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DIGITAL TECHNOLOGIES EASING THE LEARNING CURVE IN THE TRANSITION TO PRACTICUM

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ABSTRACT

Aim/Purpose	This study aims to explore the value of utilizing non-immersive virtual reality (VR) to create virtual learning environments (VLEs) to support and prepare optometry students in their transition into preclinical and clinical teaching spaces.
Background	Digital education is widely integrated into university curricula with the use of online simulators, immersive VR, and other digital technologies to support

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	student learning. This study focuses on non-immersive VR as an accessible and low-friction means of accessing VLEs to reduce students' learning burden.
Methodology	Current optometry students were invited to explore 360° 3D panoramic virtual learning environments of preclinical and clinical teaching spaces. Students were recruited to participate in an online Qualtrics survey and individual semi-structured interviews. Quantitative data was analyzed, and thematic analysis was conducted on qualitative data from students' responses to identify key takeaways on the accessibility and impact of VLEs on students' learning.
Contribution	Non-immersive VR has utility in alleviating student stress and helping transition students into practicum. The VLEs have the means to supplement the curriculum to provide support to students entering the preclinical and clinical teaching spaces.
Findings	Students engaged voluntarily with the novel VLEs and utilized the resources to help familiarize themselves with the preclinical and clinical teaching spaces. The open-access resource supported students in their preparation for practical learning and helped to reduce self-reported stress and build confidence prior to entering practical classes. Many of the students enjoyed the experience of navigating through the spaces, which helped to appease their curiosity and reduce the learning curve associated with entering new spaces. The VLEs did not replace attending practical spaces but rather were supportive learning resources that aided students due to limited face-to-face contact hours. For students with existing familiarity with the spaces, through their in-person attendance in preclinical and clinical teaching sessions prior to accessing the VLEs, the digital resources were not as beneficial compared to students who were still transitioning into practicum.
Recommendations for Practitioners	Introductory digital resources like non-immersive VR are accessible platforms that help to orient and familiarize students with new environments. VLEs can potentially help to relieve student stress and reduce the learning load associated with entering practicum or new learning spaces.
Recommendations for Researchers	More work needs to be done on how student preparation can translate to feeling less stressed and more confident in relation to transitioning from traditional learning environments to practical learning spaces.
Impact on Society	A broader application of non-immersive VR can be implemented as an introductory learning preparation tool across different disciplines to alleviate student stress and maximize the limited time in practicum to allow focus on learning outcomes and practical skills.
Future Research	Future studies should consider different cohorts to study, with a focus on objective measures of engagement with VLEs. The effect of VLEs on students' cognitive load should be assessed and assessment of self-perceived stress can be evaluated with instruments such as Cohen's Perceived Stress Scale.
Keywords	optometric education, non-immersive VR, digital learning, student stress, student confidence

INTRODUCTION

The evolution of pedagogy has been diverse with the development of technology and its inevitable integration into the educational curriculum. The transition of higher education institutions to a greater reliance on technology has been intensified by the emergence of COVID-19.

On 11 March 2020, the World Health Organisation declared the highly infectious COVID-19 disease to be characterized as a pandemic (World Health Organisation, 2020). The turbulent effect of the pandemic and attempts to reduce disease transmission led to government-imposed lockdowns worldwide, with restrictions to movement intermittently imposed hence affecting thousands of tertiary institutions. Interruptions of face-to-face classes forced a rapid shift that relied almost solely on digital education; an overarching term to describe the myriad of different modalities of teaching and education through digital formats, methods, and equipment (Car et al., 2019). The temporarily necessary shift away from traditional education – teaching, and education using non-digital methods, such as textbooks or models, and reliance on in-person interactions (Car et al., 2019) – accelerated opportunities for unprecedented reforms to traditional learning methods, even after the cessation of lockdowns.

Before the arrival of the pandemic, university students reported feelings of stress and anxiety, with predominant stressors being academic performance and the pressure of expectations to perform well (Beiter et al., 2015). These feelings also translated to postgraduate healthcare students, including dentistry, medicine, nursing, optometry, and pharmacy, with reports of depression and anxiety upon beginning their coursework (Hoying et al., 2020). Although a modicum of stress is typically normal, high levels of perceived stress in nursing graduate students were found to correlate to burnout, exhaustion, and the intention to leave their healthcare course (Ma et al., 2022).

The pandemic further exacerbated negative emotions in healthcare students, including pandemic-related stress, worry over contracting COVID-19 infections, risks of transmission, and the quality of their academic education amidst disruptions to the traditional curriculum (Curcio et al., 2022). A further look into the mental health of optometry students during the COVID-19 pandemic revealed students experienced greater levels of depression and psychological stress compared to optometrists and other eyecare professionals (Pang et al., 2021). The added levels of stress placed upon healthcare students by the pandemic, compounded by the integration of postgraduate university students into a new environment, may impact the development of practical skills during university learning and clinical placements, notwithstanding the additional repercussions on student mental health. This, in turn, has further implications for the delivery of patient care later on.

The constraints set by lockdowns and physical distancing led to the development and extensive focus on digital learning as higher education institutions needed to pivot rapidly to the ever-changing conditions imposed by COVID-19. The augmentation of curricula to combine digital and traditional learning, known as blended education (Car et al., 2019), has benefitted students greatly. The recommencement of face-to-face learning allows the continuation of the invaluable experience and practical knowledge obtained in preclinical environments and clinical placements, with digital learning concurrently offering multifaceted flexibility, allowing students to learn and work at their own pace, at the time and in the environment of their choosing (Low et al., 2023).

The application of digital education is broad, with notable advances including the use of virtual reality (VR), a computer-generated simulation where 3D objects within can be explored (Hoffman & Vu, 1997) to create a virtual learning environment (VLE) – "an environment that is based on a certain pedagogical model, provides users with experiences they would otherwise not be able to experience in the physical world and rebounds specific learning outcomes" (Car et al., 2019). VLEs can replicate physical environments in 360° panoramic images which utilize digital cameras to shoot the real physical environment. This enables manipulation of the viewpoint within digital displays in all directions around the vertical axis (Qiu & Tao, 2022). The panoramic VR facilitates a sense of presence within the VLE, allowing interactivity and the ability to roam the environment with 3 degrees-of-freedom (around rotational axes).

VR is further characterized as "immersive" or "non-immersive" (Hoffman & Vu, 1997). Immersive VR is often used in combination with a head-mounted display and peripheral haptics, allowing for stereoscopic visual displays that vary and respond to changes in the user's head and eye movements.

Conversely, non-immersive VR houses VLEs on a computer display to replicate the feeling of viewing an environment from an external vantage point with a computer mouse or joystick used to interact with the system. Unlike immersive VR which requires the use of a head-mounted display and other peripheral devices, non-immersive VR affords the flexibility for supplementary digital education to students off campus; it is easily accessible and requires only an electronic device and a stable internet connection. Non-immersive VR has been shown to be equally effective as immersive VR, with student learning-success scores having no significant difference between the two (Omlor et al., 2022).

The limited understanding of using non-immersive VR applications within optometric education and how it may contribute to student learning is a gap in the current literature. Only one study has shown the short-term use and access of VLEs to improve clinical learning outcomes for inexperienced optometry students (Woodman-Pieterse et al., 2016). Other studies have focused more on using simulators to assist students in attaining practical skills. This includes the use of online refraction simulators, which mimic the use of a refractor-head to replicate ideal patient responses for the refraction process (Alhazmi et al., 2018), and EyeSI binocular indirect ophthalmoscope, which utilizes augmented reality – the visualization of physical surroundings through a head display – to replicate an eye examination on a simulated patient (Douglass et al., 2021; Rai et al., 2017).

The present study aims to contribute to existing knowledge by exploring the use of non-immersive VR and its capacity in supporting student learning in unfamiliar learning spaces. It explores the value of digitizing preclinical and clinical learning environments into 360° panoramic virtual models by utilizing non-immersive VR as a useful adjunct to traditional education. First-year students of healthcare graduate courses are exposed to many stressors accompanying the transition into the course, including adapting to a demanding course structure and feeling overwhelmed with unfamiliar learning spaces (Silverstein & Kritz-Silverstein, 2010; Spivey et al., 2020). Likewise, students enrolled in the Doctor of Optometry at the University of Melbourne are subject to these stressors. In an already overcrowded course, it is impractical and unsustainable to incorporate multiple introductory practical sessions to increase student comfort and familiarity with new learning environments. The research questions were:

1. What do you think about the virtual equipment and environments?
2. How do you think it compares with the physical aspects?
3. What would influence your access to the virtual equipment and environments?

We hypothesized that VLEs will support students' transition to both the preclinical and clinical spaces, alongside relieving anxiety and stress when incorporated into the curriculum. Specifically:

1. VLEs will be a supportive resource to aid with students' transition into the preclinical and clinical environment. The VLEs will aid with navigation and familiarity of the aforementioned spaces and mitigate student anxiety associated with entering into unfamiliar environments.
2. VLEs of the preclinical teaching space will be most helpful for first-year students. Students in their second, third, and fourth years who have had considerable amounts of time exposed to the preclinical teaching space may find this resource less valuable.
3. VLEs of the clinical teaching space will be most helpful for second-year and third-year students. Fourth-year students, who are already familiar with the clinic, may not find it as helpful, and while first-year students may find interest in navigating through the clinic, the lack of engagement with this space in the first year within the curriculum will limit its usefulness to them.

METHODS

PARTICIPANTS

All students who were currently enrolled in the Doctor of Optometry course at the University of Melbourne were invited to participate in the study. The Doctor of Optometry is a four-year post-graduate course at a master's-level professional entry into the optometry profession (University of Melbourne, 2022) with an Australian Qualifications Framework Level 9 (Australian Qualifications Framework Council, 2013).

The method of sampling chosen was convenience sampling. A 2-factor, 2-tailed power analysis, and n=80 provided a 95% confidence interval with a 5% margin of error. This study aimed to recruit at least 90 Doctor of Optometry students across all year levels. Students were invited to explore the VLEs and had unlimited and unrestricted access through links provided on Canvas, the main University learning management system.

VIRTUAL LEARNING ENVIRONMENTS

The preclinical teaching space, and the clinical teaching space, known as Melbourne Eyecare Clinic, are two key teaching settings throughout all year levels of the Doctor of Optometry course. They were digitized into panoramic 360° 3D VLEs (Figure 1) using a 360° camera, the Insta360 Pro 2 (Insta360, 2017). The VLEs were accessible through Roslin, an educational platform developed by the Digital Learning Hub, School of Biomedical Sciences, The University of Melbourne.

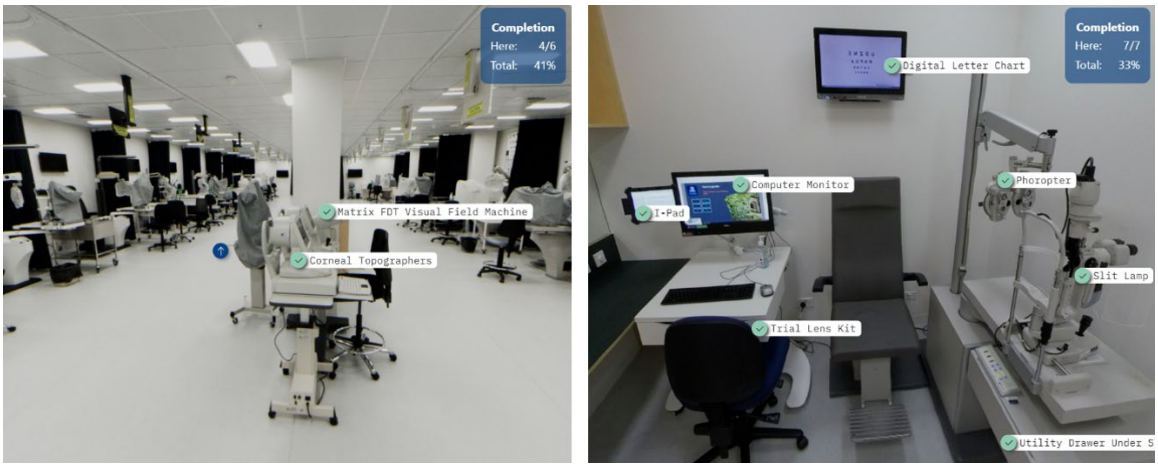

Figure 1. Panoramic 360° 3D virtual learning environment of the preclinical teaching space (left, blue arrow for navigation) and the clinical teaching space, Melbourne Eyecare Clinic (right)

All VLEs and scanned equipment had interactive labels for identification. Unopened labels were denoted by white circles with a notepad and opened labels were indicated by green circles with check marks. Opened labels further led to a concurrent window to appear, detailing the purpose of the equipment or structure, and some labels provided external links to other online virtual simulators or videos (e.g., Figure 2). Navigation through the VLEs was facilitated by clicking blue circles with arrows on the floor. The VLEs also consisted of progress and completion indicators at the top right-hand corner to help guide students through all interactive labels.

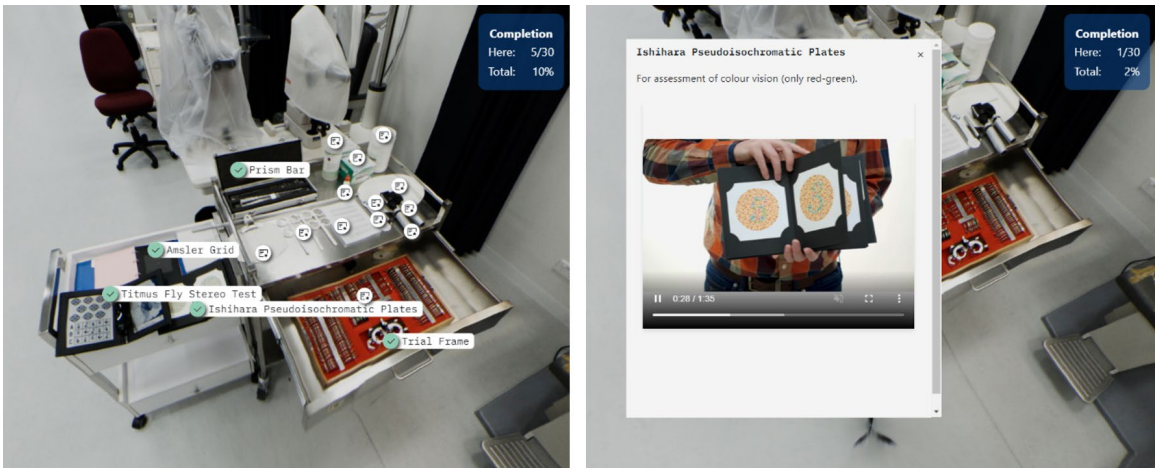

Figure 2. Labeled cubicles in the preclinical teaching space virtual learning environment, with access to external videos

In addition to digitization of the physical environments, clinical equipment such as the tonometer, direct ophthalmoscope, and retinoscope (Figure 3) was scanned into 3D models using a 3D scanner, the Artec Space Spider and scanning software, Artec Studio 15 (Artec3D, 2020). The interactive 3D models were accessible through Pedestal, a web content management system for 3D data that allowed students to observe the structure and use of the respective equipment. The components of the equipment were indicated by red pinpoints.

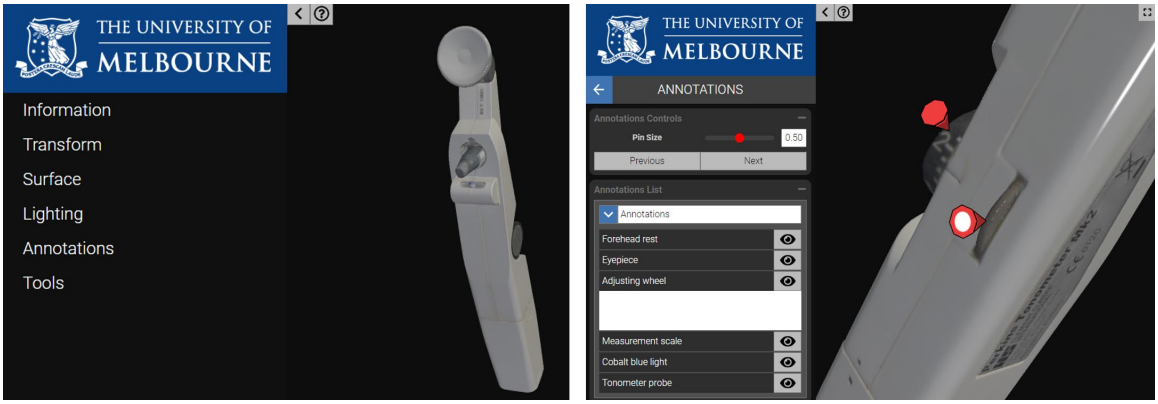

Figure 3. 360° 3D scans of a Perkins Tonometer which allowed students to examine the device in a virtual 3D environment

All participants had unlimited and unrestricted access to the VLEs and scanned equipment. The main form of interaction and engagement was navigating through the spaces and clicking on each interactive label. By accessing each label, students could learn about the name and understand the various component of each piece of equipment. Walking through the non-immersive environments virtually enabled them to be familiar and comfortable with the layout and structure of the learning spaces. The activity was considered to be completed when the completion score reached 100%.

Data Collection

All participants gave informed consent to participate in the study. Students were invited to take part in an online Qualtrics survey with 8 questions on a 5-point Likert scale and an open-ended question. The questionnaire collected demographic data, insights into students' overall satisfaction with the VLEs, level of subjective student engagement, and impact on their learning. The survey ended with a free text response to allow any additional comments (see Appendix).

Upon completion of the survey, students were invited to participate in an individual semi-structured interview, either in person (audio-recorded) or online (video-recorded, camera off) due to COVID-19 restrictions, for further elaboration on the research questions mentioned earlier.

Data Analysis

The quantitative Qualtrics survey data was exported for analysis. The qualitative data from Qualtrics free text responses, together with the transcripts of semi-structured interviews, were analyzed using thematic analysis (Braun & Clarke, 2006). Thematic analysis was used due to its ability to identify patterned responses within qualitative data. An inductive approach was taken, and the thematic analysis was performed independently across four authors. Preliminary codes were identified before themes were derived (Kiger & Varpio, 2020). All authors came together to finalize overarching themes and subthemes.

This research was approved by the Melbourne School of Health Sciences Ethics Research Committee (Ethics ID: 22358).

RESULTS

A total of 93 students (12 first-year; 49 second-year, 5 third-year, 27 fourth-year) completed the survey (Table 1). There were 57 female and 36 male participants. Seventy-five students were aged between 18 to 24 years of age, followed by 15 students aged between 25 to 29 years of age, and 3 students between 30 to 34 years of age. Of the 93 students, 78 (11 first-year; 46 second-year, 4 third-year, 17 fourth-year) participated in the semi-structured interviews. On average, students spent a total of 50 hours exploring the preclinical VLE and 11 hours exploring the clinical VLE. The survey questions had high internal consistency, with reliable responses indicated by a Cronbach α value of 0.97. The median value for the survey responses was between 4 (agree) and 5 (strongly agree) for all questions apart from question 5, which had a median value of 3 (neither). Overall, this implies that the VLEs were high quality and valuable to student learning.

The students' responses are summarised in Table 1. A total of 86% of students agreed that the digitization of the learning spaces was beneficial to their learning, and 82% agreed VLEs supplemented the course materials well, despite 49% disagreeing that they had interacted with the VLEs more than other course materials. A total of 93% of the students agreed that unrestricted access to the VLEs was useful, with 73% reporting they felt less stressed being able to access the VLEs before physically attending classes in the learning spaces. Furthermore, 85% agreed that VLEs assisted in helping them feel more confident using the equipment and navigating through the physical learning spaces.

A total of 45% of the students commented in the free-text box, with a strong consensus that VLEs were a great quality learning tool to help prepare and familiarize them with the learning spaces prior to attending classes. Students reported that navigating through the virtual spaces and equipment was an easy experience and found the detailed labeling of the components within the learning spaces useful. They appreciated the novelty of including high-quality reproductions of the learning spaces and felt that it was a fun and enjoyable learning experience.

Table 1. Likert analysis survey results

	Strongly agree (%)	*Agree (%)*	*Neither (%)*	*Disagree (%)*	*Strongly disagree (%)*
1. The digitization of the virtual equipment and environments is of high quality.	45	53	1	0	1
2. The digitization of virtual equipment and environments is more beneficial to my learning.	28	58	13	1	0
3. The digitization of the virtual equipment and environments is more useful in being able to access them when I need to.	44	49	6	1	0
4. The digitization of the virtual equipment and environments supplements the course materials well.	36	46	17	1	0
5. I have engaged with the virtual equipment and environments more than other materials in this course.	8	22	21	42	7
6. I am less stressed after familiarising myself with the virtual equipment and environments prior to attending classes.	29	44	23	3	1
7. I am more confident in using the equipment and navigating the physical environments after having virtual access.	31	53	12	3	1
8. The digitization of virtual equipment and environments should be incorporated into future teaching programs.	56	39	5	0	0

The themes generated from the interviews were: enhancing student engagement, improving student support, and gaps between interfaces (Figure 4). The students' quotes for each respective theme are shown in Table 2.

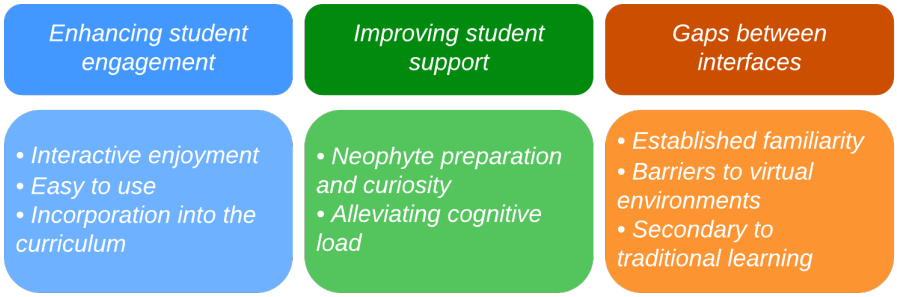

Figure 4. Overarching themes and sub-themes associated with virtual learning environments and equipment

Enhancing Student Engagement

The novelty associated with digitizing the learning spaces into VLEs aroused student curiosity and prompted them to explore the resources of their own volition.

Interactive enjoyment

Most of the students commented on the high-quality production of the VLEs and equipment, making the learning experience enjoyable. Students highlighted the fun aspect of interacting with the VLEs and likened the experience to playing a game instead of viewing it as an academic task.

Easy to use

Many students stated ease of use with the platform. The high level of detail, accurate descriptions, and representation of the environment and equipment were helpful and similar to physically being there in person. The activity was straightforward and simple to complete.

Incorporation into the curriculum

Some students suggested that the VLEs should be incorporated into the curriculum, with a subset stating that if it was compulsory and part of the curriculum, they would be incentivized to engage with the digital resources more often.

Improving Student Support

The students appreciated the digitization of the learning spaces and commented that they enjoyed exploring the VLEs at their own leisure and pace particularly, which is not possible when attending scheduled classes. The VLEs were a good introductory resource to help new students familiarize themselves with the learning environments and equipment.

Neophyte preparation and curiosity

The junior students (first-year and second-year) highlighted the benefits of engaging with the VLEs before heading into the physical spaces for learning. The VLEs helped them to understand the layout and appeased their curiosity by enabling them virtual access to restricted areas and equipment they had not yet used. Students also commented they used the resource not only for introductory orientation purposes but also to learn and understand more about the equipment available in both areas.

Alleviating cognitive load

Students expressed they felt more comfortable in the preclinical and clinical teaching environments after accessing the VLEs. By accessing the VLEs prior to attending classes, they felt less stressed with increased familiarity with the rooms and equipment. This has led to students reporting being able to focus more on learning and not be distracted by being uncomfortable in foreign settings. Students stated that the VLEs allowed them to "perform better" by making them "feel right at home". For students in senior year levels (third-year and fourth-year), they reflected back on their own stressors when beginning the course and agreed the VLEs would have been a valuable resource in reducing their anxiety.

Gaps Between Interfaces

The limitations of the accessibility and utility within VLEs were noted.

Established familiarity

Having spent a considerable amount of time being exposed to the actual physical environments already, a few of the senior students thought the VLEs were less impactful with nothing new to learn, rendering them less relevant for learning. However, other students also noted despite already being familiar with the spaces, there were areas that they were unsure about or had forgotten previously, and the VLEs were useful to refresh their memory and reacquaint themselves with the environments and equipment.

Barriers to virtual environments

The type of electronic device and internet requirements affected the student experience. It was less user-friendly when using a smartphone and poor internet connection with excessive loading time.

Secondary to traditional learning

Though students reported the VLEs being comparable to physical environments, they lacked tactile interaction and experience. Hence, they still perceive them as supplementary resources rather than a replacement for a space to acquire clinical skills.

Table 2. Students' quotes

Sub-theme	Student comments
Enhancing student engagement	
Interactive enjoyment	"I really liked the gamification of the whole thing with the completion counter. It helps to hold interest when exploring the environments and I feel pushed me to find all the key information."
	"It was quite fun to find all the clickable features as it was similar to a treasure hunt."
Easy to use	"I think because it was so nicely done, everything that I would touch and see and feel in the physical room is nicely presented in the virtual space."
	"I was able to click through all the small links and all the links were very informative. The process, going through each step from entering the door to the very end was very easy to use, I didn't have to look for any buttons."
Incorporation into the curriculum	"If it was part of the lecture notes to go over the virtual environment before attending clinic, just knowing that's available and having set tasks to do would influence how much I'm going to engage with it."
	"What would influence me to use it more, or inclined to use it is if it was assessed, if it was compulsory."
Improve student support	
Neophyte preparation and curiosity	"With this virtual environment, it's a more personalized experience because you're able to take your time and familiarise yourself with each aspect of it and also just take your time. You can just stop at any one point and take as much time as needed in order to familiarise yourself, which you can't really do when you are going in person."
	"I think if there's a room that I am unfamiliar with or piece of equipment that I don't have a lot of exposure with be more inclined to go online and have a good look around."
	"The first-person aspect makes it feel more familiar for when you actually go into the preclinical lab because it feels like you've "walked" through already."
	"Great to get to be able to orient yourself before having to operate in the environment, learning about the location and function of different areas/machines before potentially even stepping foot in the building."
Alleviating cognitive load	"I vaguely remember having one introductory preclinical session where we were introduced to the rooms and equipment. I remember this being both exciting and stressful. More stressful as I tried to note-take information about every piece of equipment and where they were located in the rooms. Due to being stressed, I wasn't actually able to absorb all the information. If this virtual software was available to us then, I believe I would have been less stressed and able to absorb more information during that introductory session."
	"Made me a bit more comfortable about the environment, and saw some things that I didn't even know was there so that was good."
	"I think it's great for before you start clinical practice, so maybe OD1 and OD2 it would be appropriate just so you're familiar with what's wrong because it can be quite an intimidating environment if you've never been there just like for us as fourth years, we only started in the clinic in third year and we didn't get to shadow anyone so it was quite intimidating so I think with a program like this, it will just help ease you into it."

Sub-theme	Student comments
	Gaps between interfaces
Established familiarity redundancy	"I probably wouldn't have accessed it, but that's because we've been here for a year, and I know the names of the equipment and where they are already so it would be more useful for people who are just starting optometry."
	"I think it also is instructive because it does teach you about the equipment and then also reminds you how to use them as well."
Barriers to virtual environments	"I would appreciate if like later on it becomes more compatible with the iPhone and iPad because right now, I do need to open up a computer to get the things to load and work and that's kind of inconvenient because my computer takes more than 5 minutes to load and sometimes when I actually need to get access to it, I don't have a laptop readily available next to me."
Secondary to traditional learning	"Maybe that's why I'm not as motivated to access the virtual world because I just feel like it's just not as interactive and I feel like it's just easier if I actually go see the room myself in person than to do it virtually."
	"I don't think it's as good as physical introduction or physical interaction with these environments and equipment."

Discussion

There are limited studies that explore the use of VLEs in a non-immersive matter within formal education. Many studies focus on the potential of immersive VR, with the use of peripheral haptics and 360° videos in healthcare education (Blair et al., 2021; Pirker & Dengel, 2021; G. V. Ryan et al., 2022). This study is the first in optometry education to demonstrate the potential of non-immersive VR in the form of panoramic 3D 360° virtual environments and equipment to aid in the familiarization of the learning spaces. The VLEs were low friction means to allow students a digital experience to navigate and familiarize themselves with the learning spaces ahead of practical classes. The novelty of the virtual resources engaged students positively as they interacted with the VLEs and explored the equipment. However, students still expressed a preference for traditional learning spaces.

Limited student exposure to in-person clinical teaching spaces requires rapid adaptation in an unfamiliar teaching environment. This means students are less able to focus on learning outcomes due to the overwhelming nature of a new physical space and unfamiliar equipment (Spivey et al., 2020). Increasing student familiarity with learning spaces will undoubtedly support learning, which can be realized with VLEs usage. Most students agreed that the digitization of the learning spaces and equipment was beneficial to their learning and increased their confidence, with unrestricted access further contributing to its usefulness.

Often, a stressor for healthcare students moving from the classroom to practicum is a lack of sufficient preparation and support (Nash et al., 2009; Radcliffe & Lester, 2003). Tchen et al. (2018) have shown it may be more beneficial to expose students to transitional resources earlier in the curriculum to further aid in reducing students' self-perceived stress. Indeed, current findings demonstrated an increase in student confidence (85%) and reduced stress (73%). This disparity may indicate greater levels of interactivity and preparation are needed to decrease stress further, possibly through introducing questioning prompts to engage learners more actively. The sites were available throughout the entire semester, which potentially grew more redundant as students became more comfortable with the spaces.

Hedonic experiences are part of intrinsic motivation – activities done by inherent interest and enjoyment – and are linked to high academic achievement due to associated increased student engagement (R. M. Ryan & Deci, 2000). In this study, students enjoyed exploring the VLEs and accessing the equipment, which is in alignment with previous studies incorporating VR into the curriculum (Brown et al., 2022; Chang, 2022; Vergara et al., 2017) and positively affecting students' motivation to learn (Blair et al., 2021). Students have described their experiences as playing computer games, which is analogous to gamification to increase participation. Almost half of the students did not engage with the VLEs more than other course materials. The resource was deliberately designed not to be too arduous in an already overcrowded curriculum which can increase from upwards of 4 hours a week (University of Melbourne, 2022).

The benefits of digitized teaching spaces on student learning can be extrapolated to other healthcare courses, potentially playing a vital role in the education of healthcare professionals in the future. Given the success of the VLEs in increasing student confidence and preparedness that fosters joyful learning, the existing pedagogical stance of healthcare courses should consider incorporating or utilizing such digital technologies. This is only possible with a good internet connection, as students had expressed frustration and distraction with slow loading times, potentially negatively affecting students' online learning performance instead (Wei & Chou, 2020). Some students also expressed a willingness to engage more if it is more user-friendly with electronic devices. This is somewhat expected since the most common modality of students' device preferences was mobile phones and laptops (Nguyen et al., 2022), thereby supporting the notion of potentially greater student engagement with the resources.

There are some limitations in this study. The participants voluntarily signed up which may lead to sampling bias due to the self-selective nature of recruiting participants. The sample also consisted entirely of optometry students from a single institution and may not be directly representative of other disciplines of study. Furthermore, there was unequal representation across all year levels, with a greater proportion of second-year and third-year participants in comparison to first-year and fourth-year students. The perceived confidence and stress levels should be better evaluated. For example, quantifying the level of perceived stress using Cohen's Perceived Stress Scale (Cohen et al., 1983) to determine the benefits of using VLEs could be an area of interest. Future research will also be useful to determine the level of student engagement objectively and the subsequent impact on student learning and how it may influence patient care and delivery.

CONCLUSION

The virtual equipment and environments aimed to help students familiarize themselves with the layout and organization of the spaces and types of equipment available in practicum. This further helped to maximize students' time during class to focus on their learning objectives in an unfamiliar environment. The VLEs provided some respite to reducing the stress of students and building their confidence transitioning to and interacting with the preclinical and clinical learning spaces.

Healthcare educators can aid students in their transition to unfamiliar, often intimidating, learning spaces by incorporating digitized versions of teaching spaces that allow for self-paced exploration into the curriculum. The importance of providing students early and unrestricted access prior to physically entering the space is highlighted, as well as the need for interactivity to maintain student interest. The usage of VLEs can be tailored to appropriate year levels, with first-year students utilizing the preclinical teaching environment and later-year students exploring the more relevant clinical environment.

The enablers included identifying and getting buy-in from key partners at the beginning of project commencement. Support was sought from digital technology experts and approval was obtained to access and scan the environments from the clinic director and subject coordinator to ensure there were no logistics and scheduling issues. To ensure sustainability and scalability, digital resources need

to be compatible with the University Learning Management System. The main barriers were cost and resources. Further research can quantify objectively and establish the effects of VLEs on student-perceived confidence and stress levels, and how that impacts clinical and learning performance.

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APPENDIX

Demographic Data – Age, Gender, Discipline

	Strongly agree (%)	*Agree (%)*	*Neither (%)*	*Disagree (%)*	*Strongly disagree (%)*
1. The digitization of the virtual equipment and environments is of high quality.					
2. The digitization of the virtual equipment and environments is more beneficial to my learning.					
3. The digitization of the virtual equipment and environments is more useful in being able to access them when I need to.					
4. The digitization of the virtual equipment and environments supplements the course materials well.					
5. I have engaged with the virtual equipment and environments more than other materials in this course.					
6. I am less stressed after familiarising myself with the virtual equipment and environments prior to attending classes.					
7. I am more confident in using the equipment and navigating the physical environments after having virtual access.					
8. The digitization of virtual equipment and environments should be incorporated into future teaching programs.					

Any other comments:

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