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Fealy, S., Jones, D. & Hutton, A. et al. (2019) The integration of immersive virtual reality in tertiary nursing and midwifery education: A scoping review, Nurse Education Today, 79, p14-19

Available from: http://dx.doi.org/10.1016/j.nedt.2019.05.002

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Accessed from: http://hdl.handle.net/1959.13/1413010

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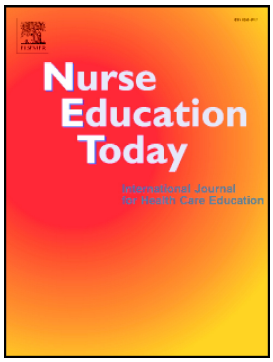

The integration of immersive virtual reality in tertiary nursing and midwifery education: A scoping review

Shanna Fealy, Donovan Jones, Alison Hutton, Kristen Graham, Liz McNeill, Linda Sweet, Michael Hazelton

PII: S0260-6917(19)30071-1
DOI: https://doi.org/10.1016/j.nedt.2019.05.002
Reference: YNEDT 4120

To appear in: *Nurse Education Today*

Received date: 16 January 2019
Revised date: 11 March 2019
Accepted date: 3 May 2019

Please cite this article as: S. Fealy, D. Jones, A. Hutton, et al., The integration of immersive virtual reality in tertiary nursing and midwifery education: A scoping review, Nurse Education Today, https://doi.org/10.1016/j.nedt.2019.05.002

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TITILE:

THE INTEGRATION OF IMMERSIVE VIRTUAL REALITY IN TERTIARY NURSING AND MIDWIFERY EDUCATION: A SCOPING REVIEW

AUTHOR(S):

Shanna Fealy RN, RM PhD Candidate[1,2,4,5], Dr Donovan Jones RN, RM, PhD[1,4,5], Prof Alison Hutton RN, PhD [1], Kristen Graham RN RM[3], Liz McNeill RN RM [3], Assoc Prof Linda Sweet RN RM PhD[3], Prof Michael Hazelton RN PhD[1].

Corresponding Author:

Name: Ms Shanna Fealy

Email Address: shanna.fealy@newcastle.edu.au

Phone: 0438297735

Institutional Address:

University of Newcastle, Faculty of Health and Medicine, School of Nursing and Midwifery, Port Macquarie Campus. PO Box 210 Port Macquarie, 2444, New South Wales, Australia.

Twitter Handles:

@shannafealy1

@donnythemidwife

Affiliations:

1. University of Newcastle, Faculty of Health and Medicine, School of Nursing and Midwifery.
2. University of Newcastle Faculty of Health and Medicine, School of Medicine and Public Health.
3. Flinders University, College of Nursing and Health Sciences.
4. Hunter Medical Research Institute
5. University of Newcastle, Priority Research Centre for Health Behaviour.

Declarations and Funding:

We the authors declare that there are no competing or conflicting interests with any of the authors for this manuscript. As this is a review article Ethical approval was not sought for this publication. No funding has been sought for this study. I declare on behalf of all authors that this manuscript has not been published or submitted for publication in any other journal. As this is a review article ethics was not required for this study.

Acknowledgements:

We would like to acknowledge Debbie Booth research librarian for her assistance with the search strategy

Author Contribution:

I declare that all named authors have contributed to the manuscript development and have approved the manuscript for publication. Shanna Fealy is the lead reviewer who devised the research protocol undertook database searches, participated in article screening and overall writing and editing of the review. Donovan Jones undertook article screening and data extraction and contributed to the overall writing of the review. Alison Hutton undertook article screening, participated in quality checking of articles and contributed to the overall writing of the review. Kristen Graham, Linda Sweet and Liz McNeill undertook initial data extraction and participated in the overall writing of the review. Michael Hazelton undertook final quality checking and contributed to overall writing and editing of the review.

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Abstract:

Background

Immersive virtual reality is an advancing technology that has the potential to change the traditional pedagogical approaches to teaching tertiary nursing and midwifery students. The application of immersive virtual reality in nursing and midwifery education may be a novel, accessible method for information provision and skill acquisition, however little is known of the extent of immersive virtual reality technology integration into tertiary nursing and midwifery programs.

Objectives:

The purpose of this review is to identify the application and integration of immersive virtual reality within nursing and midwifery tertiary education programs.

Design:

A scoping review based on the Joanna Briggs Institute methodology for scoping reviews was undertaken. An *a priori* review protocol and eligibility criterion was developed with the protocol subject to review *a posteriori* following first round screening. An electronic search of ten databases was conducted in January 2018.

Results:

A total of n= 506 non-duplicate records were identified and subjected to level one and level two screening. The search strategy and screening process identified n= 2 articles that were quality checked and included for review.

Conclusions:

There is currently a paucity of quality published literature on the application and/or integration of immersive virtual reality into nursing and midwifery tertiary education. Immersive virtual reality has the potential to increase competence and confidence for students providing accessible and repeatable learning opportunities in a fail-safe environment. There is

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a need for educators to be involved in the conceptualisation, design, integration and research of immersive virtual reality technology into undergraduate nursing and midwifery programs.

Keywords:

Midwifery, Nursing, Immersive Virtual Reality, Information Technology, Education, Simulation

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Introduction:

Information technology (IT) is rapidly changing and challenging traditional pedagogy. The large scale, and availability, of digital technology most notably mobile phone and tablet devices and associated applications, enables students to have extensive access to vast amounts of information anywhere, anytime (Chang, Lai, & Hwang, 2018). The Lancet Independent Global Commission for the Education of Health Professionals for the 21st Century urges health education institutions to rethink the current approaches to education and curriculum design to strengthen theoretical and clinical education through the adoption of IT empowered learning (Frenk et al., 2010). In the disciplines of nursing and midwifery, educators are constantly challenged to find accessible and innovative methods of teaching and learning that transition the student from novice practitioner to work ready clinician (Butt, Kardong-Edgren, & Ellertson, 2018; Irwin & Coutts, 2015). Virtual Reality (VR) is one technology that has increasingly received attention within the literature as an IT medium with potential application into nursing and midwifery education (Butt et al., 2018; Chang et al., 2018; Vottero, 2014).

Like most technology advancements VR has progressed overtime and has emerged from the research lab into a commercially available and viable product (Sherman & Craig, 2018). As VR technology advances and becomes increasingly affordable there has been a shift in focus from technology advancement to content development, integration, and application into real world industry (Sherman & Craig, 2018).

The application of VR into undergraduate nursing and midwifery education has the potential to transform theoretical and clinical learning. Virtual Reality has been proposed as a novel solution for overcoming situational and organisational barriers associated with experiential clinical skills development (Shelley Cobbett & Erna Snelgrove-Clarke, 2016; Kilmon, Brown, Ghosh, & Mikitiuk, 2010; Vidal, Ohaeri, John, & Helen, 2013). Virtual Reality

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affords the ability to provide a failsafe and accessible learning environment that may increase patient safety, through repeated exposure to educational content such as clinical skills and critical events as novice practitioners (Butt et al., 2018; Chang et al., 2018; Kilmon et al., 2010).

Immersive Virtual Reality

Virtual Reality has been used to describe a range of computer simulated programs and simulation devices including virtual worlds (Mandal, 2013; Sherman & Craig, 2018). Non-immersive VR (NVR) or desktop VR such as the popular Second Life® program provides a window into a virtual world that is displayed on a computer monitor (Irwin & Coutts, 2015; Kilmon et al., 2010). Users might create a representation of themselves called an AVATAR to interact with other users and the virtual environment itself, by using computer hardware such as a mouse and keyboard (Choi, He, Chiang, & Deng, 2015; Irwin & Coutts, 2015; Mandal, 2013).

This paper is focused on the use of Immersive Virtual Reality (IVR) defined as 'medium composed of interactive computer simulations that sense the participant's position and actions and replace or augment the feedback to one or more senses, giving the feeling of being mentally immersed or present in the simulation' (Sherman & Craig, 2018). Authentic IVR is comprised of the following 4 key components. 1) A virtual world – the space manifested by a medium such as that created by computer simulation software, programmed to resemble a real-world environment. 2) Immersion – the physical and mental sensation of being in the virtual environment. This is generally achieved through the use of individual head mounted displays (HMDs) or CAVE systems (room like spaces surrounded by computer generated imagery). 3) Sensory feedback – An IVR system provides direct sensory feedback to the participant based on their physical position. This is often referred to as tracking. 4)

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Interactivity - where the system responds and reacts to the actions of the user (Choi et al., 2015; Dubovi, Levy, & Dagan, 2017; Sherman & Craig, 2018).

The extent and application of IVR within undergraduate nursing and midwifery education is largely unknown (Cant & Cooper, 2017; Williams, Jones, & Walker, 2018). Previous systematic reviews have focused on the integration and use of virtual worlds and effectiveness of high and low fidelity simulation programs (Cant & Cooper, 2017; Irwin & Coutts, 2015). Therefore, the purpose of this study is to broaden the evidence base and undertake a scoping review of the published literature to identify the application and integration of IVR within undergraduate nursing and midwifery tertiary education programs. This review will provide a discipline specific baseline of IVR and identify areas for further research.

Methods:

This study is guided by the Joanna Briggs Institute (JBI) methodology for scoping reviews (Peters et al., 2015). This review additionally considered the work of Levac and Colquhoun (2010) and Daudt, van Mossel, and Scott (2013) to strengthening the scoping review methodology, increase rigor and ensure transparency and replicability of the study design. Scoping review frameworks assist in mapping out particular research areas of interest and allow reviewers to examine the extent and nature of the evidence available. Scoping reviews differ from systematic reviews in that the process is not fixed, enabling reviewers to redefine selection criteria based on the findings of the initial search strategy (Daudt et al., 2013; Levac & Colquhoun, 2010; Peters et al., 2015). Scoping reviews are designed to identify gaps in the published literature and may also be useful for informing the development of research questions suitable for conducting future systematic reviews (Daudt et al., 2013; Levac & Colquhoun, 2010; Peters et al., 2015).

Search Strategy

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An a *priori* review protocol and eligibility criterion was devised, with consideration given to the broad research question, based on the Population Concept and Context (PCC) elements (Peters et al., 2015). A comprehensive electronic search of ten databases was then conducted in January 2018 as per Supplementary file 1.0. Databases included: Medline, Embase, EMcare, Maternal and Infant Care, PsychInfo, Joanna Briggs Institute database (via Ovid; http://www.ovid.com/), Cumulative Index to Nursing and Allied Health Literature (CINAHL) (via EBSCO http://www.ebsco.com/cinahl), Scopus (via http://www.scopus.com), The Web of science (www.webofknowledge.com), the Cochrane library (via http://www.cochranelibrary.com). A research librarian was consulted in the initial conceptualisation stages of the search strategy. The following keyword search terms and Boolean operators were used in the search strategy: 'nursing OR midwifery' AND 'virtual reality' AND 'education OR teaching OR learning'. Keywords were mapped to data base subject headings where possible. All database search strategies were limited to English language and human studies. The search results from all databases were imported into EndnoteX8.2 reference management software for screening.

Selection criteria

During first round screening, publication titles and abstracts were reviewed independently by three primary reviewers (SF, AH, DJ) according to an *a priori* inclusion and exclusion criteria. After screening the first fifty titles and abstracts the reviewers discovered that the concept of virtual reality within the literature was variously defined so an *a posteriori* decision to narrow the concept to include only IVR was discussed and endorsed by all primary reviewers. The final *a posteriori* selection criterion is outlined in Table 1.0. Following first round screening articles marked for full text retrieval were retrieved and subject to further screening against the *a posteri*ori inclusion /exclusion criteria by (SF,AH,DJ). All articles subject to first and second round screening, not meeting the

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eligibility criteria were screened out in hierarchical order of (i) population, (ii) concept and (iii) context. Any disagreements in the selection of studies was discussed with consensus achieved. The reference lists of included studies were hand searched for any relevant articles not detected by the primary electronic search strategy.

Methodological Quality:

Articles eligible for inclusion were independently assessed by reviewers for methodological quality. Although not a necessary step in scoping review methodology the reviewers thought this would assist in identifying the strengths and limitations of included studies. Due to the heterogeneous nature of articles included in scoping reviews the quality appraisal tool developed by Hawker *et al*. (2016) was chosen, due to its ability to appraise a wide variety of research methods. In assessing methodological rigor Hawker *et al*. (2016) devised a scoring system with which studies could be rated as "good", "fair", "poor" or "very poor", using a set of explicit criteria addressing the extent to which study aims, design, sampling, data analysis and reporting of results were transparent and rigorous. Quality appraisal was conducted in the first instance by reviewer AH and finalised by reviewer MH. No articles were excluded from this review based on quality appraisal.

Data extraction

Study characteristics were extracted independently by four reviewers (LM, LS, KG & DJ) and checked by the primary author (SF). Information extracted included: publication title, authors, year, country, aim, methodology, population characteristics and summary of findings.

Results:

The flowchart in figure 1.0 details the identification, screening and inclusion of articles for this review. The primary search strategy identified n= 706 non-duplicate records. Following level one screening n= 36 articles were retrieved in full text and subjected to level two screening. A total of n= 2 articles were subjected to quality appraisal and included for review.

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Study Characteristics

The characteristics of both studies are reported in table 2.0. Both articles were published from universities within the United States of America. Kilmon *et al.* (2010)presents a concept development paper detailing the potential use and application of IVR in nursing and outlines the ongoing development of an IVR emergency crash cart simulation designed to be tested amongst nursing students (Kilmon et al., 2010). Butt *et al.* (2018)conducted a mixed methodology pilot study exploring the usability, user reaction and skill retention to a game based IVR system designed to simulate urinary catheterisation insertion in a cohort of nursing students (Butt et al., 2018). It should be noted that only one of the two included articles reported empirical data [3] while the other [8] was primarily a concept development article reporting on the development of an IVR program that would in due course be subjected to experimental testing with undergraduate nursing students. Application of Hawker et al. (2016) assessment of methodological rigor resulted in Butt *et al.* (2018) being rated as 'good' and Kilmon *et al*. (2010) being rated as 'poor' as per table 3.0. The poor rating of Kilmon *et al.* (2010) reflects the concept development nature of the article, which despite the lack of empirical data provided 'informal comment, and opinion'(Hawker et al., 2016) and thus remains in the review.

Summary of Findings

Kilmon *et al.* (2010), explore the potential use of IVR technology and presents an argument for its integration into nursing simulation education. The authors view IVR as a natural progression for simulation-based training with broad application that can benefit student learning and skill development. The application of IVR for preparing nursing students for infrequent emergency situations is the main platform for the development of an IVR program for cardiopulmonary resuscitation. The paper details the current stage in development of the simulation with particular emphasis placed on the design of a virtual crash cart that can test

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nursing students' progressive development in terms of speed and response accuracy in emergency situations (Kilmon et al., 2010). The development of the program has been described as a time and labour-intensive process. The need for collaboration with IT development teams and content experts such as nurses and midwives is highlighted as necessary team elements in the design of such programs. Funding for complete project development was seen as a critical element for project success. One limitation for the widespread application of IVR identified by the authors was the lack of standardised software for the development of IVR programmes, concluding that once programs are available IVR could be a feasible alternative for simulation-based nursing education (Kilmon et al., 2010).

The second article by Butt *et al.* (2018). described the development and testing of an IVR program designed to maintain sterile technique during urinary catheterisation (Butt et al., 2018). The potential for IVR to be used as a medium to reduce the high reported incidence of catheter associated urinary tract infections is presented as the motivation for the integration of IVR into nursing simulation education. A collaboration with the university's computer science department and school of nursing and midwifery was formed ensuring a reciprocal understanding of technology capabilities and educational needs was communicated (Butt et al., 2018). Head mounted displays and haptic glove hardware were incorporated in the programs first iteration that was then pilot tested amongst a small convenience sample of n=20 junior nursing students. As an inclusion criterion all participants in the study had to be previously deemed competent in the skill of urinary catheterisation. The focus of the study was not the ability of the program to teach the skill but how the program is able to provide opportunity for deliberate practice. The study used a matched pair technique to allocate participants to a control group (n=10) and

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intervention group (n = 10). However, due to attrition throughout the study minimum participant numbers were filled at random from a pool of 36 consenting students (Butt et al., 2018). The control group self-scheduled a one-hour catheterisation simulation practice session. Using a task trainer and supervised by two facilitators, students practiced urinary catheterisation with the supervisors focused on identifying breaches in maintaining a sterile field and providing feedback on performance. The intervention group self-scheduled a one-hour appointment to use the IVR catheterisation program using Oculus Rift headgear and wearable haptic sensory gloves (Butt et al., 2018). Students had 10-15 minute technology orientation time in the one-hour session. Multiple data collection methods included a demographic survey and questions about game playing behaviour, comfort with technology, and learning with simulation, along with the Systems Usability Survey (SUS), an objective measure post intervention, a faculty designed user reaction survey, video recorded observations of participants and recorded student conversations (Butt et al., 2018).

Findings revealed that students using the IVR system spent more time practising (25.3 mins /14.9 mins) and completed more procedures (3.9 /1.8) in one hour ($p = 0.001$) than the students who practiced using traditional task trainers ($p < 0.001$) (Butt et al., 2018). The IVR system was rated within the acceptable range using the SUS (mean scores 72.5 range 42.5 - 92.5). There was no difference in skill retention between groups at two weeks follow up. The results of the user reaction survey indicated that participants in the intervention group (n=10) agreed or strongly agreed that the program was fun and engaging (Butt et al., 2018). Of intervention participants 100% additionally agreed that

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practice using IVR would help the participant with correct catheter insertion, with 70% indicating an increased likelihood of practicing using the IVR program compared to using a task trainer (Butt et al., 2018). These findings are limited to informing the next iteration of the program. The authors additionally identified that the most significant limitation was the inability to draw any conclusions on the effectiveness of the IVR program in promoting the maintenance of sterile technique (Butt et al., 2018).

Discussion:

To our knowledge this is the first scoping review undertaken to look at the application and integration of IVR technology within tertiary nursing and midwifery education programs. A thorough search of the published literature revealed only two papers of varying quality. Using a quality appraisal instrument the paper by Butt *et al.* (2018)was assessed as being of good quality, while the paper by Kilmon *et al.* (2010) was assessed as being poor. It should be noted, however, that the latter paper was more concerned with reporting concept development for a specific IVR program for nurse education and did not report research based evidence. It did however, provide useful conceptual discussion and an outline of the process of developing an IVR simulation within nurse education. Both papers discussed the development of unique IVR prototypes for potential integration into nursing education. No papers discussed the integration of IVR into tertiary midwifery education.

This review suggests that the adoption of IVR into nursing and midwifery education is very much in its infancy with considerable potential application for clinical simulation-based education and training. The two studies essentially present research prototypes developed by highly motivated but small teams through collaborations with content experts (nurses and midwives) and university IT departments (Butt et al., 2018; Kilmon et al., 2010). One of these prototypes had been developed to the point where pilot level evaluation had been

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conducted and the outcomes reported. At the time of publication of the article the other prototype was still under development and while pilot evaluation was anticipated this had not been conducted. Neither of these projects reported a university wide approach to the integration of IVR or plans for sustainable technology integration, funding and application (Butt et al., 2018; Kilmon et al., 2010).

The potential benefits of IVR for clinical skill acquisition and critical incident simulation may allow students more practice time compared to traditional simulation methods. It is widely accepted that there are many benefits from traditional simulation methods including knowledge retention and confidence building however, these methods can be resource intensive in terms of logistics, cost and afford limited time for students to practice skills (Butt et al., 2018; S Cobbett & E Snelgrove-Clarke, 2016; Kilmon et al., 2010). In universities the teaching of clinically related health skills through face-to-face simulation continues to be a significant issue in terms of logistics and cost (S Cobbett & E Snelgrove-Clarke, 2016). It is well known that there are many benefits including knowledge retention and confidence building from using various forms of clinical simulation such as high and low fidelity and Second Life® in the provision of teaching clinical skills (S Cobbett & E Snelgrove-Clarke, 2016; Sherman & Craig, 2018; Ulrich, Farra, Smith, & Hodgson, 2014). Immersive Virtual Reality has the potential to be a useful medium or next iteration of clinical simulation and potentially a more cost effective simulation method (S Cobbett & E Snelgrove-Clarke, 2016). Immersive Virtual Reality may additionally be able to meet some of the challenges associated with achieving clinical practice experiences within undergraduate programs such as increased student numbers and decreased clinical placement opportunities (S Cobbett & E Snelgrove-Clarke, 2016).

Immersive Virtual Reality has the ability to safely immerse students in high risk, chaotic or infrequently occurring situations, developing personal and team skills (Kilmon et al., 2010).

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Standardised learning and the ease of monitoring for objective evaluation of student performance is an identified potential benefit in using IVR in midwifery/nursing education particularly with increased student numbers (S Cobbett & E Snelgrove-Clarke, 2016; Kilmon et al., 2010). Clinically-based degree programs such as nursing and midwifery are experiencing faculty shortages and increasing demands on clinical venues for student clinical placements; given these resource limitations there is an ongoing need for high quality accessible, cost-effective, high quality education. IVR affords exciting and affordable opportunities to improve nursing and midwifery education (S Cobbett & E Snelgrove-Clarke, 2016; Krishnan, Keloth, & Ubedulla, 2017).

Strengths:

We have conducted a methodologically rigorous and contemporary search of the published literature of the current state of the application and integration of IVR technology into nursing and midwifery tertiary education programs. The review identified two papers of good to poor quality in terms of research design.

Limitations:

The use of IVR technology into nursing and midwifery education is only just emerging. There is considerable scope for research to be conducted into the development, application and integration of IVR into undergraduate nursing and midwifery education.

Conclusion:

There is a paucity of quality published literature on the application and/or integration of IVR into nursing and midwifery tertiary education. Immersive Virtual Reality has the potential to increase competence and confidence for students providing accessible and repeatable learning opportunities in a fail-safe environment. Immersive Virtual Reality additionally has the potential to assist in meeting the identified challenges associated with clinical practice experiences such as increased student numbers and decreased clinical placement

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opportunities in skill acquisition. There is a need for tertiary education institutions to have a supportive strategy for the development of IVR programs in nursing and midwifery and other health professional programs to increase student learning. As the use of IVR becomes more widespread it is important that nursing and midwifery educators take a leading role in the conceptualisation, design, integration and research of this rapidly emerging educational technology within the context of nursing and midwifery programs.

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REFERENCES:

Butt, A. L., Kardong-Edgren, S., & Ellertson, A. (2018). Using Game-Based Virtual Reality with Haptics for Skill Acquisition. *Clinical Simulation in Nursing, 16*, 25-32. doi:http://dx.doi.org/10.1016/j.ecns.2017.09.010

Cant, R., & Cooper, J. (2017). Use of simulation-based learning in undergraduate nurse education: An umbrella systematic review. *Nurse Education Today, 49*, 63-71. doi:10.1016/j.nedt.2016.11.015

Chang, C.-Y., Lai, C.-L., & Hwang, G.-J. (2018). Trends and research issues of mobile learning studies in nursing education: A review of academic publications from 1971 to 2016. *Computers & Education, 116*, 28-48.

Choi, K. S., He, X., Chiang, V. C., & Deng, Z. (2015). A virtual reality based simulator for learning nasogastric tube placement. *Computers in Biology & Medicine, 57*, 103-115. doi:https://dx.doi.org/10.1016/j.compbiomed.2014.12.006

Cobbett, S., & Snelgrove-Clarke, E. (2016). Virtual versus face-to-face clinical simulation in relation to student knowledge, anxiety, and self-confidence in maternal-newborn nursing: A randomized controlled trial. *Nurse Education Today, 45*, 179-184. doi:10.1016/j.nedt.2016.08.004

Cobbett, S., & Snelgrove-Clarke, E. (2016). Virtual versus face-to-face clinical simulation in relation to student knowledge, anxiety, and self-confidence in maternal-newborn nursing: A randomized controlled trial. *Nurse Education Today, 45*, 179-184. doi:10.1016/j.nedt.2016.08.004

Daudt, H., van Mossel, C., & Scott, S. (2013). Enhancing the scoping study methodology: a large, inter-professional team's experience with Arksey and O'Malley's framework. *BMC Medical Research Methodology, 13*(1), 48. doi:10.1186/1471-2288-13-48

Dubovi, I., Levy, S. T., & Dagan, E. (2017). Now I know how! The learning process of medication administration among nursing students with non-immersive desktop virtual reality simulation. *Computers & Education, 113*, 16-27. doi:http://dx.doi.org/10.1016/j.compedu.2017.05.009

Frenk, J., Chen, L., Bhutta, Z. A., Cohen, J., Crisp, N., Evans, T., . . . Kelley, P. (2010). Health professionals for a new century: transforming education to strengthen health systems in an interdependent world. *The lancet, 376*(9756), 1923-1958.

Hawker, S., Payne, S., Kerr, C., Hardey, M., & Powell, J. (2016). Appraising the Evidence: Reviewing Disparate Data Systematically. *Qualitative health research, 12*(9), 1284-1299. doi:10.1177/1049732302238251

Irwin, P., & Coutts, R. (2015). A Systematic Review of the Experience of Using Second Life in the Education of Undergraduate Nurses. *Journal of Nursing Education, 54*(10), 572-577. doi:10.3928/01484834-20150916-05

Kilmon, C. A., Brown, L., Ghosh, S., & Mikitiuk, A. (2010). Immersive virtual reality simulations in nursing education. *Nursing Education Perspectives, 31*(5), 314-317.

Krishnan, D. G., Keloth, A. V., & Ubedulla, S. (2017). Pros and cons of simulation in medical education: A review. *Education, 5*.

Levac, D., & Colquhoun, H. (2010). O, Brien KK (2010) Scoping studies: advancing the methodology. *Implementation Science, 5*(69), 1-9.

Mandal, S. (2013). Brief introduction of virtual reality and its challenges. *International Journal of Scientific and Engineering Research, 4*(4), 304-309.

Peters, M., Godfrey, C., McInerney, P., Soares, C., Hanan, K., & Paker, D. (2015). *The Joanna Briggs Institute Reviewers Manual 2015: Methodology for JBI Scoping Reviews. 2015*. Adelaide South Australia: The Joanna Briggs Institute.

Sherman, W., & Craig, A. (2018). *Understanding virtual reality: interface, application, and design*. Sydney: Morgan Kaufmaan.

ACCEPTED MANUSCRIPT

Ulrich, D., Farra, S., Smith, S., & Hodgson, E. (2014). The student experience using virtual reality simulation to teach decontamination. *Clinical Simulation in Nursing, 10*(11), 546-553. doi:http://dx.doi.org/10.1016/j.ecns.2014.08.003

Vidal, V. L., Ohaeri, B. M., John, P., & Helen, D. (2013). Virtual reality and the traditional method for phlebotomy training among college of nursing students in Kuwait: Implications for nursing education and practice. *Journal of Infusion Nursing, 36*(5), 349-355. doi:http://dx.doi.org/10.1097/NAN.0b013e318243172f

Vottero, B. A. (2014). Proof of concept: Virtual reality simulation of a pyxis machine for medication administration. *Clinical Simulation in Nursing, 10*(6), e325-e331. doi:http://dx.doi.org/10.1016/j.ecns.2014.03.001

Williams, J., Jones, D., & Walker, R. (2018). Consideration of using virtual reality for teaching neonatal resuscitation to midwifery students. *Nurse Education in Practice, 31*, 126-129. doi:10.1016/j.nepr.2018.05.016

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Figure 1.0. Study Selection Flowchart

Table 1.0 Inclusion / Exclusion Criteria *(a posteriori*)

Inclusion Criteria	Exclusion Criteria
Population	
Nursing and Midwifery students any type (undergraduate, postgraduate, vocational)	All other health professional students and nursing and midwifery practicing professionals
Concept	
Immersive Virtual Reality (IVR) technology exclusively (Eg. Use of fully immersive 360 degree IVR i.e. use of Head Mounted Devices (HMD) products or CAVE systems eg. HTC Vive, Samsung Oculus Rift or similar with or without haptics)	Non Immersive Virtual Reality (NIVR) technology eg virtual worlds (eg.Second Life® and similar); Augmented Reality (AR) technology alone or in combination with VR use; Low and high fidelity simulation technology ie manikins; Smartphone applications; Web / computer based education and training programs; Hybrid virtual simulation models
Context	
Tertiary teaching learning and education i.e. Undergraduate university / college, postgraduate university/ college and vocational education and training programs. Studies published or translated in English. Published Quantitative ie RCT's, cohort, case control, cross sectional, proof of concept, case study papers, Qualitative study papers	All other education, teaching and learning programs (i.e. high school) Studies not published or translated in English. All other literature i.e. Opinion/discussion pieces, editorials, grey literature, thesis documents, conference proceedings.

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Table 2.0 Study Characteristics

Citation	Aim/Objective	Sample and Setting	Methods and Methodology	Outcomes	Conclusions & Quality rating
Kilmon, C. A., Brown, L., Ghosh, S., & Mikitiuk, A. (2010). Immersive virtual reality simulations in nursing education. Nursing Education Perspectives USA	Testing a prototype VR application targeting speed and accuracy of nurse response in emergency situations requiring cardiopulmonary resuscitation	Experimental testing with a population of nursing students and novice nurses from area hospitals and local medical centres in Texas, USA no information on numbers of users/participants	No information on methods or methodology was included on process or outcomes. Unsure what software/technology was used although BioMimMER is mentioned Very basic discussion included around the development process of their database - acquired a compilation of visual images of medications and equipment from local hospitals to create a life-sized virtual crash cart prototype using a touch sensitive monitor	Greater potential to learn advanced skills, e.g. chaotic or unusual situations. Scheduling of technology-based learning may be easier than traditional face to face sessions – staff and resources BioSimMER may afford a fully immersive VR platform that could be tailored to the training of health professionals in emergency situations	Experimental paper with no mention of methods or methodology, however basic description, of research concept apparent.
Butt, A. L., Kardong-Edgren, S., & Ellertson, A. (2018). Using Game-Based Virtual Reality with Haptics for Skill Acquisition. Clinical Simulation in Nursing USA	To explore the ability of VR headgear and custom haptic technology combined with game-based learning principles to promote mastery and learning retention in the clinical skill of urinary catheterisation.	A convenience sample of n=20 nursing students (Intervention, n=10 / Control n=10) were recruited at a North-Western University in the United States of America. Students were considered junior in their undergraduate nursing degree by the authors those suitable for the study had already achieved competency in urinary catheterisation.	A mixed method pilot study, exploring the usability, user reaction and skill retention to a game-based VR system for urinary catheterisation. Data on number of catheterisations completed in an hour was also collected and compared to traditional task trainers.	Participants rated the VR as a highly engaging and enjoyable way to learn. 90% of participants agreed on ease of use, confidence of using the system and desire to use the system. Participants in the VR group were able to perform more procedures in an hour compared to the control. There was no difference in skill retention between groups at two weeks post intervention Qualitative responses identified recurring themes of fun, willingness to practice repeatedly using the VR system.	Small pilot study however findings suggest that a VR catheterisation system may promote learning, skill mastery and knowledge retention. Findings not generalisable

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Table 3.0 Quality Appraisal

Questions	Butt et al	Kilmon et al
1. Abstract and title: Did they provide a clear description of the study?	good	fair
2. Introduction and aims: Was there a good background and clear statement of the aims of the research?	good	fair
3. Method and data: Is the method appropriate and clearly explained?	good	poor
4. Sampling: Was the sampling strategy appropriate to address the aims?	good	very poor
5. Was the description of the data analysis sufficiently rigorous?	good	very poor
6. Ethics and bias: Have ethical issues been addressed, and what has necessary ethical approval gained? Has the relationship between researchers and participants been adequately considered?	poor	very poor
7. Results: Is there a clear statement of the findings?	good	very poor
8. Transferability or generalizability: Are the findings of this study transferable (generalizable) to a wider population?	good	poor
9. Implications and usefulness: How important are these findings to policy and practice	good	fair
Rated as Good (G), Fair (F), Poor (P), Very Poor (VP)	G	P
Overall appraisal	Include	Include

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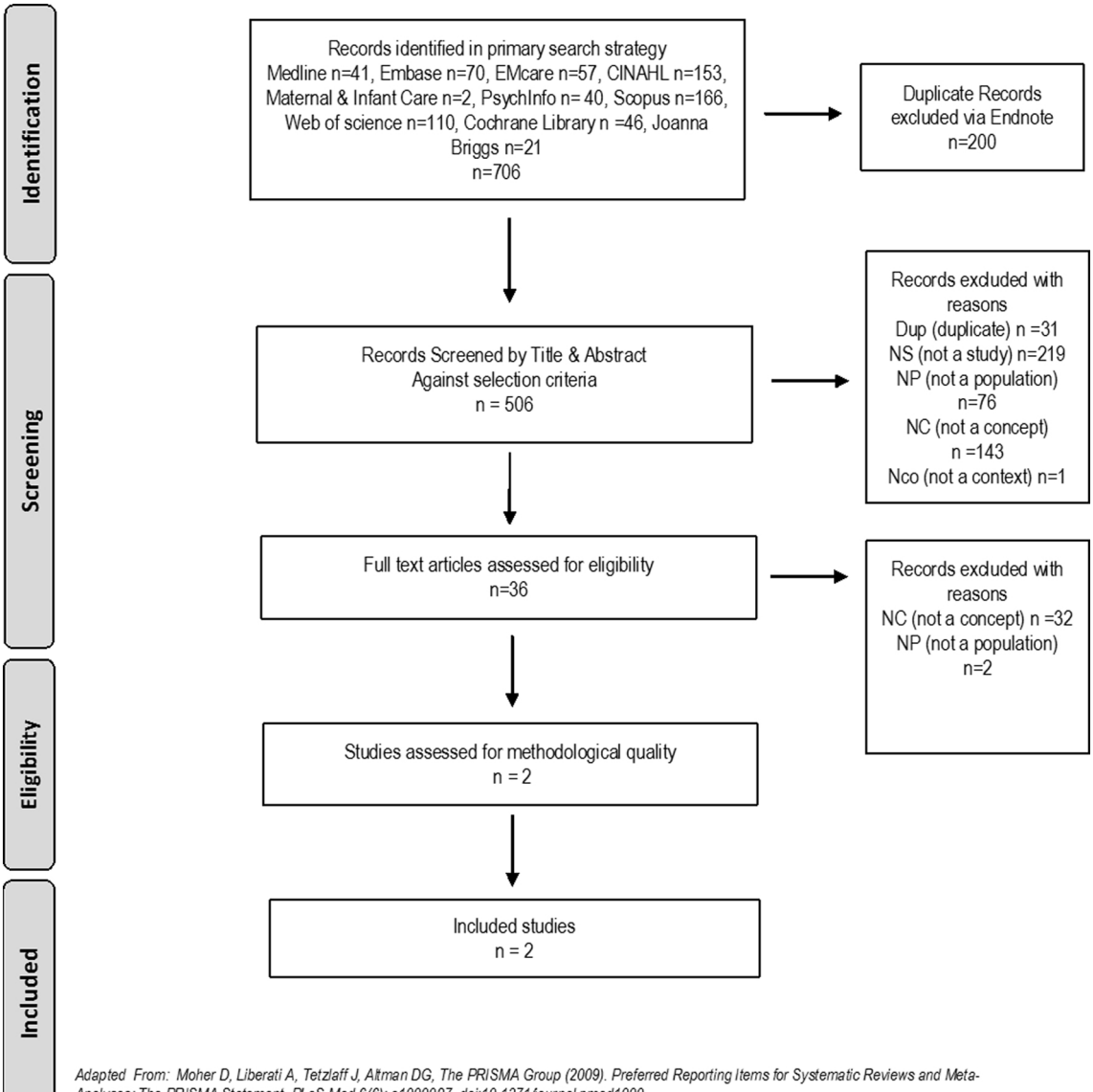

Adapted From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000

Figure 1