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## Immersive Virtual Reality as an Effective Alternative to Traditional Clinical Nursing Education: An Integrative Review

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# **Immersive Virtual Reality as an Effective Alternative to Traditional Clinical Nursing Education: An Integrative Review**

Current nursing education includes using simulation experiences to allow students to practice assessment, critical thinking, communication, and teamwork skills in a safe environment. The arrival of COVID-19 changed the face of nursing education when all in-person classes were transitioned to online learning (Blevins, 2021; Chen, 2020). When nurses were needed more than ever, clinical facilities closed their doors to institutions seeking clinical experiences for their students. Schools of nursing worldwide faced the challenge of preparing competent, skilled nurses without the benefit of hands-on experiences in patient care.

The Covid-19 pandemic has challenged and impacted nursing education to a point where a change is needed in traditional curricula to meet nursing program outcomes (Blevins, 2021). Virtual Reality (VR), defined as a computer-generated, three-dimensional image or environment that can be interacted with naturally or physically (Tolarba, 2021), can be utilized to introduce students to the intricacy of clinical situations without the risk of harming actual patients (Blevins, 2021). Immersive VR (iVR) creates an environment that masks any elements of the real world and completely immerses the user in the virtual world created by the software (Kilmon et al., 2010). IVR requires special electronic equipment, such as head-mounted displays, video caves, or gloves with sensors, to allow the user to interact with the images in a natural manner (Kilmon et al., 2010). When iVR scenarios are based on practical experiences, the user can focus solely on themselves and their interaction in the virtual world and become unaware of their actual environment (Mooney, 2017).

IVR technologies have progressed significantly in the past three decades, causing rapid growth in a wide range of applications. In healthcare, virtual surgical simulators have been

developed for training, pre-operative planning, and rehearsal (Choi, 2017). Because iVR use in healthcare is relatively new and there is little research on its effectiveness in student learning, regulatory bodies are hesitant to accept VR/iVR hours instead of traditional clinical hours. IVR is an effective tool for nurse educators to integrate into the nursing curriculum to enhance students' learning, knowledge, and skills, and to meet program outcomes (Tolarba, 2021). Therefore, the aim of this integrative literature review was to assess the usefulness of immersive virtual reality as an effective alternative to traditional face-to-face clinical education for nursing students.

### **Background**

Several studies have examined the usefulness of VR technology in nursing education. Frost et al. (2020) explored the application of VR and its contribution in nursing education. They found that VR enhanced students' reflective practice and can be used to develop clinical judgement and reasoning skills. Students overwhelmingly reported that the VR experience assisted their learning through engagement and made the content more memorable.

Smith & Hamilton (2015) evaluated the effectiveness of a VR simulation for foley catheter insertion. They found that the students in the VR simulation had an overall higher level of preparedness than the students in the traditional practice lab. Rushton et al. (2020) explored the effect VR simulation has on student confidence and competence by comparing VR simulation for Basic Life Support (BLS) cardio-pulmonary resuscitation (CPR) training versus traditional training. Students reported that feeling the panic that would occur in real-life scenarios and working through it to assist the patients, built confidence in their abilities.

Carmody et al. (2020) conducted another study to evaluate a VR environment explorer tool that allowed nursing students to access the school's simulation lab during the COVID-19

lockdown. Students appreciated interacting with their peers and having some form of simulation lab experience. Another study conducted by Chao et al. (2020) examined the effects of an iVR simulation on NG tube insertion skill competence. They found no significant difference in competence between the VR group and the traditional group, but students did report higher satisfaction scores.

Bayram & Caliskan (2019) conducted a randomized control trial (RCT) to determine the effect of a VR phone-based application on tracheostomy care for nursing students. They found that the VR students better understood suctioning and peristomal skin care than the traditional students. To add, Liu & Butzlaff (2021) conducted a study to compare a VR activity in two different settings. The researchers examined the effects of integrating VR in face-to-face classrooms and in an online learning environment to improve the quality of nursing education during COVID-19. The study adds to the literature by investigating the challenges of VR integration in an online course setting format. The researchers concluded that educators should evaluate students' prior knowledge and comfort in online learning before incorporating VR technology; a pre-training in VR technology would also be helpful to students prior to the application of its activities.

Many studies have examined the practicality, expense, and challenges VR technology integration would have on educational settings. However, very few studies have explored the new instructional design principles to improve learning in VR and how educators can apply the technology to actual teaching and learning (Liu & Butzlaff, 2021). This integrative review aims to assess the usefulness of immersive virtual reality in nursing education through an in-depth synthesis of the evidence found in the literature review to determine if it is an effective alternative to traditional face-to-face clinical education for nursing students.

## **Methods**

### **Design**

An integrative review approach was selected to evaluate the literature and discover what is known about the topic. Integrative reviews utilize a systematic process to identify, analyze, appraise, and synthesize research to gain a more robust understanding of the phenomenon (Toronto & Remington, 2020). A systematic and comprehensive search of all pertinent research literature was completed utilizing the identified key terms. Articles identified in the search were subjected to abstract review and critical appraisal. The retrieved studies were appraised for quality using the Johns Hopkins Nursing Evidence-based Practice appraisal tool and study findings were analyzed to identify relevant themes.

### **Search Methods**

A comprehensive literature search was completed using CINAHL Plus, MEDLINE (Ebsco), Ovid Nursing Collection, and Scopus databases. The literature search was conducted using keywords and keyword phrases including virtual reality; virtual simulation; immersive virtual reality; immersive VR; VR simulation; virtual reality simulation; nursing students; nurse; nursing; nursing education; nurse training; clinical education; traditional education; traditional clinical education; and face-to-face education. To increase the specificity and comprehensiveness of the literature search, a research librarian was consulted to help identify appropriate databases and keywords. Ancestry search through the selected articles' reference lists were also utilized to identify additional articles for inclusion (Toronto & Remington, 2020).

Inclusion criteria for studies included (1) written in English; (2) published between 2007 and 2022; (3) study subjects are pre-licensure nursing students; and (4) immersive virtual reality technology was used to supplement or replace traditional nursing education methods. Exclusion

criteria included (1) articles not published in English; (2) articles printed outside the date range of 2007 to 2022; (3) study subjects other than pre-licensure nursing students; (4) does not include immersive virtual reality technology used in a nursing educational setting; (5) virtual reality, including immersive technologies, used in educational fields other than nursing.

## **Results**

Five main themes were identified during thematic analysis: ‘improving student engagement/satisfaction’, ‘improving knowledge/skill acquisition’, ‘complementing traditional teaching/learning methods’, ‘improving clinical reasoning’, and ‘barriers to implementation’. While most studies exemplified more than one theme, no single theme was present in all 14 reviewed studies.

### **Theme 1: Improving Student Engagement/Satisfaction**

Ten of the reviewed studies identified the theme of improving student engagement and/or satisfaction. The mixed-methods study conducted by Hardie et al. (2020) evaluating the effects of iVR storytelling as an active pedagogy best highlights the impact of iVR on student engagement and satisfaction. Their study found that the immersive story-telling style of iVR created a strong emotional experience that held students’ attention and stimulated discussions after completion of the module. Most students described feeling “highly preoccupied” with the story, which resulted in a more profound understanding of the material (Hardie et al., 2020). Similarly, the Lee et al. (2020) mixed-methods study exploring the use of iVR in mental illness simulation, found that students felt more emotionally invested in their virtual patients and felt the experience would help them in their future practice.

Many studies reported that students generally had positive responses to their iVR experience. Students in the Thompson et al. (2020) cross-sectional study felt that using iVR

technology allowed for higher levels of engagement than traditional educational methods and an overall better learning experience. In their RCT on IV insertion skills, Jung et al. (2012) found that students who utilized iVR reported lower anxiety levels and higher satisfaction with their learning. Several studies found that students described their iVR experiences as engaging and enjoyable, and reported an increased interest in learning, increased learning satisfaction, and a preference for iVR as a learning method (Butt et al. 2018, Chen et al. 2020, Choi et al. 2021, Farra et al. 2015, Hanson et al., 2020, Saab et al. 2021).

## **Theme 2: Improving Knowledge/Skill Acquisition**

Nine of the reviewed studies identified the theme of improving knowledge and skill acquisition. Choi et al. (2021) in their review, analyzed the effectiveness and barriers of using iVR in nursing education. Out of the nine studies in this review, two of them assessed participants' cognitive performance after an immersive VR intervention. Both studies results demonstrated an increase in the participants' cognitive and learning performance, and four of the studies in this same review recommended immersive VR intervention because it improved the participants' clinical skills, such as IV catheter insertion, urinary catheterization, basic life support, or needle stick prevention.

Another study done by Woon et al. (2021) analyzed VR effectiveness training in increasing nursing students' knowledge to find out what is necessary when designing VR training. This review showed significantly higher knowledge scores with a small-to-medium effect in the VR group compared to the control group. The findings of this review demonstrate that nursing students benefit from acquiring knowledge when they receive experiential learning through VR training. The meta-analysis study done by Chen et al. (2020) assessed the efficacy of virtual reality in nursing education in knowledge, skills, performance time, satisfaction, and

confidence. The results of this study showed that VR education methods effectively improved nursing students' knowledge but did not impact students' skills. The study conducted by Wu et al. (2020) also analyzed the effectiveness of VR training but on the universal precautions to prevent needle sticks. All participants in this study showed improved performance after VR training and a 2-month follow-up survey showed good retention of the material.

Several of the other studies found comparable results that the use of VR is an effective way to promote mastery learning and retention, enhance overall learning and skill, and improve scientific or nursing knowledge of airway management (Butt et al. 2018, Jung et al. 2012, Collins & Ditzel 2021, Samosorn et al. 2020,). It was also reported that repeated exposure to content and clinical skills during a VR educational experience helps students with knowledge acquisition and retention (Saab et al., 2021).

### **Theme 3: Complementing Traditional Teaching/Learning Methods**

Three of the reviewed studies identified the theme of complementing traditional teaching and learning methods. Thompson et al. (2020) in their cross-sectional study about student engagement and experiences with virtual reality reported that students found that VR complements what they were learning in lab and lectures, making the material more concrete. The mixed study by Chen et al. (2020) found that VR has a positive effect on knowledge, but a neutral effect on skills, satisfaction, confidence, and performance time compared to other nursing educational methods such as high/low fidelity manikin, mannequin-based simulation, and plastic model. According to this study's results, VR should be used to complement other simulation methods since it is found to increase the quality and safety of clinical practice. Similarly, Jung et al. (2012) RCT concluded that the IV simulation process involving VR/haptics should be used with traditional methods such as an IV arm model.



#### **Theme 4: Improving Clinical Reasoning**

The theme of improving clinical reasoning was identified in three of the reviewed studies. The Collins & Ditzel (2021) observational study evaluating the role of iVR holographic patients in developing clinical reasoning in undergraduate nursing students found that there is value in using iVR in the development of this important skill. They concluded that iVR offers safe exposure to real-world learning experiences that cannot be replicated outside of real-life clinical contexts and provides a safer option for obtaining the clinical nursing experience that is necessary for clinical reasoning development. Similarly, qualitative results from Hardie et al. (2020) and Saab et al. (2021) indicate that having VR embedded in nursing education helps students develop decision-making and problem-solving skills.

#### **Theme 5: Barriers to Implementation**

The theme of barriers to implementation was identified in six of the reviewed studies. Several studies identified comfort and compatibility issues with the required gear. These issues include physical and visual discomfort with equipment, simulator sickness, and incompatibility with eyeglass wearers and left-handed users (Choi et al., 2021; Hanson et al., 2020; Lee et al. 2020).

Saab et al. (2021) identified challenges and threats to acquisition as a theme in their qualitative descriptive study investigating nursing student perspectives on iVR in nursing education. One of the challenges they discuss is the costs associated with integrating iVR technology and how it can potentially lead to inequities in education. Student feedback cited concerns over the costs of purchasing and maintaining equipment and converting existing educational modules into VR (Saab et al., 2021). These costs could limit the amount of purchased equipment and cause inequities in student access to the technology (Saab et al., 2021).

Other concerns raised in this study include motion sickness and its potential to cause educational inequities and the potential for physical injuries related to iVR equipment use (Saab et al., 2021). In their evaluative study, Hardie et al. (2020) reported the participants' dissatisfaction with iVR due to incompatibility issues of their smartphones with the required software used in the study. Some technical difficulties were downloading problems between the app and their smartphones.

In their systematic review, Woon et al. (2021) discussed the need for specialty training as another potential barrier to iVR integration. According to the review, the recommended VR training for students is short, thirty-minute learning sessions, as longer sessions may cause mental fatigue (Woon et al., 2021). They also state that the evidence level is low regarding the long-term impact of VR training on student learning outcomes versus the cost of implementing training.

## **Discussion**

### **Implications for Nursing Education**

iVR represents a fun and innovative technology that has the potential to transform nursing education (Choi et al., 2021). During the review, it became clear that the immersive and interactive nature of iVR profoundly impacts the learning experience. Several studies discussed how complete immersion in the scenario helped establish an emotional investment which led to a deeper understanding of the material, higher levels of learner engagement and satisfaction, and decreased anxiety levels (Hardie et al., 2020; Jung et al., 2012; Lee et al. 2020, Thompson et al. 2020). Various other studies discussed how iVR education increases students' engagement, and creativity, seeing new perspectives and diving into authentic learning experiences. Students express their high satisfaction with iVR technology with their ability to control what they want to

see instead of what a video shows them and the fun and interactive aspect of the learning experience (Choi et al. 2021 and Thompson et al. 2020).

Several studies also discussed how these same qualities provide experiential learning, which helps to improve knowledge retention, problem-solving, and decision-making abilities (Butt et al., 2018; Collins & Ditzel 2021; Hardie et al. 2020, Jung et al. 2012, Saab et al. 2021, Samosorn et al. 2020, Woon et al. 2021). This experiential learning helps solidify more abstract concepts, creating a deeper understanding of the material (Hardie et al. 2020, Lee et al. 2020, Thompson et al. 2020). This experiential learning which is learning by doing, is enhanced when students are engaged in a rich and interactive learning environment of immersive technology where iVR allows learners to make connections between theory and practice of learning content and clinical skills (Saab et al. 2021 & Hardie et al. 2020).

The authenticity provided by iVR expands the type of learning experiences that nursing programs can offer. They now have the option to create more complex scenarios, which can be used to improve knowledge and skill acquisition and help develop clinical reasoning. Rare, uncontrollable clinical experiences can now be created in a safe environment that allows students to practice the scenario multiple times, providing a safer option for obtaining the clinical experience required for developing clinical reasoning skills (Collins & Ditzel 2021, Saab et al. 2021). In conjunction with more traditional instructional methods such as labs and lectures, iVR helps support various learning styles by providing an alternative way to interact with course material (Chen et al., 2020; Jung et al. 2012; Thompson et al. 2020).

Chen et al. (2020) compared the effectiveness of iVR education to other educational methods in their study. They reported that iVR education is more effective than traditional education in that it provides tangible experiences of the virtual patient simulation combined with

a reflection tool, and students better understand what they were taught and can use the new knowledge. The researchers reported on a previous study focused on health professions education, demonstrating that iVR with more interactivity shows more effectiveness for learning expertise. The significant result of this study was that iVR education could improve nursing students' knowledge. Chen et al. (2020) found no significant difference between iVR education and other educational methods on participants' satisfaction, performance time, confidence, and skill acquisition.

Several other studies reported the use of iVR as an effective way to promote mastery learning and retention, enhance overall learning and skill, and improve scientific or nursing knowledge of airway management (Butt et al., 2018; Jung et al. 2012, Collins & Ditzel 2021, Samosorn et al. 2020,). It was also reported that repeated exposure to content and clinical skills during an iVR educational experience helps students acquire knowledge and retention (Saab et al., 2021).

## **Barriers**

While it has the potential to innovate nursing education, there are some barriers to integrating iVR, the most obvious being cost. The equipment needed to utilize iVR ranges from simple headsets with haptic sensors to complex VR cave systems (Kilmon et al., 2010). Depending on the size of the nursing program and the amount of equipment needed, integration fees can easily reach into the tens of thousands of dollars (Farra et al., 2019). These costs and the strain they would place on institutions raise concerns for the development of inequities in educational access (Saab et al., 2021). Another cost associated with iVR technology is training. Students would require specialty training to effectively use the programs and current research does not show a positive correlation between the long-term impact on learning outcomes with the

added cost of implementing training (Woon et al., 2021). These additional training expenses combined with the equipment costs put iVR out of reach for many nursing programs.

Other barriers for iVR integration include accessibility and comfort concerns for users. While the immersive, physically interactive nature of iVR is appealing to many students, it can create restrictive issues for many others. Some studies indicated barriers such as difficulty using the equipment for left hand dominant individuals, prescription glasses not being able to fit with the headgear device, visual discomfort, and simulator sickness (Choi et al. 2021, Hanson et al. 2020, Lee et al. 2020). It is important for educators and program directors to research and understand all potential barriers when selecting this kind of technology for use in nursing programs.

### **Strengths and Limitations of the Reviewed Studies**

The integrative review included 14 studies and, although the sample size is small, it does reflect the most relevant research that truly meets the aim and inclusion criteria of the review. During the search, it became apparent that the literature is saturated with studies about VR simulations in nursing education, but little information is available about iVR. The literature that does address iVR suggests that it has the potential to be an effective teaching method in nursing education, however, there needs to be more research in the field as it is very new to nursing education and its capabilities are still being explored.

### **Conclusion**

The evidence found in this literature review suggests that iVR is not currently an effective alternative to traditional face-to-face clinical education for nursing students. Integration costs make it financially prohibitive for many institutions and the lack of iVR specific research does not support it as a viable alternative for clinical experience hours. However, the studies do

show that it has the potential to innovate nursing education and provide a more consistent and substantial path for experiential learning. This paper adds to the literature in support of iVR' s capacity to increase student engagement and satisfaction, improve knowledge and skill acquisition, complement traditional learning methods, and improve clinical reasoning. While studies have demonstrated that iVR is an effective teaching tool, more research is needed to support the claim that it can be used as an alternative to traditional in-person clinical education.

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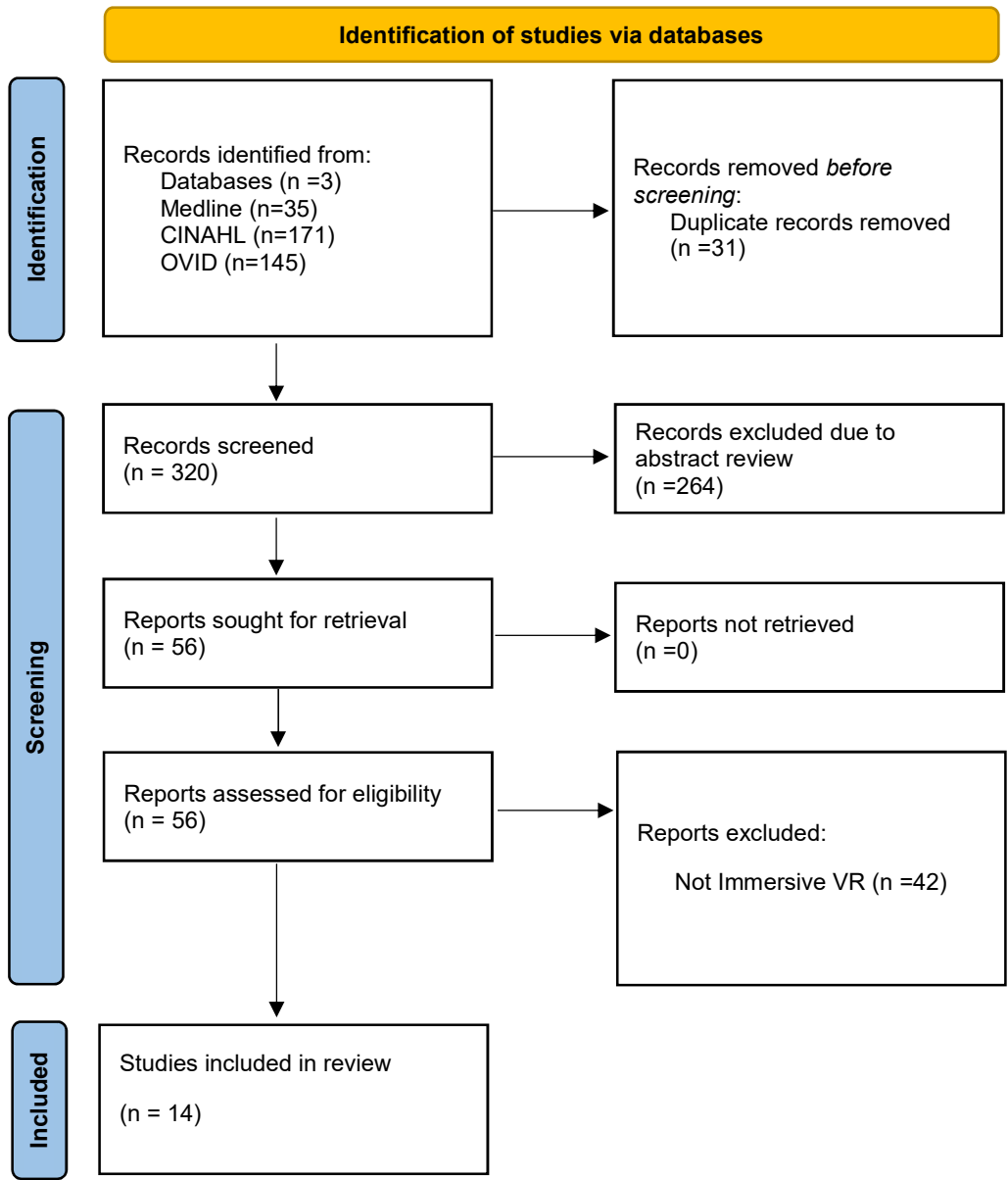
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Study	Article Name	Aim/Sample/Setting	Design	Major Findings
Butt et al., (2018)	Using Game-Based Virtual Reality with Haptics for Skill Acquisition	Explore the usability of and user reaction to a game-based VR system designed to practice urinary catheterization. 20 Junior-level BSN students	Mixed-methods pilot study. Time on task and number of procedures completed in 1 hour as measurement.	VR system usability rated favorably, engaging, and enjoyable. VR users spent more time practicing and completed more procedures in 1 hour than students practicing traditionally. Follow-up skill demonstration pass rates between groups identical 2 weeks later. Use of VR may be an effective way to promote mastery learning and retention.
Chen et al., (2020)	Effectiveness of Virtual Reality in Nursing Education: Meta-Analysis	To assess how effective virtual reality is in nursing education in terms of knowledge, skills, satisfaction, confidence, and performance time. 12 trials with 821 participants.	Meta-analysis of 12 studies with qualitative and quantitative synthesis.	VR education methods were effective in improving or enhancing nursing students' knowledge. When compared with other educational methods, VR education did not impact students' skills, satisfaction, confidence, and performance time. VR should be used to complement other simulation methods; it is found to increase the quality and safety in clinical practice.
Choi et al., (2021)	Effectiveness of Immersive Virtual Reality in Nursing Education	An analysis of the effectiveness and barriers of iVR in nursing education.	Systematic analysis of 9 experimental and quasi-experimental studies.	Studies indicated iVR technology is effective in nursing education. Barriers of iVR and suggestions to overcome them recommended.
Collins & Ditzel (2021)	Standardised Holographic Patients: An Evaluation of Their Role in Developing Clinical Reasoning Skills	Evaluate the efficacy of using standardized holographic patients to assist undergraduate nurses to develop clinical reasoning skills. 99 second year BSN students.	Observational study with qualitative feedback on overall learning experiences. Stage of skill development assessed using the Virtual Patient version of the Lasater Clinical Judgment Rubric.	All participants enjoyed the activity, reported enhanced learning. Students ranked as "Developing" or "beginning" level of clinical judgment - expected result. VR is integral to improving the future quality and safety of patient care and offers safe exposure to the real-life learning experiences necessary to develop clinical reasoning.

Farra et al., (2015)	Decontamination Training: With and Without Virtual Reality Simulation	Examine the use of VR simulation to teach disaster contamination. 106 senior-level BSN students.	Quasi-experimental study. Performance, knowledge, and self-efficacy were outcome measures.	VR group had significantly lower performance scores but completed the skill in significantly shorter period of time. No significant differences for self-efficacy or knowledge between groups. VR group reported high levels of satisfaction with VR as training method.
Hanson et al., (2020)	The effects of a virtual learning environment compared with an individual handheld device on pharmacology knowledge acquisition, satisfaction, and comfort ratings	Compare the effect on student learning, satisfaction, and comfort following exposure to a 3-D pharmacology artefact in a VR facility with viewing the same artefact using a mobile handheld device with stereoscopic lenses attached. 249 second-year undergraduate nursing and midwifery students in SE Queensland, Australia.	Pre-test/post-test design for knowledge acquisition, self-reported satisfaction scores, comfort scale.	No major statistically significant difference in knowledge acquisition between the 2 methods. VR experience scored higher in satisfaction for clinical reasoning and clinical learning. No statistical differences in satisfaction with debriefing and reflective practices. 3-D artefact is promising in terms of cost-effectiveness and accessibility for students
Hardie et al., (2020)	Nursing and Midwifery Students' Experiences of Immersive Virtual Reality Storytelling: An Evaluative Study	Investigate nursing and midwifery students' experiences using immersive virtual reality story telling as an active pedagogy, exploring how students perceive immersion, interaction, imagination, motivation, and	An evaluative study including mixed-method, cross-sectional survey, and an observational study.	VR Storytelling is found to be a positive and effective learning experience for students. Students expressed an increased level of interest, motivation, and engagement with narrative storytelling material presentation compared to traditional learning environments. Important features that increase the students' level of immersion, motivation, imagination, and interaction are: VR user's degree of active engagement to discover the story, strong emotional

		engagement with technology. 94 nursing and midwifery students in a large university in Ireland.		experience, 360 VR video experience, head-mounted displays (HMD), audio and visual features of IVR. Students were self-motivated to learn and developed a high level of problem-solving abilities after the iVR storytelling experience. However, study had limitations due to small and convenient sample at a single site, and students' self-reporting.
Jung et al., (2012)	Evaluation of practical exercises using an intravenous simulator incorporating virtual reality and haptics device technologies	Identify the educational effectiveness of skills training using VR/haptics simulation devices versus conventional methods. 114 undergraduate nursing students at Gachon University Medicine & Science in Republic of Korea	RCT with 3 groups: Group A used traditional IV arm, Group B used simulator with VR/haptics, and Group C used both tools. Venipuncture performance evaluated by NP using quantitative scale. Participants completed survey post-exercise to measure satisfaction and level of anxiety.	Grp C had the highest procedure score and shortest task time. No major statistically significant differences between the 3 groups. Grps A & C had the highest satisfaction rates. IV Simulation process involving VR/haptics improved overall skills and perception of learning and anxiety.
Lee et al., (2020)	Usability of mental illness simulation involving scenarios with patients with schizophrenia via immersive virtual reality: A mixed methods study	VR simulation is a user-friendly and engaging method to improve education about schizophrenia, thereby improving its treatment. 60 nursing students.	Mixed methods study utilizing a 17-question quantitative questionnaire and a 7-item open-ended qualitative questionnaire to evaluate ease of use and usefulness.	VR program perceived as useful and exciting. Participants reported that the program was very realistic, and they became emotionally invested in their virtual patients. A small percentage reported some discomfort with the VR gear.

Saab et al., (2021)	Incorporating virtual reality in nurse education: A qualitative study of nursing students' perspectives	To investigate nursing students' viewpoints on incorporating VR in nursing education. 26 undergraduate nursing students in a public university in Ireland.	Qualitative descriptive study with thematic analysis.	VR is engaging, interesting, and captivating, which increases students' interest in learning. Repeated exposure to content and clinical skills helps with knowledge acquisition and retention. Participants recommend VR to be embedded in nursing education to help students with decision-making and problem-solving skills. Some barriers to its use are cost and total replacement of traditional teaching.
Samosorn et al., (2020)	Teaching Airway Insertion Skills to Nursing Faculty and Students Using Virtual Reality: A Pilot Study	Using a VR intervention to teach nursing students airway management, assess VR for fidelity, realism, potential adverse effects, and efficacy of intervention. 21 undergraduate nursing students and 10 nursing faculty members from a Midwestern campus of a national school of nursing.	Survey sampling with a quasi-experimental one group pre-test/post-test design.	VR airway laboratory has high presence, no cyber sickness, and significantly improved knowledge of airway management ( $p < .001$ )
Thompson et al., (2020)	Nursing Students' Engagement and Experiences with Virtual Reality in an Undergraduate Bioscience Course	To enhance teaching and promote active learning in bioscience courses, and to explain students' perceptions of virtual reality and engagement with virtual reality in first-year nursing bioscience	Descriptive design/cross-sectional using both qualitative and quantitative data.	Results of the questionnaire: 57% of students perceived to be more engaged in the VR sessions than in labs, 78% more engaged in VR sessions than in the lectures, 91% more engaged in VR session than while reading a textbook, 57% more engaged in the VR sessions than watching the videos (fig 2).

		courses. 205 first-year nursing students in a university that offers both 3- and 4-year BSN programs.		<ul style="list-style-type: none"> <li>• Overall, students express more engagement when using VR than any other class learning activities.</li> <li>• Students describe a positive experience with the use of VR: better visual, easy equipment access, and better learning experience.</li> <li>• Students want to access and use VR equipment within and outside the classroom.</li> </ul>
Woon et al., (2021)	Effectiveness of Virtual Reality Training in Improving Knowledge Among Nursing Students: A Systematic Review, Meta-Analysis and Meta-Regression	To analyze VR effectiveness training in increasing nursing students' knowledge and to find out what is needed and necessary when designing VR training.	Systematic review of 14 RCTs.	VR training is a creative teaching strategy that provides experiential learning for nursing students increasing their learning outcomes. VR training is necessary and found to improve knowledge among nursing students. However, further research is needed in the domain of nursing education.
Wu et al., (2020)	Effect of virtual reality training to decreases rates of needle stick/sharp injuries in new-coming medical and nursing interns in Taiwan	Evaluate the effectiveness of game-based VR training on universal precautions for occupational needle stick injury prevention through Gagne's flow. 59 nursing students and 50 medical interns from Taipei Veterans General Hospital.	Prospective and pre- and post-comparison study.	All trainees showed an improved performance after VR training.





