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Hamilton, David; McKechnie, James; Edgerton, Edward; Wilson, Claire

Published in:
Innovative Practice in Higher Education

Published: 09/04/2021

Document Version
Publisher's PDF, also known as Version of record

Implementing Immersive Virtual Reality in Higher Education: A Qualitative Study of Instructor Attitudes and Perspectives

David Hamilton, Jim McKechnie, Edward Edgerton and Claire Wilson

University of the West of Scotland

Corresponding author: david.hamilton@uws.ac.uk

Abstract

The current study aimed to understand the attitudes and perceptions of higher education (HE) instructors who have previously used immersive virtual reality (I-VR) in teaching. This study employed a qualitative design by conducting semi-structured interviews with HE instructors from several disciplines and institutions. Using thematic analysis, five major themes were formulated. These included: (a) applications and benefits; (b) curriculum integration; (c) classroom logistics; (d) barriers to application; and (e) evaluation. Instructors were generally positive about using I-VR as a pedagogical tool, proposing a range of novel applications and uses. However, logistical and technical problems were prominent which made implementation and widescale adoption challenging. The implications of these prominent attitudes are discussed, alongside a range of practical recommendations for applied future practice.

Keywords: Higher Education; Virtual Reality; Attitudes; Qualitative Methods; Thematic Analysis

ISSN: 2044-3315

Introduction

The use of technology as a pedagogical tool in higher education (HE) is not a new phenomenon. The applications and educational benefits of technology-aided instruction has been studied for more than half a century (Hooper and Rieber, 1995). In addition, research has attempted to identify the various attitudes, constructs, and factors that predict whether these systems will be embraced by users and facilitators (Davis, 1989). Where once desktop-computers and overhead projectors would have been regarded as highly innovative and novel teaching methods, the 'fourth industrial revolution' has heralded a new-age of pedagogical technologies with the potential to change how HE is delivered (Schwab, 2016, p. 11). One such technology that has attracted the interest of educators is Virtual Reality (VR). The multi-disciplinary nature of VR has made a clear and concise definition of its characteristics challenging (Jensen and Konradsen, 2018). However, the virtual world will typically be interactive in that it provides feedback as a result of actions taken by the users, as well as allowing for variables to be tested and manipulated (Sherman and Craig, 2018). VR has generally been broken down into two main categories: non-immersive, and immersive. Non-immersive VR allows the user to interact with a computer generated or virtual environment using a 2D screen, mouse, and keyboard (Lee, Wong and Fung, 2010). Conversely, Immersive Virtual Reality (I-VR) provides multisensory stimulation facilitated by the use of a head-mounted-display (HMD) (Jensen and Konradsen, 2018). The HMD completely immerses the user by surrounding the visual field with information from the virtual environment. In addition, 360° audio, haptic feedback, and limb tracking are commonly employed to increase the sense of presence in the virtual space.

Immersive Virtual Reality Applications in Higher Education

In recent years, the applied use of I-VR in HE has steadily expanded. A major factor is the increased availability of low-cost and accessible HMDs that are still

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capable of displaying high-fidelity graphics (Jensen and Konradsen, 2018). A systematic review conducted by Radianti et al. (2020) found that science, engineering, and health-based subjects were the most common disciplines using I-VR as a pedagogical tool in HE. Additional research has also explored the specific educational outcomes that I-VR has been used to teach; the two most common of these being procedural skills and cognitive information (Jensen and Konradsen, 2018).

I-VR can be used in procedural skills training to teach a specific sequence of actions or movements that can then be transferred to real world scenarios (Jensen and Konradsen, 2018). This application of I-VR has most commonly been employed in the context of surgical or dental education (Lungu et al., 2021). The justification for this being that a novice can repeatedly practice dangerous or complex procedures on a virtual patient without risk to themselves or others. This is until a student reaches a certain level of competency where it would be safe for them to be exposed to a real patient. However, the use of I-VR to teach procedural skills has also been employed in HE more generally. For instance, Bharathi and Tucker (2015) developed a virtual engineering laboratory so that functional analysis tasks could be performed using an Oculus Rift HMD. The study demonstrated that students completed the assigned task significantly faster using the HMD than with a non-immersive 2D alternative. Furthermore, a post-experiment questionnaire indicated that students were more satisfied with their learning when using I-VR than the alternative. Procedural learning using I-VR has also been employed in a diverse range of other HE subjects from nursing (e.g. Farra, Smith and Ulrich, 2018) to computer science (Zhou et al., 2018).

I-VR has also been utilised in cognitive learning and attempts to teach theoretical concepts or declarative information, especially when this information is highly abstract or visual. For instance, the technology has been used to help HE engineering students visualise spatial arrangements through interaction and manipulation using an Oculus Rift HMD (Fogarty, McCormick and El-Tawil, 2018). Similar applications have been employed in biological education by allowing students to visualise strands of DNA (Lamb et al., 2018) or the inside of a microscopic human cell (Johnston et al., 2018). Similar to the principals of procedural learning, virtual fieldtrips or excursions to inaccessible and dangerous locations (e.g. under the ocean) can also be undertaken using the technology (Markowitz et al., 2018). This facilitates the students' ability to construct their own cognitive understanding through experiential learning and perspective taking.

Instructor Attitudes Towards Immersive Virtual Reality

Understanding instructors' attitudes towards educational technology such as I-VR is essential in predicting whether it will be accepted as a teaching tool or not (Hussin, Jaafar and Downe, 2011). This encompasses one of the most fundamental tenets of behavioural psychology; attitudes ultimately influence behaviour (Ajzen and Fisbbein, 1974). If researchers and institutions can identify and understand these attitudes, it becomes easier to facilitate I-VR's applied use in the classroom.

The first major barrier to understanding these attitudes is that research examining the perceptions of HE instructors is sparse. Most research has either focused on student attitudes towards I-VR (e.g. DePape et al., 2020) or that of schoolteachers or teachers-in-training (e.g. Cooper et al., 2019; Fransson, Holmberg and Westelius, 2020). Therefore, the degree to which the attitudes of high-school teachers are generalisable to HE institutions is difficult to ascertain. However, there may be common perceptions, barriers, and practicalities that underpin attitudes towards I-VR across educational establishments.

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The most fundamental attitudes to understand are those concerned with *how* and *for what* I-VR should be used? Apart from experimental research examining learning outcomes in specific disciplines, little attention has been paid to HE lecturers' perceptions of I-VR application. However, schoolteachers have intimated that highly abstract or conceptual topics such as those taught in physics, mathematics, or geography could benefit from I-VR (Dengel, 2018; Serin, 2020). Chou and Hoisington (2018) extended this idea further by proposing that I-VR could be used for virtual fieldtrips and excursions which would allow students to experience simulated environments; an approach which would be especially practical if the environment was too inaccessible or dangerous to be visited in reality (Cooper et al., 2019). Although these attitudes do not pertain directly to HE, there is no reason to think that these potential applications could not be of benefit to university students also.

Although limited research has examined attitudes towards I-VR and syllabus integration, the general consensus is that its use should be aligned with specific goals and learning objectives. Fransson, Holmberg and Westelius (2020) conducted interviews with schoolteachers in Sweden and found they were adamant that I-VR should not be used as a 'flash-in-the-pan' (p. 3397). Instead it should be used to complement the predefined learning outcomes prescribed within the larger syllabus or module. As one teacher noted, this means constantly assessing I-VR's purpose as a learning tool in the classroom, to ensure it is enhancing learning as opposed to being used as a gimmick. Like any form of technology (e.g. computers, projectors, tablets), HE instructors must ensure that it is the learning outcome itself that dictates whether I-VR is used, and not the other way around (Picciano, 2009). To integrate I-VR in a spurious manner could render its application redundant regardless of whether this is done in a high-school, college, or university environment.

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One prominent set of attitudes found among instructors relates to perceived internal and external barriers to I-VR implementation. In a study of HE computing instructors, Alfalah (2018) found that lecturers envisaged problems such as a lack of finance, training, resources, time, and administrative support. The need for professional development services prior to I-VR implementation was also deemed essential. Despite this, instructors were still positive about using I-VR as a pedagogical tool provided the requisite support was in place. Almost identical barriers have been identified by non-HE faculty, such as those in primary school and high school (Chou and Hoisington, 2018; Cooper et al., 2019; Fransson, Holmberg and Westelius, 2020). This would suggest that these barriers are universal and a common concern. As a result, practical solutions and recommendations could help alleviate these concerns across the board as opposed to within just a specific institution. It is therefore important to examine the perspectives and attitudes of instructors who have already implemented the technology in order to inform best practice and ensure I-VR's effectiveness as a pedagogical tool.

Current Study

Problem Statement

It is important to recognise that the literature examining I-VR's educational utility is typically drawn from lab-based studies. This presents problems as educational research conducted in a controlled setting may not account for the many practical issues encountered in a natural classroom environment. As Southgate and Smith (2017) state, classrooms are dynamic and unpredictable in ways that laboratories are not. Therefore, conclusions reached in lab-based I-VR research may not necessarily be ecologically valid. To bridge the gap between experimental and applied research, it is important to understand the attitudes and experiences of those who will ultimately facilitate I-VR's use in the classroom; the instructors.

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Theoretical framework

As previously mentioned, research examining the attitudes of HE instructors has often been neglected; where attitudes have been gathered, these tend to come from the HE students undergoing the VR experience itself rather than the facilitator. This poses a concern because, as Alfalah (2018) intimates in the Educational VR System Model, the perceptions of students *and* instructors must operate in tandem to develop an effective I-VR system; the attitudes of one group cannot be considered without the other. Therefore, understanding how HE instructors perceive I-VR is essential for future practice.

Previous research has commonly employed quantitative techniques such as questionnaires to gather instructors' attitudes towards I-VR (e.g. Alfalah, 2018; Serin, 2020). Although this method can be useful, it is often unable to provide the depth of insight that qualitative approaches can. In addition, previous studies have often investigated the attitudes of educators who are not currently using I-VR in teaching, but might in future. This means instructors have limited experience of the practical considerations associated with implementation and adoption. Conversely, participants in the current study all have teaching experience using I-VR in HE, giving them an informed perspective of the technology.

Objectives

By conducting semi-structured interviews with HE instructors across various disciplines, the current study set out to examine several key areas:

(A) Understand why instructors chose to use I-VR, and how they evaluated the experience.

(B) Examine the kinds of tasks that I-VR was used for, and how it was integrated into curricula.

(C) Understand the logistical considerations of implementing I-VR in the classroom.

(D) Identify the barriers encountered whilst implementing I-VR in teaching.

Design and Methods

Participants

The study recruited lecturers currently employed in a teaching capacity at UK-based HE institutions. All participants were required to have experience of implementing I-VR as a pedagogical tool to deliver teaching to students. In this study, I-VR was defined as the viewing of 360° films or computer-generated imagery via a head-mounted-display (HMD), and implementation was defined as the applied use of the technology with students during lectures, seminars, or workshops. The use of I-VR for surgical or dental training was not included in the study as this represents a highly specialised and niche utilisation of the technology.

In total, seven participants (three male; four female) were included in the study. This sample size has been deemed sufficient for qualitative research employing thematic analysis (Braun and Clarke, 2013; Fugard and Potts, 2015). Participants were drawn from three separate HE institutions in the United Kingdom. They had between 4 – 21 years of total teaching experience (M = 10.6; SD = 6.8). They had also been using I-VR in an educational capacity for between 1 – 5 years (M = 2.1; SD = 1.2). Participants were drawn from a range of subjects and faculties including science, health, and creative industries. An overview of participant demographics can be found in Table 1.

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Table 1. Participant demographics and overview of VR application

Participant code	Gender	VR teaching experience (years)	Subject discipline(s)	HMD(s) used	Application
P1	Female	5	Psychology	Oculus Rift	VR used for experiential learning and perspective taking to teach psychological theories.
P2	Male	2	Creative industries	Oculus Rift	VR used to provide lecture capture facilitation as well as aiding revision sessions for assessments.
P3	Female	2	Nursing	Oculus Rift and Samsung Gear-VR	Combination of HMDs used to give students an embodied experience of what it is like to be a patient in a hospital.
P4	Female	2	Nursing	Oculus Rift	VR used for experiential learning and simulating sensory differences for first-responders and healthcare staff.
P5	Male	2	Health and life science	Samsung Gear-VR	Mobile-VR used to teach procedural knowledge needed in a healthcare setting.
P6	Male	1	Health and life sciences	Oculus Rift	Oculus Rift was used to teach students cognitive and declarative knowledge as it related to life sciences.
P7	Female	1	Biological sciences	HTC Vive	VR used as a way of visualising bone structures in the human body as part of a biology and physiology module.

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Data collection and transcription

A semi-structured interview technique was employed in this study, based on the guidelines set out by Smith and Osborn (2003). This technique used the interview schedule as means of guiding the conversation as opposed to stringently adhering to a specific set of questions. Semi-structured interviews allowed for the researcher to follow-up on insights raised by the participant that were not considered whilst initially devising the interview schedule (Smith and Osborn, 2003). See Appendix for a copy of the associated prompts.

Each interview was conducted by the principal researcher (DH) to ensure continuity of style and approach. These were all conducted in a private room at the participant's own institution, lasting around 60 minutes. The entirety of the interview was recorded using a digital voice recorder. Upon completion recordings were transcribed verbatim by the principal researcher, and then imported to NVivo-12 to assist analysis.

Thematic analysis

Thematic analysis (TA) as set out by Braun and Clarke (2013) was used as the qualitative method of analysis. Due to limited qualitative research examining HE instructors' perceptions of I-VR, TA offers a theoretically flexible approach to data analysis (Braun and Clarke, 2013). An inductive, or bottom-up, approach was undertaken, in that no preconceived coding or thematic framework was used to instruct analysis. Codes were both semantically and latently coded, in that not only was the surface meaning provided by the interviewee noted, but also the researchers' interpretation of underlying concepts or ideas. The principal researcher was responsible for the generation of initial codes and early themes. These were then reviewed by the three co-authors who provided feedback and suggestions on how the codes corresponded to the proposed themes and wider dataset. A final meeting among all four researchers rearranged, split, and

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discarded themes until a unanimous decision was reached as to the reliability of the final five overarching themes and associated quotations. Figure 1 provides a step-by-step account of each part of the analysis process.

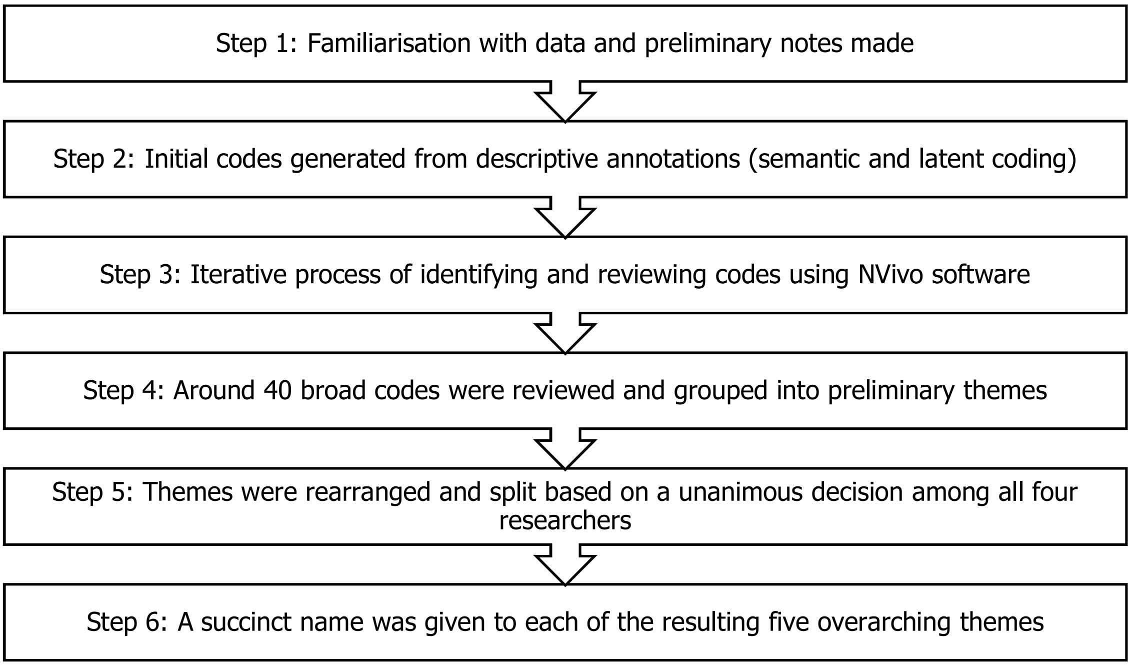

Figure 1. Step-by-step process for thematic analysis

Findings and Discussion

By employing thematic analysis, five main themes were formulated. These included: (a) applications and benefits; (b) curriculum integration; (c) classroom logistics; (d) barriers to application; and (e) evaluation.

Applications and benefits

The applications and benefits theme concerns the kinds of tasks for which HE instructors used I-VR, as well as the perceived pedagogical benefits afforded by the technology. Instructors identified several domains where they felt the technology could be successfully integrated into their particular subject area.

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Experiential learning, or tasks that required someone to take the embodied perspective of another person were commonly considered to be uniquely suited to I-VR. Instructors remarked that the ability of I-VR to provide a first-hand perspective could increase empathetic response, and eventually lead to demonstratable changes in behaviour. Furthermore, instructors reinforced that this ability could not be replicated by using approaches such as didactic teaching. It is the immersive nature of the I-VR experience itself that elicits a response that can ultimately assist in changing attitude and behaviours. Instructors made several remarks regarding this:

> "It gives them a first-person perspective of what is going on, rather than in a traditional lecture where it goes in one ear and out the other. This puts them in a situation where they can relate to what is happening."
> Participant 5.

Many instructors hoped that by allowing their students to embody the lived experience of another, I-VR would elicit an empathetic response. Some instructors even said that their students displayed positive changes in behaviour and their applied practice. For instance, nursing students became more aware of sensory processing differences in their patients as a result of an I-VR experience, and so changed how they interact and convey information. Far from being merely anecdotal, research in the field of psychology has demonstrated the technology's ability to increase empathetic response. For instance, Herrera et al. (2018) found that I-VR could facilitate long-lasting and demonstratable attitude change by undergoing an emotionally salient experience (i.e. homelessness) in I-VR. Therefore, the desire of instructors to use the technology to facilitate affective learning does seem to be consistent with the findings of previous empirical research.

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Using I-VR to provide affective learning and first-hand perspective taking was not the only pedagogical application identified by instructors. Several participants used or promoted the technology for cognitive learning purposes. This included applications such as teaching theory, revising material, or visualising abstract or conceptual problems. Instructors felt that I-VR could help solidify theoretical concepts that were first learning in class using traditional teaching methods. As one instructor remarked:

> "We would use VR at the end which […] encapsulated all the theory and hands-on stuff that we done."
> Participant 3.

Hussein and Nätterdal (2015) made a similar observation by proposing that VR could help bridge the gap between acquired theoretical understanding and applied use. An example of this type of application was provided by an instructor in the current study who used I-VR to aid student revision. They would film 360° videos of important seminars, workshops, and group activities that could then be reviewed by students at a later date provided they had access to an HMD. This would allow the student to revise and solidify theoretical concepts learned in class in an immersive manner, and then apply this understanding to examinations, essays, or assessments. Using I-VR as an educational revision tool appears to be a relatively novel application that has rarely been mentioned in previous studies. However, experimental research does suggest that it has the potential to be an effective use of the technology. For instance, Molina-Carmona et al. (2018) found that multimedia engineering students who revised for an examination using I-VR had significantly better learning outcomes than those who used a non-immersive alternative (i.e. a desktop computer).

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Curriculum integration

A recurrent theme in the data was that of curriculum integration, or how educators envisage I-VR being used and applied within the syllabus. As Southgate and Smith (2017) previously highlighted, this is a component of pedagogical I-VR research that has been often neglected. The most prominent attitude of participants was that I-VR should be integrated into the curriculum as a form of blended or multimodal learning. As Garrison and Kanuka (2004) note, blended learning combines traditional methods of teaching with technology to achieve a set learning outcome. Technology does not replace existing methods, but rather complements and supplements them. The current study found that instructors would utilise a range of didactic and technological approaches to achieve a set learning outcome in their classes. Instructors were keen to stress that it was important to integrate the I-VR experience into pre-existing methods of teaching.

> "Education works that way. We have VLEs; we have online resources; we have Padlet; we have Turning Point. We have all these different technologies, that hopefully enhance the learning experience. VR should be used in that capacity. It should not be a replacement; it should be an enhancement."
> Participant 2.

Instructors also tended to be cautious about integrating I-VR as a stand-alone method of teaching in their curriculum. Although the consensus was that I-VR could be effective when applied properly, it could not be seen as applicable in all scenarios. One participant summed up this attitude succinctly when they noted:

> "(VR) is not a panacea, but there is certainly a place for it."
> Participant 1.

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One of the implications of I-VR being viewed as a supplementary learning tool was that instructors acknowledged that careful planning had to be undertaken to ensure that the technology was appropriately integrated into the course. As one instructor remarked:

> "It's not a toy. So, for us it has to be integrated into the teaching, it has to mean something. It has to reinforce the session that we use. So, it was very carefully planned."
> Participant 7.

These attitudes are consistent with what Picciano (2009) termed as 'blending with purpose' (p. 7). This approach places learning outcomes as the driving force behind the choice of teaching materials used, as opposed to the technology itself dictating the objective. Instructors explicitly stated that to use I-VR without a predefined pedagogical purpose could impair the learning process. This was especially true if the technology was shoehorned into parts of the curriculum where its use was not warranted. Prior research in other institutions have reported similar attitudes. For instance, schoolteachers were vehement that I-VR should only be used for a specific purpose, and as part of a well-structured and designed lesson (Fransson, Holmberg and Westelius, 2020). Simply using the technology because of its novelty, or without a predefined objective could render its use redundant. In practice, this means that the technology should be used only when it can provide a unique perspective on a given topic. As a result, I-VR is not suitable for all subject areas or disciplines, and discretion must be exercised by module coordinators and instructors as to whether its use will confer an educational benefit for their students or not.

Classroom logistics

Classroom logistics refers to how the instructor behaves and organises the I-VR lesson itself. This includes considerations such as the physical space, classroom management, and the need for additional support from members of staff and faculty.

Most instructors referred to the fact that they did not have access to a dedicated I-VR space for teaching and had to manage with normal classrooms or lecture halls. This was often due to stringent room bookings, limited space on city campuses, or as a result of the number of students in the class itself. This could constrain the types of I-VR experiences that instructors could offer to students. For example, if chairs could not be moved, I-VR applications that required locomotion or extended movement were unable to be used. Instead, only experiences that required the student to remain in a seated position could be employed in teaching. As a result of these logistical considerations, a desire for a dedicated I-VR space or lab was almost universal. However, as instructors noted, universities often lack the resources or physical space to provide such a facility. Therefore, it is often the case that instructors had to work within the confines of their physical environment to deliver I-VR teaching.

A second logistical consideration was the number of students typically in each class. Most instructors noted that large class sizes created logistical problems in organising and managing the lesson, as well as often needing to utilise additional staff members to assist. Instructors mentioned that they would often recruit other members of their faculty to be present in the classroom during I-VR lessons. For those who were unable to do this, they often conveyed the attitude that this was indeed a necessity for future practice.

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> "I guess what we have learnt is that you need enough people in the room to be able to support them (the students)."
> Participant 4.

Instructors also noted that they would need to consider how to manage the classroom appropriately to facilitate both traditional and I-VR learning. For instance, often classes would need to be broken down into multiple sub-groups to accommodate all students and give them a chance to undergo the I-VR experience.

> "When we have three groups, all of them can't use it (VR) at the same time. So, we have to break down the sessions. We have to work out, 'right, one group can do the VR activity in the morning, the other in the afternoon.' […] The set-up time and planning is huge."
> Participant 3.

A common attitude was that I-VR can often be cumbersome to use in an applied setting, and additional staff members and appropriate planning is essential to successful implementation. Instructors therefore must give as much consideration to classroom management and logistics as they do to curriculum integration.

Barriers to application

One of the most common attitudes were the barriers encountered whilst using I-VR. These impaired the ability of the instructor to utilise the technology fully and are represented in two distinct subthemes based upon the nature and source of the barrier: institutional; or second-order.

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Institutional barriers

Institutional barriers relate to the attitudes and perceptions that instructors had towards their institution's facilitation of I-VR teaching. Instructors were generally not encouraged by the level of financial backing, investment or support they received from their own university. Instructors commonly remarked that although their institution was receptive towards using I-VR in teaching, they seldom made the financial investment needed. This made acquisition of headsets, computers, and software licences challenging.

> "If the university want to go down this line then they will need to spend money, and they are not willing to."
> Participant 5.

The problem of procuring financial backing for I-VR is not exclusive to the current study and appear to be prevalent among instructors and educators (Chou and Hoisington, 2018; Cooper et al., 2019). Specifically, both the current study and existing literature found that instructors worried about acquiring funds from their institution to purchase HMDs and other necessary equipment.

When instructors were asked why institutions would not financially invest, many said that this was due to scepticism regarding I-VR's longevity and economic feasibility. As one participant remarked:

> "People are saying 'it is just a fad.' Therefore, they are not prepared to put any level of investment in […] for something that may or may not be just a fad."
> Participant 2.

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Interestingly, some instructors were understanding of their universities' reticence to make the financial injection necessary. If indeed I-VR fails to have a long-term future as a pedagogical method, universities may fail to see a tangible return on their investment. As one instructor noted, institutions must weigh up the potential risks of making such a large investment.

The most common barrier resulting from a lack of institutional investment was obtaining enough headsets for the entire class. This often meant that HMDs had to be shared and rotated among multiple students, limiting the amount of time each person had with the technology.

> "It presents quite a lot of logistical problems for looking at equipment. Trying to get 230 students through the experience of using VR is quite a challenge [...] So our main problem is getting equipment especially when we have only six headsets at the moment."
> Participant 3

Additionally, instructors remarked that many applications of I-VR made the presumption that students themselves had access to the technology, which was often not the case. This meant that students commonly could not access I-VR experiences outside of designated class times. One possible solution would be to implement an approach similar to that of Olmos et al. (2018) referred to as bring-your-own-device (BYOD). BYOD involves students using their own smartphones to view I-VR material by attaching them to a mobile-HMD such as the Google Cardboard (Olmos et al., 2018). However, this may cause additional problems such as insurance and liability concerns if a device is broken during classroom use. Additionally, it assumes that all students have a compatible phone that is capable of being inserted into a mobile-VR headset.

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Problems resulting from the institutions' IT and software systems was another common impediment. Ports being blocked by a firewall, poor internet connectivity, and restrictions accessing common VR platforms like Steam and Unity were noted. Even if these problems could be addressed, some educators had serious concerns that most universities do not have the technical infrastructure necessary to adopt I-VR. For instance, one instructor noted that they recorded lectures or seminars on a 360° camera for students to watch. However, a traditional one-hour lecture could generate a file in excess of 50-gigabytes. The instructor noted that no current university platform such as the virtual learning environment (VLE) could accommodate files of that size to be uploaded or shared.

A lack of institutional investment and technological infrastructure are two of the issues raised by instructors in the study. Similar to Alfalah (2018), instructors were also concerned with the lack of an institutional support network and administrative guidance. This often led to instructors having nowhere to turn if they ran into problems using the technology. This led to nearly all participants stating that they were forced to use their "own initiative" when implementing I-VR into their teaching. This often consisted of trying various approaches to I-VR teaching to see what worked best. Based on these findings, it seems prudent to suggest that a centralised support network is an essential component of efficient I-VR implementation. A pooling together of knowledge from across the university, even in an informal manner, could give instructors the support and guidance they need to facilitate the technology in their classrooms.

Regardless of the institutional barriers encountered, nearly all instructors agreed that it would take a shift in educational policy to accommodate I-VR in HE. This means that faculty, institutions, government, and third-parties will all need to interact to provide the conditions necessary for widespread adoption of the technology. For instance, barriers related to technical infrastructure cannot be solved by the institution alone and will require input and guidance from others to find efficient solutions.

Second-order barriers

Ertmer (1999) defined second-order barriers as those that are intrinsic to the individual themselves such as beliefs around self-efficacy and technological confidence. It is well established that these internal factors can influence the behavioural intention to use and adopt technology such as I-VR (Davis, 1989).

Although instructors noted that I-VR was a novel teaching method, they often remarked that their own lack of technical skills or proficiency was a barrier to upscaling or utilisation. Surprisingly, many of the instructors interviewed confessed to not being technically savvy themselves but enjoyed using I-VR regardless. Statements like "I'm not technical" and "I'm a complete novice" occurred frequently. Several studies have identified a lack of self-efficacy and technical skills as being a source of apprehension among schoolteachers and HE instructors (Alfalah, 2018; Fransson, Holmberg and Westelius, 2020). Therefore, appropriate institutional support and training is essential to give instructors the skills and knowledge necessary to implement I-VR effectively. Fortunately, as Lee and Shea (2020) demonstrate, it does not take long for individuals to develop the skills required when quality training is offered.

Self-efficacy and a lack of technological confidence was also cited as a reason for sub-optimal VR experiences being used in the classroom. Instructors remarked that they did not know where to find bespoke material that was specifically relevant to their lesson. As a result, a few instructors attempted to create their own-tailor made I-VR experiences. Unfortunately, a lack of confidence and

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proficiency using 360° cameras, editing software, creation suites, and HMDs meant that this was extremely challenging. It is therefore important to note that a lack of self-efficacy does not merely impact on the ability to use HMDs, but rather extends to the quality of I-VR experiences that are able to be offered to students. As a result, a holistic approach to professional development is needed to cover all aspects of training necessary to implement I-VR. This should include both the technical and pedagogical skills necessary to apply the technology.

Evaluation

Instructors emphasised the importance of evaluating the I-VR teaching in their institution. Nearly all instructors interviewed thought it was important to gather feedback on the students' experience of I-VR learning through formal (e.g. questionnaires) or informal means (e.g. verbal feedback). The outcome of the evaluative process was important in deciding whether I-VR teaching was worth continuing to pursue. Students generally enjoyed using the technology which created excitement, heightened motivation, and resulted in the achievement of set learning outcomes. As one instructor noted, this influenced the decision to continue using I-VR:

> "We would love for it to continue because it has been evaluated so well. It just added a different vibe to the room. They were excited. They were looking forward to it."
> Participant 1.

These attitudes are similar to a number of other studies that have investigated how instructors perceive student engagement (Serin, 2020; Lee and Shea, 2020). Encouragingly, when students themselves are asked to self-report their level of enjoyment whilst using I-VR, they commonly express similar attitudes (e.g. Fogarty, McCormick and El-Tawil, 2018) with Heafner (2004) also concluding that anecdotal and empirical research has found that motivation and engagement through technology can have a positive impact on student attainment. Similarly, in the present study, instructors were keen to emphasise that their evaluation showed tangible benefits to student learning. In one case, students were able to apply what they learned as a result of I-VR to a real healthcare setting:

> "For those students who went out to practice recently having used VR, the provisional feedback has been that they have been able to implement things already. Seeing the results, it has definitely been worth it."
> Participant 3.

Although students enjoyed I-VR sessions, instructors did witness some trepidation on the part of the user. Sometimes students were self-conscious using the I-VR equipment in front of their peers. This was often the result of their physical actions (e.g. arm movements) in VR being without context to an outside observer. This sometimes led to embarrassment and a failure to interact fully with the technology, especially in front of large classes. A potential solution was to display what the user saw in VR onto a screen so that everyone else could watch it. This would mean that the observer could witness what the user was doing, providing a point of reference for their physical movements. Additionally, smaller class sizes or the ability to use the HMD privately could help alleviate some of the anxiety associated with I-VR use.

Instructors also raised concerns that some students reported cybersickness, or the inability to use I-VR due to medical conditions. This is a common problem that has been identified already as a barrier towards educational integration of HMDs and associated technology (Jensen and Konradsen, 2018; Southgate and

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Smith, 2017). It is imperative that future practice factors in these considerations and makes alternative methods of learning available for students who cannot partake in I-VR.

Conclusion

Using a qualitative methodology, the current study set-out to understand the attitudes and experience of HE instructors towards I-VR. Instructors proposed a range of benefits and novel applications for I-VR teaching such as embodied experience and perspective taking. Furthermore, instructors expressed that I-VR teaching was evaluated well by the students who participated. However practical barriers relating to financial backing, institutional support, and self-efficacy were common. This impacted how effectively the technology could be implemented in their respective subjects or departments. Universities will therefore need to invest both financially in the technology as well as in staff training and support to help alleviate some of the most important obstacles. Ultimately, it will be this response that will dictate whether I-VR has a long-term future in HE.

References

Ajzen, I. and Fisbbein, M., 1974. Factors influencing intentions and the intention-behavior relation. *Human Relations*, *27*(1), pp.1-15.

Alfalah, S.F., 2018. Perceptions toward adopting virtual reality as a teaching aid in information technology. *Education and Information Technologies*, *23*(6), pp.2633-2653.

Bharathi, A.K.B.G. and Tucker, C.S., 2015. Investigating the impact of interactive immersive virtual reality environments in enhancing task performance in online engineering design activities. *International Design Engineering Technical*

ISSN: 2044-3315

Conferences and Computers and Information in Engineering Conference, Boston, MA, 2-5 August, 2015. ASME, p. V003T04A004

Braun, V. and Clarke, V., 2013. *Successful qualitative research: A practical guide for beginners*. London: SAGE.

Chou, C.C. and Hoisington, D.A., 2018. Promises and constraints of virtual reality integration: Perceptions from pre-service teachers and K-12 students. *18th International Conference on Advanced Learning Technologies, Mumbai, India, 9-13 July, 2018.* IEEE, pp. 361-363.

Cooper, G., Park, H., Nasr, Z., Thong, L.P. and Johnson, R., 2019. Using virtual reality in the classroom: preservice teachers' perceptions of its use as a teaching and learning tool. *Educational Media International*, *56*(1), pp.1-13.

Davis, F.D., 1989. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, pp.319-340.

Dengel, A., 2018. Student primary school teachers' attitude towards virtual reality in primary school education. *4th Annual International Conference of the Immersive Learning Research Network, Missoula, MT, 24-29 June, 2018*. Technischen Universitat Graz, pp.234-246.

DePape, A.M., Barnes, M., Marsden, E. and Pawliw-Levac, M., 2020. Students' experience with a virtual reality tool: Brain stories. *Innovative Practice in Higher Education*, *4*(1), pp.78-107.

ISSN: 2044-3315

Ertmer, P.A., 1999. Addressing first-and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development*, *47*(4), pp.47-61.

Farra, S.L., Smith, S.J. and Ulrich, D.L., 2018. The student experience with varying immersion levels of virtual reality simulation. *Nursing Education Perspectives*, *39*(2), pp.99-101.

Fogarty, J., McCormick, J. and El-Tawil, S., 2018. Improving student understanding of complex spatial arrangements with virtual reality. *Journal of Professional Issues in Engineering Education and Practice*, *144*(2), p.04017013.

Fransson, G., Holmberg, J. and Westelius, C., 2020. The challenges of using head mounted virtual reality in K-12 schools from a teacher perspective. *Education and Information Technologies*, *25*(4), pp.3383-3404.

Fugard, A.J. and Potts, H.W., 2015. Supporting thinking on sample sizes for thematic analyses: a quantitative tool. *International Journal of Social Research Methodology*, *18*(6), pp.669-684.

Garrison, D.R. and Kanuka, H., 2004. Blended learning: Uncovering its transformative potential in higher education. *The Internet and Higher Education*, *7*(2), pp.95-105.

Heafner, T., 2004. Using technology to motivate students to learn social studies. *Contemporary Issues in Technology and Teacher Education*, *4*(1), pp.42-53.

ISSN: 2044-3315

Herrera, F., Bailenson, J., Weisz, E., Ogle, E. and Zaki, J., 2018. Building long-term empathy: A large-scale comparison of traditional and virtual reality perspective-taking. *PloS One*, *13*(10), p.e0204494.

Hooper, S. and Rieber, L.P., 1995. Teaching with technology. In Ornstein, A.C. (ed.) *Teaching: Theory into Practice*. Needham Heights, MA: Allyn and Bacon, pp. 53–80

Hussein, M. and Nätterdal, C., 2015. *The benefits of virtual reality in education - A comparison study*, BSc Thesis, University of Gothenburg, viewed 15 February 2021, <http://hdl.handle.net/2077/39977>.

Hussin, N.H., Jaafar, J. and Downe, A.G., 2011. Assessing educators' acceptance of Virtual Reality (VR) in the classroom using the Unified Theory of Acceptance and Use of Technology (UTAUT). *International Visual Informatics Conference, Selangor, Malaysia, 9-11 November 2011*. Springer, pp.216-225.

Jensen, L. and Konradsen, F., 2018. A review of the use of virtual reality head-mounted displays in education and training. *Education and Information Technologies*, *23*(4), pp.1515-1529.

Johnston, A.P., Rae, J., Ariotti, N., Bailey, B., Lilja, A., Webb, R., Ferguson, C., Maher, S., Davis, T.P., Webb, R.I. and McGhee, J., 2018. Journey to the centre of the cell: Virtual reality immersion into scientific data. *Traffic*, *19*(2), pp.105-110.

Lamb, R., Antonenko, P., Etopio, E. and Seccia, A., 2018. Comparison of virtual reality and hands on activities in science education via functional near infrared spectroscopy. *Computers & Education*, *124*, pp.14-26.

ISSN: 2044-3315

Lee, E.A-L., Wong, K.W. and Fung, C.C., 2010. How does desktop virtual reality enhance learning outcomes? A structural equation modelling approach. C*omputers & Education*, *55*(4), pp.1424-1442.

Lee, C.K. and Shea, M., 2020. Exploring the use of virtual reality by pre-service elementary teachers for teaching science in the elementary classroom. *Journal of Research on Technology in Education*, *52*(2), pp.163-177.

Lungu, A.J., Swinkels, W., Claesen, L., Tu, P., Egger, J. and Chen, X., 2021. A review on the applications of virtual reality, augmented reality and mixed reality in surgical simulation: An extension to different kinds of surgery. *Expert Review of Medical Devices*, DOI: 10.1080/17434440.2021.1860750

Markowitz, D.M., Laha, R., Perone, B.P., Pea, R.D. and Bailenson, J.N., 2018. Immersive virtual reality field trips facilitate learning about climate change. *Frontiers in Psychology*, *9*, DOI: 10.3389/fpsyg.2018.02364.

Molina-Carmona, R., Pertegal-Felices, M.L., Jimeno-Morenilla, A. and Mora-Mora, H., 2018. Virtual reality learning activities for multimedia students to enhance spatial ability. *Sustainability*, 10(4), p.1074.

Olmos-Raya, E., Ferreira-Cavalcanti, J., Contero, M., Castellanos, M.C., Giglioli, I.A.C. and Alcañiz, M., 2018. Mobile virtual reality as an educational platform: A pilot study on the impact of immersion and positive emotion induction in the learning process. *Eurasia Journal of Mathematics, Science and Technology Education*, 14(6), pp.2045-2057.

ISSN: 2044-3315

Picciano, A.G., 2009. Blending with purpose: The multimodal model. *Journal of Asynchronous Learning Networks*, *13*(1), pp.7-18.

Radianti, J., Majchrzak, T.A., Fromm, J. and Wohlgenannt, I., 2020. A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education*, *147*, p.103778.

Schwab, K., 2016. *The fourth industrial revolution*. Geneva: World Economic Forum.

Serin, H., 2020. Virtual Reality in Education from the Perspective of Teachers. *Amazonia Investiga*, *9*(26), pp.291-303.

Sherman, W.R. and Craig, A.B., 2018. *Understanding virtual reality: Interface, application, and design*. Burlington, MA: Morgan Kaufmann Publishers.

Smith, J. A. and Osborn, M., 2003. Interpretative phenomenological analysis. In Smith, J. A. (ed.) *Qualitative Psychology: A Practical Guide to Methods*. London: SAGE, pp. 53–80.

Southgate, E. and Smith, S.P., 2017. Designing and conducting research using immersive technologies in schools: Seven observations. *Virtual Reality Workshop on K-12 Embodied Learning through Virtual & Augmented Reality, Los Angeles, CA, 19 March 2017*. IEEE, pp.1-2.

Zhou, Y., Ji, S., Xu, T. and Wang, Z., 2018. Promoting knowledge construction: a model for using virtual reality interaction to enhance learning. *Procedia Computer Science*, *130*, pp.239-246.

ISSN: 2044-3315

Disclosure Statement: The authors declare that the contents of the article represent their own work. This article is not under consideration for publication elsewhere, nor has it previously been published. There are no conflicts of interest.

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Appendix

Q1: Background and demographics questions.	
Prompt	**Question**
A	What faculty position do you currently have within the university?
B	What courses do you typically teach?
C	How many undergraduate/graduate students do you typically teach in a semester?
D	What kinds of technology do you use in the classroom, and how long have you used it for?

Q2: What was the nature of the virtual reality used in your teaching?	
Prompt	**Question**
A	Describe the VR experience you used in teaching (presentation, headset type, length, etc.).
B	When did the VR experience take place?
C	Who was involved in the experience (what student group, module, class, etc.)?
D	Where did the VR experience take place (simulation lab, classroom, lecture theatre, etc.)?

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Q3: Why did you decide to use I-VR, and what was the rationale behind the decision?	
Prompt	**Question**
A	What were you trying to achieve by using I-VR?
B	Why was I-VR chosen as the teaching method? What benefits does it have over others?
C	What were your thoughts prior to implementing the technology in teaching?
D	Did these thoughts change as you continued to use the technology in teaching?
E	How did you measure/evaluate the experience?

Q4: What barriers and facilitators existed when using I-VR?	
Prompt	**Question**
A	What internal knowledge did you draw upon when you were teaching using VR?
B	Describe the nature of any external support from colleagues or faculty that assisted.

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C	Were there any barriers (internal or external) that existed which made VR implementation challenging?

Q5: What are your thoughts about the future use of I-VR in education?	
Prompt	**Question**
A	What are your thoughts on I-VR now that you have used the technology in teaching?
B	What are your thoughts on the impact of using I-VR in teaching for both yourself and your students?
C	Based on your experience of I-VR, what other disciplines, skills, or domains do you think it has the potential to be utilised in?

ISSN: 2044-3315