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Breaking boundaries and opening borders by clicking into an inclusive virtual simulated learning environment

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Abstract

This paper examines the utility of virtual simulation as an inclusive learning activity. Using a framework derived from literature, the Virtual Simulated International Placements (VSIP) were developed, and we explored the experiences of learners and facilitators to identify the pedagogical practices that they adopted during the learning activities with an approach inspired by phenomenography. Data from focus groups with 6 learners and 6 facilitators who participated in the VSIP were analysed along with 64 survey responses from learner participants. The findings of the study indicate there were three key concepts of the virtual simulation which supported inclusive learning environments. Overall, the participants' reflections indicated that the VSIP offered an accessible and usable way to engage in international placements that supported a personalised learning journey. Finally, the findings suggested VSIP should incorporate a diverse range of perspectives, backgrounds, and experiences to create and promote an inclusive learning environment. Further research can explore if these activities create a greater acceptance of different peoples' perspectives and cultures as well as impact stereotypes and biases. In addition, key concepts that made this teaching and learning activity inclusive could aid future investigation into how and why virtual simulations can be inclusive.

Keywords Higher education · Inclusive education · International placements · Virtual simulation

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1 Introduction

Educators actively seek ways to accommodate the varying needs of learners who face difficulties in traditional learning environments so that they may engage, access, and perform in higher education. This is driven and supported by policy, legislation and regulation in higher education (May & Bridger, 2010). However, there are learners who do not come forward or report difficult circumstances or disabilities (Griful-Freixenet et al., 2017). There are various reasons for learners to withhold such information, but the ultimate outcome is that a lack of inclusion builds an invisible barrier to accessible higher education (Griful-Freixenet et al., 2017). In addition to this, there are learners who may face barriers that are generated by the learning activities themselves or only emerge as a response to the course of study (Morgan & Houghton, 2011). Despite learning activities being theoretically inclusive, by failing to acknowledge the subjective and individual approaches of learners, their perception of accessibility and usability can be impeded and consequently the learning process is also hindered (Schmidt, 2022). Increasing inclusivity in learning and assessment, through removing boundaries, can enhance the potential of individuals and their potential to contribute to communities and our global world regardless of the composition of the student cohort (Ajjawi et al., 2022; Griful-Freixenet et al., 2017). This reinforces the need for using an inclusive lens when designing learning activities.

The emergence of this paper and the framework for Virtual Simulated International Placements (VSIP) came from the first round of analysis that consisted of interviewing learners and facilitators from Australia and India who participated in VSIP (Edgar et al., 2023). This initial study identified that VSIP supported the learning process for developing core competencies for optometry students such as clinical reasoning, communication, and evidence-based practice (Edgar et al., 2023). Reflections from facilitators and learners validated that the VSIP supported to deliver the intended learning outcomes (Edgar et al., 2023). It also investigated the use of VSIP in terms of facilitator and students' acceptance, but a key benefit was the perceived accessibility of the VSIP and the platform itself (Edgar et al., 2023). The aim of this study is to evaluate the framework that was developed for VSIP to understand how this supported an inclusive approach to virtual simulation. We investigated the non-linear phenomenon of how the VSIP are perceived by learners and facilitators to support inclusion in the learning environment by using a qualitative approach inspired by phenomenography. The primary purpose of this study was to answer the following question: What key concepts contribute to an inclusive learning environment using virtual simulation for VSIP? The results will potentially have a positive impact on curriculum development when designing virtual simulation learning activities that are inclusive.

2 Inclusive education

2.1 Pedagogy of inclusive education

Inclusive education is used to describe a pedagogical approach where learning activities and assessment are designed in a way that can engage all learners in meaningful, accessible and relevant curricula (Kym, 2014; Tai et al., 2023). Inclusive education practice acknowledges that all learners are different and learn and develop differently (Omiko et al., 2017). Currently there is no universally accepted definition of inclusion (Armstrong et al., 2009). For the purpose of this study, inclusive education is defined as outlined by Tai et al., 2023 not focusing on *who* belongs to specific equity groups but on *what* is done to encourage inclusion for all learners.

One approach for designing inclusive learning activities is using the Universal Design for Learning (UDL) principles which guide the design of environments and educational materials (Rogers-Shaw et al., 2018). These aim to remove barriers in education to maximize accessibility for all learners regardless of their abilities, backgrounds or preferred learning styles (Rogers-Shaw et al., 2018). When UDL is applied, learners are presented with opportunities to learn in different ways and are provided with approaches that meet their different needs. This can be achieved through 1) multiple means of engagements, 2) multiple means of response/action, and 3) multiple means of representation (Rogers-Shaw et al., 2018). This approach guides learning design to allow for flexible ways to engage learners, flexible ways learners are presented with information and reduces barriers with opportunities for accommodation of the diverse needs of learners such as limited English language capabilities (Rogers-Shaw et al., 2018). To adopt learning for inclusion, UDL, many publications discuss the advantage of harnessing digital technology (Bagon et al., 2018).

Technology can be used to support inclusive education. The benefits of using digital technology for inclusive education has long been reported in terms of assistive technologies for learners who have identified that they have a disability (Arslantas & Gul, 2022). However, digital technology can also be used to create an opportunity for educators to engage all learners in active, personalised, meaningful, and collaborative learning (Coker & Mercieca, 2023; Starcic, 2010). This requires educators understanding how technology can be incorporated to create an inclusive learning environment.

3 Research motivation

Virtual simulation as a learning activity can use the advantages of digital technology to support inclusion in the learning environment. Within the digital learning environment there is a breadth of literature on assistive technologies to support engagement in learning activities. For example, studies have shown that virtual

simulation can be used as teaching aids for learners with diverse needs (Arter et al., 2018; Di Paolo et al., 2023; Espinosa-Castaneda & Medellin-Castillo, 2021; Fitzgerald et al., 2018). These range from assistive technologies for low vision learners to alternative interventions for learning activities for neurodiverse cohorts (Arter et al., 2018).This makes virtual simulation a promising strategy in inclusive education. Yet, the majority of the literature focuses on children and not the use of virtual simulation in higher education for inclusive education. One systematic review demonstrated that simulation literature has not prioritised inclusion (Smallheer et al., 2022). In a recent study, the authors of this paper uncovered that VSIP supported learners' accessibility to teaching and learning by using virtual simulation (Edgar et al., 2023). The present study attempts to explore the key concepts that are perceived to support inclusion in this established virtual simulation program from the experiences of learners and facilitators to begin to address this gap in literature.

4 The theoretical framework of the VSIP

4.1 Content generation through co-design

The generation of content for the VSIP was based on learner and academic feedback. Learning activities within the VSIP were problem based virtual simulations generated from authentic clinical cases (Edgar et al., 2023). Academics involved in the project from each institution agreed upon topics that were relevant to the optometric scope of practice in their respective countries (Australian and India) and represented clinical areas of specialty which were aligned to the course curriculum of each institution (Fig. 1). All learners from each institution were then sent an electronic survey that collected their preferences to anticipate the needs, and interest of a diverse group of learners. The learners were instructed to select these based on a self-identified area of weakness and one on a self-identified area of strength. Sessions were arranged to cater for the learner's preferences and

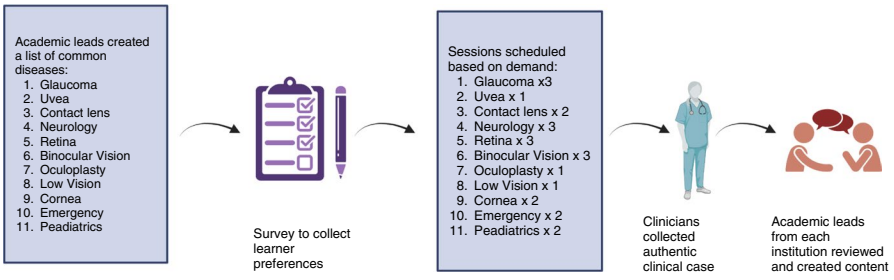

Fig. 1 Co-design process for the Virtual Simulated International Placements Created with BioRender.com. Descriptive caption: Rectangle image containing a list of common diseases, directional arrow pointing towards image of a survey, directional arrow pointing to rectangle containing list of scheduled sessions based on demand, directional arrow pointing towards image of a clinician, directional arrow pointing toward two people with speech bubbles

authentic clinical cases were collected to generate content for the learning activities with pedagogical objectives and academic structure (Fig. 1). Academics from both institutions evaluated the learning activities created for relevance to their learner cohorts.

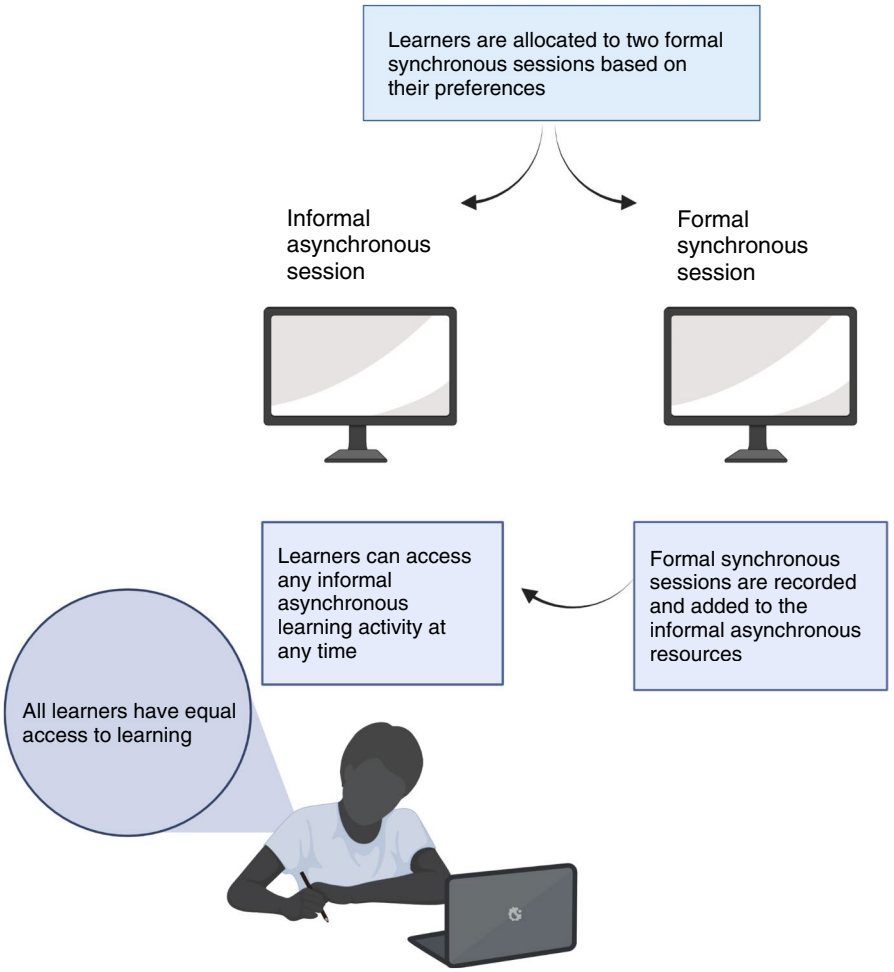

Fig. 2 Availability of the formal, informal, synchronous, and asynchronous learning activities Created with BioRender.com. Descriptive caption: Rectangle image containing description of formal session allocation, two directional arrows pointing towards a computer screen with text above them to represent synchronous and asynchronous sessions, a directional arrow from the synchronous session to the asynchronous session. A student with a pen and laptop at the bottom of the image with a though bubble containing text

4.2 Availability of formal, informal, synchronous and asynchronous learning activities

The VSIP were developed based on the principles of UDL with synchronous and asynchronous learning activities. Each learning activity covered a clinical case from one of these topics and no session was repeated. The learners were rostered to two of the twenty-one formal synchronous learning activities based on their self-identified needs (Fig. 2). At these formal synchronous sessions at least 10 learners from India and Australia were present with at least one facilitator from each institution. The sessions were led by a learner from each institution. Prior to participating in the formal synchronous sessions, learners were allowed the flexibility to complete an associated informal asynchronous learning activity based on the clinical case in preparation for the scheduled session following UDL principles (Rogers-Shaw et al., 2018). This allowed learners to read, engage with content and prepare notes before using it in the formal synchronous learning activities where students drove the case discussion, engaging with colleagues from across the globe, sharing knowledge and ideas. Facilitators provided their perspectives and clinical reasoning underpinning their approach to case management. It also enabled the learners to set personal learning goals prior to the synchronous learning activity.

Through multiple means of engagement and representation these sessions were designed with inclusivity in mind. Following UDL principles the synchronous formal learning activities were recorded, and these recordings were available immediately following the learning activity to all learners in the virtual simulation platform to watch alongside the asynchronous learning activity (Rogers-Shaw et al., 2018). All the asynchronous learning activities were available for all learners to complete at any time when they choose to enter the virtual simulation platform (Rogers-Shaw et al., 2018). In this way each learner was provided an equal and unique opportunity to engage in a personal learning journey.

4.3 VSIP designed with embedded accessibility techniques.

To allow more time for learners to process and respond to the learning activities they were delivered in both asynchronous and synchronous formats (Lieberman, 2018). A video recording with closed captions and a written guide were used to brief learners and facilitators prior to the VSIP commencing. When imagery was used descriptions were provided or discussed in the learning activities (Lieberman, 2018). All content developed with audio was supplemented with printed text (Lieberman, 2018). For example, all formal synchronous sessions were completed in English and captions were provided to assist the language comprehension. Transcripts were made available for subsequent viewing of the recordings of each session. All VSIP learning activities were available to interact with by using a mouse and keyboard. These features contributed to the accessibility of the VSIP framework (Edgar et al., 2023).

5 Methods

5.1 Sample and data collection

To explore the framework a cross-sectional mixed methods evaluation was performed with learners and facilitators from optometry programs in Australia and India using focus groups and pre-existing deidentified data collected from the course curriculum teaching and learning activities. All participants involved in the VSIP program for 2021 were invited to participate in the study. The learners from Australia were enrolled in their second year of the Bachelor of Vision Science/Masters of Optometry at Deakin University. Learners from India were enrolled at the Elite School of Optometry in their 3^{rd}-4^{th} year of the Bachelor of Optometry or 1^{st} -2^{nd} year of their Master of Optometry. Facilitators that were included in this study were teaching academics from each institution ($n=20$) that also worked as clinicians in the field of optometry ($n=9$) or ophthalmology ($n=11$).

5.2 The format of the VSIP

The VSIP were held over five weeks in January – March 2021. All learners attended two of the twenty-one available sessions that were scheduled during this time. A facilitator from each institution was present at each session and a maximum of twenty learners, approximately ten per institution to allow the possibility of individual contribution from each learner. All sessions were video recorded and made available to every learner in the VSIP platform after completion of the synchronous learning activity. All sessions were communicated with English with a live transcription provided on the screen as each institution instructed and assessed in English as part of their curriculum.

5.3 Discovery of the key concepts that support inclusive education in virtual simulated international placements

A thematic analysis was performed on the open-ended survey questions as well as focus group data using an approach inspired by phenomenography (Dahlgren & Marton, 1978). The coding was preformed until saturation was achieved using inductive coding and deductive coding (DeCuir-Gunby et al., 2011). The researchers had a strong research background in qualitative research and professional background in optometry education which contributed to the robustness of the triangulation process. Any excerpt from the data was allocated to only one sub-concept. All data was read by two independent coders (AE and AN) who then performed the first round of analysis by reviewing 10% of the responses. The results of this process were used to develop draft concepts and a codebook. Following this a meeting was held between AE & AN to negotiate concepts and through this the generation of sub-concepts and identifying anchor examples that supported descriptions. The coders (AE and AN) then reviewed all the remaining

data before coming together again to further discuss the coding and refine definitions of themes and subthemes expressing similar ways of understanding the phenomenon to the same conceptions. One independent coder (JA) provided external validity by using the codebook independently to review the data and then discussed areas of overlap, disagreement, merger of codes and exclusion of content until consensus was reached with AN and AE to articulate the essential meanings of certain concepts. The core meaning of these concepts were labelled and then compared for similarities and differences. All co-authors agreed upon the representative comments by participants used for illustration of dimensions.

5.4 Usability testing

The System Usability Scale (SUS) was used to measure perceived usability in learner participants (Brooke, 1996). This is a five-point 10-item inventory that alternates positive responses left and right to avoid complacency of the user (Brooke, 1996). The scoring system requires rating on all 10 items which inquire on a digital products efficiency, satisfaction, and effectiveness (Bangor et al., 2008). The range of scoring is from 5 (strongly agree), 4(agree), 3 (neutral), 2(disagree) and 1 (strongly disagree). Items that are left blank receive a score of 3 (the median interval). There are adjustments that need to be made due to the alternating items where the score will range from 0 to 4 (Brooke, 1996). For even-numbered items the raw score should be subtracted from 5. For odd-numbered items, 1 should be subtracted from the raw score. The adjusted scores are calculated they should be added together and multiplied by 2.5 for a standard score between 0 (poor perceived usability) to 100 (excellent perceived usability). The SUS has an acceptable coefficient alpha of 0.91(Brooke, 1996).

The SUS score provides a numerical measure of usability. There have been some studies published to classify SUS scoring. For example when the SUS is used as an adjective rating scale scores have been classified as follows: between 100 and 90.90 as the best; 90.90–80.50 as excellent; 80.50–71.40 as good; 71.40–50.90 as OK; and below 50.90 as poor (Bangor et al., 2008). However, these have not been tested on all interface modalities nor on education technology (Vlachogianni & Tselios, 2022). To assess the usability of the VSIP a score of 63.83 was determined to be satisfactory based on previous investigation on similar interfaces tested within a university population (Vlachogianni & Tselios, 2022).

6 Findings

Learners were invited from Australian ($n=92$) and India ($n=75$). A total of 64 survey responses were received from 167 learners (39%) with 19 from Australia and 45 from India. There were 12 focus group participants (learners $n=6$ and facilitators $n=6$).

Table 1 Concepts and sub-concepts; how VSIP supports inclusive education

Concept	Dimension
Inclusive digital technology experience	Engagement through digital technology
	Availability of the virtual experience
Enfranchisement	Comfort and accessibility
	Customised learning journey
	Overcoming limitations
	Equality
Enrichment	Different perspectives
	Exposure to diverse clinical cases
	Cross cultural interconnection

6.1 The codebook with concepts and anchor examples

The findings indicate the three key concepts of the VSIP that supported an inclusive learning environment and delivered inclusive education to learners from Australia and India. These are described in Table 1 as *Inclusive digital technology experience*, e*nfranchisement* and *enrichment*. The following section outlines the dimensions of these concepts that have been defined through iterative analysis along with illustrative quotes that highlight the dimensions in Table 2. This categorises the combined experiences derived from individual statements.

6.1.1 Engagement through digital technology

The engagement dimension recognises that learners felt peers engaged in the learning activities and worked collaboratively to an extent which positivity impacted on their learning. The authenticity of the virtual simulation enhanced engagement of learner participants in the learning activities. Learner and facilitator participants expressed that they were not only connected virtually but also interacting to co-create knowledge and recognised that this was made possible by the VSIP.

6.1.2 Availability of the virtual experience

This dimension refers to the availability of a VSIP and how this impacted the participant's experience. Many participants referred to the VSIP as being a resource that was available to them at any time, meeting their individual needs. Learner participants commented on the capability of the VSIP to directly connect them across the globe to peers and clinicians in a different country for international education. Facilitators and learner participants referred to this being available to all learners despite geographic location and socioeconomic status as there was no additional financial burden for the students to avail this experience.

Table 2 Dimensions and anchor examples

Dimension	Quotations from participants
Engagement through digital technology (6.1.1)	*"Interacting with people all over the world at the same time."* (P38) *"Other learners asking different questions and clearing doubts too."* (P37) *"I felt like it was more engaging because I could ask questions pertaining to what we might see in practice. It felt like a more authentic experience of using and applying rather than lots of information that could easily overwhelm."* (P10) *"Learned the same from others and realised my own shortcomings in the cases I partook in."* (P17)
Availability of the virtual experience (6.1.2)	*"We can attend from home and communicate with specialists from India."* (P40) *"… I was able to access and work through the individual content in my own time before the live session which could be viewed from the comfort of home."* (P14)
Comfort and accessibility (6.1.3)	*"I liked that I could be at home and also learn from the placement and participate. I also liked that I could raise my hand and not feel too embarrassed."* (P33) *"I had microphone issues, but I managed to contribute through the chat room."* (P15) *"I feel more comfortable and engaged with the learning, as the travel can sometimes make me feel too tired in the lecture environment."* (P14)
Customised learning journey (6.1.4)	*"Visual stimulation helps me to visualise and understand concepts more clearly."* (P25) *"It is very important for me to have more explanation and teaching than self-research."* (P6) *"The virtual simulation …gave me the ability to research in my own time, whilst guiding me through clinical decision making, which would be less organic in a lecture format, as I would be less likely to explore on my own if I had already seen what a clinician would decide to do. I liked that I could work through things on my own, and then compare my thought processes to professionals in the field."* (P23)
Overcoming limitations (6.1.5)	*"There were benefits, such as being able to hear the opinions of the other participants without any background noise, as well as the ability to look up any key concepts I didn't know about."* (P23) *"So, when we actually interacted with the experts, our thought process or my thought process regarding this subject also changed a bit. So, I thought, OK, it is not so difficult anymore."* (P4)
Equality (6.1.6)	*"… the videos of the certain procedures some learners must not have seen so they would have they got an opportunity to learn about the details the instruments from this and also the expert opinion…"* (P60) *"…availability of teachers."* (P13) *"…it was really useful for everyone."* (P57) *"…helped everyone equally."* (P4)

Table 2 (continued)

Dimension	Quotations from participants
Different perspectives (6.1.7)	*"…where I got a bit stuck with my thinking and I wasn't quite sure…I would kind of handballed over to the Indian facilitators to get their perspective…I feel like I gained a lot from it as well."* (P7) *"It allows for us to work through the case before hand and then get many different perspectives."* (P3) *"Communicating with other optometry learners showcases the different thinking styles in managing the conditions."* (P9) *"…I learned more through the answers of the other participants."* (P39) *"It was very interesting… knowing other learners from other University and their perception."* (P23)
Exposure to diverse experience (6.1.8)	*"It gives better exposure and an interactive platform to discuss and understand a case."* (P53) *"Benefits included being able to experience cases that we would rarely see such as ocular trauma and emergency."* (P4)
Cross cultural interconnection (6.1.9)	*"…got to learn about procedures that's been followed in both Australia and in India. And also, it was really informative to learn as separate cases."* (P5) *"It was very interesting to incorporate our colleagues from India and hear their ideas and knowledge."* (P12)

6.1.3 Comfort and accessibility

Learners and facilitator participants described the ease of taking up a VSIP learning activity. There was a resonance of regard for the VSIP to provide participants with the ability to participate in the convenience of their home. They implied that the learning activities could be completed independent of physical location. Despite the convenience of the VSIP there were instances where learner participants highlighted challenges with technology however access to multiple forms of communication mitigated this challenge to an extent. Other challenges were brought on by different time zones of participants for synchronous sessions.

6.1.4 Customised learning journey

The VSIP, as expressed by learner participants, allowed for them to develop their own learning journey. They were allowed to engage with the materials based on their preferences, based on their individual demands on time and based on their preferred way of learning.

6.1.5 Overcoming limitations

Learner participants continually referred to the VSIP as an opportunity to overcome personal limitations through engagement. They demonstrated the ability to accept challenges present within self and used the learning activities in the VSIP to cross the challenges.

6.1.6 Equality

Facilitator and learner participants commented on the virtual simulation providing opportunities that were uniform and fair to all. There was a general agreement that the VSIP gave learners equal access to learning opportunities that they would have otherwise not obtained.

6.1.7 Different perspectives

The VSIP gave learners and facilitator participants exposure to different perspectives. There was appreciation for being able to understand differences in practice from a source of truth. The discussion acknowledged the value of being exposed to clinical stance based on differing social, cultural, and geographic environments.

6.1.8 Exposure to diverse experience

Learner participants appreciated that the VSIP was able to provide them with unique experiences that they might not have had the chance to in the physical setting. They also commented that it gave learners the opportunity to practice skills and techniques that they may have not had exposure to in their home country. Facilitators and learners expressed that they had been exposed to a presentation of cases and management, covering different specialties, and including rare cases that they may not have seen in other settings.

6.1.9 Cross cultural interaction

Interacting with people in different culture and environment was expressed by all participants as helping to generate cultural awareness and understanding which resulted in respect for people of different backgrounds.

6.2 SUS

The scores for the SUS based on the VSIP overall show participants satisfaction with usability of the VSIP, 64.92 for all participants, which is above 63.83 that was previously defined as satisfactory in a study with university students. Using the adjective scale, the mean score for all participants, participants from Australia

Table 3 System Usability Scale results from all learner participants

Item	Question	Maximum possible score	M ± SDs
Total score ($n = 64$)		100	64.92 ± 13.18
Total India ($n = 45$)		100	67.50 ± 12.29
Total Australia ($n = 19$)		100	58.82 ± 13.50
1	I think that I would like to use this system frequently	4	3.00 ± 0.71
2	I found the system unnecessarily complex	4	2.30 ± 0.91
3	I thought the system was easy to use	4	2.72 ± 0.82
4	I think that I would need the support of a technical person to be able to use this system	4	2.53 ± 1.02
5	I found the various functions in this system were well integrated	4	2.94 ± 0.53
6	I thought there was too much inconsistency in this system	4	2.56 ± 0.87
7	I would imagine that most people would learn to use this system very quickly	4	2.76 ± 0.88
8	I found the system very cumbersome to use	4	2.72 ± 0.96
9	I felt very confident using the system	4	2.60 ± 0.95
10	I needed to learn a lot of things before I could get going with this system	4	1.90 ± 1.16

Abbreviations: *M* Mean score, *SDs* Standard deviations

and participants from India are within the OK category. The results of the SUS are summarised in Table 3.

7 Discussion

7.1 The key concepts that contributed to an inclusive learning environment for VSIP.

This qualitative study that interviewed learners and facilitators who participated in VSIP in optometry programs from Australia and India identified three concepts that supported an inclusive learning environment within the virtual simulation. Recent literature has proposed methods that could support embedding aspects of diversity, equality, and inclusion into the content of virtual simulation exist (Blodgett et al., 2022; Ciasullo, 2018; Nakajima et al., 2022). One study focuses on how to create content for cultural humility training and embed this into virtual simulation (Nakajima et al., 2022). However, evaluations of these methods are not reported. This is particularly important in the context of inclusive education which is ultimately measured by the learner's experience and as such is a limitation of these works. In the present study, that incorporates both learner and facilitator perspectives, the inquiry focuses instead on *how* the design of VSIP can create inclusive education. The three concepts from this study: Inclusive digital technology experiences; Enfranchisement; and Enrichment were found to support inclusion in virtual simulation.

7.1.1 Inclusive digital technology experience by engagement through digital technology and availability of the virtual experience

Authenticity in learning activities has many educational benefits particularly in virtual simulation. An experience is authentic when it captures the truth of what is being learnt and represents real-world situations or solutions (Jacobson, 2017). For virtual simulation, authenticity increases the credibility of the learning activity and increases participants engagement with the learning experience (Edgar et al., 2022). This differs from the traditional learning environment where often learners can be physically present but may be separated from full engagement (Woodcock et al., 2022). Making changes to the learning environment, instruction and content are strategies that support learners to engage with learning (Lindner & Schwab, 2020). In this study the authors found that the engagement through VSIP helped learners feel included within the learning environment. They freely expressed that the opportunity to collaborate with experts and peers by authentically engaging with the virtual simulation activities impacted their learning. Engagement leads learners to subjectively perceive involvement and that they feel included (Granlund, 2013; Sorkos & Hajisoteriou, 2021). In this study the virtual simulation enabled engagement by using digital technology for collaboration and this supported the inclusive learning environment that was created.

Availability of the virtual simulation was another dimension of the inclusive digital technology experience. In the context of inclusive education, the availability of the virtual simulation as a resource meant that it meets individual learners learning needs by being able to access the educational material flexibly, at any time, much like the principles of UDL (Rogers-Shaw et al., 2018). In this study the availability of the virtual simulation was not impacted by geographical location or socioeconomic status. The low bandwidth requirement of the system meant that other than the occasional delay in the video feed, access to broadband did not limit participation. Where physical international placements can be limited due to funding, lack of transport, or insufficient resources the virtual simulations supported all learners to participate and support potential educational outcomes (Simon & Ainsworth, 2012). Overall, as there was adequate availability of the virtual simulation as the learners and facilitators reported it promoted equitable access to the learning activities.

7.1.2 Enfranchisement with: comfort and accessibility; a customised learning journey; overcoming personal limitations; and equality.

Accessibility is paramount to incorporate into virtual simulation through the perspective of inclusion. Inclusive education often refers to accessibility as a crucial aspect. In UDL this is not just access to information, but access to learning (Rogers-Shaw et al., 2018). Further work on defining access to education describes going beyond being present and physical access to intellectual and sensory access (Ainscow, 2005). The environments where learners learn should be accessible to all regardless of backgrounds, abilities, and educational institutions. This cross institutional study demonstrated that virtual simulation can be designed to be accessible for different educational institutions, cultural backgrounds, and abilities such as English as second language. Moreover, the virtual simulation had included concepts that provided participants the ability to participate with the comfort of at home physical location as the learning activities could be completed independent of physical location. The analysis concluded that multiple forms of communication met the different needs of a diverse group of learners enfranchising the learning environment to be comfortable and accessible to all learners.

Virtual simulation can offer equality of learning experiences that overcome personal limitations with personalised learning. In the traditional classroom learners from low socio-economic backgrounds face challenges related to engagement and belonging during the course of a degree (Burke et al., 2016). Research has shown that these learners are at risk of poor performance (Harvey et al., 2017). In this study, the VSIP framework incorporated the unique strengths and weaknesses of learners by asking them to choose which sessions they would like to participate in, thus helping them to overcome personal limitations. Additionally, this opportunity for learners to make their own learning decisions enabled them to take ownership of their learning and each session was led by a learner from both institutions. They were able to create individualised plans for their learning and set goals. The learners in this study reflected on the equality of the experience. By recognising that learners have different identities and personal circumstances that influence how they study and participate in the virtual simulation created an inclusive learning environment

(Morgan & Houghton, 2011). In this study an inclusive learning environment supported learners through enfranchising personalised learning experiences that enabled learners to overcome personal limitations. This approach recognised that each learner is unique and provided equal access to an opportunity to overcome personal limitations.

7.1.3 Enrichment with different perspectives, exposure to diverse clinical cases and cross-cultural interconnection

Virtual simulation can provide enrichment through unique experiences and exposure to diverse opinions, diversity in experience and cross-cultural interaction that supports inclusive education. Interaction between cultures can promote cultural awareness and respect among learners with diverse backgrounds (Sorkos & Hajisoteriou, 2021). It is well known that international placements can help learners develop cultural competency (Peiying et al., 2012). In the VSIP collaborating with offshore institutions promotes diversity and cultural awareness among learners and faculty (Edgar et al., 2023). The results from this present study show that learners and facilitators appreciated and learnt from each other's cultural diversity. The learners engaging in this form of learning activity will be exposed to diverse cultures and traditions as well as the different ways in which we think clinically and otherwise (Edgar et al., 2023). Through the institutions working together there were opportunities for learners and academic staff to collaborate to create meaningful experiences and build relationships with people of diverse backgrounds in the VSIP. Enrichment of virtual simulation with this type of educational setting could help reduce prejudice and increase tolerance. This could be further investigated to explore if the VSIP impacts stereotypes, biases and create a greater acceptance of different people's perspectives and cultures while reducing exclusion from learning activities.

7.2 SUS

The usability of learning experience and adoption of digital technology such as the VSIP is important to consider for inclusive education. The SUS tool is the most widely adopted tool for evaluating usability and whilst there is no absolute scoring range requirement, a score of greater than 51 is considered to be "OK" on an adjective rating scale (REF). Yet, educational technology studies have found usability levels are different depending on the type of technology (Vlachogianni & Tselios, 2022). When interpreting these scores the contextualisation needs to be considered when making comparisons to different systems (Brooke, 1996). One study on educational technology published scores for university websites ($M = 63.83$, $SD = 16.52$) and internet platforms ($M = 66.25$, $SD = 12.42$) considered to be at a good level (Vlachogianni & Tselios, 2022). This compares well to this study's mean SUS score of 64.92 and the similar conclusion can be made that this is at an acceptable level. Further studies using the SUS with VSIP will develop a more meaningful understanding of the scoring, however a range of metrics should be used to understand user experience in addition to usability.

The different ways that language was used indicated that for the VSIP this was a holistic barrier for some learners. English was the medium of instruction, which aligned to the context of both cohorts of learners in India and Australia. However, linguistic nuance presented as a potential barrier for some students' learning experiences, given the globalised audience. Linguistic nuance included challenges understanding accents, colloquialisms and the pace or cadence of speech. In addition, another barrier was digital exclusion. This should be considered when designing solutions for inclusive education using educational technology. The digital world offers far-reaching access to many people however this can also be a barrier and disabling tool to many people as well (Khalid & Pedersen, 2016). If usability is not considered in design of digital activities such as virtual simulations, then people can also be excluded. This was essential in the design of the VSIP program and resources were arranged for learners and facilitators to connect to the learning activities if personal devices were not accessible.

8 Conclusion

The framework for VSIP developed in this study ensured that learners could see, hear, interact, collaborate, question and manipulate their own learning journey. The VSIP framework attempted to support many learners' diverse needs by using UDL principles and allowing flexible access to all the learning resources and recordings. By collecting student topic preferences, the needs of learners and interest of a diverse group of learners were able to be anticipated. This study evaluated how the framework that was developed for VSIP supported an inclusive approach to virtual simulation and identified the key concepts that contribute to an inclusive learning environment using virtual simulation. The key concepts, based on all participants' reflections include: 1) Inclusive digital technology experience, 2) Enfranchisement and 3) Enrichment. One way to create an immersive experience is for the digital technology to deliver the chosen narrative/problem but in addition needs to consider how it will support engagement, availability, and usability. All participants need to be able to equally contribute and participate in the virtual simulation by enfranchising them with accessibility and comfort in a personalised journey. Finally, the virtual simulation should incorporate diversity of perspectives, backgrounds, and experiences. These results have shown that virtual simulation can be used to support inclusive education by promoting diversity and awareness of culture that in turn could better serve learners to be prepared for a globalised world. In this study these concepts where what made the VSIP to be perceived to be inclusive.

8.1 Limitations and future works

A limitation in this study is the novel educational technology makes it difficult to draw definitive conclusions from predefined scores on the SUS. Although there is a good body of research that has investigated using SUS with education technology, literature acknowledged the score is dependent on the context and the type of technology used.

Further studies using the SUS with VSIP will develop further understanding of the scoring. This study was conducted within the discipline of optometry and two universities, one in each country, covering particular geographic locations. The results should be interpreted carefully until further data demonstrates similar results from other establishments of education and professional contexts.

In further research on VSIP, it can be explored if the learning activity can result in a greater acceptance of different peoples' perspectives and cultures as well as impact stereotypes and biases. In addition, key concepts that made this teaching and learning activity inclusive could aid future investigation into how and why virtual simulations can be inclusive. Moreover, further work could attempt to evaluate which concepts of the inclusive design are strongly predictive of improved learning.

Abbreviations IEC: International Eyecare Community; VSIP: Virtual Simulated International Placements; SUS: System Usability Scale; M: Mean score; ± SDs: ± Standard Deviations

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Authors contribution A.K.E led the conception, design, analysis and interpretation of the work, developed the framework for virtual simulated international placements, wrote the main manuscript text, prepared figures and tables. A.N made contributions to design, thematic analysis, interpretation of these data, reviewed the framework and contributed to the manuscript text. J.A.A made substantial contributions to the conception, thematic analysis, reviewed the framework and interpretation of these data. N.C made substantial contribution to the conception and design of the work and contributed to the introduction. L.C made substantial contribution to the qualitative data collection and contributed to the introduction and discussion text. All authors revised and reviewed the manuscript.

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Data availability The dataset generated and analyzed during the current study is available to the authors but is not publicly available due to ethical guidelines. The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval This study was approved by the Human Ethics Advisory Group Health (HEAG-H 30_2021) at Deakin University. The study was reviewed and approved by the Ethics committee and Institutional Review board of the Vision Research Foundation, Chennai, India (1150-2023P). All necessary permissions for conducting the research were obtained from the relevant administrators and all methods were performed in accordance with the relevant guidelines and regulations. Written informed consent was obtained from all the participants after all aspects of the study were explained.

Consent Not applicable.

Competing interests The authors declare that they have no competing interests.

References

Ainscow, M. (2005). Developing inclusive education systems: What are the levers for change? *Journal of Educational Change*, *6*. https://doi.org/10.1007/s10833-005-1298-4

Ajjawi, R., Tai, J., Boud, D., & Jorre de St Jorre, T. (2022). *Assessment for inclusion in higher education: Promoting equity and social justice in assessment* (1st ed.). Routledge. https://doi.org/10.4324/9781003293101

Armstrong, A. C., Armstrong, D., & Spandagou, I. (2009). *Inclusive education: International policy & practice*. Sage.

Arslantas, T. K., & Gul, A. (2022). Digital literacy skills of university students with visual impairment: A mixed-methods analysis. *Education and Information Technologies, 27*(4), 5605–5625. https://doi.org/10.1007/s10639-021-10860-1

Arter, P., Brown, T., Law, M., Barna, J., Fruehan, A., & Fidiam, R. (2018). Virtual reality: Improving interviewing skills in individuals with autism spectrum disorder. *Society for Information Technology & Teacher Education International Conference*

Bagon, Š., Gačnik, M., & Starcic, A. I. (2018). Information communication technology use among students in inclusive classrooms. *International Journal of Emerging Technologies in Learning (iJET)*, *13*(6), 56.

Bangor, A., Kortum, P. T., & Miller, J. T. (2008). An empirical evaluation of the system usability scale. *International Journal of Human–Computer Interaction, 24*(6), 574–594. https://doi.org/10.1080/10447310802205776

Blodgett, N. P., Howard, V. M., Phillips, B. C., Andolsek, K., Richard-Eaglin, A., & Molloy, M. A. (2022). Developing virtual simulations to confront racism and bias in health professions education. *Clinical Simulation in Nursing, 71*, 105–111. https://doi.org/10.1016/j.ecns.2022.03.009

Brooke, J. (1996). Sus: a "quick and dirty'usability. *Usability Evaluation in Industry, 189*(3), 189–194.

Burke, P. J., Bennett, A., Burgess, C., Gray, K., & Southgate, E. (2016). *Capability, belonging and equity in higher education: Developing inclusive approaches*. Newcastle, NSW: Centre of Excellence for Equity in Higher Education, The University of Newcastle.

Ciasullo, A. (2018). Universal design for learning: The relationship between subjective simulation, virtual environments, and inclusive education. *REM, 10*(1), 42–48.

Coker, H., & Mercieca, D. (2023). Digital technology for inclusive education: Reflecting on the role of teachers. In *Inclusion, Equity, Diversity, and Social Justice in Education: A Critical Exploration of the Sustainable Development Goals* (pp. 233–243). Springer.

Dahlgren, L. O., & Marton, F. (1978). Students' conceptions of subject matter: An aspect of learning and teaching in higher education. *Studies in Higher Education, 3*(1), 25–35.

DeCuir-Gunby, J. T., Marshall, P. L., & McCulloch, A. W. (2011). Developing and using a codebook for the analysis of interview data: An example from a professional development research project. *Field Methods, 23*(2), 136–155.

Edgar, A., Macfarlane, S., Kiddell, E., Armitage, J., & Wood-Bradley, R. (2022). The perceived value and impact of virtual simulation-based education on students' learning: A mixed methods study. *BMC Medical Education, 22*(1), 823. https://doi.org/10.1186/s12909-022-03912-8

Edgar, A. K., Armitage, J. A., Arambewela-Colley, N., Chong, L. X., & Narayanan, A. (2023). Virtual simulated international placements as an innovation for internationalisation in undergraduate programs: A mixed methods study. *BMC Medical Education, 23*(1), 258. https://doi.org/10.1186/s12909-023-04260-x

Espinosa-Castaneda, R., & Medellin-Castillo, H. I. (2021). Virtual haptic perception as an educational assistive technology: A case study in inclusive education. *IEEE Transactions on Haptics, 14*(1), 152–160. https://doi.org/10.1109/toh.2020.3001586

Fitzgerald, E., Yap, H. K., Ashton, C., Moore, D. W., Furlonger, B., Anderson, A., Kickbush, R., Donald, J., Busacca, M., & English, D. L. (2018). Comparing the effectiveness of virtual reality and video modelling as an intervention strategy for individuals with Autism Spectrum Disorder: Brief report. *Developmental Neurorehabilitation, 21*(3), 197–201. https://doi.org/10.1080/17518423.2018.1432713

Granlund, M. (2013). Participation: Challenges in conceptualization, measurement and intervention. *Child: Care, Health and Development*, *39*. https://doi.org/10.1111/cch.12080

Griful-Freixenet, J., Struyven, K., Verstichele, M., & Andries, C. (2017). Higher education students with disabilities speaking out: Perceived barriers and opportunities of the universal design for learning framework. *Disability & Society, 32*(10), 1627–1649.

Harvey, A., Andrewartha, L., Edwards, D., Clarke, J., & Reyes, K. (2017). Student equity and employability in higher education. *Report for the Australian Government Department of Education and Training. Melbourne: Centre for Higher Education Equity and Diversity Research, La Trobe University*.

Jacobson, J. (2017). Authenticity in immersive design for education. In D. Liu, C. Dede, R. Huang, & J. Richards (Eds.), *Virtual, augmented, and mixed realities in education* (pp. 35–54). Springer Singapore. https://doi.org/10.1007/978-981-10-5490-7_3

Khalid, M. S., & Pedersen, M. J. L. (2016). Digital exclusion in higher education contexts: A systematic literature review. *Procedia-Social and Behavioral Sciences, 228*, 614–621.

Kym, F. (2014). *The future of learning and teaching in next generation learning spaces*. Emerald Group Publishing Limited. https://doi.org/10.1108/S1479-362820140000012024

Lieberman, M. (2018). Technology can help address accessibility challenges, but many say it's an incomplete solution. *Inside Higher Ed*. Available from https://www.insidehighered.com/digital-learning/article/2018/05/02/technology-can-help-address-accessibility-challenges-many-say

Lindner, K. T., & Schwab, S. (2020). Differentiation and individualisation in inclusive education: a systematic review and narrative synthesis. *International Journal of Inclusive Education*, 1–21. https://doi.org/10.1080/13603116.2020.1813450

May, H., & Bridger, K. (2010). Developing and embedding inclusive policy and practice in higher education. *York: Higher Education Academy*, *13*.

Morgan, H., & Houghton, A. M. (2016). Inclusive curriculum design in higher education. Generic considerations for effective practice across and within subject areas. Hg. v. The Higher Education Academy. Zugegriffen, 21. Available from https://www.heacademy.ac.uk/sites/default/files/resources/generic_considerations_of_inclusive_curriculum_design.pdf

Nakajima, A., Teame, D., & Kostiuk, S. (2022). Equity, diversity, and inclusion in simulation. *Clinical Simulation in Nursing*, *71*, 4–8. https://doi.org/10.1016/j.ecns.2022.08.004

Omiko, A., Igwe, I., & Ukpa, J. (2017). Using of inclusive education to enhance the teaching of chemistry to the visually impaired students in secondary schools. *International Journal of Emerging Trends in Science and Technology, 4*(05), 5148–5156.

Di Paolo, A., Beatini, V., Di Tore, S., & Todino, M. (2023). How serious can promote inclusion, history and cultural heritage through the Virtual Reality. *Journal of Inclusive Methodology and Technology in Learning and Teaching, 3*(1).

Peiying, N., Goddard, T., Gribble, N., & Pickard, C. (2012). International placements increase the cultural sensitivity and competency of professional health students: A quantitative and qualitative study. *Journal of Physical Therapy Education*, *26*(1). https://doi.org/10.3352/jeehp.2019.16.4

Rogers-Shaw, C., Carr-Chellman, D. J., & Choi, J. (2018). Universal design for learning: Guidelines for accessible online instruction. *Adult Learning, 29*(1), 20–31. https://doi.org/10.1177/1045159517735530

Schmidt, M. (2022). Activity theory as a lens for developing and applying personas and scenarios in learning experience design. *Journal of Applied Instructional Design*. Available from https://edtechbooks.org/jaid_11_1/activity_theory_as_a

Simon, J., & Ainsworth, J. W. (2012). Race and socioeconomic status differences in study abroad participation: The role of habitus, social networks, and cultural capital. *International Scholarly Research Notices*, 2012. https://doi.org/10.5402/2012/413896

Smallheer, B., Chidume, T., Spinks, M. l. K. H., Dawkins, D., & Pestano-Harte, M. (2022). A scoping review of the priority of diversity, inclusion, and equity in health care simulation. *Clinical Simulation in Nursing*, *71*, 41–64. https://doi.org/10.1016/j.ecns.2022.05.009

Sorkos, G., & Hajisoteriou, C. (2021). Sustainable intercultural and inclusive education: Teachers' efforts on promoting a combining paradigm. *Pedagogy, Culture & Society, 29*(4), 517–536. https://doi.org/10.1080/14681366.2020.1765193

Starcic, A. I. (2010). Educational technology for the inclusive classroom. *Turkish Online Journal of Educational Technology-TOJET, 9*(3), 26–37.

Tai, J., Ajjawi, R., Bearman, M., Boud, D., Dawson, P., de St, J., & Jorre, T. (2023). Assessment for inclusion: Rethinking contemporary strategies in assessment design. *Higher Education Research & Development, 42*(2), 483–497. https://doi.org/10.1080/07294360.2022.2057451

Vlachogianni, P., & Tselios, N. (2022). Perceived usability evaluation of educational technology using the System Usability Scale (SUS): A systematic review. *Journal of Research on Technology in Education, 54*(3), 392–409. https://doi.org/10.1080/15391523.2020.1867938

Woodcock, S., Sharma, U., Subban, P., & Hitches, E. (2022). Teacher self-efficacy and inclusive education practices: Rethinking teachers' engagement with inclusive practices. *Teaching and Teacher Education, 117*, 103802. https://doi.org/10.1016/j.tate.2022.103802