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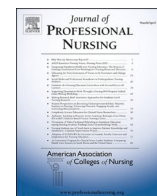


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Use of theory to guide integration of virtual reality technology in nursing education: A scoping study[☆]

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ABSTRACT

Background: There is growing interest among academic nurse educators in using virtual reality (VR) environments as a pedagogical tool to enhance student learning.

Purpose: The aim of this scoping study was to identify the theories or conceptual models that informed the application of virtual reality technology in nursing education programs.

Methods: A scoping study using the Arksey and O'Malley (2005) framework was conducted. A search strategy recommended and executed by a research librarian yielded 18 final articles for review.

Findings: There is limited use of theory or a conceptual model, particularly of nursing origin, to guide the integration of VR technology for student learning.

Discussion: More research is needed to define best practices for application of VR technology for specific curricular needs, and for theory development based on specific concepts and disciplinary perspectives of learning.

Introduction

There is growing interest among academic nurse educators in using virtual reality (VR) environments as a pedagogical tool to enhance student learning. Broadly defined, VR is a digitally-constructed space that "...perceptually surrounds the user, increasing his or her sense of presence or actually being within it" (Bailenson et al., 2008, p. 104). VR technology can provide the user a multisensory experience with the ability to assume a virtual representation, i.e., avatar, to interact with virtual others, objects, and a 3-D world, independent of real-life. The degree to which users are immersed in a digital space can vary, depending on the hardware and software used. In non-immersion, i.e., desktop VR, individuals use a computer's keyboard and mouse to view and manipulate a virtual environment observed on the computer's screen. In immersive VR, individuals typically use a head-mounted

display, earphones, and hand controllers (Hamilton et al., 2021). Regardless of the equipment and degree of immersion, the common element of VR is interactivity (Fox et al., 2009).

Applications of virtual environments have been used in nursing education for various purposes, such as to help students develop and practice clinical skills (Berg & Steinsbekk, 2021); learn complex concepts through participation in a virtual community (Levet-Jones et al., 2015; Shuster et al., 2011); role-play in simulated and unfolding patient/family scenarios (cite); and collaborate in interprofessional teams (Davis et al., 2016).

VR provides unique opportunities for learning that are not available in traditional in seat, hybrid, or online asynchronous classrooms. Although all of the factors that promote learning in VR simulations are unknown, a well-constructed virtual environment facilitates the sensation of psychological presence and engages multiple senses, which

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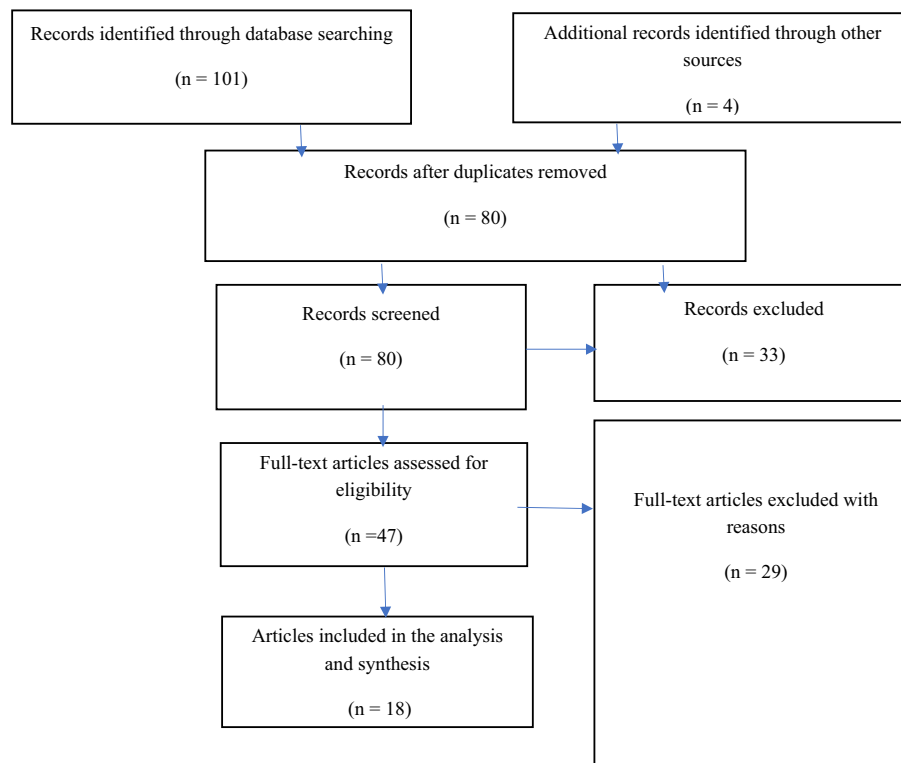


Fig. 1. Preferred reporting for systematic reviews & meta-analysis (PRISMA) diagram of study selection process.

enable an individual to experience and respond to an environment as if it is their “real-world” (Bailenson, 2018). Of particular interest to nursing is VR’s potential to assist students to embody the lived experience of others, which can facilitate understanding of complex and nuanced concepts. Compassion, for example, can be difficult for students to comprehend without the opportunity to engage in compassionate experiences and construct meaning out of these experiences. Digital immersion in a virtual community allows students to interact with and develop emotional connections with others throughout unfolding scenarios, bringing to life and integrating concepts learned in the classroom (Giddens & Walsh, 2010; Shuster et al., 2011). In addition, these virtual experiences can help students examine personal belief systems and limited understandings that may negatively influence attitudes toward and treatment of others.

Pedagogy—defined here simply as deliberative strategies to enhance learning in others—requires a theoretical framework for educators to structure experiences that address the affective, cognitive, psychomotor and sociocultural domains of learning, helping students to build and transfer knowledge and engage in behavior change. Yet the absence of identified theoretical frameworks in studies of VR technology application for learning has been noted (Liaw et al., 2018; Makransky & Peterson, 2021), while appropriate theoretical frameworks have been suggested (Green et al., 2014; Leibold & Schwarz, 2017).

In light of this finding we conducted a scoping study using the Arksey and O’Malley (2005) framework. A scoping study is a useful method for examining the range of research evidence when the topic is broad; it is not meant to be an exhaustive, in-depth study but rather a pragmatic approach to quickly identifying key concepts underpinning a topic and available literature (Arksey & O’Malley, 2005). We explicitly characterized our investigation as a scoping study rather than review following recommendations for nomenclature consistency (Levac et al., 2010).

The aim of this scoping study was to identify the theories or conceptual models that informed the application of virtual reality technology in nursing education programs. The research question that guided the scope of inquiry was: What is known from existing literature about

the theories or conceptual models used to guide integration of virtual reality in nursing education programs?

Methods

The five stages of the Arksey and O’Malley framework are well known, with literature notably extending and refining the process for team based mixed methods scoping reviews noted (Arksey & O’Malley, 2005; Vazquez-Westphal et al., 2021). The first stage begins with identifying the research question. We purposefully formulated a broad question to maximize capture of the relevant literature. Stages two through five are identified in the subheadings used in this section. An optional sixth stage is consulting with various stakeholders who can provide insight about the research topic and recommend additional studies (Arksey & O’Malley, 2005). PRISMA 2020 reporting guidelines (Fig. 1) were followed (Page et al., 2021).

Identifying relevant studies

The scoping study team consisted of the authors, who are faculty in a college of nursing at a private liberal arts university (a PhD-prepared Associate Dean of Research and Scholarship, a DNP-prepared Associate Dean of online nursing programs, a PhD-prepared Clinical Associate Professor) and the director of the Health Sciences & Nursing Library. Collectively the nursing faculty has extensive experience in nursing practice, research, and review methodologies, and the librarian has seven years’ experience in research and faculty support. The librarian recommended, designed and executed the search strategy based on the scoping study research question. Since the research topic carried both a health sciences and education component, the databases CINAHL, MEDLINE, ERIC, and Education Research Complete (all EBSCO) were selected to be searched for relevant English studies through a ten-year period from 2011 through 2021. We chose this initial timeframe based on Hamilton et al.’s (2021) systematic review of immersive virtual reality adoption in education, in which the authors

Table 1
Summary findings of studies.

Author(s)	Aim/purpose	Theory/conceptual model	VR type	Nursing program
Claman (2015)	Test the hypothesis that web-based synchronous instruction utilizing Multi-user Virtual World Environments (MUVES) increases student engagement compared to traditional asynchronous learning methods.	Community of Inquiry (CoI)	The synchronous MUVE platform was Venuegen (www.venuegen.com) and the asynchronous learning platform was the learning management system Blackboard. Venuegen is a MUVE similar to Second Life and The Neighborhood. Participants create avatars and interact synchronously in different environments. Content can be uploaded and edited online to further support learning.	Master of Nursing Family Nurse Practitioner
Foronda et al. (2014)	Evaluate the intervention of virtual simulation to teach leadership styles to students in a master's program in nursing education.	Jeffries' Simulation Model	Virtual reality system: Virtual world of CliniSpace, created by Innovation in Learning, Inc., Los Altos Hills, CA. Students logged into the virtual world on their personal laptops and chose avatars.	Master of Nursing
James et al. (2012)	Investigate the use of a virtual environment for developing communication skills and understanding of other disciplines	Situated learning, constructivism, reflective learning, Biggs constructive alignment	Computer, Second Life 3-D online virtual environment	Master of Nursing (midwifery and mental health)
Jane Cook (2012)	Present an example of an innovative educational strategy using a theoretical framework for the design and evaluation of a virtual world simulation for family nurse practitioner (FNP) students.	Constructivist learning theory and experiential learning principles	Second Life® 3-D online virtual world	Master of Nursing Family Nurse Practitioner
Josephsen and Butt (2014)	Evaluate the effectiveness of an unfolding multipatient simulation focusing on collaborative practice competencies.	Cognitive learning, specifically constructivism	Virtual Multipatient Simulation	Baccalaureate Nursing
Kardong-Edgren et al. (2019)	Evaluate the usability of a VR game system for sterile catheterization practice	Overlearning	iPad, headset, Leap motion sensors	Baccalaureate Nursing
Mabry et al. (2020)	Explore use of a virtual presimulation to increase self-efficacy in high-fidelity emergent clinical scenario simulation performance	Deliberative practice Self-efficacy	Computer, web-based virtual simulation interactive software	Baccalaureate Nursing
Menzel et al. (2014)	Evaluate the effectiveness of a multi-user virtual environment on changing nursing student attitudes toward people living in poverty	Active cooperative learning	Computer, Second Life 3-D online virtual environment	Baccalaureate Nursing
Palumbo et al. (2016)	Evaluate the use of a virtual environment to promote interprofessional competencies	Benner's Novice to Expert	Computer, virtual environment; video conferencing	Master of Nursing Family Nurse Practitioner
Peddle et al. (2019)	Explore what undergraduate nursing students learned about non-technical (NTS) skills following interactions with virtual patients (VPs)	Constructivist learning theory	Computer, web-based virtual simulation interactive software (Virtual Simulated Patient Resource) with virtual patients	Baccalaureate Nursing
Samosorn et al. (2020)	Explore feasibility and use of a contemporary immersive virtual reality simulation (CIVRS) for airway management knowledge gain	Bauman's layered-learning	Desktop computer with Oculus Rift + Touch VR Headset Bundle	Baccalaureate Nursing
Stuart et al. (2021)	Explore use of a VR simulation to improve SBAR handoff communication skills	Self-care deficit Investment theory	Desktop computer with 360 images for environment; Qualtrics for voice simulation	Baccalaureate Nursing
Sweigart et al. (2016)	Test the utility and acceptability of VLE immersive training using the TeamSTEPPS curriculum. Examine the change in teamwork attitudes regarding interprofessional communication.	Experiential learning theory	Virtual platform and T-TAQ	Baccalaureate Nursing Graduate students in medicine, occupational therapy, social work
Verkuyl et al. (2022)	Describe the evaluation process used to collect data about the learner experience in order to design or improve virtual games that support student learning	Means End Theory	Virtual gaming simulations (VGSs) accessed by computer	Baccalaureate Nursing
Verkuyl et al. (2019)	Examine the impact of three different debriefing methods (self-debrief only, self-debrief followed by a small-group debrief, and self-debrief followed by a large-group debrief) on nursing students' knowledge and debriefing experience after playing a VGS	3D (defusing, discovery, and deepening) model of debriefing	Virtual gaming simulations (VGSs) accessed by computer	Baccalaureate Nursing
Verkuyl et al. (2018)	Describe the usability testing completed on a newly developed virtual gaming simulation (VGS) for nursing students.	Technology Acceptance Model	Virtual gaming simulations (VGSs) accessed by computer	Baccalaureate Nursing
Weeks et al. (2013)	Describe a model of education underpinned by constructivist, cognitive apprenticeship and situated pedagogical approaches which supports the active building of medication administration knowledge and skills.	Constructivism	Virtual Authentic Dual Assessment and Diagnostic Environments	Baccalaureate Nursing
Wright et al. (2018)	Evaluate the effectiveness and participant satisfaction of vSimfor Nursing in an Adult Health Nursing course	Constructivist paradigm	Computer	Baccalaureate Nursing

Table 2
Summary findings of constructs and VR applications.

Author(s)	Theory/conceptual model	Underlying construct	Application
Claman (2015)	Community of Inquiry (CoI)	Learning in fully online courses occurs through teacher and instructor interaction that integrates social, teaching, and cognitive presence	Change beliefs/ attitudes
Foronda et al. (2014)	Jeffries' Simulation Model	Successful learning from simulation results from the confluence of teacher, student, educational practices, outcomes, and simulation design characteristics	Gain knowledge
James et al. (2012)	Situated learning theory, constructivism, reflective learning, Biggs constructive alignment	Situated Learning: learning is grounded in real-world, everyday situations Constructivism: Students create their own learning through interactions with their environment and reflecting on the experiences. Reflective learning: rethinking experiences to develop understanding and knowledge Biggs constructive alignment: students construct their own learning through doing relevant learning activities to achieve desired outcomes. Teaching methods, curriculum, outcomes, and assessment are aligned.	Gain skills
Jane Cook (2012)	Constructivist learning theory and experiential learning principles	Constructivism: Students create their own learning through interactions with their environment and reflecting on the experiences. Experiential learning: students learn by participation in and analysis of experiences.	Guide design and evaluation outcome
Josephsen and Butt (2014)	Constructivism	Constructivism: Students create their own learning through interactions with their environment and reflecting on the experiences.	Gain skills
Kardong-Edgren et al. (2019)	Overlearning	Repeated practice of a skill after initial mastery enhances long-term retention.	Gain skills
Mabry et al. (2020)	Deliberative practice Self-efficacy	Deliberative: That deliberate practice is seen as important for improving performance and this	Change beliefs/ attitudes

Table 2 (continued)

Author(s)	Theory/conceptual model	Underlying construct	Application
		necessitates effort but is not an intrinsically pleasurable activity	
		Self-efficacy: personal beliefs about the ability to perform a task is influenced by enactive and vicarious experiences, verbal persuasion, and physiological and affective states	
Menzel et al. (2014)	Active cooperative learning	Intellectual and emotional engagement of students working in small groups enhances individual and collective learning	Change beliefs/ attitudes
Palumbo et al. (2016)	Benner's Novice to Expert	Experts develop knowledge and skills over time through education and multiple experiences	Gain skills
Peddle et al. (2019)	Constructivist learning theory	Constructivism: Students create their own learning through interactions with their environment and reflecting on the experiences	Gain skills
Samosorn et al. (2020)	Bauman layered learning model	Knowledge acquisition and transfer to practice can occur anytime and anywhere using a multimodal educational approach	Gain knowledge
Stuart et al. (2021)	Self-care deficit Investment theory	Self-care deficit: Development and becoming are ongoing process to which individuals contribute through deliberate action.	Gain skills
		Investment theory: Individuals are motivated to maximize rewards while minimizing costs	
Sweigart et al. (2016)	Experiential learning theory	Students learn by participation in and analysis of experiences.	Change beliefs/ attitudes
Verkuyt et al. (2022)	Means End Theory	Individuals' perceptions of product attributes and their benefits are related to derived value	Guide design and evaluation outcome
Verkuyt et al. (2019)	3D (defusing, discovery, and deepening) model of debriefing	Student reflection on processes that influenced decisions during simulation experiences creates new mental models for future practice	Gain knowledge
Verkuyt et al. (2018)	Technology Acceptance Model	Positive perceptions of usefulness and ease of use of technology leads to acceptance and usability of the technology	Guide evaluation outcome
Weeks et al. (2013)	Constructivism Situated learning theory and cognition	Constructivism: Students create their own learning through interactions with their	Guide design

(continued on next page)

Table 2 (continued)

Author(s)	Theory/conceptual model	Underlying construct	Application
Wright et al. (2018)	Constructivism	environment and reflecting on the experiences.	
		Situated learning theory and cognition: learning is grounded in real-world, everyday situations that require problem-solving Constructivism: Students create their own learning through interactions with their environment and reflecting on the experiences.	Gain knowledge and skills

noted the increase in relevant literature published since 2013. The original search was performed in August 2021; the search was updated, first in January 2022 to include articles that were published since August 2021 and then again in March 2022 to include any relevant articles published since January. Also, as part of the search, the reference lists of relevant articles were harvested, and several key journals were hand searched for studies published during the ten-year period. Articles included in this scoping study met the following criteria: (a) the study design included the use of immersive or non-immersive VR technology in nursing higher education; (b) published in English; (c) peer-reviewed; (d) identified a theory or conceptual model.

Study selection.

All three nursing authors independently reviewed titles and abstracts to determine if the articles met the inclusion criteria. The authors also read and screened independently full-texts of potentially relevant articles. At all points in the process of identifying relevant studies, questions about inclusion were referred to the entire scoping study team for consensus. Reference lists of included articles were manually reviewed for additional studies.

Charting the data

The three nursing authors collaborated a priori on the data for extraction, which were selected to answer the research question. Variables of interest included study aim or purpose, theoretical or conceptual model, VR type, and VR application (Table 1). The first author

developed a data-charting form using an Excel (Microsoft, Washington, DC) spreadsheet. All nursing authors extracted data independently for all included articles. Questions or discrepancies were resolved through discussion by all three authors. As a quality check for inter-rater agreement, the third nursing author (LE) randomly selected ten retained articles from all databases for the first two authors to conduct independent data extraction. The first two authors then met to review and compare their extraction results and confirmed 100 % inter-rater agreement.

Collating, summarizing, and reporting the results

Both quantitative and qualitative approaches were used for data analysis and summary in this team-based scoping study (Vazquez-Westphal et al., 2021). In addition to using frequencies and percentages to characterize the data, the nursing authors undertook a thematic analysis of the predominant underlying constructs of the theories and conceptual frameworks and how they were applied to guide VR integration. We chose to explore these variables in order to understand how the specific theoretical and conceptual constructs were related to the VR technology application elements and used to promote learning and desired behaviors. In addition, we considered broad categories of applications of VR, adapted from those identified by Colquhoun et al. (2010) in a scoping review of the use of theories in knowledge translation. The final thematic analysis represented an iterative approach in which all three nursing authors discussed and came to consensus on theoretical and conceptual constructs and the categories of VR application.

Findings

Categorically, the frameworks from the retained studies ($n = 18$) fell into four general categories. Table 1 contains detail on the summary findings of studies and Table 2 details underlying constructs of the frameworks and the specific categories of VR application. Paper publication dates ranged over a 10-year time span from 2012 to 2022.

The first cluster of four papers was those where theory was used to guide design and/or outcome evaluation in VR integration (Jane Cook, 2012; Verkuyl et al., 2018; Verkuyl et al., 2022; Weeks et al., 2013). Weeks et al. (2013) primarily used theory for VR integration to guide design whereas Verkuyl et al. (2018) primarily used theory for VR integration to guide outcome evaluation. The other two papers in this category employed theory to both guide design and outcome evaluation in VR integration (Jane Cook, 2012; Verkuyl et al., 2022).

Almost half of the papers ($n = 8$) used theory to guide VR integration

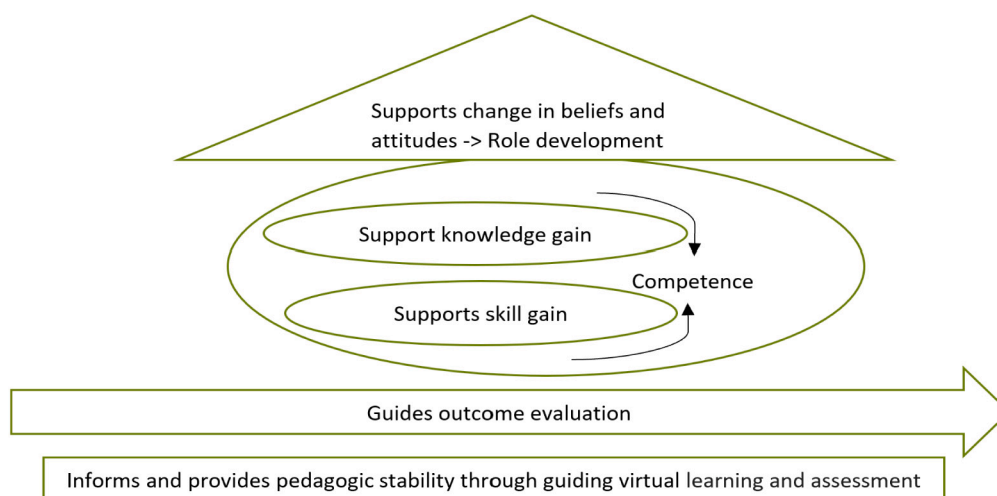


Fig. 2. Applied theory toward VR integration in nursing education.

in order to support the gain of knowledge and/or skills. Nursing is a profession with both clinical and didactic roots. The literature on theory use in VR integration echoes this in that the earliest paper (James et al., 2012) used theory to support an application designed for skill gain. Skill gain is also a theme where a nursing theory, *Benner's Novice to Expert* (1984), is employed (Palumbo et al., 2016).

Six papers used frameworks that fit into the thematic category of 'skills gain' (James et al., 2012; Josephsen & Butt, 2014; Kardong-Edgren et al., 2019; Palumbo et al., 2016; Peddle et al., 2019; Stuart et al., 2021). Frameworks within three papers fit the thematic category of 'knowledge gain' (Foronda et al., 2014; Samosorn et al., 2020; Verkuyl et al., 2019). The National League for Nursing (NLN) Jeffries Simulation Model (2005) used by Foronda et al. (2014) is also one of the few instances where a nursing theory was employed. Wright et al. (2018) straddled both categories in this theme in that the theoretical application was toward knowledge and skills gain in nursing education.

Change in beliefs and attitudes are important in role development. There were four papers where the framework fit the thematic category 'change in belief/ attitude' (Claman, 2015; Mabry et al., 2020; Menzel et al., 2014; Sweigart et al., 2016).

Discussion and recommendations

The findings from this scoping study span a 10-year period and provide a depiction of how theory has been employed over time in nursing education to support VR integration. In order to further synthesize the findings a map was created of putative interplay, i.e., the conjectured interaction, and fit among the categories of VR framework application in nursing education to date (Fig. 2). In short, the map presents the application themes that emerged from the analysis in an organized pictorial which depicts how nursing has used theory to guide integration of virtual reality technology into education over time (Fig. 2).

Theory has served to undergird pedagogy and support outcome evaluation. Theory has supported VR integration to develop skills and knowledge acquisition, which together are attributes of and support competence development (Fukada, 2018). In addition, the change in beliefs and attitudes are seminal in role development across the nursing curricular levels, from prelicensure to graduate levels.

Primarily non-nursing theory has supported VR integration in nursing education, and it is worthy to note that only two of the frameworks applied in the retained studies were considered to have originated from the profession of Nursing, namely *Benner's Novice to Expert model* (1984), and the National League for Nursing Jeffries' Simulation Model (Jeffries, 2005). The other theories used stem from the educational and humanities literature, as well as from the social sciences literature. Given the plethora of nursing theories available, the lack of nursing theory applied to VR integration was an unexpected finding that resulted from this scoping study. While Walker and Avant (2018) state that "theories guide both research and practice" (p. 44), a likely explanation for the lack of applicable theory may be that nursing theories are currently generated to inform clinical rather than pedagogical practice. Walker and Avant (2018) posit this lack of applicable theory can be due to the nature of nursing as a young science (p. 44). Questions on why nursing theory has not been employed to a greater extent within our own pedagogy integrating VR in nursing education warrants further investigation in studies designed to parse out factors associated with theory selection and implementation in nursing education, generating knowledge which can then be applied in theory construction (Clark, 2000).

Study limitations

Findings from this scoping study are limited based on a number of factors. The methodological quality of the retained studies was not critically appraised, affecting the empirical soundness of the identified gaps in knowledge in the literature and the recommendations for policy

and practice (Daudt et al., 2013; Pham et al., 2014). In keeping with the established methodology of Arksey & O'Malley, 2005, we did not appraise the level of the evidence we retained for this study. Because there is a gap in knowledge about this relatively new phenomenon and its application in nursing education, we did not want to overlook or exclude evidence that might have contributed useful insight, notwithstanding possible study design flaws.

We did not consult with stakeholders, and while described as an optional sixth step in scoping study methodology (Arksey and O'Malley (2005), stakeholder inclusion may have contributed additional insight to both the search strategy and interpretation of study findings. Finally, relevant studies may have been missed due to the access limits of the selected databases.

Conclusions

The growing interest in use of virtual reality (VR) environments for nursing education predated COVID-19, although the pandemic accelerated the need to develop alternative approaches for student learning, particularly due to restricted access to clinical sites. The rapid deployment of virtual environments to meet didactic and immediate clinical learning objectives during the pandemic has resulted in a growing body of literature on faculty and student experiences with virtual reality and on VR's promise as an innovative platform to create rich learning experiences that enhance traditional teaching methods.

Despite the growing acceptance and adoption of VR for student learning in nursing education, findings from this scoping study demonstrate there is limited use of theory or a conceptual model to guide the integration. In addition, not all studies that do identify a framework sufficiently explicate the linkage between the theories or conceptual models and the type of VR intervention, i.e., the degree of immersion. Effective pedagogy requires incorporating the multiple ways students learn to frame and structure teaching-learning strategies. With so many nursing and learning theories available to consider for pedagogical focus, more formal work needs to be done to define best practices for application of VR technology for specific curricular needs, based on specific concepts and disciplinary perspectives of learning. More research is needed to understand better the existing theories and conceptual models that are most appropriate for using VR technology to facilitate the knowledge and skills development essential for contemporary nursing practice. Finally, research is also needed to parse out concepts and articulate statements that illuminate theoretical constructs useful in moving the science forward toward development of VR technology nursing theory.

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