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Immersive Learning Research Network

An Exploration of Immersive Virtual Reality as an Empathic- Modelling Tool

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Abstract. Due to greater population diversity, today's designers must stretch their 'Empathic Horizon' [2] to reach beyond their own experiences. Empathic modelling, in the form of wearable simulations of impairments, is an established method for extending designers' empathy. However, such techniques must be translated into the digital realm to facilitate future designers in designing for diversity. This study of student designers, described in this short paper, aimed to a) investigate the four phases in the process of empathy in design practice and b) develop an insight into social VR in this learning context. Predominately using VR headsets, 13 students navigated and interacted in a challenging urban environment as either a wheelchair user or a visually impaired person. Students completed the Empathy in Design Scale [5] and a contextual task (to assess learning transfer) pre/post the VR activity. Moreover, they were observed throughout the session and a group interview was conducted. The Empathy in Design Scale post-immersion ratings exhibited statistically significant improvements in the students' empathy. The contextual task demonstrated learning benefits in both the breadth and depth of relevant insights gained. The group reflection offered some insight into the behaviour and ratings, with students commenting on the realism of the immersion and the value of direct experience. The video analysis demonstrated students engaged in a realistic fashion when embodied in wheelchairs/with visual impairments. Recommendations are given regarding how best to implement VR in teaching practice to enhance empathy of design students towards those with different world perspectives.

Keywords: Empathy, Design, Disability, Higher Education, Virtual Reality, Social VR.

1 Introduction

With the acceptance of the Social Model of Disability [1], today's designers are under pressure to design for wider inclusion. However, growing diversity within the population presents significant challenges to the designers 'empathic horizon', that is the extent to which they can draw upon their own experiences to design for others [2]. Situating empathy within the design field draws upon its longer standing psychological roots, adopting the differentiation between emotional/affective empathy (feeling another's emotions) and cognitive empathy (understanding another's emotions) [3]. Kouprie at al [4] discuss a 'Framework for empathy in design' derived from the proposition that a designer "steps into the life of the user, wanders around for a while and then steps out of the life of the user with a deeper understanding of this user". Both emotional and cognitive empathy contribute to the framework's four phases in the process of empathy in design practice - Discovery, Immersion, Connection and Detachment and it is one of the founding blocks for the Empathy in Design Scale developed by Drouet et al. [4] which is a standardised, self-reported measure aiming to provide a quantitative measure of empathy in design.

Various empathic design tools can be applied within teaching to increase the empathic horizon of students thereby enabling their delivery of more inclusive solutions as future designers. Passive methods to embed empathy in design include personas, storytelling and empathy maps, with more interactive methods comprising role-play and wearable simulations [3]. Wearable simulations are a form of empathic modelling tool which Torrens [6] describes as "a well-used method through which designers can gain some experience of the constraints of a defined medical condition that manifests itself in a form of impairment" and they are of proven benefit to design in industry

[7, 8]. With increasing digitalisation, it is important that the benefits of empathic modelling are translated from the physical to the digital world. In this respect, Ott and Freina [9] identify the education advantages of Virtual Reality (VR) as: exploring physical inaccessibility, engaging in dangerous scenarios, reduction of ethical constraints, time travel and impossible contexts. Moreover, VR affords designers (and students of design) to explore empathy in worlds that are yet to exist, thus aligning with speculative/experiential futures work which aims to realise abstract, potential worlds in a more concrete, experiential form [10, 11].

Wiesemüller et al. [12] investigated the teaching of accessibility using VR and found that the technology facilitated a change in perspective and awareness of accessibility in a manner which increased motivation and simplified the topic. Götzelmann and Kreimeier [13] and Pérez et al. [14] both developed an interface permitting wheelchair users to navigate a virtual world using their own wheelchair, thus opening the potential for the co-design of the built environment. However, the work of Hoter and Nagar [15] enabled non-wheelchair using students to adopt wheelchair using avatars. It was found that the physical and psychological situations they experienced as avatars gave rise to sensations of discomfort, frustration and anger which had the effect of not only engendering empathy with wheelchair users but raised concerns regarding wider social rights. Research by Häkkilä et al. [16] regarding VR simulation of visual disabilities found students were receptive to this form of learning and considered it improved their empathy. However, unfamiliarity with the technology, set up time and lack of a shared virtual environment across the student cohort were noted as limitations. Jensen et al. [17] in their review of 21 studies regarding the use of head-mounted displays found that such displays offer advantages over less immersive technologies with regard to psychomotor skills related to head-movement, such as visual scanning, and also emotional response to difficult situations both of which were pertinent to the immersive task in this study.

To extend existing work, we have conducted an exploratory pilot utilising both sensory impairment (visually impaired avatars) and physical impairment (wheelchair user avatars) which were applied through group immersions across the design student cohort. The aims of the research were to:

1) to investigate the four phases in the process of empathy in design practice
2) develop an insight into social VR in this learning context.

2 Methodology

2.1 Participants

Thirteen students (six male and seven female aged 20-25 years) were recruited as participants for the study. All students were currently enrolled in the final year of their undergraduate course in product design and registered for an optional module in Inclusive Design. Prior to this, the students undertook compulsory modules in 'Understanding people' in their first and second years. No explicit incentives were given to students to take part – although the topic of empathy in inclusive design was integral to that week's teaching. Ethical approval was given by the University's ethics committee with concerns pertaining to simulation sickness addressed via self-screening and alternative use of a lap top version.

2.2 Equipment/space

The study took place within a theatre room at the University allowing all students to have a safe 'guardian' space when immersed in VR. In addition, a large projection screen enabled a third person perspective to be provided from within the virtual world – see Fig 1 where it can also be observed that students are seated for the wheelchair avatar condition. This roaming camera view was especially important when engaging with students in the onboarding process and for engaging with the audience (i.e. students waiting their turn).

In terms of hardware, 12 of the 13 students accessed the virtual world using a Pico 4 Enterprise VR headset – whereas one student used their laptop computer (due to concerns over sickness – see bottom left of Figure 1). All headset users also wore headphones to minimise bleeding of sound from the real-world. The study utilised the Mozilla Hubs social VR platform which operates on the browser – and therefore can be accessed across multiple devices (headsets, desktop, laptop, mobile). Four bespoke impairment avatars using the Blender 3D modelling software were created to represent a range of potential disabilities. Together with a baseline (no impairment) avatar, these were uploaded to the Hubs platform. Specifically, the following five avatars could be chosen by students in the study:

- No impairment – A standard/generic robot avatar was made available (eye position 1.7m above ground)
- Mobility impairment - An avatar was parented to a wheelchair object, so that the student eye position was significantly reduced compared to a 'standing' avatar (eye position 1.1m above ground).
- Visual impairments – Three avatars were created with a hemisphere mesh parented to the armature head bone with varying transparent texture effects to represent visual impairment due to either cataracts (blur effect

across visual field), glaucoma (blur predominant in peripheral vision) or macular degeneration (blur in central portion of visual field).

Fig 1. Real world space used in study (together with virtual world view on large screen).

2.3 Tasks/scenarios

Candy and Dunagan [11] in their work 'Designing an experiential scenario' proposed the 'Experiential Futures Ladder' as a mechanism for making the abstract, real. It comprises moving from the 'Setting' (a theme or kind of future) to the 'Scenario' (sequence of events) to the 'Situation' (encounters in a physical form). In our work the 'Setting' equated to a virtual city environment that was deliberately challenging to navigate (low light levels, poor contrasts, sunset and its potential for glare, multiple moving vehicles, etc), which had to be navigated with an impairment, as shown in Fig 2. The 'Scenario' related to the tasks to be undertaken: 1) find and then use an ATM/cashpoint to withdraw some money; 2) find a shop and check the opening times (based on a sign close to the shop door) – both tasks also involved numerous roads crossings. These activities were chosen as they are common activities that require spatial perception (peripheral vision) as well as visual acuity (central vision). The 'Situation' related to the interactions undertaken e.g. identifying zebra crossings, tracking approaching cars, reaching to the ATM screen, reading the shop times sign, etc. This link shows a video within the virtual world[1], including the range of avatars utilised in the research.

2.4 Data collection

Given the educational context of the work, Kolb's experiential learning theory was applied [18] which showed significant overlap with the Empathy in Design Scale [5]. This resulted in five student tasks (plus an additional baseline task) assessed by:

- **Empathy in Design Scale.** The scale in its original version relates to the design of a service and assesses employee empathy towards the service users. For this study, the wording was amended to reflect the context of assessing student empathy towards visually and mobility impaired individuals, approximated through avatars, within a challenging environment. Although the design context (service and environment) and characters (employees and capability impaired individuals) differed, the underlying premise of an experiential learning context (with the stages of: Discovery, Immersion, Connection and Detachment – refer to Table 1, column 1) which underpins the scale, remained constant. The scale was completed pre- and post VR immersion to determine the impact of the immersive VR experience on the students' self-ratings relating of empathy.

[1] https://www.youtube.com/watch?v=mbSUOgcIvbo accessed on 24 April 2024.

Baseline (no impairment)

Wheelchair

Cataracts

Glaucoma

Macular degeneration

Fig 2. Visual perspectives based on the five impairment avatars used in the study.

- **Contextual task.** This was designed to investigate transfer of learning i.e. to determine if any learning from the immersive VR activity was extrapolated to an analogous task, in this case, supermarket shopping. Pre VR immersion, a baseline was established at the start of the session regarding the students' perceptions of factors which might be challenging for an individual with a visual or mobility impairments when shopping in a supermarket. Post VR immersion the students were asked if they had any further information to add.
- **Group reflection.** Following the VR immersion, a group reflection was held covering all aspects of the learning experience to probe the students' empathic responses (i.e. attitudes, emotions, catalysts, etc.), see Figure 3.
- **Video observation.** Throughout the study, a video camera placed within the physical room captured objective behaviours (visual and auditory), from within both the physical and virtual spaces.

Table 1 shows the application of these models to the student tasks and the data collected.

Table 1. Rationale for data collection.

Kouprie et al. [4]	Kolb et al. [18]	Student tasks	Data collection
			Contextual task (Pre-VR immersion)
Emotional interest/ Discovery (EI)		Students have selected this optional module	Empathy in Design Scale ratings + Group reflection
Sensitivity/ Immersion (S)	Concrete Experience	Students use VR to immerse themselves in daily tasks undertaken by capability challenged avatars	Empathy in Design Scale ratings + Group reflection + Behaviour video
Personal Experience/ Connection (PE)	Reflective Observation	Students reflect on their experience	Empathy in Design Scale ratings + Group reflection
Self-awareness/ Detachment (SA)	Abstract Conceptualization	Students identify what they have learnt	Empathy in Design Scale ratings + Group reflection
	Active Experimentation	Students consider how they might apply their learning	Group reflection + Contextual task (Post-VR mmersion)

GROUP REFLECTION

Empathic experiences

EI - Emotional Interest/Discovery

- How did you feel about the opportunity to explore challenged capabilities via VR?

S - Sensitivity / Immersion

- What did you feel when undertaking the tasks?

PE - Personal experience/connection

- To what extent do you think that this has added to your understanding of others with challenged capabilities?

Impacts to future design practices
SA - Self-awareness/Detachment
- What made an impact on you?
- What did you learn which was new?

Active Experimentation (Application)
- How do you think you will apply what you have learnt about challenged capabilities today in your future design work?

Fig 3. Structure and content of group reflection exercise.

2.5 Procedure

Students were informed of the study in advance and the risks involved (especially related to the possibility of VR-induced sickness). Therefore, they could opt into the research, rather than be forced to opt out. They then completed a consent form followed by the contextual task and the Empathy in Design Scale. A VR training session then took place (lasting approximately 20 minutes), to familiarise students with the VR headsets, their controls and the tasks they would be required to undertake. Half of the students then wore the headsets and entered the virtual world together with the module convenor (teacher) -who also wore a headset to assist within the city space. Two research assistants were present in the real world to help any students who were struggling with the technology. Within the virtual world, students then undertook the two tasks whilst embodied by each of the five avatars in turn. They were encouraged to talk aloud while undertaking the tasks using the spatial audio capability of the Mozilla Hubs platform. When all students had carried out the tasks, students swapped over so the remaining participants could complete activities. Once all students had completed the immersive tasks, the post VR immersion data collection was applied. The whole study took approximately 1.5 hours to complete.

3 Results

3.1 Empathy in Design Scale

Figure 4 shows the mean ratings of students for the four constructs of the Empathy in Design Scale [5] captured immediately before/after the VR session. The graph shows a trend for increased empathy ratings for all constructs following the VR experience. According to paired t-tests, these differences reached significance for the sensitivity/immersion, personal experience/connection and self-awareness/detachment constructs. Therefore, students believed that following the VR session, they were more:

- immersed and interested in the user's world/points of view without judgment: $t(9)=-3.243$; $p<0.01$
- connected with users on an emotional/personal level; $t(9)=-2.281$; $p<0.05$
- able to consider the needs of these users better in their role as a designer/independent person; $t(9)=-2.653$; $p<0.05$.

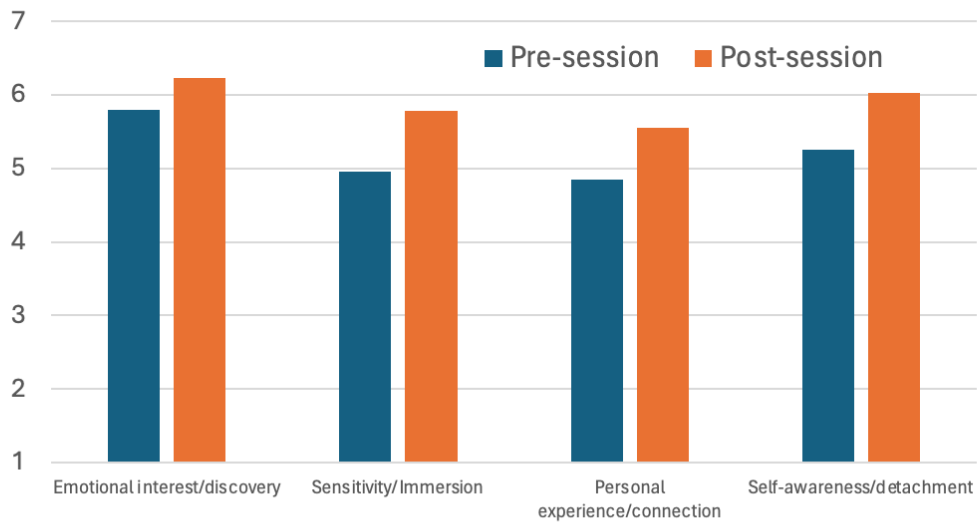

Fig 4. Mean ratings for empathy on 1-7 scale pre/post VR session, where 1=Does not describe me at all; 2=Barely describes me; 3=Somewhat describes me; 4=neutral; 5=Generally describes me; 6=Mostly describes me; 7=Completely describes me.

3.2 Contextual task

Prior to the VR teaching session, the students identified a range of relevant vision and wheelchair mobility-related challenges related to the contextual task of shopping (Table 2). Most notably, issues of reach by wheelchair users within the store environment were reported concerning two key stages within the shopping task – product selection and checkout (9/10). (The remaining participant stated 'Difficult to get products' and whilst this could relate to reach, it could also relate to not being able to locate required products and was thus excluded from the findings). Vision-related responses concerned navigating to specific areas within the store (aisle identification and signage) (5/10) and, once there, identification issues were reported in the context of product selection and checkout use (7/10). Insufficient space (within aisles and within the checkout area) (5/10) was also noted as were further challenges for wheelchair users in the form of using trolleys and carrying shopping. Five additional challenges were noted by single participants with 'people looking at you' and 'takes a lot of time' demonstrating further insight.

Table 2. Pre-session contextual task comments.

Challenged identified	Number of participants
Reaching high/low (shelves, counters, checkouts, into trolley)	9
Identification (labels, checkouts, prices, products on shelves)	7
Navigation (aisle identification and signage)	5
Insufficient space	5
Using trolley when wheelchair user	4
Wheelchair user carrying shopping	2
People looking at you, how to put everything in your bag, not easy when walking in supermarket, takes a lot of time, manoeuvring wheelchair over door lips	1

Following the VR teaching intervention, the pre-session question was again posed with the intention of identifying and adding further relevant issues (Table 3). This showed that there was a greater appreciation of visual issues (6/10). The two participants who had not previously noted visual issues with either identification or navigation, now had this appreciation with one stating, at a more general level, "*It's hard when you can't see clearly*", while the other gave specific instances e.g. "*cannot see prices/names/info; cannot see what pin number you're filling in; seeing others*". Across the other participants, additional insights into vision included: "*the effects of glairs [sic] on the eyes*", "*the impact colour has on the visually impaired*", "*distance of seeing things*" and "*contrast of things*". The earlier theme of 'insufficient space' extended into broader aspects of spatial awareness (2/10) e.g. "*simply spatial awareness and getting around as much as possible*" and "*Knowing where you are*". For two participants, although they considered that they had some awareness of challenges faced by those with impaired vision and wheelchair users, they had not appreciated the extent of the impacts of those challenges e.g. "*While I had guessed the problems they may face the extent and effects of these problems are far greater than I realised*" and "*It is more difficult than I expected*". One participant cited feelings of vulnerability having not previously raised any psychological insights.

Table 3. Post-session contextual task comments.

Challenged identified	Number of participants
Greater appreciation of visual issues	6
Greater awareness of spatial issues	2
Appreciation of extent of impacts	2
Vulnerability	1

The participants were able to offer a wide range of relevant considerations prior to the VR teaching intervention which may derive from earlier compulsory user-centred design modules in 'Understanding People' 1 & 2 undertaken in their first and second years and the further elective module of 'Inclusive Design' undertaken in their final year. However, even with this informed level of appreciation, the VR teaching intervention afforded the opportunity for enhanced learning by 1) extending their learning e.g. the participant who had not initially identified the visual impacts to the task, and 2) deepening their learning e.g. the participant who better appreciated the extent of the impacts. This exercise did evidence some transfer of learning, such as greater insights relating to vision and recognition of spatial awareness in a shopping context.

3.3 Group reflection

Whilst the group reflection was led by the research team to draw out the students' learning experience, the findings reported here are drawn from both the students' comments and the researchers' observation, thus providing a more holistic understanding.

Empathic experiences. For the majority of the students this was their first experience with VR. Six students primarily volunteered, with those who had initially been reticent keen to join later as headsets became available. In the interim they participated via the laptop until a headset became free or viewed via the large projection screen. From their actions and verbal expressions, the students appeared to be engaged in and enjoying the learning task.

They were surprised as to how real the immersed experience felt with some taking the view that they felt like they had been somewhere, as well as expressing feelings of vulnerability. A value was seen in experiencing the capability challenges in practice in the VR world compared to just seeing visual representations of the conditions. Being able to undertake spontaneous actions with no consequences was also noted as a facet of the VR world. Student compliance in engaging with the learning tasks within the VR world was generally good, although some were distracted with either exploring other parts of the VR world or introducing new elements into it.

Impacts to future design practices. These predominantly related to visual aspects concerning their impact on spatial awareness of the environment they were in. A key learning outcome was the heightened appreciation that what they imagined it might be like to be a wheelchair user or have a visual impairment was different to what they actually experienced – subsequently leading to an awareness that, in the future, they could not rely on assumptions.

3.4 Video Analysis

Upon entering the VR world, the novelty of the situation was reflected in spontaneous student comments of "*Oh, wow*" and "*That is crazy, It's really cool!*". When interacting with the vision avatars, the students' behaviour was representative of their engagement within the VR world. e.g. two students physically leant forward to read the cashpoint and several turned from side to side, at least three times, in order to cross the road with one student reacting to the perceived danger with exclamations of "*Woah!*" And "*Oi!*". When they selected the wheelchair avatar, several students were observed adopting physical adaptation techniques in order to view the cashpoint such as tilting their heads up and/or leaning forward to raise their eyelevel. Furthermore, four students were observed raising their hands to try to reach the cashpoint.

4 Conclusions

To address the first aim of investigating the four phases in the process of empathy in design practice, four approaches were adopted – the Empathy in Design Scale, contextual task, group reflection and video analysis. The video analysis of the students' real-world actions provided some evidence of engaging in 'another's' world through the behavioural responses they exhibited to the difficulties their challenged avatars were experiencing in the virtual world.

These behavioural responses were reflected in the findings of the pre- and post-VR immersion rating scores for the Empathy in Design scale which indicated significant improvements to the students' empathy in terms of being:

- immersed/interested in the user's world/points of view without judgement,
- connected with users on an emotional/personal level, and
- able to consider the needs of these users better in their role as a designer/ independent person.

The group reflection provided insight into the findings relating to behaviour and ratings, with students commenting on the realism of the immersion and the value of directly experiencing the challenges faced by the avatars. Taken together, these measures investigated students' understanding of being in another's shoes, with the contextual task progressing to investigate their learning by encouraging the application of that understanding to an analogous context. The VR immersion evidenced learning improvements in terms of both breadth and depth of relevant insights. It can therefore be concluded that immersive VR enhances empathy in design and that the combination of measures applied were effective in determining this.

With respect to the second aim of developing an insight into social VR in this learning context, the authors observed that during the on-boarding process, of those students who were waiting in the virtual world for the remainder of the cohort to join, some explored the virtual world whilst others appeared confused/disengaged.

Once the module convenor entered the VR world and provided direction there was greater engagement, but this appeared to be focused between convenor-student with minimal student-student interaction. The large projection screen provided a further mechanism for students to be involved in the task, although as observers opposed to direct participants (headset and laptop users). This enabled those who either could not or chose not to directly participate, to experience, to some degree, what their participating peers were experiencing, thus enabling an element of a shared social experience. Additionally, this sharing of the virtual world to non-participants had the potential to provide sufficient confidence amongst most non-participants to volunteer to wear a headset.

The pilot has indicated future research enhancements covering technical set-up and experimental design. In the onboarding phase, an instructor needs to already be present in the VR world to welcome and direct students in a holding room where interactions can be controlled. Whilst engaging with the VR immersion tasks, consideration needs to be given to increasing a) the reality of the representation e.g. limiting the virtual world powers, such as flying, to just those relevant to the students' task, and b) the fidelity of goal-based task interactions e.g. pressing buttons to enter a pin number on the cash machine. In addition, more control of real world/virtual world sound is needed to reduce interference and investigators need to be present in the real world to support the tasks students are undertaking, e.g. positioning chairs for engagement with the wheelchair avatars and assisting students experiencing technical difficulties with the equipment. This would also help with the social aspect of the activity as would ensuring all the avatars have the student's name associated with them to aid identification. Martingano et al. [19] stated that to increase cognitive empathy "requires deliberate mentalizing effort" and thus future activities regarding the application of understanding may benefit from greater instruction when applied to an analogous context.

The contribution of this work in terms of the design field concerns the application of VR to design students, with a view towards developing this approach as a digital design tool. It applies underlying academic theory to the investigation of empathy across the four phases in the process of empathy in design practice and in so doing, employs four intertwining, complementary data collection activities. The paper also provides some contributions related to the use of social VR for engaging students with the topic of empathy – in particular, through their shared experience in a real and virtual space.

In the future, research in this area could be extended to include design students who have not received specific 'design for inclusion' teaching. This would enable comparison of the impact of VR on the extent and type of differences of changes in empathy between these two student groups. The work could be further extended to practicing designers, most of whom it is likely would not have receiving specialist inclusion teaching. This would enable investigation of the extent to which empathy in design may be absent amongst experienced designers or may be acquired through experience. In line with Häkkilä et al. [16] unfamiliarity with the technology may be an impacting factor. This could be investigated through the recruitment of participants more experienced with the technology, although currently this characteristic within the student population is more limited.

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