ($\sigma = 4.012$) demonstrating the relative stability of the results and therefore a superiority of VR.

Table 5.9: Results for Test2 administered during the main study

Medium	μ	σ	$\tilde{x}$	**R**	**IQR**
Text	29.46	5.732	29.5	25	8
360D	32.93	5.663	34	18	9
360V	38.36	5.583	37.5	16	10
360VP	40.26	9.309	42	32	18
VED	48.14	6.075	49	24	8
VEV	53.36	4.396	52.5	15	5
VEVP	57.37	9.816	57	32	16

A comparison between Test1 and Test2 demonstrated that participants had a 69% chance of retaining the knowledge they had received through the descriptive text method, a greater than 80% chance of recovering the knowledge transferred by the 360°image, and a greater than 90% chance of recovering the knowledge transferred by VR.

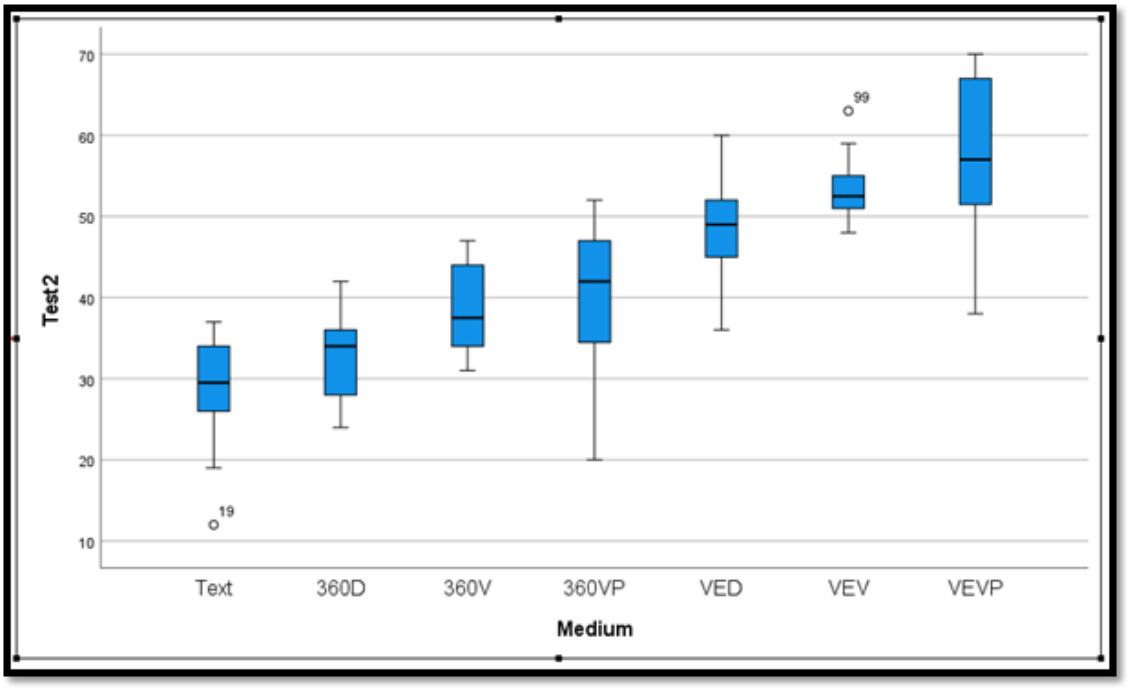


Figure 5.12: Boxplot highlighting correlation between media variations and participants' performance in Test2 (memory)

Figure 5.12 shows how participants scored on the assessment Test2, which was administered between 10 – 14 days after the participants performed the experiment to assess the correlation between the media and the knowledge retained. Based on an analysis of the data, the VEVP (see table 5.9 and figure 5.12 for $\tilde{x}$ and IQR), the test scores of the VEVP

showed a right skew implying that most of the participants scored above the median, which was also above the IQR for all the other media variations. The VEV had a more compact set of results as demonstrated by its IQR (IQR = 5) with participants' scores leaning to the right skewed-ness implying that most scored between the $\tilde{x}$ = 52.50 and Q3 = 55.25. VEV participants scored better than VED (based on $\tilde{x}$ and IQR referenced in table 5.9 and figure 5.12) whose results were more evenly spread between Q2 and Q3. In terms of knowledge retained, Virtual Reality, based on the scores of participants, showed more power than the other media variations. The 360VP participants' $\tilde{x}$, R and IQR were higher than the 360V participants' $\tilde{x}$, R and IQR (see table 5.9 and figure 5.12)although the 360V shows a right skew (implying most participants scored higher than $\tilde{x}$ = 37.50) while the 360VP has a left skew meaning that most participants scored below $\tilde{x}$ = 42.

5.5.7 Usability

Univariate Analysis on usability and its correlation with the different factors of the IV was statistically significant with an F value of F (6,115) = 20.16, $p < 0.001$.

On average, across all groups, μ = 4.66 with σ = 1.265. Individually, the scores for the seven factors in terms of μ, σ, $\tilde{x}$, R, and IQR, are represented in table 5.10.

Table 5.10: Results showing participants' rating of usability of the media during the Main study

Medium	μ	σ	$\tilde{x}$	**R**	**IQR**
Text	3.36	1.254	3.00	3.00	1.00
360D	4.71	0.914	5.00	3.00	1.00
360V	5.29	1.069	5.00	3.00	1.00
360VP	4.79	0.787	5.00	3.00	1.00
VED	5.07	0.829	5.00	2.00	2.00
VEV	6.07	1.072	5.00	6.00	2.00
VEVP	6.105	0.658	5.00	3.00	2.00

Based on figure 5.13 VEVP and VEV ($\tilde{x}$ = 5, and IQR = 2) scored the highest although based on the spread represented by the IQR most VEVP participants rated the medium between "good" and "excellent" for usability while the VEV participants rated the medium

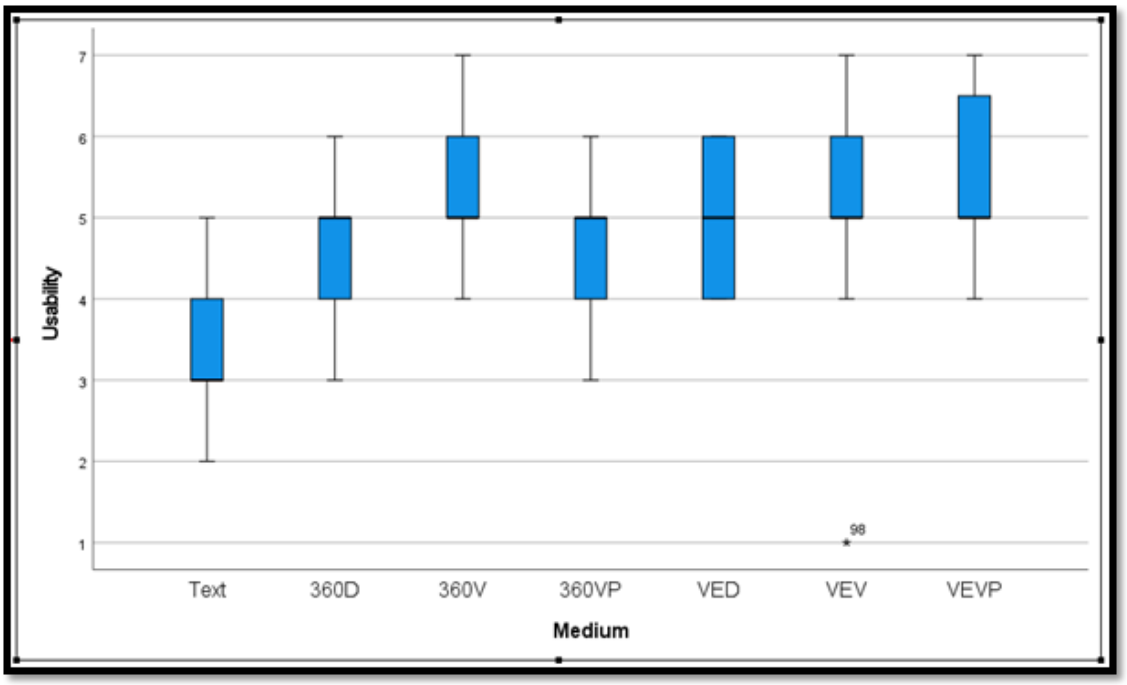


Figure 5.13: Boxplot showing how participants rated the different media variations on usability

between "good" and "very good". The responses from the Text participants revealed a rating of between "average" and "above average" based on the spread represented by the IQR.

5.5.8 Mauchly's Test of Sphericity

Mauchly's test of sphericity was used to test whether or not the assumption of sphericity was met in the repeated measures ANOVA (sphericity refers to the condition where the variances of the differences between all combinations of related groups are equal [80]). Violation of the assumption would have meant an inflated F-ratio and therefore unreliable ANOVA results. Mauchly's test indicated that the assumption of sphericity had been violated given the F value of F(1.111, 134.411) = 497.347, $p<.001$ (statistically significant result), implying that the assumption of sphericity had been met. The degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity (ε=.278). The results show that the dependent variables (*"Usability", "Experience", "Presence", "Test1" and "Test2"* were significantly affected by the different levels of the medium (Text, 360D, 360V, 360VP, VED, VEV, and VEVP). We also applied the same test to the independent variables

as a between-subjects factor. It showed a statistically significant result (F[1.568, 180.319] = 5862.131, p<.001) and also met the assumption of sphericity.

5.5.9 Analysis of Partial Eta Squared

Based on an analysis of η_p^2 for dependent variables (Experience: η_p^2 = 0.606, Presence: η_p^2 = 0.943, Test1: η_p^2 = 0.503 and Test2: η_p^2 = 0.701), it was determined that the independent variables (media of knowledge transfer) had a large effect on the dependent variables (*"experience", "illusion of presence", "Test1", "Test2", and "usability"*).

5.5.10 Pairwise Comparisons

The independent variable had seven levels (Text, 360D, 360V, 360VP, VED, VEV, and VEVP). Recognising the possibility of a type I error due to the types and number of previous tests conducted, we sought to compare pairs of the different media variations using the Bonferroni Correction. We measured if each of the "levels" were statistically different from each other. For each of the Dependent variables, we conducted 21 different pairwise comparisons, implying 126 comparisons for the five dependent variables in addition to the CSV. For each test we used an α=.05 (or a confidence level of 95%).

5.5.11 Test1

The test of between subjects effects showed a non-statistical result of F(6,115) = 31.787, p<.001 and η_p^2 = .624 which showed that 62% of the time, the independent variable influenced the scores in *"Test1"*.

The Pairwise comparisons showed a statistically significant difference between the text and three other factors (VED, VEV, VEVP). Accordingly, when compared to the 360D, the

Text ($p<1.000$), 360V ($p<0.929$) and 360VP ($P<.081$) all had statistically insignificant differences while the VED ($p<.001$), VEV ($p<.001$) and VEVP ($p<.001$) all showed statistically significant differences.

Additionally, VED showed no statistically significant difference when compared to the 360VP ($p<1.000$) although it had statistically significant differences with Text and 360D ($p<.001$) as well as the 360V ($p<.019$).

The 360V showed a statistically insignificant difference when compared to the 360D ($p>.929$), VED ($p>.008$), but a statistically significant difference when compared to the VEV ($p<.001$) and VEVP ($p<.001$). The same outcome held true with the comparison against the 360VP, with only the VEV ($p<.001$) and VEVP ($p<.001$) showing statistically significant differences.

Only the comparison against the VEVP and the other factors showed a statistically significant difference for all the factors of $p<.001$ across the board.

There was however no statistically significant difference when the VEVP was compared to VEV ($p<1.000$). This analysis showed the VEV and the VEVP to be statistically significantly different from the other factors (Text, 360D, 360V, 360VP, and VED) although the VED was also statistically significantly different from Text, 360D, and 360V.

All the other pairwise comparisons showed no statistically significant difference between the other four variations (Text, 360D, 360V, 360VP). The VEV was also not statistically significantly different from the 360VP ($p=.088$), although it was statistically significantly different from 360V ($p<.019$), 360D ($p<.001$), and the text ($p<.001$).

5.5.12 Test2

The test of between subjects effects showed a non-statistical result of F(6,115) = 61.835, p<.001 and η_p^2 = .763 showed that 76.3% of the time, the independent variable influenced the scores in *"Test2"*.

The Pairwise comparisons showed no statistically significant difference between Text and 360D (p<1.000), 360D and 360V (p<.929), 360D and 360VP (p<.081), and 360V and 360VP (p<1.000). There was also no statistically significant difference between VEV and VEVP. All pairwise comparisons against the VE factors showed a statistically significant difference between VEs (VED, VEV and VEVP) and the other DV factors (Text, 360D, 360V and 360VP). There was however no statistically significant difference between VEV and VEVP (p<1.000).

5.5.13 Experience

We then used the DV *"Experience"* (see figure 5.9). All six factors (360D, 360V, 360VP, VED, VEV, VEVP), showed a statistically significant difference with the *"Text"* with η_p^2 = 0.689. The F value was F(6,115) = 42.559, p<.001 and the P value was p<.001 across all the six aforementioned variations.

Additionally, VEVP showed superiority to the rest, scoring p<.001 (Text, 360D and VED), and p<.007 (360V), and p<.003 (360VP). There was however no statistically significant difference when the VEVP was compared to VEV (p<1.000). All the other pairwise comparisons showed no statistically significant difference between the other four variations (360D, 360V, 360VP, and VED) including the VEV which showed no statistically significant difference except in the case of the VEV vs 360D ((p=.001) and VEV vs Text (p<.001).

5.5.14 Presence

Using the Bonferroni correction (which has a confidence level of 99%), we compared the seven different levels of the independent variable using the DV *"presence"* (see figure 5.10). They (360D, 360V, 360VP, VED, VEV, VEVP), all showed a statistically significant difference with the *"Text"* with a $\eta_p^2 = 0.946$.

The F value was F(6,115) = 336.889, p<.001 and the P value was p<.001 across all the six aforementioned variations. Additionally, VEV and VEVP showed a statistically significant difference (p<.001) when compared with 360D, 360V, 360VP, and VED. They however showed no statistically significant difference when compared to each other (p<.422).

All the other pairwise comparisons showed no statistically significant difference between the other four variations (360D, 360V, 360VP, and VED) except in the case of the 360V compared to the 360VP which showed a statistically significant difference (p<.016).

5.5.15 Usability

The test of between-subjects effects showed a non-statistical result of F(6,115) = 20.155, p<.001 and $\eta_p^2 = .513$ showed that just over half of the time, the independent variable influenced the scores across all five independent variables.

The Pairwise comparisons showed a statistically significant difference between Text and all the other six factors (p<.001). There was no statistically significant difference between 360D, 360V, 360VP and VED (p<1.000), although a comparison between 360D and VEV showed a statistically significant difference (p<.008).

There was also a statistically significant difference between the 360D and the VEVP (p<.002). On the other hand, there was no statistically significant difference between 360V and 360VP (p<1.000), VED (p<1.000), VEV (p<.776) or VEVP (p<.410). There was

also no statistically significant difference between 360VP and VED ($p<1.000$). There was however a statistically significant difference between 360VP, VEV ($p<.007$) and VEVP ($p<.001$). The VED : VEV ($p<.171$), VED : VEVP ($p<.072$) and the VEV : VEVP ($p<.171$) also showed no statistically significant difference when compared to each other.

5.6 Discussion

This study showed important tendencies that knowledge transfer, experience, usability and presence were strongly impacted by the type of medium used and the level of realism presented. On average, VR outperformed all the other variations most likely due to its inherent ability for interaction and engagement.

The 360°came second and the text variation, third. The significant difference in the performance of VEV and VEVP on the one hand, and the Text, 360D, 360V, 360VP and VED on the other, can be surmised as the import of the fidelity or level of realism and the triangulation between immersion, sense of presence and engagement as shown in figure 1.4 in Chapter 1. The effect of fidelity and interaction can also be seen in how 360VP consistently outperformed 360V and 360 and VED on some occasions.

Overall, it could be argued that a lower level of engagement and the interactiveness of the text and 360°images may have had the biggest impact on their relatively lower scores on memory processing.

For refugees to better comprehend the descriptive text, and to appropriately apply that knowledge, they would have required prior knowledge of the NHS or the Glebe Road Surgery. This would have helped them to formulate mental models of what they were being asked to internalise. The same applies to the 360°images, where more images would have been required to provide a more wholesome story, and potentially fill "information gaps". The general lack of prior knowledge meant that participants who were exposed to the text and 360°images, possessed a poorer internal source of information which then made mental model construction from the information provided, relatively more difficult.

On the other hand, the VE offered alternative routes for mental model construction. In particular, it did this through its inherent ability to bring the participants into the health system and thus create a lasting memory of what that system actually looks like, and the experience of navigating it.

5.7 Summary

According to our study, the use of virtual experiences offers the potential as an important knowledge acquisition tool for refugee integration.

The obtained results indicated clearly that the VR could be used as a powerful knowledge transfer tool because of its superior ability to transfer knowledge to users, its interactiveness which allows for repeat movements, thus allowing for memory retrieval and consolidation and re-consolidation during usage and the higher level of satisfaction (experience) derived from its usage.

Chapter 6

The Effect of Media on Memory

This chapter presents the results of a longitudinal study of the knowledge retained by the participants in the second experiment. It investigates further the basic conclusions arrived at in chapter five related to the efficacy of the different media of knowledge transfer used during the experiment. Eighty-nine out the initial 122 participants took part in this study. It was conducted six months after the initial study to ascertain the rate of decay of the knowledge transferred six months earlier.

6.1 The Objectives of the Longitudinal Study

The aim of this study was to establish the efficacy of each of the three media in establishing a long-lasting memory among participants. It measured to what extent participants could recall the knowledge they had received. This was assessed by use of the same 14-question questionnaire presented to them as Test1 (immediately following the experiment), Test2 (10 – 14 days after the experiment) and now Test3 (six months after the experiment).

6.2 Materials and Tasks

All participants were provided with the same questions that had been administered as Test1 and Test2. The information contained in all three components was identical for all participants. They were requested to respond to the 15–question questionnaire to the

best of their recollection and to ensure that the answers were objective and based on their recollection.

6.3 Selection of Participants

The participants were notified by email, phone calls and through their leadership. Person-to-person contact played a major role in ensuring that 89 of the 122 participants who had participated in the second experiment returned to take part in the assessment Test3.

- Text (Text): N = 19
- 360-degree Image on a Desktop (360D): N = 11
- 360-degree Image on the HTC Vive (360V): N = 10
- 360-degree Image on the HTC Vive Pro (360VP): N = 16
- VE on a Desktop (VED): N = 10
- VE on the HTC Vive (VEV): N = 8
- VE on the HTC Vive Pro (VEVP): N = 15

All participants had the same knowledge that they had acquired during the experiment.

6.4 The Procedure

Participants who were exposed to the second experiment were contacted by email and through person-to-person contact, to engage in the longitudinal study. They were then given instruction on how to respond to the 15–question assessment questionnaire before being allowed to complete it.

6.5 Control Mechanisms

All the participants (N = 89) received the same instructions, including specifically being instructed not to confer with each about any aspect of the experiment. They were put in

separate rooms and monitored as they took the test. They all came into the experiment with the same level of knowledge about the study. At the end of each session participants were informed of how the results from the study would be used and asked them if they had any questions that they would like answered.

6.6 Results

In order to analyse the effect of the media on knowledge transfer and retention, the results of Test3 were evaluated based on the seven media variations (see section 6.3).

6.6.1 Multivariate Analysis

A MANOVA was done to analyse the results across all seven DVs. Using Pillai's trace, we found that the group main effect was significant, F (8,82) = 5.842, p ¡ 0.001. The η_p^2 was 0.299 implying a 30% chance that the media would have an independent effect on knowledge transfer and retention. We then conducted a univariate ANOVA due to the multifactorial nature of the analysis.

6.6.2 Univariate Analysis for Test3

A univariate analysis of Test3 was then conducted in addition to pairwise comparisons amongst the factors. The main effect of Test3 was significant, F (6,82) = 15.086, p ¡ 0.001. On average, the mean and standard deviation across all groups were μ = 24.84 and σ = 13.828. Individually, the scores for the seven factors in terms of μ, σ, $\tilde{x}$, R, and IQR,are represented in table 6.1.

The η_p^2 of 0.525 signified a large effect size (over 50%) of the media on knowledge transfer and retention or 52.5% of the variance in the dependent variable (Test3) is attributable to the media.

Table 6.1: Results for Test3 administered during the Longitudinal study

Medium	μ	σ	$\tilde{x}$	**R**	**IQR**
Text	12.32	1.701	12	7	3
360D	20.00	5.292	21	11	8
360V	21.60	8.369	21.5	9	5
360VP	24.06	6.923	24	28	7
VED	24.40	10.762	26	18	8
VEV	33.75	13.936	35	22	11
VEVP	42.80	16.721	45	27	11

Pairwise comparisons with Bonferroni corrections were conducted to reduce the possibility of a type 1 error. The Pairwise comparison sorted by means showed no statistically significant difference between the "Text" and the 360D (p = 0.907), 360V (p = 0.386), and the VED (p = 0.051), but a statistically significant difference between the Text the 360VP (P = 0.016), the VEV (p = 0.000) and the VEVP (p = 0.000). The means plots and pairwise comparisons showed a significantly superior mean for the VEVP, when individually compared to all the other factors although a match-up between the VEVP and the VEV showed no statistically significant difference (p = 0.828).

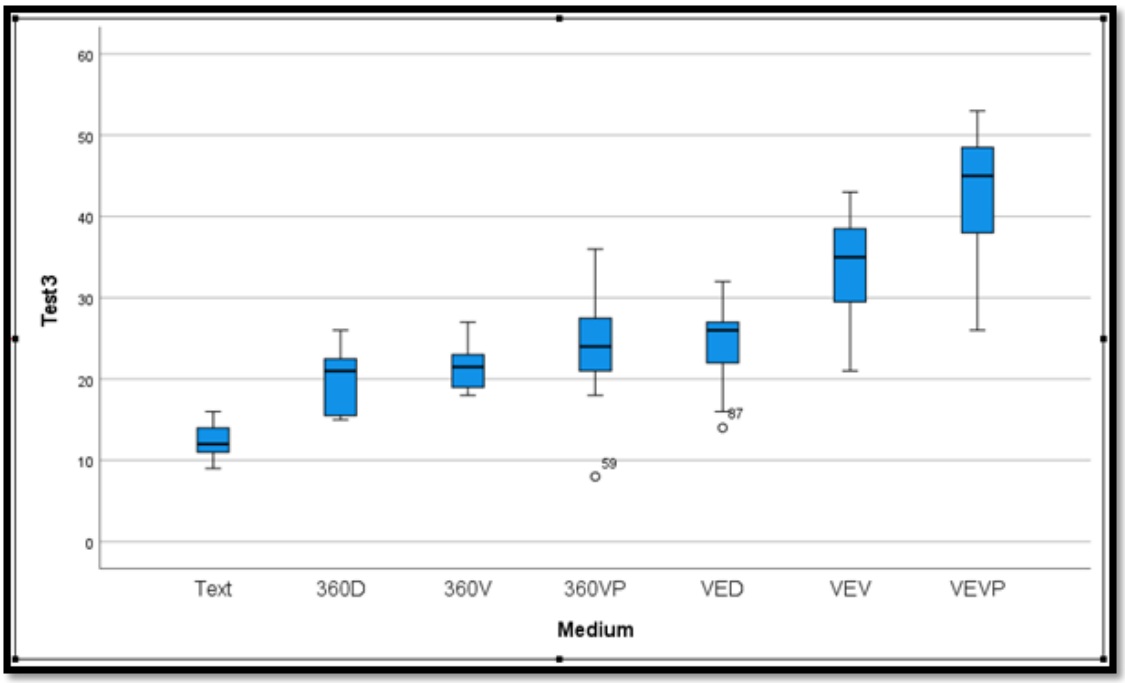


Figure 6.1: Boxplot showing the correlation between the media variations and long - lasting memory based on assessment Test3

Figure 6.1 shows how participants scored after the third assessment test. The test

was administered 6 months after the participants performed the experiment to assess the correlation between the media and long-term memory. Unlike the results in Test2, all the media variations, are right skewed except for the Text (left skew), and the 360VP (symmetrical distribution). This means that with the exception of the Text participants most of whom scored above the median ($\tilde{x}$ = 12), and the 360VP participants, all the other participants scored below the median score. Nonetheless, the VEVP participants scored better than the rest of the participants although the IQR (IQR = 11) and Range (R = 27) show a much wider dispersal of the scores. The VEV participants ($\tilde{x}$ = 35, R = 22 and IQR = 11) scored better than the other groups (Text, 360D, 360V, 360VP and VED), who were more evenly matched.

6.7 Discussion

The longitudinal study revealed critical linkages between assessment Test3 (a measurement of participants' ability to remember) and the knowledge transfer media. It showed the importance of the triangulation between immersion, sense of presence and engagement, and the import of a high level of realism, and its power to elicit knowledge retention. These conclusions were evident based on the use of pairwise comparisons where the VEVP and to a lesser extent the VEV, outperformed the other media of knowledge transfer. The importance of fidelity was evident in terms of how the VEV outperformed the other multifactor (Text, 360D, 360V, 360VP and VED). The importance of fidelity also showed in terms of the superiority of the 360VP over the VED.

6.8 Summary

The overarching aim of this study was to ascertain whether VR, compared to other media, was the most efficacious medium of knowledge transfer, and retention. Our overriding hypothesis was that "new" knowledge can cause a change in attitudes and behaviour based on the underlying premise that refugees when they arrive in third countries, have limited

knowledge of their environment which makes it harder for them to integrate into their new societies. The experiments indicated a linear correlation between the type of medium used to provide information and the amount of knowledge transferred and retained. The longitudinal study indicates that participants who were exposed to the more interactive media with a high level of realism, were more likely to retain the information they had received.

Chapter 7

Thesis Discussion

The purpose of this research was to bring a deeper understanding to the effectiveness of virtual reality in eliciting knowledge transfer and retention, ultimately affecting perceptions, cognition, and behaviours. In this regard, the research aimed to contribute towards an understanding of how such knowledge transfer can be more effectively used to help refugees integrate more smoothly into third countries.

Chapters 4 and 5 outlined the experiments conducted to investigate the veracity of the hypothesis that VEs were the most efficacious of three media used to transfer knowledge. Chapter 6 was a longitudinal study on which of the media performed best in influencing retention of knowledge or enabling participants to better remember the knowledge that they had received. Chapter 7 summarises the main findings of the two experiments and delves into the potential impact of this research.

7.1 Summary of Main Findings

The use of VEs to enhance knowledge transfer is based on their intrinsic power to transmute virtual experiences into "real world environments" and to draw human beings into performing actions within the virtual world, as though they were in the real world. They provide an emotional engagement by their ability to present information in a manner that

appeals to a human's selective attention to various stimuli (visual, auditory and haptics). Through their natural appeal brought about by interactiveness buttressed by the level of realism or a plausible closeness to interacting with the real world, they allow for a more fulsome and efficient use of memory. This is born of users' ability to navigate VEs and revisit the experience over and over again without inhibitions arising from inaccessibility.

This research supports the premise that VEs draw users into habitation of virtual situations that leads to deeper than usual engagement and strengthen knowledge transfer, retention, and replication. The research has proposed a high-fidelity virtual experience in order to activate a higher degree of engagement, immersion and knowledge transfer. It also proposes the illusory appeal of VEs to enhance perception of users and increase their ability to replicate whatever knowledge they may have attained. Our results show the potential of virtual reality in knowledge transfer and retention, and the relationship between perceptual presence users in a virtual non-space and the level of knowledge transferred.

7.1.1 The Correlation between Knowledge Transfer and Fidelity

The experiment in Chapter 5 investigated the correlation between fidelity and knowledge transfer in both the VE and the 360°images in order to assess how much of an influence graphical fidelity had on the amount of knowledge transferred. The study measured how participants scored in the assessment tests when using higher fidelity media (VEVP and 360VP), compared to the other media where the fidelity was lower. The findings indicate that the higher the fidelity as represented by the graphic detail of VE or 360°images, the higher the assessment test scores. It is notable however that although the HTC Vive Pro has higher resolution and therefore would have had a relatively higher level of realism, there was no statistical difference between the VEVP and the VEV. Nonetheless, there was statistically significant mean difference between the VEVP and VEV on the one hand, and all the other media factors on the other, demonstrating that fidelity had a major role to play in the efficaciousness of VEs as a medium of knowledge transfer but that role

diminished when the HMDs were measured against each other (see table 5.8. Indeed, the poor performance of the 360VD in the first experiment underlined the importance of graphical fidelity considering that there was no statistical mean difference between the "Text" and 360VD.

Accordingly, based on the results of the experiments and the longitudinal study, it could be surmised that there is a correlation between graphical realism and the process of knowledge transfer. Previous studies have pointed to the vitality of fidelity. Ruggeroni (2003) [98] studied immersiveness and the knowledge transfer process and concluded that knowledge transfer is enhanced by fidelity or the relationship or resemblance of the VE to the real world. The study also highlighted the importance of interaction with the real world as being central to knowledge transfer. As such, the transfer of knowledge is a sort of inter-spherical process where the user moves from one world or sphere to another by suspending disbelief. This makes the level of believability, interactivity, and immediate feedback crucial.

In most cases refugees do not get to experience resettlement countries before they arrive. And so, the experiment was an attempt to respond to questions of how we can draw refugees into inhabiting a situation, in this case the Glebe Road Surgery as a representative feature of UK National Health Service (NHS) using three disparate media. The movement in the environment was therefore not just spatial but abstract as well. More than the other media (the Text, the 360°images and to a lesser extent the 360°video), the VE offered the possibility to view the "abstract" world from different perspectives which according to Lackner et al (1998) [63] enhances the sense of being there; the illusion of presence. The results of these two studies support our finding that fidelity and presence play a central role in knowledge transfer and that is what makes VEs potentially more effective than the other media that were measured against the VE. Figure7.1 illustrates the affect of presence and interactivity and how it would influence knowledge transfer.

As shown in Figure 7.1 knowledge transfer is influenced by the sense of presence,

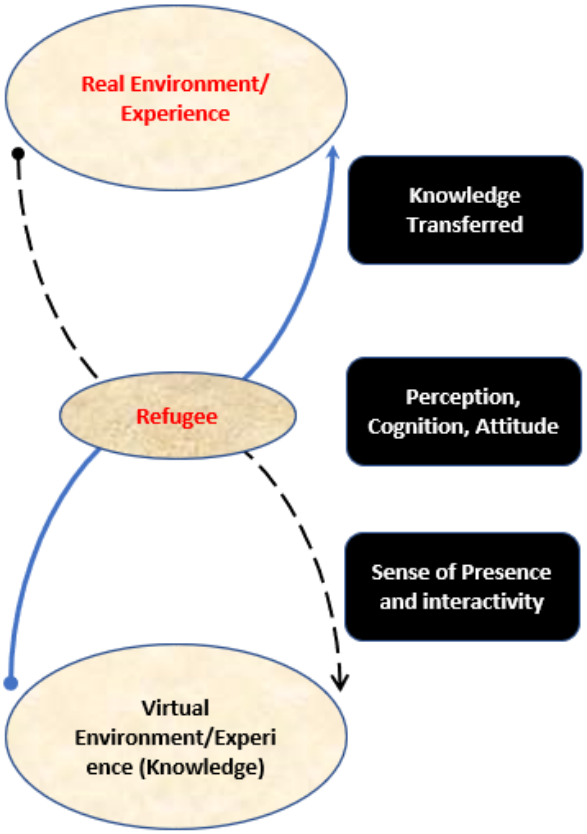


Figure 7.1: A Hypothetical Representation of Knowledge Transfer as influenced by bringing together VEs and the Real World (Modified from Ruggeroni (2001) Transfer Schema [98]

interactivity and immediate feedback and it works in a continuous loop due to a VE's ability to allow the participants to revisit their experience over and over again and to compare the virtual experience with what they already knew. In other words, the VE and the real world were correlated by an asymptotic relationship comprised of visual fidelity, which influenced the perceptions, cognition, and attitudes of participants to the actual context. This resulted from the formulation of mental representations arising from the linear relationship between the VE or the depictive representations and the knowledge transferred. These were induced by the sense of being "there" (present) and the ability to interact within the Virtual Environment (spatial navigation without interaction with specific objects). It should be noted that some of these mental representations are a feature of previous experiences which fed into cognitive processes as outlined by the conclusions presented in Chapter 5.

To further clarify these assumptions, additional research on the affect of multi-sensory VEs on knowledge transfer is necessary. This would inform interpretation on the import of multi-sensory engagement, and immersiveness to cognition, perception, and attitudes.

7.1.2 Sense of Presence and Knowledge Transfer

The results from the experiment outlined in Chapter 5 indicate that participants who experienced a higher sense of presence also attained a higher level of knowledge transfer. The sense of presence was measured by the robust 32-question Witmer and Singer questionnaire (Witmer and Singer, 1998) [132]. The primary conclusion based on the responses of participants was that generally participants experienced a higher sense of presence with the VEVP when compared with the VEV, VED, 306VP, 360V, 360D and the Text. The importance of presence on knowledge transfer and the correlation thereof, is also underlined by the pilot experiment where VEV scored higher than both the Text and the 360VD on sense of presence as well as on assessment Test1 which was the measure of knowledge transfer. Conversely, 360VD which had much poorer visual fidelity in the pilot experiment, demonstrated no statistically significant difference both in terms of presence as well as Test1, when compared to the "Text" component of the experiment. There was also a statistically significant mean difference between VEV in the pilot experiment (see table 4.5) and VEVP in the second experiment (see table 5.6). Note that the VEV in both experiments had roughly the same scores ($\mu = 159.50$, $\sigma = 10.196$ and $\mu = 172.21$, $\sigma = 21.906$).

The implications that we draw from both sets of experiments were that design features of the media and specifically of VEs (the use of the HTC Vive Pro in the second experiment which had better visual fidelity features), as well as 360°video and images, gives rise to positive effects in the form of better scores for knowledge transfer and retention and in general spatial cognition.

These results showed a clear correlation between sense of presence and knowledge transfer and are supported by the conclusions of a previous study by Coelho (2006) [22], which found that presence is the essence of any experience in VR. As in the Coelho study, our research found that both the technological experience (design) and the psychological experience (appearance) were central to the participants' experience. It also found a correlation between the experience of participants and the level of knowledge transfer, and retained.

7.1.3 The Correlations between Experience and Medium Efficacy in Knowledge Transfer

The first and second experimental studies of this thesis investigated the potential impact of the participants' experience on knowledge transfer. The experiments allowed participants to spatially navigate the environment, experience it and by so doing gain knowledge about the Glebe Road Surgery. According to Hudson (2019) [52], experience is equitable to satisfaction. This study suggests that experiences are based on "things, surroundings and other people". The study confirmed that interactivity with things in the VE plays a vital role in increasing the feeling of presence in the VE and thus had a positive effect on the satisfaction of the participants with the VE as a medium of knowledge transfer. Indeed Sutcliffe (2016) [121] supports this view by asserting that designing VEs with interaction increases the positive experience of users. This study did not delve into the importance of social interactions to the participants experience in part because there is no consensus as to the importance of social interactions. For instance, Hudson (2019) study [52] indicated an inverse relationship between social interaction and experience as epitomised by immersion. The study noted that the more the social interaction the less likely the possibility of immersion. Other studies such as Vella (2016) [129] and Nagy (2014) [86] however show the opposite.

We determined that for purposes of our study, social interactions between participants

would act as an interference and therefore negatively impact the participants' experience as embodied by immersion. Moreover, this view is supported by Sweetser (2005) [122] who showed that social interaction interrupts immersion and could negatively impact experience. We suggest that this effect is particularly potent in the type of experience we studied because it is focused on achievement of individual outcomes. These assertions on interaction and immersion as the underlying features to participants' experience are underpinned by the findings resulting from the transitions in design made to the second experiment from the first. These changes included minimising of external interferences, such as chatter from other participants, ensuring each participant was accorded enough personal space without interference. In addition, changes to the fidelity of the 360°representations led to an improved mean score on experience while the introduction of the HMD for the 360°representations and the HTC Vive Pro for the VEs also resulted in improved mean scores for the "Experience" as a DV.

Accordingly, the mean scores for "Experience" during the second experiment see 5.5 were an improvement on the mean scores recorded in the pilot study as highlighted in table 4.3. The VEV for instance scored $\mu = 6.07$ and $\sigma = 0.514$ compared to the pilot study where it scored $\mu = 5.430$ and $\sigma = 1.284$. It should also be noted that in both the first and second experiments, the η_p^2 for "Experience" as a DV was 0.437 and 0.606 respectively implying a large sized effect of nearly 44% in the first experiment and 61% in the second experiment (after the changes) that the type of medium used impacted the participant's experience. Furthermore, there were linear correlations between "Presence", "Experience", Test1 and Test2 with higher mean scores in "Presence" largely correlating with higher "Experience" mean scores and translating into higher mean scores in Test1 in both experiments.

7.1.4 Knowledge Transfer, Retention and the Concept of Memory

Chapters 4, 5 and 6, discussed aspects of knowledge transfer, retention, and memory consolidation. The research measured knowledge transferred via the three media using

three assessment tests (Test1, Test2 and Test3). Test1, which was conducted immediately following the experiments, targeted to what extent knowledge had been transferred to the participants by use of the three identified media of knowledge transfer, and through the multifactorial approach used in the second experiment. Both cases raised the question of transfer from the virtual world to the terrestrial world. The results in Test1 of the pilot experiment returned the following mean scores for the different media: Text: μ = 69.91 and σ = 25.3; 360VD: μ = 67.5 and σ = 23.103; and VEV: μ = 95.57 and σ = 22.159. The η_p^2 based Bonferroni correction was 0.474 implying a nearly 50% (or one out of two) probability that the media would have an independent effect on knowledge transfer. These results also demonstrated the superiority of VE on knowledge transfer in part because of the large size effect of fidelity, presence, immersion, and experience as previously discussed in this chapter.

In the second experiment, the scores from Test1 differed significantly from the scores attained during the first experiment. This was in part because of design changes made to the second experiment in response to lessons learned from the pilot study. These design changes included, amongst other things, changes to the form, substance, and number of questions. The Test1 administered during the first study was a 21-question questionnaire. The questions were reformulated and reduced to 15 in the second experiment and thus the difference in mean scores. This also meant that it was difficult to compare the two Test1 results. Based on the 21 – question questionnaire, the mean scores in test 1 were μ = 69.91 for the Text, μ = 67.5 for the 360VD and μ = 95.57 and σ = 22.159 for the VEV. The η_p^2 based on the Bonferroni correction was 0.474 implying a nearly 50% chance that the medium impacted Test1 scores.

During the second experiment however, the mean scores were slightly different. Based on the mean and SD scores for the Text, the 360D and the VEV as shown in table 5.7, it is clear that the scores in second experiment were much more centred towards the mean than during the first, which is perhaps attributable to the changes made to the questionnaire to

reduce subjectivity and inject objectivity. VEVP returned superior scores, although it is notable it had a higher standard deviation than the VEV. The η_p^2 based on the Bonferroni correction was 0.624 implying that there was a high probability (about two-thirds or 62%) that the medium was impacted by the results in Test1.

As part of the second experiment, a second test (Test2) was administered to ascertain participants' ability to retain the knowledge they had gained during the experiment. The test was administered 10 – 14 days after the experiment. The results of Test2 once again showed the VEs to be superior to the other media (360°and the Text). This was the same method used by Chittaro (2015) [20]. That study compared an HMD-based immersive game for educating passengers about aviation safety with a traditional aviation safety education method (the safety card). They assessed the knowledge transferred and retained by administering a knowledge test before, immediately after and one week after the experimental condition. As in this study, our experimental evaluation using the Bonferroni correction, showed that, the VEs (particularly VEV and VEVP) produced greater knowledge transfer which was maintained after 10 days. People who used the Text and the 360°suffered statistically significant loss of the acquired knowledge after the 10 – 14 days.

A third test was run six months after the experiment to assess the level of memory decay that had occurred. The means plots and pairwise comparisons showed a significantly superior mean for the VEVP, when individually compared to all the other factors although a match-up between the VEVP and the VEV showed no statistically significant difference ($p = 0.828$). This demonstrated the superiority of immersive VE over the other multifactors in ensuring no statistically significant memory decay.

7.2 The Correlation between Experience and Knowledge Gained

Engagement, fidelity or the level of realism, the sense of presence, leading to satisfaction or "memorable" experience turned out to be central issues to the research presented in

this thesis. In order to investigate the impact of experience and by extension fidelity and sense of presence on knowledge transfer, lessons learned from the first experiment were used to transform the second experiment. Changes were made to the text by removing elements that were deemed unnecessary and unrepresented in the 360°and the VR media. Further changes were made to the 360°and the VR media by ensuring that they were both displayed using the same output and that the output was varied to ensure incrementally better graphical displays by using a high quality 4k screen and then progressively moving on to the HTC Vive and the HTC Vive Pro which have significantly different visual displays (see table 1.1). Additionally, social distractions were minimised by ensuring that participants did the experiments in silent conditions, to enhance the sense of presence and the immersive tendencies of the HMDs. Although the study specifically focused on the visual output and did not use the audio output, we determined outside noise would have been a distraction and sought to limit it. A common outcome was that the sense of presence was an important factor in eliciting knowledge transfer and retention.

Considering the knowledge transferred and retained between the three tests (Test1, Test2, and Test3), the results of this experiment confirm that the sense of presence and immersive tendencies of VEs made them more effective than the 360°Video, 360°images and the Text. In addition to the aforementioned, a few observations held true. First, participants were allowed to spend as much time as they wanted in the experimental condition. Second, within the group, they mostly displayed similar knowledge as epitomised by the low Standard Deviation scores (particularly during the second experiment) which shows that they paid attention to the material provided to them. Third the unstable nature of the Test1 results in the pilot study as evidenced by the large sized standard deviations (see table 4.6) for the Text, the 360VD and the VEV as opposed to their SD during the second experiment as highlighted in table 5.7. In the second experiment the SD between Test1 and Test2 was relatively more stable demonstrating that the changes in conditions outlined previously in this chapter, enhanced the transfer and retention of knowledge. Finally, while the results of this study consistently demonstrate the power of VEs, it is important to note that the study was conducted under controlled conditions which means a different study under a different

set of conditions might be necessary to determine the superiority of VEs Importantly, the merits of the VEs are further emphasised when the differences between Test1 (conducted in the immediate aftermath of the experiment), Test2 (10 – 14 days after the experiment) and Test3 (six months after the initial experiment), which show that there was no statistically significant loss of knowledge after six months as opposed to the 360°images and the Text where participants suffered statistically significant knowledge loss. One of the factors to which this could be attributed, was the relationship between their experiences as aroused by their sense of presence triggered by the illusory appeal of VEs, and transfer and retention. This is supported by the Silverstein et al. (2002) [108] and Kruglikova (2010) [61]. In both studies, the effectiveness of a VR system was evaluated by administering a test that consisted of 24 questions, before (pre-test), immediately after (post-test) and six months after a 45-minutes experiment. In both evaluations, there was no significant degradation in a retention test performed 4-6 weeks after the last repetition.

Therefore, VEs ability to offer better emotional arousal in the form of a more positive experience, as well as the advantages related to interactivity and therefore the ability to go over the same scene several times allows for superior knowledge transfer and retention, as well as memory consolidation through these repeat actions. Engagement and experiences are essential features that would allow for design features in a virtual system targeting refugees, to make it conform to these two features and thus make it more attractive for purposes of integration. It is however self-evident that given the cost of the head mounted displays used during the experiment, it may not be realistic to avail VEs to refugees using the HMD. Therefore, running the Desktop VE was also important, and it also showed marginally better results (though not statistically significant in terms of experience from the 360VP). The Desktop facilities, though inferior to the immersive nature of the HMDs would be more accessible to refugees thus maximising the advantages of this research. Indeed, as demonstrated during our study, the graphics need not be changed but user interface, particularly the navigation using the desktop controls, needs to be redesigned so that it is more applicable to the context of the desktop (navigation using the handheld controls was easier for several participants especially after they had been in the virtual

environment for a few minutes).

This research confirmed the hypothesis that in terms of knowledge transfer and retention, the medium was central to outcomes. It also confirmed the superiority of VR because of its immersiveness or sense of presence, the positive experience by users, and its ability to aid knowledge retention through repeat acts which help in memory consolidation.

7.3 Limitations of This Research

This research introduces a knowledge transfer and retention simulation which could be used to help refugees to study more about the countries to which they will eventually be resettled. It could also be used to enhance access to the UK NHS which was the subject of our study. We worked with a VR expert (Professor Kurt Debattista), a visualisation expert (Professor Alan Chalmers), a clinical psychologist (Professor Caroline Meyer), a clinical anatomy and medical education expert (Professor Peter Bazira) and two NHS practitioners (Dr. Kate Mwesigwa and Dr. Arthur Iga) to develop and setup the system. However, it might be necessary to collaborate more with educationists, and neuropsychologists to further develop a system that is usable in refugee settings. The system was designed for a controlled environment such as an experimental study but not for the "real" world and it might be helpful to conduct further research on the usability of the system. As a matter of fact, the mean scores for usability showed no statistically significant difference between all the media which suggests that a further study might be required to further investigate the usability of the system for end users in an actual refugee setting. In addition, one of the limitations of using the HTC Vive HMDs which overall had better outcomes, is the fact that they are tethered to a computer making it hard for users to move freely. This however can be remedied with the use of wireless or cheaper HMDs.

With regard to technical limitations, the simulation was often distorted and on several occasions the participants found themselves outside the VE and unable to get back in, requiring the assistance of the chief investigator. This may however have been down to the workmanship and may not be a generalised challenge related to VEs.

On participants selection, all participants were at undergraduate level and beyond. This

means that there was a homogeneity of knowledge, skills, and desire to receive knowledge among the participants who were also roughly within the same age group. However, this cohort (university level education) of the refugee population is less than 5%. It is therefore not clear whether for instance refugees at a more advanced age could have suffered a greater loss of the knowledge transferred, than was realised during the study. As such, further studies need to be conducted with a more diverse population sample in order to draw more generalisable conclusions from the results.

The evaluations of knowledge transfer and retention had several limitations which included participants' subjective responses in some cases, and the superior knowledge of some participants particularly during the pilot study.

The more detailed discussion on some of these issues will be outlined in the last two sub-sections of this chapter. We appreciate the general difficulty in assessing knowledge transfer and retention because of the multiplicity of factors that could positively or negatively impact knowledge transfer and retention or the loss and degradation of knowledge gained.

This research focused on the narrow concept of knowledge transfer using three disparate media and is hence limited in understanding issues such as the broader psychological issues around cognition, perception and replication. For instance, issues around language barrier, which is one of the biggest negative factors affecting refugee integration, were not studied and hence the need for further research to explore whether for instance it is enough for the refugee to have an abstract understanding of their third countries without being able to communicate.

Yet another limitation of the study was the use of printed questionnaires, which according to Alexandrovsky et al (2020), are disadvantaged in VR studies because transitioning from virtuality to reality for self-reporting on VR experiences may lead to problems such as break in presence, disruption of the immersive experience and even systematically bias the responses [2]. Future studies could therefore focus on how to mitigate this through other means such as a hybrid between embedding the questionnaires in the virtual environment and the use of print questionnaires or out of VR questionnaires. Indeed, Alexandrovsky et al (2020) posit that while there is a higher level of enjoyment for "in-VR-questionnaires",

there is a lower usability.

7.4 The Potential Effects of a High Level of Realism and Sense of Presence on Refugees

As discussed in Chapter 4 and 5 of this thesis, we suggested a high level of realism for the 360°video and the VE. To improve the visual fidelity from the pilot study, a number of adjustments were made. They included a change from the use of the Samsung Gear 360 High Resolution VR Camera with a video of 4096 x 2048 and 24 FPS to the use of the SpheronLite 360-degree camera which has a 360°camera with full spherical HDR imaging. It offered sharper and more accurate spherical imagery and, unlike the Samsung 360 Gear, required no image stitching. In addition, because it captured the images in a single rotation, it produced a seamless image with no parallax image distortion issues.

With regard to the VE used during the pilot experiment, there were design issues that needed to be corrected. Part of them had to do with distortions within the VE as well as the unnatural lighting which negatively impacted the level of realism and thus participants' experience. We invested significant time into correcting these design issues (the lighting and the design distortions). It was evident during the pilot study that, for instance, participants who took part in the experimental 360°video navigation spent a much shorter time that those who used virtual reality. We surmised that most of them lost interest within the first few minutes of attempting to navigate the environment and were eager to navigate the VE.

A number of studies have investigated the impact of the sense of presence as a function of experience. Ijsselsteijn (2000) [53] named four determinants of presence including fidelity, the match between sensors and the display, content factors and user characteristics including the perceptual, cognitive and motor abilities. All these determinants were contained in our experiments and improvements made to them to enhance the sense of presence

in the second experiment. Bailenson et al. (2002) [7] posited that greater detail or level of realism enhanced the sense of presence while Grassini et al. (2020) [44] determined that higher sense of presence contributed to increased transfer of knowledge. Sas (2006) [101] highlighted two positions. One that the role of presence in enhancing knowledge transfer was linked to design factors and the second that at best it is difficult to make a linear correlation between presence and task performance. In this study however we suggested that the experience would improve knowledge transfer. No previous study has made this linkage in part because of the difficulties involved in measuring sense of presence as also determined by Ijsselsteijn (2000) [53].
In relation to the activation of knowledge transfer, to the best of our knowledge no previous study has investigated the linear relationship between sense of presence or experience and knowledge transfer, certainly not amongst refugees.

Although this study did not measure the correlation between sense of presence, experience and knowledge transfer particularly amongst refugees it showed that a high sense of presence was matched by a high level of experience which both showed linkages to high test scores. The one linkage demonstrated was their connection to specific media. Indeed, the η_p^2 of 0.943 for presence, 0.606 for Experience, 0.503 for Test1, 0.701 for Test2 and 0.757 for Test3 demonstrated that more likely than not, there was a causal connection between presence, experience and knowledge transfer and retention. One of the weaknesses of measurement of presence in particular was our use of subjective measures (post-hoc test). Although we observed that participants who experimented with the VEs tended to spend longer navigating the environment in relative terms to other participants, it was not clear whether this was linked to the overall experience, and we did not engage in any objective measurement of these demonstrated traits.
However, it could be assumed, that the VE design in the second experiment, the higher level of realism, the conducive external environment, the ease of navigating the VEs, the interactivity and overall, the relatively higher level of immersion in comparison to the other media, resulted in a higher level of knowledge transfer. Further investigation is however

required to identify the actual linkages between "Presence", "Experience" and knowledge transfer and retention.

7.5 Issues with Measuring Knowledge Transfer and Retention

This thesis used a single method of measurement of knowledge transfer and retention, in the form of the three different tests with a mixture of objective and subjective questions. We however did not measure verbal, behavioural, or physiological responses which would have given a more fulsome gauge of the knowledge transferred.

Our focus was cognitive knowledge assessments, and we used a post-test assessment to assess the knowledge gain and the knowledge-gain loss. The post-test assessment is however problematic because of a number of issues such as prior knowledge of participants that they were being assessed, which could have affected their objectivity. In addition, there was always the risk of participants responding in a manner they thought would be preferable to the investigator. To mitigate some of these pit falls, we administered the tests on three different occasions, making participants aware of assessments. Participants were informed of Test1 and Test 2 prior to the tests being administered. They were only informed that there would be a Test3, just a month before it was administered. It is not plausible that the significant gains seen over the immediate, 10 – 14 day and six months period could have occurred without the knowledge transfer experiment. To this extent and in addition to the fact that the participants in the second experiment were completely oblivious to the UK NHS, we feel that the study was immune to peripheral factors that could have otherwise affected the validity of just one or two tests such as "history, maturation, and testing effect" as postulated by Campbell (1963) [14]. In future, it might helpful to design and measure verbal, behavioural, and physiological responses.

7.6 Issues around Selecting the Media of Knowledge Transfer

The key focus of this research was identifying whether VEs were the most effective means of transferring knowledge and retaining that knowledge. The study identified a descriptive method of knowledge transfer (Text) and a depictive method of knowledge transfer (VEs). It was however determined that the technological distance between the "Text" method and the VEs was far too great and that a third method, the 360°video and images needed to be introduced as a counterweight to the superiority of VEs. The study proved that VEs were superior to the other media (Text, 360°video and 360°images). An important distinction however was that there was no statistically significant difference between the VED and the high fidelity 360°images which then brought into contention the importance of fidelity, sense of presence and experience as the key factors that gave VEs the edge over the other identified media. The identification of the three media and their variations as highlighted in Chapter 5, does not mean the VEs are the most efficacious of any media that is available. This was not the focus of our study which simply focused on identifying whether VEs were better alternative traditional methods of knowledge transfer for refugees during resettlement and integration. These are the descriptive text and to a lesser extent, the 360°video.

7.7 The Benefits and Impact of This Research

The significant benefit of this research is to have better insights on how we can use virtual reality to help refugees integrate into third countries. This research is the first to examine the correlation between VEs, sense of presence and experience/satisfaction, and knowledge transfer and retention for purposes of refugee integration. The research is essential in identifying the key factors affecting presence including design factors particularly as they relate to Knowledge transfer. It also makes the important linkages between the virtual world and the real world and how knowledge gains and knowledge-gain loss would occur.

By gaining insights into how VEs impact knowledge transfer and retention, the study builds on a body of knowledge on meta plasticity, and neuropsychology which could lead to enhancements in the use of VE in knowledge transfer and retention. Indeed Laborieux et al (2021) posit that although neural networks have eclipsed normal human performance abilities in many situations, they are still susceptible to forgetting: particularly when new tasks are introduced over previous ones (humans will rapidly forget learned tasks when new ones are introduced). In addition to neuronal plasticity adjustments made by the brain to overcome this phenomenon, knowledge transfer techniques can be developed to alleviate forgetting or knowledge loss [62]

The research findings also point to the importance of multiple causal factors that impact the effectiveness of VEs including both internal design issues but importantly also, external issues such as social interruptions, and space. The causal factors could be diminished or isolated in real-time to ensure maximum effectiveness. We noted with regard to design issues that issues related to lighting the VE portrayed an unnatural environment and adjustments had to be made to ensure that the graphic detail matched the specific expectations of participants.

This study developed a knowledge transfer scenario within a virtual environment (a UK Based Surgery). There are no previous available studies that have reproduced a knowledge transfer scenario specifically for refugees, based on a VE and using the three media that we used (including the variations that we applied to the three media for purposes of fidelity and sense of presence). We have demonstrated through our study that this knowledge transfer scenario is applicable in real life and future work could focus on measuring the application of the knowledge in the form of behaviour change, in the real world, as a measurement of whether knowledge transfer occurred.

This was for the most part a simple VE without social interactions (the human representations in the VE such as a receptionist, an actual doctor, or patients). We determined that visual selective attention would improve cognition, perception and perhaps even performance. We thus modified the visual inputs to allow for voluntary visual processing, to

allow participants to allocate attention to specific locations within the VE. This view is supported by the findings in the Mangun (1995) study [78] which focused on pointed to visual-spatial selective attention affecting human's ability to appreciate an environment in its entirety.

Future research could focus on the inclusion of social interaction in order to evaluate how such interaction would affect interactivity, presence and enhance the experience. There is also the importance of fidelity. We suggest that high fidelity of virtual reality through selective rendering, will help enhance the use of VE in a variety of other usages amongst refugees, including in schools, health outreach, and psychosocial support to trauma patients and victims of violence.

A major challenge will be around delivering to refugees, high-quality, cost-efficient systems that can arouse the same levels of experience at a low cost. In addition, attention needs to be paid to issues related to cost as well as bring into the rendering, social interactions.

7.8 Summary

This chapter summarises the key findings of this study and discusses the potential impact, limitations and applicability of the issues about its general applicability.

The overall findings of this research were: VEs demonstrated superior outcomes with regard to knowledge transfer and retention when compared to the other identified media of knowledge transfer and the variations outlined below.

1. Descriptive Text.
2. 360°Video cast on a desktop.
3. 360°Images cast on a desktop.

4. 360°Images cast on an HTC Vive.
5. 360°Images cast on an HTC Vive Pro.
6. A Virtual Environment cast on a desktop.
7. A Virtual Environment cast on an HTC Vive HMD.
8. A Virtual Environment cast on an HTC Vive Pro HMD.

In addition:

- Appropriate fidelity levels are essential in ensuring the illusory appeal of Virtual Reality, suspension of disbelief and a high sense of presence which is in turn enhances the user experiences and aides knowledge transfer and retention.
- There is a correlation between the immersive nature of the VEs and the knowledge transferred and retained.
- The low mean scores on usability point the challenges faced by participants in using the VR system as well as the other media variations.

In this chapter, we also discussed the potential effects of introducing behavioural fidelity into the experiment in order to enhance the level of realism.

Finally, the chapter discussed how to mitigate visual-spatial selective attention and how such interventions could positively or negatively impact the outcomes of the experiment.

Amongst the benefits of this research were the identification of causal or mediating factors for knowledge transfer and retention and how they can be activated to ensure maximum efficacy. We suggested the inclusion of social interaction to enhance interactivity, presence and user experience. We also suggested that the use of VEs could be expanded into other sectors in refugee response programmes such as in schools (especially given the limited number of learning facilities), to increase access to healthcare and to provide psychosocial support to trauma patients and victims of violence.

Chapter 8

Conclusion and Future Work

Virtual Reality has been a common stay in knowledge transfer for decades now. It has been used in a wide range of applications, including enhancing socialisation, facilitating communication, treating of phobias, delivering training and skills transfer, treating PTSD, eliminating biases, and deepening our understanding of our environment, among other thing.

Although several studies have been carried out on the effectiveness of Virtual experiences (VEs) in knowledge transfer, none of the studies, quite covers the use of virtual reality in helping refugees integrate in third countries. The study presented in this thesis was motivated by the need to explore the potential of virtual reality for this purpose in the face of increased forced displacement and the resulting need to enhance the socio-economic inclusion of refugees in their new host countries. It was also motivated by the significant the difficulties that many refugees find in navigating Europe's socio-economic systems because of their limited knowledge about them.

The central research question in this thesis concerned the efficacy of VEs as a medium of knowledge transfer. Two sets of experiments, a pilot study and a second experiment were conducted to assess the efficacy of three identified media of knowledge transfer (Descriptive Text, 360°video and images and Virtual Reality). Two sets of participants N = 37 for the pilot study and N = 122 for the second experiment, were recruited. An

assessment test was administered immediately following each of the two experiment to determine the level of knowledge transferred or gained. As part of the second experiment, a second assessment test was administered within 10 – 14 days following the experiment to determine the level of knowledge retained. A longitudinal study (N = 89) was then conducted six months after the second experiment to determine the "knowledge – gain" loss.

The methodology used during the study was able to broadly map a knowledge transfer process based on specific outcomes (see figure 2.2). Although the study used the tests to measure knowledge transfer, it also measured other key factors that can influence knowledge transfer such as "Experience" with the medium, the sense of "Presence" felt during the experiment, and "usability" of the medium. Although these factors are non-exhaustive, they point to some important elements that could affect the knowledge transfer process and outcomes. It was for instance surmised that the experience or satisfaction of the participants which was in large part influenced by the sense of presence, had a correlation with the eventual outcomes. It was also surmised the design changes made in relation to fidelity and design distortions which had been encountered during the first experiment, had positively impacted the level of knowledge gained.

8.1 A Practical Lesson

8.1.1 Measurement of Knowledge Transfer and Retention

To obtain better results, the measurement of knowledge transfer needs to be flexible enough to capture a range of both physiological, psychological, and verbal effects. This would be the view of knowledge transfer not just as being about high and low scores but also a collection of other important factors such as the ability to formulate memories and the ability to replicate the knowledge gained. Such methods will affect the overall assessment of how successful future experiments will be. They would also help in dealing with limitations

associated with just the use of post – tests. Moreover, the diversity of participants and an even greater diversity of the actual refugee population requires that measures of knowledge transfer are structured in a way that can more positively engage with this diversity.

8.2 Recommendations for Future Research

Overall, the study identified issues around the measurement of knowledge transfer which is complex in part because knowledge transferred cannot be measured on a continuum and that is why the study deemed it necessary to conduct three tests. Although we believe that our selection of measurements was robust enough and significant in determining whether knowledge transfer and retention had occurred, more could be done in the direction of combining both post-tests, and verbal, behavioural, or physiological assessments. Nonetheless, there is nothing to suggest that the inclusion of these other types of measures would necessarily deliver a different form of results.

An interesting addition might also be the use of a structural equation modelling (SEM) and thus a bigger sample size. According to Fan et al. (1999) [33] the greater the sample size, the stronger the test. They posit that large sample sizes affect the model fit because of the minimal level of discrepancies between the sample covariance matrix and the reproduced covariance matrix. As opposed to sample sizes of $N \geq 50$ which produces a non-convergence of about 5% and an improper solution rate of about 23%, and sample sizes of $N \geq 100$ which have a non-convergence of 0.25% and an improper solutions rate of about 8%, sample sizes of $N \geq 200$ and beyond record 0% non-convergence and 0% improper solutions rate [33]. Such a wide sample size would hopefully cover the diverse nature of refugee populations. The only challenge with such a large sample size would be recruiting the participants. Hickey et al (2018) also discuss the vitality of power calculations which could be used to determine the sample size required for statistical significance [50].

This study was undertaken using one environment. Although this environment was deemed as representative of the NHS given GPs' role as gatekeepers to the NHS, other

environments, including other GP surgeries, would help strengthen the generalisation of the results. In addition, more work could be done to investigate how diversity (age, gender, personality, etc) might impact on the results obtained.

Future research could also focus on the efficacy of Multi-Sensory VEs in knowledge transfer, and whether the addition of other sensory stimuli, audio, smell, temperature, helps or hinders knowledge acquisition. Also missing in this study were humans within the virtual environment. Humans are, of course, a major feature of any doctor's surgery and would enhance the level of realism, the sense of presence and immersion. Another important element for further research is the introduction of interactive elements such as the automated check-in, as is presently the case in some UK GP surgeries.

Technological acceptance specifically amongst refugees is an important element in the use of Virtual Reality for either further research amongst refugees or for purposes of refugee integration in third countries. This is the view put forward by Pantziaras, et al (2012) who postulates that acceptance of VR technologies particularly amongst under-served refugees is key to using this technology for knowledge transfer. Indeed, according to them, acceptability is very important for refugees in part because they typically base their decisions on expectations [89].

For the most part, refugee situations do not have large amounts of funding allocated to them. As such, it is important to couch any VR deployment within specific cost parameters. Indeed, this view is supported by Gamberini, et al (2015) who posits that the increased uptake in the use of VR for training suggests an increased preference in the medium due to its suitability and cost effectiveness when compared to conventional training methods [37].

In terms of the design of experiment, participants were allowed to spend as much time in the experimental conditions as they wanted. Given the amount of time spent in the 360°and Virtual Environments, it was determined that there must have been repeat movements within these environments. However, these were not measured, and further research could monitor the number repeat movements made by individual participants,

what is of interest to them in the environment and how it could impact the knowledge gained.

The cognitive approach hypothesizes that knowledge transfer is based on retention of several representations across different situations of use [29]. VR is an important tool for knowledge transfer. It is therefore important to link the assertions highlighted by Dohn et al (2020) in their definition of the cognition approach to the neurobiological approach to memory retention as highlighted in Rudy (2004) [97] and by Roediger (2007) [94] to arrive at the most optimum time for the skills transfer. In addition to timing repeat movements, future research could focus on designing experiments that specifically pay close attention to timing including the most optimum time for a knowledge to be transferred or gained. Indeed, Szulanski et al 2016 postulate that effective knowledge transfer is a function of timing and neglecting timing can have an impact on methods [123].

This research used the same questions three different times to ascertain whether knowledge had been transfer, and retained and whether a memory had been formulated. A limitation of this method is the tendency of people to sometimes focus on remembering the questions or the answers, rather than the actual knowledge on which they are being tested. A future area of research alteration to this research could be the use of a different set of questions for the first, second and third experiments.

An area that could benefit from future research is investigating the effect of collaborative learning on knowledge retention as advanced by Souza et al (2020). They highlighted two disparate arguments that would have been helpful to the research among refugee communities. The first is the potential of VR in knowledge transfer and retention when the subject matter is not previously known to participants. This was indeed a focus of this study. The second argument which was not investigated is the effect of collaborative learning on knowledge retention. This is indeed an area that could be further investigated especially in refugee settings where groups-based dynamics are vital to personal continuity in "disrupted life trajectories" [26].

A final, often undervalued, but nonetheless highly important part for further research would be the use of Virtual Reality among non-college educated refugees, as well as

amongst children (under 18 years of age) who form the vast majority of refugee populations (data2.unhcr.org). All participants in this research either had a university degree or were at undergraduate level.

8.3 Final Word

Although refugees face significant challenges in adapting to life in resettlement countries, often culturally different from their countries of origin, Virtual Reality could play a significant role in aiding their integration into their new environments and thus offering them a better quality of life. This study is a step towards considering how VR could be designed and deployed to ensure appropriate, efficient and cost-effective solutions to the challenges of refugee integration into third countries.

Appendix A

Descriptive Text (Pilot Experiment)

Access to the NHS through a GP Practice

During migration, refugees suffer considerable loss, which affects their ability to navigate their "new societies". This is compounded by a lack of knowledge on how to access the most essential services in their countries of asylum or resettlement.

On 28th March 2017, we held a Focus Group Discussion with key stakeholders in refugee assistance within the UK. The key question addressed during this meeting regarded how Virtual Reality could be used to improve the lives of refugees particularly their ability to integrate into UK society. Among the priority areas discussed were access to healthcare, livelihoods, education, housing, and decision making in general. It was agreed that the most urgent needs facing refugees in the UK is access to healthcare including how to navigate the NHS and mental health services. We also held a separate meeting with the UN Refugee Agency. We agreed to set the scenario around access to healthcare within the UK with a specific focus on facilitating and understanding how to navigate the decision and access tree to healthcare.

Studies reveal that some of the greatest barriers to migrants accessing healthcare in the UK include administrative and legal barriers, a lack of knowledge or understanding of the healthcare system and of their rights. The UK Department of Health also reveals that vulnerable persons such as refugees have poorer access to health due in part to a lack

of knowledge and information resources. On Saturday 20th October 2018, we visited the Glebe Road Surgery in London and with their permission, designed a model of a Health Service Centre for this experiment. This model is intended to educate participants about access to the NHS.

Your task will be to read through the textual description below (which includes a description of the Glebe Road Surgery). Based on the information provided, we will assess if you are able to access the Practice with ease.

Access to Health Care in the UK

For most people in the UK, primary health care is the first point of contact with the health system. Healthcare is free for all people residing legally within the UK. Primary health care is provided by independent contractors including General Practitioners (commonly known as GPs), dentists, pharmacists and optometrists, who deliver it physically through face-to-face visits to an NHS walk-in centre or by telephone through the 111-telephone service. Although it is a free service, prescriptions, dental care, eye care, wigs and fabric support are not free, and all patients are required to pay for them (except if they have been exempted).

It can be difficult to select which service is right for you given the variety of options. The NHS has loose guidelines on how these choices can be made. The choice is primarily based on a person's judgement regarding the level of urgency of the ailment. For instance, if you require urgent medical help but you do not consider your condition life threatening, you can simply call the NHS 111-telephone service for advice. If, however you or someone else have a serious illness or injury, or if a life is at risk, then you should call 999. You can also visit a walk-in centre, an urgent care centre or a minor injuries unit in cases of minor illnesses or minor injuries.

You could also ask your local pharmacist for advice about minor illnesses such as

diarrhoea, headaches, sore throats, or travel sickness.

Accessing Your GP

If you are not feeling well but you do not consider it an emergency, the UK NHS requires you to make an appointment with your GP. GPs are the first port of call for most patients because they are a gateway to other NHS services. There are also experts in a number of different areas such as family medicine, preventative care, health education, and treating people with multiple and long-term conditions. There are however a few prerequisites before you can access a GP.

First, you need to register with a local GP by filling out a GMS1 form. You can choose a GP practice that is most appropriate to your needs. The NHS has a website that can help you compare GP Practices based on available facilities, services, access and performance. Such a comparison can help you decide which GP you will choose. You can also ask other people on their opinions of GPs. Once you have decided on a GP Practice, they are obligated to accept you, unless they have reasonable grounds for a refusal. In case they refuse, they are obliged to give your grounds/reasons for their refusal in writing. Such grounds must not include race, gender, social class, age, religion, sexual orientation, appearance, disability, or a medical condition.

Once you have registered with the GP, you will be required to make an appointment in case of illness so that you can get medical advice. In order to book an appointment, you have to talk to your GP practice (over the phone or in person) or visit their website. Based on your need, you could get an appointment on the same day. You will need to provide details of your condition and this information will enable the receiver to assess your needs and to book an appropriate appointment for you.

When you arrive at your GP Practice on the day of your appointment, you will need to see the receptionist who will receive you and provide you with details on how and when

you can see your GP. There will also be a number of listening and visual aids that can help you with directions on how and when to access your GP for your appointment.

If you have children, you need not worry about where you will leave them as the local GP has a play area for children where you can monitor them even as you await your appointment with the doctor. When your doctor is ready to meet with you, your name and the location of your GP will be announced over a public address system. Be mindful of the fact that your doctor may not be ready to meet with you at the prior appointed time due to a number of reasons which might include accumulative delays emanating from meetings with prior clients. It is important that you wait until your name is announced through the PA System or by one of the Practice staff.

You will then go in to see your GP who will work with you to resolve your health issue. The GP will evaluate your condition and advise you on how to proceed. The advice may include declaring you healthy, a referral to purchase medicines from a pharmacist, or a referral to another NHS facility that is better suited to help in resolving your health condition.

Accessing the Glebe Road Surgery

As with all the GP surgeries, before you visit the Glebe Road Surgery, you would have to go through the steps described above.

The Glebe Surgery is at 1 Glebe Road, Barnes, in London. Once you arrive at the entrance, you will open the door and the reception area is about five metres down the hall.

The space immediately inside the entrance doors provides the user with their first experience of the surgery. The transition from outside to the inside is gradual with nice warm lighting. This lead you to the reception area, which has a wooden brown oak counter about 1.5 metres high.

The open counter has a sign at high level and a clock, which is plainly visible. The desk is quite big and can accommodate at least three reception staff during peak usage.

Behind the counter is a TV monitor on which the names of patients are broadcast to facilitate their seeing a doctor. Also behind the reception is an enclosure (glass) that is fully glazed, in which patients' records are confidentially kept. It enables the patients to see how their records are handled. The reception area also has a wooden floor, which covers a space of about two by four metres. Although the reception area is narrow, it is designed to allow the smooth flow of patients into and out of the building.

Patients congregate in the area right in front of the reception area. There are three different sets of blue seats on which patients can seat once they arrive. They are situated to the right (7-seater), directly in-front of the reception desk (12-seater) and to the left of the reception area (7-seater). Further down to the left of the reception area is a children's play area that has a giant picture of a dinosaur on the wall.

There is a pay phone immediately to the left of the reception area which is safely out of the way of the passage of patients. There are two doors directly in-front of the reception area which lead to doctors' private rooms, all of which are situated behind the wall directly in-front of the reception area. Once you get there either one of the two doors, you will find the doctors' rooms as well as toilets, facilities for nappy-changing, bottle-feeding and breast-feeding.

The reception area is also adorned by a number of Public Health posters on flu, healthy eating, the winter campaign, identity guidelines, medicine management and self-care among other things. It also has a few art pieces (see pictures below). The posters provide information to help you prevent illnesses that can be self-treated. They also help in keeping you busy as you await your name to flash across the TV monitor in the reception area.

After a few minutes of waiting, you will hear your name and be asked to go through one of the doors directly in-front of the reception area to see your GP.

Appendix B

21 - Question Assessment Test

A few questions to test how much information you were able to retain after the experiment

1. The NHS has essential gatekeepers whose role it is to facilitate your access to the Healthcare system. Based on your experience, are you able to name these gatekeepers?

2. After meeting the receptionist, it may happen that you forget some of the details she/he will have given you. How else can you access these details? Try to list as many ways as possible.

3. The most common way to access the Healthcare System in the UK is through the General Practitioner (GP). Are you able to name the ways in which you can access the GP?

4. Why is it important to have access to a GP as a first step towards accessing healthcare in general?

5. There are several steps that a person must take in order to physically access a GP. What is the first step you must take in order to access the GP?

6. The GP has been heralded as a gateway to other Specialised Health Services. What are these health services?

7. Why would you consider a GP extremely essential to meeting your health needs?

8. When you arrive at your local GP with your children, you will be required to leave them outside the facility until you have completed your appointment with the doctor. Briefly (in 2 – 3 lines) discuss the accuracy of this statement.

9. Does offering as much detail to the receptionist of the GP practice about your health condition ease your access to your GP?

10. Although GPs are obligated by law to accept you as their client, they can reject your application in a few case. Are you able to name some of the reasons that could make a GP refuse your application?

11. From Question 10 above although a GP is allowed to refuse your application, there are absolute red lines or things that no GP is allowed to use against you in refusing to accept your application. What are these?

12. What is the role of the surgery welcome team or receptionists in helping you access your local GP?

13. Selecting your GP Practice can be often tedious and confusing. Based on your experience, what are the different avenues available to you that could help you in making the best decision in this regard?

14. In January 2017, Mr. Abdallah Miiro, a Japanese refugee living in the UK, developed a throat infection. He tried to treat the infection by buying throat lozenges over the counter but was not successful. The infection got worse. Mr. Miiro does not know anything about the UK Health system. Kindly advise him on the steps he must take in order to get his medical issue resolved.

15. How best can you use your interpreter to help you access your GP?

16. If you were a helper to an elderly person or a person with disabilities, what kind of information must you communicate to the GP to ensure that they can physically access the service/practice?

Access to the Glebe Road Surgery

17. Are you able to name the fixtures that are around the reception area? (Name these fixtures with as much detail as possible).

18. About how many reception staff can the reception counter accommodate especially during peak usage?

19. What is the purpose of the TV monitors around the reception area?

20. Behind the reception is an enclosure (glass) that is fully glazed. What is the purpose of this enclosure?

21. Describe the seating arrangement in and around the reception area with a much detail as possible.

Appendix C

Descriptive Text (Second Experiment)

Accessing the Glebe Road Surgery

As with all the GP surgeries, before you visit the Glebe Road Surgery, you would have to go through the steps described above.

The Glebe Surgery is at 1 Glebe Road, Barnes, in London. Once you arrive at the entrance, you will open the door and the reception area is about five metres down the hall.

The space immediately inside the entrance doors provides the user with their first experience of the surgery. The transition from outside to the inside is gradual with nice warm lighting. This lead you to the reception area, which has a wooden brown oak counter about 1.5 metres high.

The open counter has a sign at high level and a clock, which is plainly visible. The desk is quite big and can accommodate at least three reception staff during peak usage.

Behind the counter is a TV monitor on which the names of patients are broadcast to facilitate their seeing a doctor. Also behind the reception is an enclosure (glass) that is fully glazed, in which patients' records are confidentially kept. It enables the patients to see how their records are handled. The reception area also has a wooden floor, which covers a space of about two by four metres. Although the reception area is narrow, it is designed to

allow the smooth flow of patients into and out of the building.

Patients congregate in the area right in front of the reception area. There are three different sets of blue seats on which patients can seat once they arrive. They are situated to the right (7-seater), directly in-front of the reception desk (12-seater) and to the right of the reception area (7 seater). Further down to the left of the reception area is a children's play area that has a giant picture of a dinosaur on the wall.

There is a pay phone immediately to the left of the reception area which is safely out of the way of the passage of patients. There are two doors directly in-front of the reception area which lead to doctors' private rooms, all of which are situated behind the wall directly in-front of the reception area. Once you get there either one of the two doors, you will find the doctors' rooms as well as toilets, facilities for nappy-changing, bottle-feeding and breast-feeding.

The reception area is also adorned by a number of Public Health posters on flu, healthy eating, the winter campaign, identity guidelines, medicine management and self-care among other things. It also has a few art pieces (see pictures below). The posters provide information to help you prevent illnesses that can be self-treated. They also help in keeping you busy as you await your name to flash across the TV monitor in the reception area. After a few minutes of waiting, you will hear your name and be asked to go through one of the doors directly in-front of the reception area to see your GP.

Appendix D

14 - Question Assessment Test

1. Based on your assessment, there may be a number of ways to access the surgery. Please choose the correct one(s).

    - Telephone call only
    - Telephone call and walk in
    - Walk-in only
    - Website
    - Telephone Call, Walk-in and Website

2. When you arrive at the Glebe Road Surgery with your children, you will be required to leave them outside the facility until you have completed your appointment with the doctor. Briefly (in 2 – 3 lines) discuss the accuracy of this statement.

3. What is the role of the surgery welcome team or receptionists in helping you access the surgery or your GP?

4. What is the role of the receptionist to help you access your GP?

5. Are you able to name the fixtures that are around the reception area? (Name these fixtures with as much detail as possible).

6. About how many reception staff can the reception counter accommodate especially during peak usage?

7. Behind the reception is an enclosure (glass) that is fully glazed. What is the purpose of this enclosure?

8. Describe the seating arrangement in and around the reception area with a much detail as possible.

9. In January 2017, Mr. Abdallah Miiro, a Japanese refugee living in the UK, developed a throat infection. He tried to treat the infection by buying throat lozenges over the counter but was not successful. The infection got worse. Mr. Miiro does not know anything about the UK Health system. How can you advise him on the steps he must take in order to get his medical issue resolved?

10. If you were a helper to an elderly person or a person with disabilities, what kind of information must you communicate to the GP to ensure that they can physically access the service/practice?

11. What is the purpose of the TV monitors around the reception area?

12. How many doors would lead you to a GP within the Glebe Road Surgery Practice?

13. Based on your assessment, what information is available to tell you how many doctors are available at the surgery?

14. What are the opening and closing times of the GRS?

Appendix E

32 - Question Presence Questionnaire

Scales: 1 = Very Poor; 2 = Poor; 3 = Average; 4 = Above Average; 5 = Good; 6 = Very Good; 7 = Excellent - Please circle the appropriate option.

1. How much were you able to control events?

2. How responsive was the environment to actions that you initiated (or performed)?

3. How natural did your interactions with the environment seem?

4. How completely were all of your senses engaged?

5. How much did the visual aspects of the environment involve you?

6. How much did the auditory aspects of the environment involve you?

7. How natural was the mechanism which controlled movement through the environment?

8. How aware were you of events occurring in the real world around you?

9. How aware were you of your display and control devices?

10. How compelling was your sense of objects moving through space?

11. How inconsistent or disconnected was the information coming from your various senses?

12. How much did your experiences in the virtual environment seem consistent with your real-world experiences?

13. Were you able to anticipate what would happen next in response to the actions that you performed?

14. How completely were you able to actively survey or search the environment using vision?

15. How well could you identify sounds?

16. How well could you localize sounds?

17. How well could you actively survey or search the virtual environment using touch?

18. How compelling was your sense of moving around inside the virtual environment?

19. How closely were you able to examine objects?

20. How well could you examine objects from multiple viewpoints?

21. How well could you move or manipulate objects in the virtual environment?

22. To what degree did you feel confused or disoriented at the beginning of breaks or at the end of the experimental session?

23. How involved were you in the virtual environment experience?

24. How distracting was the control mechanism?

25. How much delay did you experience between your actions and expected outcomes?

26. How quickly did you adjust to the virtual environment experience?

27. How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?

28. How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?

29. How much did the control devices interfere with the performance of assigned tasks or with other activities?

30. How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?

31. Did you learn new techniques that enabled you to improve your performance?

32. Were you involved in the experimental task to the extent that you lost track of time?

Appendix F

29 - Question Immersive Tendencies Questionnaire

Scales: 1 = Very Poor; 2 = Poor; 3 = Average; 4 = Above Average; 5 = Good; 6 = Very Good; 7 = Excellent - Please circle the appropriate option.

1. Do you ever get extremely involved in projects that are assigned to you by your boss or your instructor, to the exclusion of other tasks?

2. How easily can you switch your attention from the task in which you are currently involved to a new task?

3. How frequently do you get emotionally involved (angry, sad, or happy) in the news stories that you read or hear?

4. How well do you feel today?

5. Do you easily become deeply involved in movies or TV dramas?

6. Do you ever become so involved in a television program or book that people have problems getting your attention?

7. How mentally alert do you feel at the present time?

8. Do you ever become so involved in a movie that you are not aware of things happening around you?

9. How frequently do you find yourself closely identifying with the characters in a story line?

10. Do you ever become so involved in a video game that it is as if you are inside the game rather than moving a joystick and watching the screen?

11. On average, how many books do you read for enjoyment in a month?

12. What kind of books do you read most frequently? — (CIRCLE ONE ITEM ONLY!)

    - Spy novels
    - Adventure
    - Westerns
    - Biographies

13. How physically fit do you feel today?

14. How good are you at blocking out external distractions when you are involved in something?

15. When watching sports, do you ever become so involved in the game that you react as if you were one of the players?

16. Do you ever become so involved in a daydream that you are not aware of things happening around you?

17. Do you ever have dreams that are so real that you feel disoriented when you awake?

18. When playing sports, do you become so involved in the game that you lose track of time?

19. Are you easily disturbed when working on a task?

20. How well do you concentrate on enjoyable activities?

21. How often do you play arcade or video games? (OFTEN should be taken to mean every day or every two days, on average.)

22. How well do you concentrate on disagreeable tasks?

23. Have you ever gotten excited during a chase or fight scene on TV or in the movies?

24. To what extent have you dwelled on personal problems in the last 48 hours?

25. Have you ever gotten scared by something happening on a TV show or in a movie?

26. Have you ever remained apprehensive or fearful long after watching a scary movie?

27. Do you ever avoid carnival or fairground rides because they are too scary?

28. How frequently do you watch TV soap operas or docu-dramas?

29. Do you ever become so involved in doing something that you lose all track of time?

Appendix G

Experience and Usability

Scales: 1 = Very Poor; 2 = Poor; 3 = Average; 4 = Above Average; 5 = Good; 6 = Very Good; 7 = Excellent - Please circle the appropriate option.

Text

1. How did you enjoy the experience (Experience)
2. How good is this media in conveying the information? (Usability)

360 Video

3. How did you enjoy the experience (Experience)
4. How good is this media in conveying the information? (Usability)

VR Experience

5. How did you enjoy the experience (Experience)
6. How good is this media in conveying the information? (Usability)

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