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Review Article

Exploring the use of immersive virtual reality in nursing education: A scoping review

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Immersive;
Nursing education;
Nursing students;
Scoping review;
Virtual reality

Abstract

Background: Virtual reality is an emerging technology for nursing education. This technology can provide visual, motor, and auditory immersion into a virtual environment, thereby mimicking reality. Virtual reality may be an effective pedagogical tool for nursing educators to meet the learning needs of nursing students.

Objective: The aim of this scoping review was to map the existing literature on the use of immersive virtual reality implemented within nursing education programs with nursing students.

Design: Scoping review following established methodology.

Data sources: A database search of ERIC (OVID), Medline (OVID), PubMed, Web of Science, and CINAHL Plus with Full Text, and Nursing and Allied Health Database. Records published between January 2010 and August 2022.

Review methods: Two reviewers independently screened titles and abstracts of 2115 articles. Fourteen articles were included in this scoping review.

Results: Five major themes were identified in the thematic analysis: Self-confidence, Skill acquisition, Improved learning outcomes, Perspective taking, and Promoting engagement. Immersive virtual reality is being utilized in a variety of clinical settings and with different intended purposes. Most virtual reality research is focused on end-user satisfaction and perceptions of usability.

Conclusions: This scoping review provides a comprehensive understanding of the use of immersive virtual reality within nursing education. There is a range of definitions of virtual reality utilized within

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nursing literature. Further research is necessary to study this growing area of technology for nursing education.

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Nursing faculty are consistently exploring new and innovative technologies to deliver programs which are practical, meaningful, and effective. One example of an emerging technology in nursing education is virtual reality (VR). VR can provide varied levels of immersion into a virtual environment, thereby mimicking reality. This technology creates the possibility of facilitating repeated access to clinical environments and scenarios such as emergency departments, operating rooms, and long-term care facilities to meet learning outcomes.

There are many emerging definitions of VR, from computer-based simulations and 3-dimensional environments to fully immersive experiences of the auditory, visual, and motor senses (Kardong-Edgren, Breitkreuz, Werb, Foreman, & Ellertson, 2019; Miller & Bugnariu, 2016). The lack of definitional consensus for how the term VR is being defined is creating complexities as to how the term is being applied within research studies. One contributing factor to this confusion may be the use of the terms simulation, augmented reality, and VR interchangeably. Kardong-Edgren et al. (2019) has suggested the definition of VR be expanded to include the levels of immersion based on inclusiveness, extensiveness, surrounding, vividness and proprioceptive feedback. For the purpose of this review, VR has been defined as an immersive simulated experience where the user can interact within the three-dimensional, virtual environment, through multisensory modalities, using a head-mounted device and haptic technology. Two variables are often considered: immersion and presence. Immersion represents the ways in which the user can interact within the virtual space through various sensory stimuli (Kardong-Edgren et al., 2019). Presence refers to the extent to which the user experiences the simulated environment (Kardong-Edgren et al., 2019). There is a need to explore how VR has been used within nursing programs utilizing this definition.

Background

Traditional nursing programs include the use of theoretical learning within the classroom, and the use of clinical experiences in a variety of practice settings where students can apply their theoretical knowledge (Oermann, Shellenbarger, & Gaberson, 2021). However, digital education technologies have become more common within nursing education programs as an adjunct to facilitate learning. One example of digital technology is VR. The use of VR training programs shows evidence of success within the nursing profession (Farra, Smith, & Ulrich, 2018; Smith et al., 2018) and broader health science professions (Aksoy, 2019; Dyer, Swartzlander, & Gugliucci, 2018; Wilson, O'Connor, Taylor, & Carruthers, 2017). Simulated experience provides the opportunity to practice repeatedly in a protected environment, to solidify skills, and receive real-time feedback (Gurusamy, Aggarwal, Loizidou, Davidson, & Gurusamy, 2013; Kilmon, Brown, Ghosh, & Mikitiuk, 2010; Kyaw et al., 2019). Immersive VR shows a positive correlation between the repeatable nature of VR simulation training on performance and demonstrates advantages in an educational context, particularly health care, where skills are continually updated (Jütten et al., 2017). Based on the variance of how VR has been defined, to the best of our knowledge there is no review about how VR, as defined in this review, is being used within nursing programs. Therefore, the aim of this scoping review was to review the use of immersive VR in education for nursing students and identify relevant gaps in literature. The research question used to guide this scoping review was: How is immersive VR being utilized in nursing education?

Methods

A scoping review is a systematic form of knowledge synthesis which maps evidence to answer a research question (Arksey & O'Malley, 2005). Scoping reviews are relevant "to disciplines with emerging evidence in which the paucity of randomized controlled trials makes it difficult for researchers to undertake systematic reviews" (Levac, Colquhoun, & O'Brien, 2010, p. 1). The analysis and reinterpretation of extant quantitative and qualitative data provide an overview of the state of the science regarding the research question (Levac et al., 2010). The methodological framework used to map studies addressing the use of immersive VR in nursing education

Table 1 – Summary of inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Nursing students (certificate, diploma, degree)	Graduate programs
Use of immersive virtual reality	Use of other technology
English	Device evaluation
2010-2022	Program evaluation
Primary research articles	Grey literature
	theoretical and conceptual papers

was the model of Arksey and O'Malley (2005), extended by Levac et al. (2010). Recommendations to clarify and enhance the scoping methodology include: (1) clarifying and linking the purpose and research question; (2) balancing feasibility with breadth and comprehensiveness of the scoping process; (3) using an iterative team approach to selecting studies; (4) extracting data; (5) incorporating a numerical summary and qualitative thematic analysis, reporting results, and considering the implications of study findings to policy, practice, or research; (6) incorporating consultation with stakeholders as a required knowledge translation component of scoping study methodology (Levac et al., 2010). A prior review protocol was not published. Within this methodology, the PRISMA-ScR reporting recommendations were followed for this review (Tricco et al., 2018).

Identification of relevant studies

Eligibility criteria

Inclusion criteria were primary peer-reviewed studies with all types of qualitative, quantitative and mixed designs from 2010-2022, published in English, with full text available. Studies included enrolled nursing students (undergraduate, diploma, and certificate) and use of immersive VR. Immersive VR was defined as an immersive simulated experience where the user can interact within the three-dimensional, virtual environment, through multisensory modalities, using a head-mounted device and haptic technology. Table 1 summarizes the inclusion and exclusion criteria.

Information sources and search strategy

A search of the academic literature was completed by the primary author with assistance from the university subject librarian and library guides, as necessary, within the following databases: ERIC (OVID), Medline (OVID), PubMed, CINAHL Plus with Full Text, and Nursing and Allied Health Database, and Web of Science. Databases were searched using the terms detailed in Table 2, and title and abstracts were assessed to determine if articles met the inclusion criteria (Table 1). The key search terms were identified based on a review of relevant keywords from prior literature searches and group member expertise. The search strategy comprised two categories (nursing education, VR) with multiple synonyms. MeSH-Browser was consulted for relevant terms. The search included variations of the following terms in each category and the Boolean connectors of (AND) and (OR) connected the terms in the two columns. Truncation was utilized to include all possible endings of the search term.

Selection of sources of evidence

The initial search identified 2,115 articles. Results were downloaded into Endnote 20™ to enable duplicates to be identified and removed. After removing 296 duplicates, the results were exported to Microsoft Excel. 1,819 titles and abstracts were reviewed independently by two authors with an aim to minimize selection bias. When the reviewers did not reach consensus in the initial review they met to discuss and reach a decision. Full-text analysis was completed for 51 articles. Figure 1 illustrates the flow chart of included articles. Full-text articles were assessed by the lead author in consultation with the secondary author to reach consensus. Thirty-seven studies were excluded because: they did not fit the definition of VR ($n = 30$); the population did not include nursing students ($n = 5$); the study was a review of the hardware and did not include a nursing education component ($n = 2$). Ultimately, 14 articles were deemed relevant to the research aim and question.

Data Charting Process

The lead author extracted the study characteristics, methodology, findings, and implications for nursing from the selected articles (Table 3). Data were reviewed and confirmed by the second author. The final articles included in this review were evaluated for quality using the critical appraisal tool developed by Hawker, Payne, Kerr, Hardey, and Powell (2002). This quality appraisal tool was chosen because it is suitable for assessing the quality and rigour of studies with various designs thorough a well defined nine-item criterion ultimately producing a final score.

Table 2 – Summary of search terms

Nursing education	Virtual realit* (reality, realities)
Nursing school	Virtual environment
Nursing program* (program, nursing programs)	VR
Nursing student* (student, students)	Immersive technolog*
Student nurse* (nurse, nurses)	(technology, technologies)

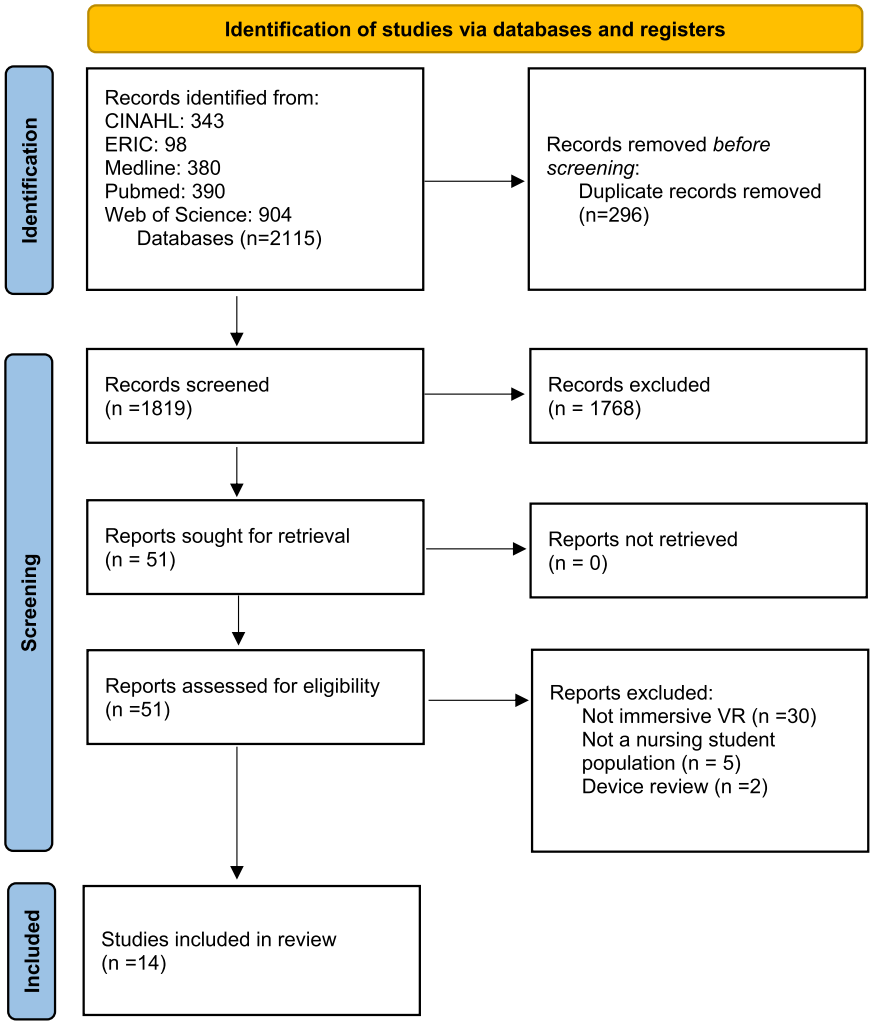


Figure 1 PRISMA flow chart of included articles (Tricco et al., 2018).

This tool assesses various study aspects, including the abstract and title, introduction and objectives, methodology, sampling techniques, data analysis, ethics/biases, findings/results, generalizations, usefulness, and implications. Each of these elements was rated on a scale from 1 (poor quality) to 4 (high quality), with a maximum possible score of 36 points. The total score was then categorized into one of three quality ranges: very poor (0-9), poor (9-18 points), fair (19-27 points), or good (28-36 points). No studies were excluded based on their quality appraisal score. Each study reviewed received a score within the range of 'fair'' or 'good'.' No studies received a total score of less than 27 or were determined to be of 'poor' or 'very poor' quality.

Text was analyzed using Braun and Clarke's (2006) six-phase thematic analysis. First, articles were read and reread, by two members of the research team who noted down any excerpts of text that contributed to answering the research question. Relevant excerpts were then extracted and sorted into codes. Sub-themes linking the different codes were generated and presented research team. Data analysis was conducted by three members of the research team with the aim of improving research credibility and confirmability (Cope, 2014). Results were clustered according to themes of immersive VR use. Since scoping reviews intend to map available literature and guide further research, studies were included regardless of their

Table 3 – Study characteristics

Authors (Year)	Country	Aim	Methodology	Participants/Population	Findings	Implications for Nursing	Quality Appraisal /39
Adhikari et al. (2021)	Scotland	Evaluate the effects of the immersive VR game on self-efficacy with preregistration nurse and explore perceptions of acceptability and applicability of the game in nursing education	Mixed-methods sequential 1. Pretest post-test intervention using Nursing Anxiety and Self-Confidence with Clinical Decision Making sale. 2. Descriptive qualitative approach exploring student nurses' perceptions of the game	19 3rd year preregistration nurses ages 25-45	26.1% increase in mean confidence score postintervention and 23.4% decrease in anxiety. Four broad themes were generated: Acceptability, Applicability, Areas of Improvement and Limitations	Findings suggest the VR intervention increases confidence and reduces anxiety when caring for a person who is showing signs of deterioration due to sepsis. The game shows promise as a pedagogical approach	Good (36)
Botha et al. (2021)	South Africa	Provide insight into South African nursing student experiences while being immersed in a virtual environment managing a foreign object in the airway	Mixed-methods concurrent design; observational data and questionnaire	34 3rd year undergraduate nursing students (6 pilot tested)	Experiences were mostly positive. Some students experienced dizziness, nausea and feeling off-balance. Students found the virtual environment to be realistic, easy to use, and comfortable to wear	The scenario was useable to the extent the nursing students felt they would benefit from this as a teaching and learning method	Good (33)

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Table 3 (continued)

Authors (Year)	Country	Aim	Methodology	Participants/Population	Findings	Implications for Nursing	Quality Appraisal /39
Butt et al. (2018)	United States	Explore the usability of, and user reaction to a game-based VR system designed to practice urinary catheter insertion	Mixed-methods postintervention System Usability Survey and user-reaction survey. Two-week follow-up return demonstration	20 junior-level undergraduate nursing students in their 5th or 6th semester	VR game was helpful, fun, engaging and preferred over a task-trainer; there was no difference in ability to demonstrate the skill in the two-week follow-up between the experimental and control groups	VR may provide a new way to help students deliberately and repetitively practice procedural skills, potentially leading to greater skill retention	Good (34)
Chang and Lai (2021)	Taiwan	To understand the experience of nursing students in using VR skill learning process	Qualitative focus groups with content analysis	60 nursing students (55 women 5 men) from a two-year program	Students found the VR convenient but had to adapt to the VR. They could learn the skill quickly, it was stress free and environmentally friendly. Students felt the VR lacked a sense of reality compared to conventional teaching methods	VR may be a supportive learning tool for nursing students but still lacks a sense of reality and does not fully replace traditional teaching methods	Good (33)

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Table 3 (continued)

Authors (Year)	Country	Aim	Methodology	Participants/Population	Findings	Implications for Nursing	Quality Appraisal /39
Chao et al. (2021)	Taiwan	Examine the effects of an immersive three-dimensional (3D) interactive video program on improving nursing students' nasogastric tube feeding skill competence	Randomized controlled trial	45 nursing students from a university in northern Taiwan	Although there were no significant differences in students' knowledge, skill, and confidence between the two groups, participants' average satisfaction score with the immersive 3D interactive video program in the intervention group was significantly higher than in the comparison group that watched a regular video	Both immersive 3D interactive video program and regular demonstration video could improve nursing students' learning outcomes. This study provides useful information for nursing faculty members for designing and developing teaching methods for the acquisition of nursing skills	Good (35)
Chu-Ling (2022)	Taiwan	To explore the effect of immersive VR teaching on learning performance regarding in-dwelling urinary catheter skills.	Quasi-experimental design intervention and follow up questionnaire and focus groups	43 postbaccalaureate nursing students	Students were highly satisfied with the immersive VR and stated that it provided a pleasurable learning experience and exerted a positive impact on them	Immersive VR can be an effective teaching tool for students to learn how to place Foley catheters in female patients	Fair (27)

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Table 3 (continued)

Authors (Year)	Country	Aim	Methodology	Participants/Population	Findings	Implications for Nursing	Quality Appraisal /39
Farra et al. (2018)	United States	To provide new evidence in how varying levels of immersion are perceived by nursing students using disaster-based VR experiences	Qualitative focus groups with content analysis	100 senior baccalaureate nursing students	Students in moderate and high immersion identified positive learning experiences. Participants enjoyed the experience, felt comfortable learning, and were impressed with the level of realism	Varying levels of VR simulation demonstrate equal or improved learning outcomes with higher levels of immersion	Fair (27)
Kardong-Edgren et al. (2019)	United States	To evaluate the usability of a VR game system for sterile catheterization practice	Quantitative survey	29 Undergraduate junior and senior nursing students and two nursing faculty	Seventy-five percent of participants rated the game as positive overall on the User Reaction Survey. Left-handed players had more difficulty playing the game. Players with prescription glasses could not comfortably place the Oculus Rift over their glasses to play	Usage of the game was positive and entertaining. A left-handed version of the game and provision for glasses wearers would enhance the usability of the game	Good (34)

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Table 3 (continued)

Authors (Year)	Country	Aim	Methodology	Participants/Population	Findings	Implications for Nursing	Quality Appraisal /39
Lange et al. (2020)	Germany	To observe the degree of acceptance of VR applications by nursing students in Germany	Qualitative semistructured open-ended interviews	12 nursing students who had taken anatomy (4 male 8 female)	VR was rated positively. The higher the personal affinity the more useful the technology appears. Motivation to learn was increased by using VR. Cost is still a barrier	VR programs can be an important, supporting part of the training to deepen learning, i.e., anatomy. The technology has to be easy to use and understandable to lead to great affinity and acceptance	Good (35)
Ma et al. (2021)	United States	To investigate the feasibility and effectiveness of a computer role-playing game on nursing students' empathy with a focus on immersiveness and perspective	Quantitative 2 × 2 between-subjects design	69 undergraduate nursing students from two universities	Playing the game in VR led to greater spatial presence and empathy. Playing in the health care provider's perspective elicited greater empathy, when compared to the patient family perspective	Using VR in empathy training through perspective taking my improve nursing students' empathy	Fair (27)

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Table 3 (continued)

Authors (Year)	Country	Aim	Methodology	Participants/Population	Findings	Implications for Nursing	Quality Appraisal /39
Saab et al. (2022)	Ireland	To explore nursing students' views of using VR in healthcare	Qualitative descriptive study guided by naturalistic inquiry	26 third year undergraduate nursing students from two programs	Participants described this technology as novel, enjoyable, immersive, memorable and inclusive. They questioned, however, the suitability of VR for older adults, reported minor technical difficulties and stressed the importance of prior preparation in the use of the technology	VR was recommended for use in outpatient healthcare settings, schools and the community. Participants suggested using VR in health promotion, disease prevention and management, and to promote nurses' empathy towards patients	Good (35)
Samosorn et al. (2020)	United States	To examine whether an educational intervention with a pilot contemporary immersive VR simulation builds knowledge and is feasible to implement among nursing students and faculty	Quasi-experimental one-group pretest-post-test design combined with survey sampling	10 faculty members and 21 nursing students	Faculty and students rated the VR airway laboratory as having high presence, no cyber sickness, and significant improving knowledge of airway management	VR can be used as an intervention in nursing education	Good (37)

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Table 3 (continued)

Authors (Year)	Country	Aim	Methodology	Participants/Population	Findings	Implications for Nursing	Quality Appraisal /39
Siah et al. (2022)	Singapore	To evaluate the efficacy, attitude and confidence of nursing students in a virtual perioperative setting designed to teach patient safety procedures	Single-group descriptive study design	207 third year undergraduate nursing students	Students felt either neutral or positive about the use of VR toward their efficacy, confidence and attitudes	The application of virtual-reality simulation in this study offers promising potential as a viable alternative to physical clinical simulation	Good (37)
Thompson et al. (2020)	Canada	To describe students' engagement and experiences with VR in a first-year nursing course on anatomy, physiology, and health assessment	Mixed-methods concurrent design	46 first year undergraduate nursing students	Students perceived their engagement to be higher in VR compared to other teaching methods. Their experiences were positive with students reporting that they found it easy to use, it helped their learning, and they recommended more of it	VR is an accessible tool for supporting student engagement. The Exploratory Learning Model is a useful conceptualization for integrating VR into a course	Good (33)

quality appraisal scores. Table 3 provides an overview of the study characteristics, the main results of the included publications and the quality appraisal score.

Results

Study characteristics

The studies were conducted in several countries: Canada (Thompson, Thompson, & McConnell, 2020); Germany (Lange et al., 2020); Ireland (Saab et al., 2022); Scotland (Adhikari et al., 2021); South Africa (Botha, de Wet, & Botma, 2021); Singapore (Siah, Xu, Teh, & Kow, 2022); Taiwan (Chang & Lai, 2021; Chao et al., 2021; Chu-Ling, 2022); United States (Butt, Kardong-Edgren, & Ellertson, 2018; Farra et al., 2018; Kardong-Edgren et al., 2019; Ma, Huang, & Yao, 2021; Samosorn, Gilbert, Bauman, Khine, & McGonigle, 2020). Sample size varied from 12-207 nursing students. Despite an inclusion criterion of published literature from 2010 and on, 12 of the 14 studies were published within the last three years (Adhikari et al., 2021; Botha et al., 2021; Chang & Lai, 2021; Chao et al., 2021; Chu-Ling, 2022; Kardong-Edgren et al., 2019; Lange et al., 2020; Ma et al., 2021; Saab et al., 2022; Samosorn et al., 2020; Siah et al., 2022; Thompson et al., 2020). This finding may suggest an increased interest and access to immersive VR within nursing education.

One study was a randomized controlled trial (Chao et al., 2021). Five utilized mixed methods (Adhikari et al., 2021; Botha et al., 2021; Butt et al., 2018; Chu-Ling, 2022; Thompson et al., 2020). Five were qualitative studies (Chang & Lai, 2021; Farra et al., 2018; Lange et al., 2020; Saab et al., 2022; Siah et al., 2022). One was a pre-test post-test design with one group comparing the means of a knowledge test before and after the immersive VR intervention (Samosorn et al., 2020). One was a 2 × 2 between subjects design (Ma et al., 2021). One was a quantitative survey (Kardong-Edgren et al., 2019).

Synthesis of results

A qualitative review of the 14 articles resulted in five major themes identified in the thematic analysis included: Self-confidence, Skill acquisition, Improved learning outcomes, Perspective taking, and pPromoting engagement.

Self-confidence

The theme of self-confidence appeared in several studies throughout the review (Adhikari et al., 2021; Chao et al., 2021; Farra et al., 2018; Siah et al., 2022). Adhikari et al. (2021) found a statistically significant increase in self-confidence and decrease in anxiety for participants after engaging in an immersive VR sepsis game, this increased self-confidence was reinforced within the qualitative interviews. Within their focus groups following an immersive VR simulation, participants in another study reported feeling more confident and suggested the VR simulation was less intimidating than traditional mannequin-based simulation (Farra et al., 2018). Although students' self-confidence to perform the skill of nasogastric tube insertion increased for the participants who used the interactive VR, there was no statistically significant difference in improvement when compared with a group who viewed a traditional demonstration (Chao et al., 2021). Students who participated in the perioperative VR scenario reported higher levels of self-efficacy and confidence to perform the responsibilities of a scrub nurse (Siah et al., 2022).

Skill acquisition

The review revealed four studies where immersive VR was utilized for skill acquisition (Butt et al., 2018; Chang & Lai, 2021; Chu-Ling, 2022; Kardong-Edgren et al., 2019). Skills included: catheter insertion, and nasogastric tube insertion (Butt et al., 2018; Chang & Lai, 2021; Chu-Ling, 2022; Kardong-Edgren et al., 2019). Because all of these skills would be considered invasive and not appropriate for students to practice on each other, or a standardized patient within the lab setting, this suggests VR may present a viable solution for invasive skills practice.

Compared with the control group, the nursing students who practiced catheter insertion using a VR simulation had the same ability to demonstrate sterile technique as the students who used a traditional set-up in the school's simulation laboratory (Butt et al., 2018). Participants in the nasogastric immersive VR simulation felt this teaching strategy had the advantages of being less stressful and more environmentally friendly alternative for learning skills (Chang & Lai, 2021). However, participants also expressed there was a learning curve to the VR which took time (Chang & Lai, 2021). This learning curve is also suggested by Kardong-Edgren et al. (2019) who found users who self-identified as a "gamer" found the simulation less challenging and less demanding for practicing a catheter insertion. Although these findings may suggest VR is not necessary for learning these skills, it may present a viable alternative requiring less space and consumable supplies.

Improved knowledge

This theme was reflected in four studies from the review (Adhikari et al., 2021; Chao et al., 2021; Saab et al., 2022; Samosorn et al., 2020). Samosorn et al. (2020) conducted a pilot study to determine whether an immersive VR simulation increased knowledge and skills for teaching airway insertion. Findings indicated a significant increase in

knowledge between pre-test and post-test scores and suggested VR could make a meaningful contribution to learning (Samosorn et al., 2020). Similarly, participants in the immersive VR simulation teaching nasogastric tube insertion had improved knowledge following the intervention, however, participants did not score significantly higher than those who viewed a traditional demonstration video (Chao et al., 2021). Although Saab et al. (2022) did not evaluate a specific outcome, focus group feedback suggests immersive VR may be suitable for various learning styles through the visual, audio, and motor features of the technology while limiting knowledge overload. Similarly, Adhikari et al. (2021) found a positive perceived impact on knowledge and an opportunity for reflection on knowledge gaps and areas of improvement by participants.

Perspective taking

The theme of perspective taking emerged during the analysis and included two studies (Ma et al., 2021 & Saab et al., 2022). Ma et al. (2021) compared playing a game in immersive VR to non-VR and found participants had statistically significant higher empathy scores when playing in immersive VR. This finding is consistent with the work of Saab et al. (2022) where participants in the study suggested immersive VR would be a meaningful way to increase nurses' empathy toward patients. One participant suggested it could be used within dementia care to help healthcare workers understand how it feels to be spoken to in a childlike tone (Saab et al., 2022).

Promoting engagement and satisfaction

Several studies noted the use of immersive VR made the students feel they were more engaged in the scenarios (Adhikari et al., 2021; Botha et al., 2021; Butt et al., 2018; Chao et al., 2021; Farra et al., 2018; Lange et al., 2020; Saab et al., 2022; Thompson et al., 2020). Farra et al. (2018) sought to provide new evidence in how varying levels of immersion were perceived by nursing students. Within the study, the students who engaged in a higher level of immersion, consistent with the definition in this study, reported the feeling of being present in the hospital to the extent they forgot where they were. Engagement could also be considered by the amount of time spent using the application. Butt et al. (2018) noted the students who used VR comparted to a traditional simulation lab spent a longer amount of time practicing and completed more procedures.

Although in the study conducted by Chao et al. (2021) knowledge and confidence were not significantly different compared to the control group, there was a statistically significant higher satisfaction level within the group utilizing the VR. This finding is similar to Thompson et al. (2020) where the students' qualitative responses suggest a positive experience with VR, because it was more active, immersive, and realistic than passive teaching techniques. Students who participated in the VR intervention conducted by Saab et al. (2022) described the immersive VR as more memorable, novel, and enjoyable, than other conventional teaching methods, and attributed this result to the immersion and interactive nature of the application. This theme was also present in the interview themes from Adhikari et al. (2021); Botha et al. (2021); Siah et al. (2022); and Lange et al. (2020) where the majority of participants felt the simulation was immersive, realistic, and interactive.

Discussion

The aim of this scoping review was to map the available nursing literature as it relates to the use of immersive VR within nursing education. Although virtual reality has contributed to improved outcomes for students and patients (Donnelly, McLiesh, & Bessell, 2020; Kravitz et al., 2022; Williams, Stephen, & Causton, 2020), little is known about how virtual reality is being utilized within nursing education. The results of this scoping review show the characteristics of available studies regarding the use of immersive VR in nursing education and provide an overview of the current state of research concerning this topic. Within the scope of this review fourteen studies have been published (Adhikari et al., 2021; Botha et al., 2021; Butt et al., 2018; Chang & Lai, 2021; Chao et al., 2021; Farra et al., 2018; Kardong-Edgren et al., 2019; Lange et al., 2020; Ma et al., 2021; Saab et al., 2022; Samosorn et al., 2020; Thompson et al., 2020).

The findings of this review suggest there are ongoing efforts to evaluate the impact of VR within nursing education (Adhikari et al., 2021; Chao et al., 2021; Ma et al., 2021; Samosorn et al., 2020). However, a majority of the studies reported user self-perception as anecdotal feedback (Botha et al., 2021; Butt et al., 2018; Chang & Lai, 2021; Chu-Ling, 2022; Farra et al., 2018; Kardong-Edgren et al., 2019; Ma et al., 2021; Saab et al., 2022; Siah et al., 2022; Thompson et al., 2020).

The studies included within the scoping review reflect a variety of settings and patient populations including emergency (Adhikari et al., 2021; Botha et al., 2021; Samosorn et al., 2020), older adult (Ma et al., 2021; Saab et al., 2022), medical-surgical (Butt et al., 2018; Chang & Lai, 2021; Kardong-Edgren et al., 2019) and perioperative (Siah et al., 2022). This review also revealed that the value of VR for nursing education may be more broad than skill acquisition, and may support development of the "art of nursing" skills such as communication, empathy, and confidence (Adhikari et al., 2021; Chao et al., 2021; Farra et al., 2018; Ma et al., 2021; Saab et al., 2022; Siah et al., 2022).

Several studies demonstrated that greater levels of immersion during the VR experience impacted the overall

outcome of the study (Farra et al., 2018; Saab et al., 2022; Thompson et al., 2020). Conversely, two of the studies evaluating skill acquisition (Butt et al., 2018; Chao et al., 2021) did not find immersive VR contributed to a significant difference in the ability to perform the skill, compared to more traditional teaching methods. Chang and Lai (2021) noted participants felt the VR was lacking a sense of reality largely due to the touch sensation within the immersive VR when using the technology to perform the skill of nasogastric tube care. Although the data was not significant, because VR was not found to be inferior for skill acquisition, there may still be value in utilizing this technology compared to alternatives, because of the reduction in consumable supplies, space allocation, and cost (Chang & Lai, 2021). However, cost was viewed as a barrier, not an advantage, in Lange et al. (2020). Because the focus population of this study was students, the perception of cost to a nursing program may need to be further studied with a broader population focus including academic administrators and simulation faculty. As technology is rapidly evolving these noted deficits may become less of a barrier and therefore consistent, ongoing research is needed.

The themes from this scoping review reflect and reinforce trends from the broader health professions education community. While the focus for this review was undergraduate nursing students, it is important to recognize that nursing is not the only health professions program adopting immersive virtual reality as a teaching tool. For example, Francis, Bernard, Nowak, Daniel, and Bernard (2020) utilized immersive virtual reality to provide orientation to the operating room with second year physician assistant students, and the experimental group demonstrated a statistically significant difference in improved self-efficacy compared to the control group. Similarly, Stepan et al. (2017) and Bakhos et al. (2020) both saw improvement in self-reported self-confidence, compared to control groups when immersive VR was used as a teaching intervention for audiology and medical students respectively.

Any new technology utilized for teaching can only be as effective as the people conceptualizing, designing and implementing it. Therefore, given the pace VR is evolving, there will be ongoing need for professional development and research with, and for, nursing faculty to feel confident to use this technology with students. Nursing faculty must be engaged in the purposeful design of VR applications to ensure their alignment with best-practice and curriculum outcomes. If educational institutions wish to invest in VR infrastructure within nursing and health professions programs, there will need to be consideration of the time and expertise needed to train and effectively use this technology.

Nursing researchers are using a variety of terminology to describe immersive VR. The term was present in excluded studies, which included desktop games, augmented reality, mannequin-based simulation, and 360^0 room projection. This scoping review reinforces the recommendation from Kardong-Edgren et al. (2019) to include the level of immersion and the equipment used within the VR descriptions or definitions in all study publications to increase clarity for the reader. Despite an inclusion criterion of studies published since 2010, all of the included studies were published since 2018. The recent increase in available research suggests VR is a new and growing area of nursing education research as technology advances and becomes more widely available.

Limitations

This scoping review presents the current range of evidence regarding the use of immersive VR within nursing education. The findings should not be generalized to other populations or contexts. The methodological quality of the studies did not influence the inclusion or exclusion of any paper in this scoping review, since this type of design provides an overview of the body of literature in a given topic, however the appraisal has been included to support the reader with the application of the findings in this scoping review (Munn et al., 2018). For this reason, our findings reflect the scope of use to date, but cannot be used to make future recommendations regarding any specific use of immersive VR as a teaching method, nor should conclusions be drawn other than those presented. Because of the variance in definitions and terminology utilized, potentially relevant articles containing the use of immersive VR within nursing education may have been excluded. A broad search strategy was incorporated to mitigate this limitation. A limitation of this review is that most studies were conducted with small samples in single nursing courses, at single sites, or within one geographical region. Only peer-reviewed published nursing education literature was included. Grey literature, theoretical and conceptual papers were not part of the search strategy. Finally, we only reviewed English language research. To conduct a more comprehensive review of the use of immersive VR in nursing education, the scope should be expanded to include graduate level programs and continuing education. Future reviews could include the use of varied levels of immersion.

Conclusion

Immersive VR is emerging as a viable technology for nursing education; therefore, a comprehensive understanding of how this technology is being utilized with undergraduate nursing students is necessary to help inform future directions for implementation. This scoping review revealed that immersive virtual reality has the potential to improve self-confidence, assist with skill acquisition, improve learning outcomes, provide opportunity for perspective taking, and promote engagement with nursing students. Because

only 14 studies met the review inclusion criteria, there is a need for further research as to how to best implement this technology, and to better understand the strengths and limitations of immersive VR in nursing education. This scoping review included studies which did not find VR to be a superior teaching approach, which suggests that nursing educators should approach the use of this technology mindfully and engage in ongoing evaluation of the effectiveness of VR. Overall, the studies included in this review did trend toward largely positive outcomes with VR use in nursing education which suggests that this technology may be a worthwhile investment for nursing education.

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The authors declare no conflict of interest.

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Laura Vogelsang: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Sheri Wright:** Formal analysis, Conceptualization. **Tracie Risling:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Anthony de Padua:** Writing – review & editing, Methodology, Conceptualization. **Donald Leidl:** Writing – review & editing, Methodology, Conceptualization. **Jay Wilson:** Writing – review & editing, Methodology, Conceptualization. **David Thompson:** Writing – review & editing, Validation.

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