African Journal of Health, Nursing and Midwifery
ISSN: 2689-9418
Volume 6, Issue 2, 2023 (pp. 53-86)
www.abjournals.org

VIRTUAL REALITY AND SERIOUS GAMING IN RE-ENGINEERING CLINICAL TEACHING: A REVIEW OF LITERATURE OF THE EXPERIENCES AND PERSPECTIVES OF CLINICAL TRAINERS

Lucy W. Kivuti-Bitok[1], Joyce Jebet Cheptum[2], Mariana Mutwiri[3],

Susan Wanja[4] and Irene Ngune[5]

[1]Nursing Sciences, University of Nairobi. Email: lukibitok@uonbi.ac.ke

[2]Nursing Sciences, University of Nairobi. Email: jjcheptum@gmail.com

[3]Consultant Pharmacist. Email: marianamutwiri@gmail.com

[4]Faculty of Health Sciences, St Paul's University Kenya. Email: snwanja@gmail.com

[5]Nursing Sciences, University of Nairobi& Department of Nursing, Edith Cowan University. Email: i.ngune@ecu.edu.au

Cite this article:

Kivuti-Bitok L.W., Cheptum J.J., Mutwiri M., Wanja S., Ngune I. (2023), Virtual Reality and Serious Gaming in Re-engineering Clinical Teaching: A Review of Literature of the Experiences and Perspectives of Clinical Trainers. African Journal of Health, Nursing and Midwifery 6(2), 53-86. DOI: 10.52589/AJHNM-MFH6YYS8

Manuscript History

Received: 3 Feb 2023

Accepted: 21 March 2023

Published: 12 May 2023

ABSTRACT: *Re-engineer clinical teaching through innovative approaches such as virtual reality (VR) and Serious Gaming (SG) may increase patient safety. While several studies have focused on the experiences and perceptions of learners about VR and SG, few have if any have focused on the instructors. We reviewed and appraised published evidence to establish the experiences and intention to adopt VR and SG in clinical teaching. Relevant articles were sourced from five databases (PubMed/Medline, Informit, +A Education, ProQuest-ERIC, and CINHAL-EBSCO host). Experiences of clinical trainers were reported using the technological, pedagogical, and content knowledge (TPACK) model. The intention to adopt VR and SG was synthesized using the Technology Adoption Model (TAM). Clinical trainers had a positive attitude towards VR and SG. Those with longer professional experience were less likely to adopt VR and SG, while more experienced trainers were more likely to benefit from VR and SG. VR and SG are practical pedagogies for clinical instruction, but training is required for novice users. Cost-benefit analysis of VR and SG as clinical training approaches is needed.*

KEYWORDS: Virtual Reality, Serious Gaming, TPACK, TAM, Clinical Instruction.

African Journal of Health, Nursing and Midwifery
ISSN: 2689-9418
Volume 6, Issue 2, 2023 (pp. 53-86)
www.abjournals.org

BACKGROUND

There is an emphasis to apply technology in clinical learning and re-engineer clinical simulation by adopting innovative approaches such as virtual reality (VR) and Serious Gaming (SG) in order to increase patient safety (Ma & Zheng, 2011; Krishnan, Divya & Vasu, 2015). The two approaches have varying operational definitions with a call to unifying the definitions of VR (Kardong-Edgren et al., 2019). A more recent definition of Virtual Reality Simulations has been proposed as "use of a variety of immersive, highly visual, 3D characteristics to replicate real-life situations and/or health care procedures" and is distinguished from computer-based simulation in that it generally incorporates physical or other interfaces, such as a computer keyboard, a mouse, speech and voice recognition, motion sensors, or haptic devices (Ahrq, 2020, p. 56). Serious gaming on the other hand has been defined as computer games designed for serious learning purposes and provided via digital gadgets (Alvarez & Djaouti, 2012). Both VR and SG applications are simulations of actual clinical events that provide immersion and interaction for the user. While VR is applied broadly in clinical learning, such as completing procedures, SG is primarily designed for problem-solving and patient assessment purposes (Gentry et al., 2019).

VR and SG also reduce the need for physical contact with actual patients, reduce the cost of training and offer simulated tasks of different levels of difficulties. VR and SG may be employed as complementary clinical instruction methods, in situations that require reduced person-to-person contact and where life learning opportunities are scant (Krishnan, Divya & Vasu, 2015). Simulation via VR provides on-demand clinical experience, compensates stretched resources, reduces clinical errors, and shortens training curves (Alaker, Wynn & Arulampalam 2016). These applications provide immersion for the user and perform complete medical procedures in various clinical fields of medical education (Pantelidis et al., 2018). VR elements can be added to the real world, resulting in Augmented Reality (AR), which aims at seamlessly super-imposing a virtual image over the participant's real-world, hence enhancing the learning process (Milgram & Kishino, 1994). AR can be a mixed physical manikin creating a Mixed Reality (MR) to enhance learning further. Thus, VR, AR, and MR are all encompassed in the "reality-virtuality continuum" pg 145 (RV), which connects authentic environments to completely virtual ones (Billinghurst, Clark & Lee 2014). These technologies have not only been used in clinical teaching but also in other situations such as an intervention in mental health disturbances (Hatta et al., 2022).

SG has been viewed as encompassing VR and a combining VR and SG in clinical instructions has been reported to increase performance and satisfaction levels among learners (Mansoory et al., 2021). These applications can be adopted at varying levels to train students in clinical procedural tasks (Tang & Yao, 2020), human anatomy and general health care education (Pantelidis et al., 2018). VR and SG are validated approaches, and the acquired skills are transferable to real situations (Pantelidis et al., 2018). However, they cannot entirely replace the clinical instructor but can improve or replace some conventional clinical training methods (Pottle, 2019; Tang & Yao, 2020). The acceptability and adoption of VR and SG in clinical teaching may be influenced by the perspectives and experiences of clinical trainers.

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

Several studies on VR and SG have focused on students' experiences (Gauger, 2018; Birt, 2017; Kowalewski, 2015), but few studies have reported on the experiences of clinical trainers. This review focused on the experiences of clinical trainers to inform practical insights on developing simulation training and demonstrate how VR and SG are adopted in clinical instruction. We interrogated if clinical trainers would adopt SG and VR as complimentary clinical training. We documented their experiences with VR and SG technology, pedagogy, and delivering content knowledge using the TPACK model (Koehler, Mishra & Yahya, 2007). Further, we synthesized their intentions to use VR and SG using the Technology Adoption Model (TAM) (Davis, 1989), which has previously been applied in assessing intention to adopt online learning (Liu et al., 2010). In our review, clinical trainers included faculty, practitioners, and postgraduate students involved in teaching clinical skills in healthcare training facilities. The role of postgraduate students, residents, and registrars in clinical instructions (Ma & Zheng, 2011; Post, Quattlebaum & Benich, 2009) has been long-standing and postgraduates perceive themselves as clinical trainers (Bing-You & Sproul, 1992). Over 70% of postgraduate students have reported the intention of being equipped with clinical teaching skills (Post, Quattlebaum & Benich, 2009; Ayodele & Sciences, 2020; Owolabi, Afolabi & Omigbodun, 2014). Clinical trainers and academics have a role in curriculum review which should incorporate VR and SG in response to current challenges (Ferguson et al., 2015). At the same time, Clinical instructors need commitment to reflective lifelong learning that embraces technological advancements including VR and SG vital in the critical role of teaching, appraising, optimizing care, and improving health outcomes (Ferguson et al., 2015; Aggarwal et al., 2010).

Technological advancements in clinical instruction however have unique adoption challenges. The high infrastructural investment cost of both space and technology may not be affordable, especially in low resource settings (Krishnan, Divya & Vasu, 2015). Clinical instructors often have competing interests and may have insufficient time for designing and implementing VR and SG-supported curricula. The development and design of VR and SG software may be done by non-health professionals and may not always reflect the instructional needs of end-users (Krishnan, Divya & Vasu, 2015). At the same time the inanimate nature of VR and SG may lead to insouciant learners (Krishnan, Divya & Vasu, 2015) while other users may have conflicting religious orientations (Velev & Zlateva, 2017). The results of this study may assist in identifying enablers and challenges faced by clinical trainers in VR and SG since their adoption of VR has been reported to be low (Levac et al., 2017; Deloitte, 2018). A comprehensive address of the enablers and barriers to adoption of VR and SG among clinical instructors is paramount for wider adoption.

Clinical training institutions could use the results to determine their preparedness, identify areas of concern, strengthen and possibly draw a road map for adoption and inculcation of VR and SG in among clinical trainers. This report could lead to discourse in determination of proportions of clinical internships that could be supplemented with VR and SG in developing clinical competencies among clinical trainees without compromising the learner and patients' safety . In order to realize these potential benefits of VR and SG, it is necessary to investigate the experiences of clinical instructors regarding the same. The experiences are expected to shape their intention to adopt VR and SG as instructional methods.

Identification of the instructor population’s likelihood of adoption would shed light into systematic planning in addressing possible issues of concern. We therefore needed to answer the following questions.

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

1. What are the experiences of clinical health care trainers regarding Virtual Reality (VR) and Serious Gaming (SG)?

2. What are the perspectives of clinical trainers regarding the ease of use of VR and SG?

3. Do clinical health care trainers intend to adopt the use of VR and SG in clinical training?

METHOD

Search Strategy and Study Identification

Relevant articles published in English were electronically sourced from five academic databases:

PubMed/Medline, Informit, +A Education, ProQuest-ERIC, and CINHAL-EBSCO host. The articles were searched in November 2021, employing the following strategy. The keywords and their combination used for the search were ((((virtual reality) OR (mixed reality) OR (serious gam*)) OR (Healthcare simulation) AND (((perspective) OR (opinions))OR (attitude))) AND ((clinical trainers) (simulation educator*) OR (health professionals)(faculty))) AND (effectiveness) with Abstract, Free full text, Full-text Filters. We limited our search to literature that had been published within the past 10 years to avoid documenting obsolete technology. We included the term mixed reality to avoid missing out on any study that may have used MR as alternative terms or may have indeed used mixed reality.

Inclusion and Exclusion Criteria

We based the eligibility criteria on the year of publication of the study as well as the Population, Intervention, Comparison and Outcome (PICO) approach. For this study, the population was the clinical trainers. The intervention was VR, SG or a combination of the two applications. The comparison was the reported success of the instructional technology applied during the study, and the outcome was the experience, perception and attitude of the clinical trainers. We included studies published in English and those that reported opinions, experiences and perspectives of clinical trainers about VR or SG. We included studies that focused on health professionals, clinical trainers and postgraduate students as they often play a role of clinical trainers especially in low resource settings. Studies were excluded: when full texts were unavailable, were not written in English, and did not focus on clinical instructors.

Study Selection and Extraction

As shown in Figure 1, 1059 papers were identified from the databases, while two were identified through other sources. After removing duplicates, 1061 identified references were uploaded in Ryann software (Rayyan, nd) by one author (IN). With blinding on, potentially relevant titles and abstracts were screened and evaluated for relevance by four authors (IN, JJ, LKB and SW). Each author made an independent decision on including, excluding or maybe options. The results were compared after unblinding. For the studies that met the selection criteria, full texts were retrieved when available. Where discrepancies with inclusion or exclusion of an article occurred, the reviewers met online and deliberated on the article until a consensus was reached. The second round of selection and screening was done with blinding on. Each author screened the articles independently and made a decision based on the inclusion

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

and exclusion criteria. After unblinding and building consensus, the authors identified (n =97) potentially relevant articles. With blinding on, the articles (n=97) were further subjected to a more detailed evaluation by each author and 73 articles were excluded for various reasons as denoted in the Prisma flow diagram (Figure1).

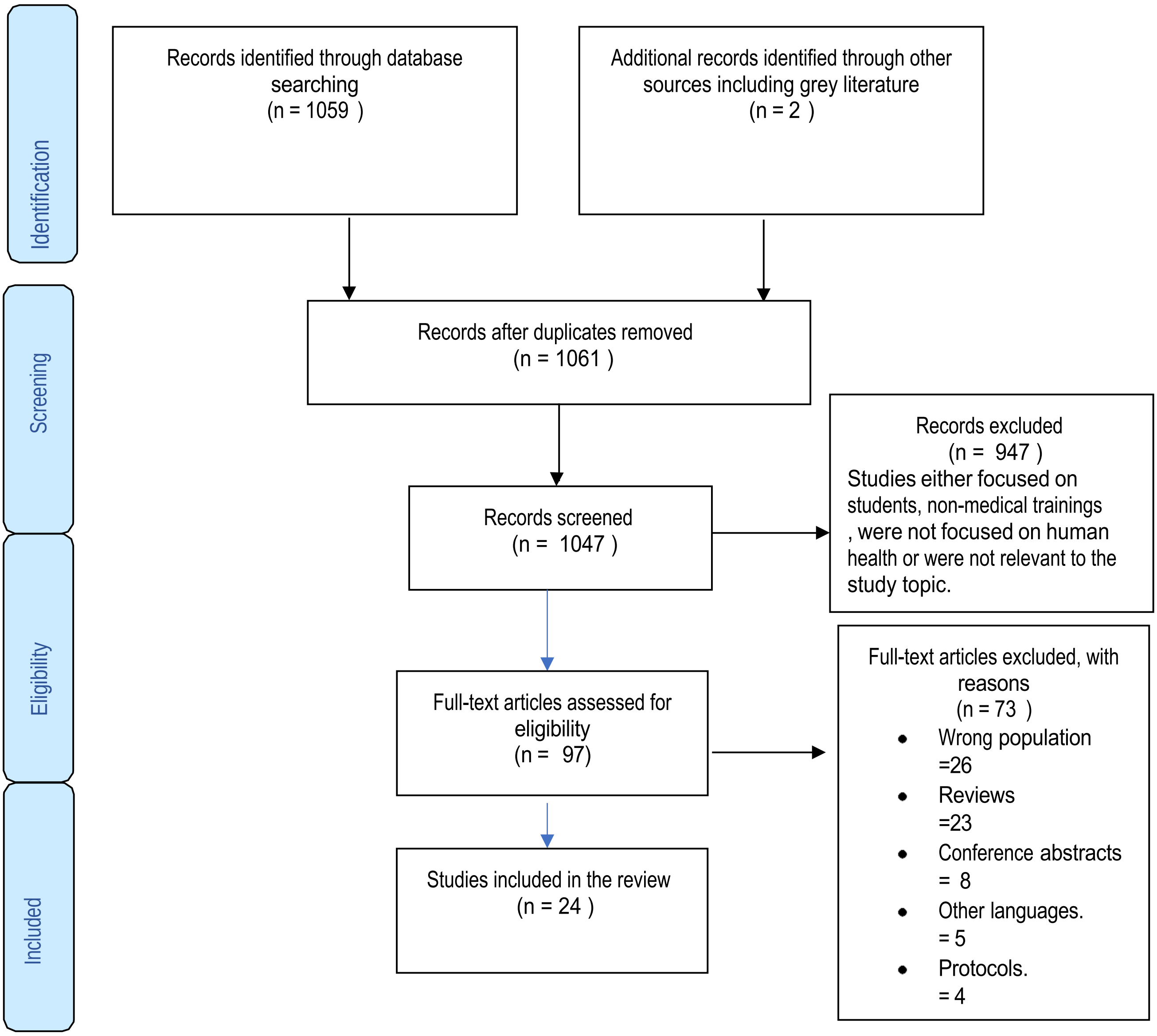

Figure 1: Prisma flow diagram showing selection of articles

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

Four authors (LKB, JJ, SW and IM) independently reviewed the remaining 35 studies and excluded (n =11) articles because they did not examine the opinions of the clinical instructors. Finally, a total of 24 studies were included for the review. To avoid inter-rater bias and data entry errors, two authors (JJ and LKB) extracted data using the agreed-upon criteria as detailed in Table 1. The small number of studies could partially be explained by the diversity of the nomenclature around VR and SG terms. Potentially, this meant some articles might have been missed.

DATA EXTRACTION AND SYNTHESIS

All the studies included in this review were assessed for potential risk bias based on the 25 constructs of inherent bias outlined in the MMAT tool and were evaluated as low. The studies included in this study provided sufficient details of the study population, the inclusion criteria were clearly described, control and intervention groups were comparable at entry (where applicable to the study design), the outcomes were measured in the same way for all the groups, and statistical analysis was appropriate for the design of the study. One study did not provide a sample size (Parham et al., 2019), but the characteristics of the sample were well described, therefore was included. The results are presented in the risk of bias Table 2.

The following information was extracted (when available) and tabulated for interpretation:

Study design and methods, type of stimulation, length of training (Table 2). Components of the TPACK model, such as technology (VR and SG), the content taught using VR and SG in the simulation sessions, and knowledge transmitted using VR and SG, are summarized in Table 3.

The clinical instructors' perceived usefulness of the technology, ease of use, attitude towards use, intention to use and actual usages are extracted and presented using the TAM approach and are shown in Table 4. Due to the heterogeneity of the methods and data collection tools of included studies, the quantitative data pool was not possible (Harden & Thomas, 2010).

Therefore, the included studies were synthesized and presented in a narrative form.

Assessment of Study Quality

Two authors (IN and MM) used the Mixed Method Appraisal Tool (MMAT) to appraise quantitative, qualitative, and mixed methods studies. The MMAT tool includes 25 methodological criteria of five study designs (qualitative, quantitative randomized, quantitative non-randomized, quantitative descriptive and mixed methods) (Hong et al., 2018). Each study was checked for quality by one author blindly and then rechecked by a second author. In areas where the authors disagreed, there were discussions until unanimity was reached.

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

RESULTS

We analyzed a total of 24 articles. Publications were reported from a diverse range of countries, with the majority being from first economy nations, such as the USA, Canada, UK, Singapore, Netherlands (n=20). Only three studies were conducted in third economy countries; Ghana, India, and Zambia. The target group for most publications was primarily medical doctors (n=16/24). Most studies were conducted with only one group as a pre-post-test design (=20/24). Table 2 shows the characteristics of the studies that were included in the review. We presented the results in two sections: The first section reports the experiences of clinical trainers based on the Technological, Pedagogical, Content and Knowledge (TPACK) model while the second section we capture the clinical trainers' perspectives and intentions to adopt VR and SG using the Technology Adoption Model (TAM).

Technology

Of the 24 studies that were evaluated, 14 studies employed virtual reality; four studies used mixed reality, while two studies used virtual patients in the training of health professionals and postgraduate students. At least five studies used SG technology, while two studies combined SG and VR. The technologies employed in virtual reality included virtual reality-3D printed laryngotracheal model produced with computer-aided design (Gauger et al., 2018), 3D Virtual Immersive Environment (Gauger et al., 2018) and 360 degrees virtual reality (VR) video (Yoganathan et al., 2018). The studies examined utilized technologies for surgical training skills, which included virtual reality laparoscopic simulator (El-Beheiry, McCreery & Schlachta, 2017) and a laparoscopic virtual reality simulator (Verdaasdonk et al., 2009). The orthopedic simulations included a VR simulator for a scoliosis surgical procedure and a VR simulator for the reconstruction of skull base tumors (El-Beheiry et al., 2017; Gourishetti & Manivannan, 2019). The gynecologic procedures included Virtual Reality Surgical Simulation (VRSS) for a total abdominal hysterectomy (TAH) with bilateral pelvic lymphadenectomy (Olszewski et al., 2018), CPR+automated external defibrillator (AED), VR Simulation (Wong et al., 2018) and virtual reality simulator for laparoscopic colorectal resection (Wynn, Lykoudis & Berlingieri, 2018). Another study also looked at ophthalmic operations using the EyeSI virtual reality simulator of ophthalmic surgery (la Cour et al., 2019). Virtual peritoneal dialysis (PD) simulator was also used (Olszewski et al. 2018). The physical simulation was performed with virtual reality in one study that was simulating on-base skull tumors (Shao et al., 2020). The four studies that used mixed reality used different ways of training, which included mixed reality educational space and virtual patients (Antoniou et al., 2017), mobile mixed reality simulation using bring your device (BYOD) technology (Birt, Moore & Cowling, 2017), virtual reality, augmented reality, and tablet-based application (Moro et al., 2017), and augmented and virtual reality technology (eREAL) in a real classroom (Salvetti et al., 2019). One study described a model for both immersive virtual reality (IVR) and non-immersive virtual reality (NIVR) (Gourishetti & Manivannan, 2019).

We identified seven studies that described gaming training. In some, there was a mix of virtual reality and gaming. Some of the games described include Game-based e-learning (GbEl) instruction with a conventional script-based instruction in the teaching of phase contrast microscopy urinalysis (Boeker et al., 2013), 3D scenario-based simulation game (Buttussi et al., 2013). Serious game was utilized to optimize situation awareness in the minimally invasive surgery (MIS) environment and gaming application for laparoscopy (Graafland, Bemelman & Schijven, 2015; Kowalewski et al., 2017). Serious gaming has also been used in learning

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

management systems, as identified in an explorative study (Ofosu-Ampong et al., 2020). Virtual patients were also used during virtual reality sessions (Antoniou et al., 2017; Dafli et al., 2019; Padilha et al., 2019).

Our study identified that some faculty had not learned to teach using simulation technology and this was identified as a challenge identified in the utilization of VR, AR, and SG (Dillard et al., 2009; González-Yebra et al., 2019; Wynn et al., 2018). In addition, some procedures were reported as not successful despite being done by experts because of the inability to utilize technology (Gauger et al., 2018). Technological knowledge was found to be lacking among clinical trainers since most of the participants were not acquainted with video games and 3D applications (Buttussi et al., 2013).

Pedagogy

The pedagogical approaches applied were poorly or not described in 19 out of the 24 studies that we reviewed. Yoganathan et al. (2018), in their study, employed face-to-face teaching in virtual reality training, while González-Yebra et al. (2019) used synchronous distance learning in immersive 3D environments. Another study utilized an online questionnaire narrated by the surgeon and adopted a case-based approach (Moro, Stromberga & Stirling, 2017; Padilha et al., 2019). Online didactic lectures were adopted in virtual reality surgical simulation (Parham et al., 2019). In comparison to traditional learning, VR is more effective and leads to improved skills. This is further demonstrated by Shao et al. (2020), who reported a better effect on the VR group than on the traditional teaching group. There was a high degree of satisfaction with the use of second life as a teaching-learning resource, thus increasing pedagogical knowledge (González-Yebra et al., 2019b). The Technological Pedagogical Knowledge (TPK) was affected in one study, which established that the trainees could quickly lose 'gaming character' due to the integration of educational contents, affecting their enjoyment and motivational capacity (Boeker et al., 2013). The use of virtual patients to improve pedagogical content knowledge (PCK) can be applied in different sectors to enhance learning (Dafli et al., 2019). One study reported that most of the faculty had not learned to teach using simulation outcomes, thus affecting pedagogical knowledge (Dillard et al., 2009). In one study, the teachers had less than satisfactory Technological Pedagogical Knowledge (TPK) (Frøland et al. 2020a).

Content and Knowledge

The content that was included in virtual reality and serious gaming varied from surgical training skills, patient care, and advanced life support. The surgical skills had laparoscopic simulation (Kowalewski et al., 2017; Verdaasdonk et al., 2009; Wynn et al., 2018), needle insertion (Manivannan, 2019), ophthalmic surgery (la Cour et al., 2019), and skull base neurosurgery (Shao et al., 2020). Other procedures simulated included peritoneal dialysis (Olszewski et al., 2018), radical surgery for the treatment of invasive cancer (Parham et al., 2019), cardiopulmonary resuscitation (Wong et al., 2018), and provision of care to patients with heart failure (Dillard et al., 2009). Simulation has also been used for the evaluation and learning of clinical reasoning (Dafli et al., 2019). The results of this review indicated that there was satisfaction and perception with part-time classroom attendance in an immersive 3D environment (I3DE) (González-Yebra et al., 2019b). The serious games reviewed in this study consisted of evaluating a 3D serious game for advanced life support retraining (Buttussi et al., 2013), and competition on voluntary usage of a laparoscopic simulator (El-Beheiry, McCreery, & Schlachta, 2017a). The games were played on mobiles via web or virtual reality technologies

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

(Frøland et al., 2020a) or serious games on the computer (Maurits Graafland, Bemelman & Schijven, 2015).

Friedrich et al. (2017) compared desktop-based and mobile-based simulation while Ofosu-Ampong et al. (2020) used gamification research to test students in learning management systems. Fidelity 3D printed laryngotracheal simulator (Gauger et al., 2018), while Antoniou et al. (2017) mentioned that the educational scenario, implemented through the virtual patient case, enhanced decision-making and elicited clinical reasoning skills in trainees. When used for training surgical skills, virtual reality was found to lead to an improvement in knowledge, procedural time, self-reported confidence, and performance quality in the surgical skills global test (Gauger et al. 2018). While assessing laparoscopic skills, Verdaasdonk et al. (2009) established that those who had more than 30 attempts of the procedure scored highly compared to those who had fewer attempts. When exposed to the techniques of virtual reality, the experts were found to take a shorter time compared to the novice learners (Wynn, Lykoudis & Berlingieri 2018). This may indicate the need for a more prolonged exposure for the novice as compared to the experts. In a survey done using a peritoneal dialysis simulator in which users responded to a satisfaction survey, Olszewski et al. (2018) established that there was a statistically significant mean increase of 36.4%, SD 19.9 (95% confidence interval, 34.1 to 38.6, P=0.001), between pre-and post-test scores for the 300 users that completed the structured curriculum. Seventy percent (16 of 23) of the participants were satisfied or very satisfied with the simulator. While 87% felt the simulator was relevant to their clinical practice, 74% reported it was up-to-date and reflected current best practice and evidence, with 78% stating they would recommend the simulator to others.

Repeated attempts using virtual reality led to significantly higher scores (González-Yebra et al., 2019; Verdaasdonk et al., 2009; Wynn et al., 2018). Using augmented reality, learners achieved mastery with a high-fidelity simulation scenario and repeated cycles (González-Yebra et al.,2019). In addition, Birt et al. (2017) established statistically significant improvement in test scores for students provided with the paramedic simulation tools compared to traditional teaching skillsWhile (Manivannan 2019) reported a just noticeable difference that immersive virtual reality

(IVR) was better than that of the non-immersive virtual reality (NIVR) Technological content knowledge was likely to increase when the students became more accustomed to the virtual devices and applications (Moro, Stromberga, et al., 2017).

Perceptions and Adoption Trajectories

Many factors influence the perception and adoption of technology among clinical instructors. Motivation for use affects the utilization of simulation, thus improving technology (El-Beheiry et al., 2017). Individuals who have a positive attitude towards technology and view technology as easier and more beneficial to use are more likely to adopt instructional support. We adopted the Technology Acceptance Model (TAM) developed by Davis (1989), who classified these determinants into three categories: perceived ease of use, perceived usefulness, and attitudes. We analyzed clinical instructors' perspectives regarding the use of VR and SG in the clinical setting. The interaction of their views of usefulness, ease of use, and attitude towards SG and VR indicated an increased likelihood of the trainers adopting the two technologies. It is hoped that the adoption of VR and SG would translate to an increase in their use by the clinical trainers and an inculcation and adoption of the same by their trainees. We extended and populated the

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

variables in the TAM model in VR and SG based on what was reported by clinical trainers, as shown in Figure 2.

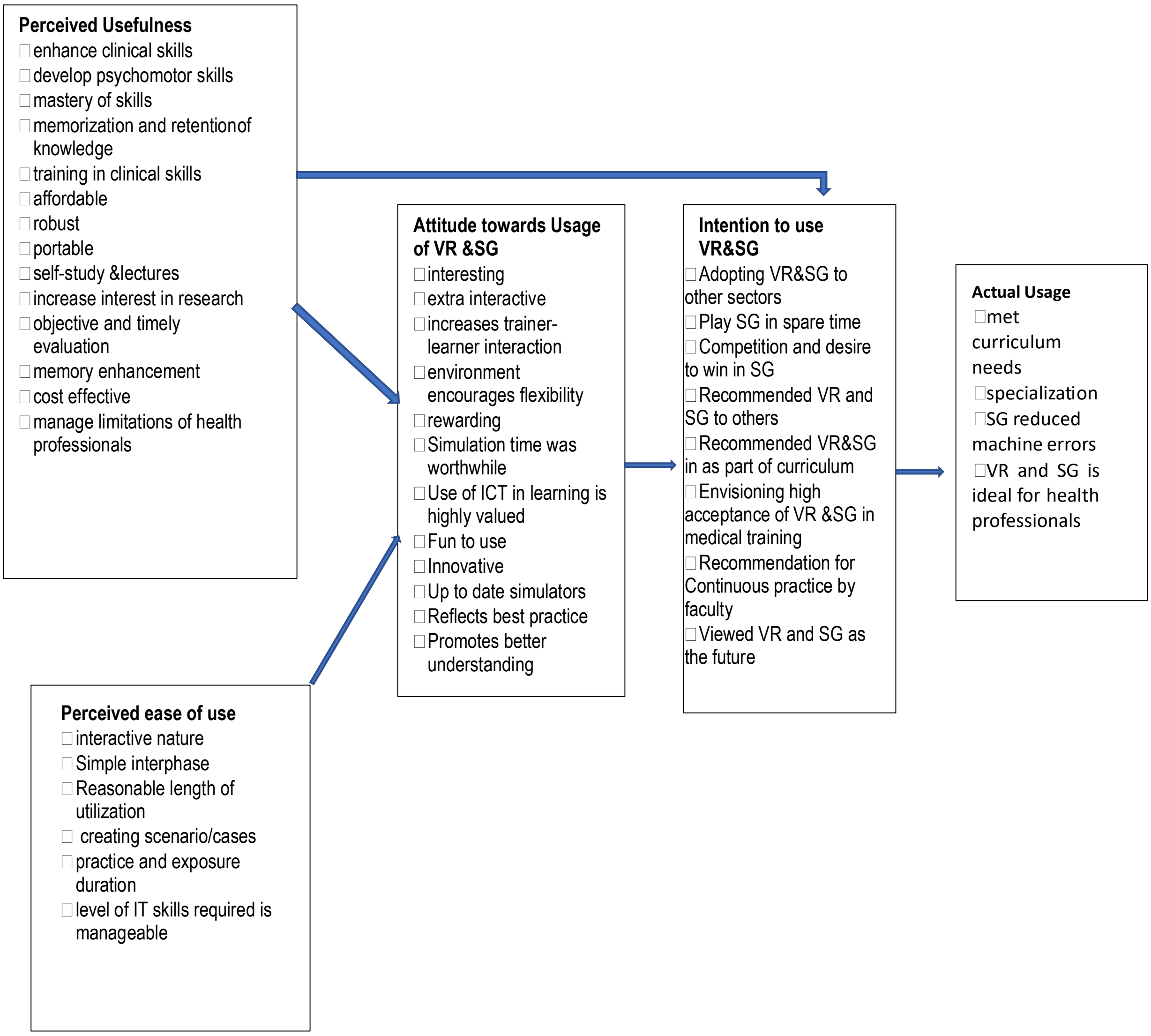

Figure 2: Technology Acceptance Model (TAM) showing Interplay of factors in adoption of VR and SG in clinical training Adopted from (Davis,1989).

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

Perceived Usefulness

Clinical instructors generally found VR and SG helpful in non-academic and academic spheres.

In their study involving postgraduate students (González-Yebra et al., 2019a), the participants considered a synchronous VR virtual campus as a conciliation of work, family, and personal life. VR and SG experience may enhance clinical instructions and learning and can create long-lasting memories as it involves immersive participation rather than a passive audience. VR and SG have been reported to be useful in enhancing the retention of skills and knowledge gained in Advanced Cardiac Life Support (ACLS) (Buttussi et al., 2013), training of peritoneal dialysis (Olszewski et al., 2018), neural surgery (Shao et al., 2020), operating nurses and surgeons (Graafland, Bemelman & Schijven, 2015). While Dillard et al. (2009) reported that VR leads to better organization and experience in clinical judgment, Olszewski et al. (2018) reported that Peritoneal Simulator was viewed as relevant to clinical practice. VR has also been reported to aid in the memorization of clinical conditions (Dafli et al., 2019). VR not only enhanced hysterectomy training resulting in proficiency with the skill but was also found to be affordable, portable, and robust (Parham et al., 2019). VR has also been reported to mitigate health professionals' limitations in cardiopulmonary resuscitation (CPR) education (Wong et al., 2018). VR and SG ranging from simple to complex are likely to contribute to the development of psychomotor skills (Wong et al., 2018; Wynn, Lykoudis & Berlingieri, 2018).

However, Olszewski et al. (2018) reported that the technology is less likely to be adopted if the scenarios simulated are deemed to be too simple. VR and SG experiences have been cited as beneficial for self-study and lectures (Frøland et al., 2020b), as well as increasing convenience for the instructor (Shao et al., 2020). This is because realistic scenarios can easily be reconfigured, and feedback can be given to enable mastery of a skill (Parham et al., 2019). The control of distraction while using VR and SG coupled with focused and clear content may lead to memory enhancement (Wong et al., 2018). One study recommended a quiet and safe training environment to provide a platform for the repetition of learning and provide an objective evaluation of the learner (Wong et al., 2018). Two studies that reported on the cost-effectiveness of VR and SG showed that they reduce the time and cost of training surgeons and they compensate for the lack of cadavers (Parham et al., 2019; Shao et al., 2020). However, even though VR and SG contribute to and enhance clinical skills, it is not equivalent to real-life experience (Dafli et al., 2019).

Perceived Ease of Use

Overall, the clinical trainers reported ease of use of VR and SG applications (Frøland et al., 2020) and reported positive experiences (Dillard et al., 2009). The reviewed studies reported increased students interactions with phlebotomy application (Frøland et al., 2020b) and a reported 70% satisfaction with the peritoneal dialysis simulator (Olszewski et al. 2018) further attesting to perceived ease of use. However, VR and SG can also be challenging to educators (Frøland et al., 2020b) and surgical trainers (Graafland, Bemelman & Schijven, 2015). Some challenges related to the length of simulation time, may lead to minimized utilization of VR and SG (Olszewski et al., 2018).

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

Additionally, low utilization has also been linked to ill-preparedness and insufficient opportunities for practice (Wong et al., 2018). Interphases viewed as difficult to use may reduce the utilization of VR and SG (Olszewski et al., 2018). Other clinical trainers reported the creation of Virtual Patients being time-consuming and requiring critical information technology (IT) skills (Dafli et al., 2019)

Positive attitudes increased the intention to use VR & SG (Frøland et al., 2020). Clinical instructors perceived VR and SG positively (Frøland et al., 2020b; Graafland et al., 2015), increased student interactions (Dafli et al., 2019), and found the technologies interesting (Frøland et al., 2020b). Virtual patients in gaming were more enjoyable to use than traditional patients (Dafli et al., 2019). They availed more attractive and interesting learning scenarios that allow increased trainer student interaction (Dafli et al., 2019). The simulation environment was reported to encourage flexibility and was rewarding (Dillard et al., 2009), making deliberate time used in simulation worthwhile. The use of technology was highly valued and was linked to improved learning (Frøland et al., 2020b). Other studies reported that the simulator was up to date and reflected best practice (Olszewski et al., 2018), and in some cases, aroused the interest to learn among students (Shao et al., 2020).

Other trainers reported VR as fun and innovative and attractive to young learners, possibly promoting better understanding and willingness to learn (Wong et al., 2018). It is worth noting that more experience could derail technology adoption in clinical set up (Wong et al., 2018). Graafland et al. (2015) reported that experienced surgeons found the SG use in surgical training boring, while VR in cardiopulmonary resuscitation training was reported as low (Wong et al., 2018) among this group.

Intention to use VR and SG

The VR and SG experiences of trainers elicited varying reactions. Some of the trainers exposed to SG reported that they would play the game in their spare time (Graafland et al., 2015), while those who simulated advanced cardiac life support (ACLS) were willing to devote one hour per month to retrain the skills using EMSAVE an SG (Buttussi et al., 2013). The motivation to use technology in some studies emerged from the competitive component of the simulation. Competition and the desire to win may increase voluntary learning of laparoscopic skills (Verdaasdonk et al., 2009). In other experiences, a mentor in a project that used HoloLens felt that the competitors generally had higher scores in time spent in simulation, speed of procedure and were more likely to continue simulation longer than non-competitors (El-Beheiry, McCreery & Schlachta, 2017b), while Verdaasdonk et al. (2009) found that SG competition may not increase voluntary usage and simulation of laparoscopic surgery.

The by-in of use of VR in peritoneal dialysis resulted in 78% of trainers reporting that they would recommend a peritoneal dialysis simulator to others (Olszewski et al., 2018). Trainers would recommend increased use of simulators if it was part of the curriculum (Olszewski et al., 2018) and recommended embedment of VP into the core curriculum of medical training and envisioned high acceptance of VP (Dafli et al., 2019). While VR and SG increased motivational levels to train students (Dillard et al., 2009), ongoing practice was required by faculty as well as the continual development of specific pedagogical skills was imperative for successful adoption of VR and SG (Dillard et al. 2009).

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

In CPR education, participants recorded the potential in VR as a tool for novice and experienced health professionals (Wong et al., 2018), while clinicians who felt a procedure was important in their specialization were more likely to adopt the laparoscopy simulation (El-Beheiry, McCreery & Schlachta 2017b). It was however noted that use of VR and SG cannot be used in isolation but is most suitable in blended learning (Wong et al., 2018). The potential use of VR and SG in other sectors was noted (Dafli et al., 2019), though affordability of technology paused reservations of use (Frøland et al., 2020b). The more experienced generation, on the other hand, is reportedly likely to encounter difficulties in the use of VR (Wong et al., 2018).

Actual Usage

VR and SG have been used in various aspects of healthcare training including cardiac support training (Buttussi et al., 2013), in laparoscopy training (El-Beheiry, McCreery, and Schlachta 2017b), in dialysis (Olszewski et al., 2018), in laboratory procedures (Frøland et al., 2020b) and in ophthalmology ophthalmic surgery (la Cour et al., 2019), among others. In comparison, VR may be more widely used than SG. This may be explained by the view that VR is used more in clinical procedures while SG is more adaptable in evaluation and assessment. Of the 24 studies reviewed, 13 were reported among medical doctors, 2 were reported among nurses, 6 were reported from biomedicals and the rest were unspecified (refer to study characteristics table). In comparison to medical doctors, VR and SG seem to be less adopted by allied health clinical trainers.

The motivation to inculcate the use of VR and SG were driven by different factors. The users of VR and SG felt that their use met the curriculum needs of clinical trainers (Dafli et al., 2019). In operating theaters, users reported that serious gaming dealt with machine errors in surgery (Graafland et al., 2015). In CPR education, 'fidelity, engagement, resource conservation, and memory enhancement features of VR' were reported as ideal for health professionals' (Wong et al., 2018). Virtualization of education has gone through several changes each driven by trainers' and trainees' priorities, evolving communication, and collaborative technologies.

DISCUSSION

Our study found that virtual reality and serious gaming (SG) are becoming more applicable, especially in circumstances that require blended learning. This is in congruence with findings that extended reality (XR) provides or complements training in circumstances where danger or cost renders the traditional training methods less attractive (Kaplan et al., 2020). VR and SG have been adopted and used to train on various medical procedures across the medical specialization (Buttussi et al., 2013; El-Beheiry, McCreery & Schlachta, 2017b), in dialysis (Olszewski et al., 2018; Frøland et al., 2020b; la Cour et al., 2019). Virtual simulations of complex surgical procedures helped the medical professionals have a better understanding and made them more familiar with the different tools used for surgery. These technologies were found to have the potential to build the competence and confidence of the learners and also improve their knowledge owing to the immersion that came along with it and the repeated cycles of performing the procedures. VR and SG have been adopted as effective platforms for learning based on improved outcomes. With immersive technology, VR can provide an opportunity for creativity, widen imagination, cultural exposure, and global interconnectedness

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

(Barrado-Timón & Hidalgo-Giralt, 2019; Han, Weber, Bastiaansen, Mitas & Lub, 2019; Pottle, 2019).

VR is an effective educational tool that can be used for blended learning for both the novice and the experts (Wong et al., 2018), and can be applied in therapeutic and rehabilitative services (Liu et al., 2010). Despite its low usage, VR has been embraced by many educators as beneficial in learning and student's engagement. Virtual reality creates a learning environment that is appealing to the learner and faculty by simulating a real environment for education, training and an imaginary environment for interaction (Ogbonna, 2020). This review established better understanding, thus making them more familiar with the different tools used for surgery (Izard et al., 2018). Virtual simulations provide an environment for repeat practice; as a result, the learner gains more confidence which will eventually build their competence. Repeated attempts using VR have established noted improvement in performance implying that repeated performance improves knowledge and skills acquired. Adopting virtual reality in the training of health care professionals could lead to much more competence and confidence in performing surgical procedures. Virtual reality, in comparison to traditional learning, has been found to be more effective and leads to improved skills (Shao et al., 2020). It also provides a participatory aspect in learning, thus enabling a clear view of the procedures that enhance the skills. This, therefore, builds a case for the adoption of VR and SG in clinical training. Successful adoption of VR and SG is not determined by the clinical trainers alone. The complexity of adoption is influenced by a number of players including trainees and institutions of learning. Even though our review focused on the clinical trainers, it is worthwhile noting that studies done among students have reported positive attitudes and intention to use VR (Sabalic & Schoener, 2017; Zackoff et al., 2019), while another synthesis of literature had inconclusive findings on attitudes and satisfaction (Kyaw et al., 2019). This therefore means that the adoption of the ecosystem needs to be investigated in more broader perspectives.

Even though the limited studies we reviewed suggest benefits of VR and SG in clinical instruction, it is imperative that further inquiry into these benefits be replicated via the intended and unintended positive and negative effects of their adoption preferably through dynamic synthesis methods. Based on the TPACK analysis, our study established the potential use of VR and SG as clinical instructional methods. The use of VR and SG was reported more among medical doctors in relation to allied health disciplines. The allied healthcare clinical trainers could learn more from the medical specialists. At the same time only one study was reported from a developing country (Ofosu-Ampong et al., 2020). There is therefore a need to investigate the adoption trajectories of VR and SG in low resource settings. A TAM would act as a starting point. It was noted that longer clinical training experience was likely to be a barrier to adopting VR and SG as complementary clinical training.

Virtual reality presents a number of benefits to the users, for instance achievement of optimal learning, intelligence feedback gathering mechanism, presentation of repeatable scenarios, training are globally accessible, cost effective and increased throughput. It has also been found to be more effective in experiential learning and transitioning from conventional teaching methods to more innovative methods (Asad et al., 2021). The serious games could be used to provide an off-site training owing to the complexity of some surgical procedures and hence improving the technological pedagogical content (TPC) and content knowledge (CK) (Graafland, Bemelman & Schijven, 2015).

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

The usage of VR and SG in clinical training however has its potential and real negative side. Apart from the high cost of a number of applications, the use of virtual reality has been associated with some physiological side effects for example cyber sickness or simulation sickness. Some participants experienced headaches, dizziness or blurred vision (Moro, Stromberga et al., 2017; Park & Lee, 2020). This was attributed to the possible altering motion and mismatch between the visual and vestibular systems. The development and persistence of cyber sickness is influenced by personal characteristics, such as user behavior, individual characteristics, skill of individual and psychological differences of individuals (Tayebeh Beniasadi et al., 2020).

Other studies have found that technological factors, such as the resolution of the displays contribute to the symptoms (Kolasinski, 1995; Mitrousia & Giotakos, 2016). Emotional effects have also been associated with the use of VR and SG (Lavoie et al., 2020). At the same time, a number of challenges and obstacles have been reported in the use of VR and SG in clinical instruction. Clinical instructors have reported insufficient training in simulation and view of long preparation time for simulation (Kundra & Cherian, 2014). While performing VR simulation on cardiopulmonary resuscitation, Wong et al. (2018) reported challenges of inadequate resources, insufficient practice opportunities, lack of motivation, sub-optimal frames of mind and the common mistakes made by students included poor technique, jumbled steps and sequence, and inaccurate landmark identification Another challenge is the cost of the technologies. It was established that VR simulations can be used for high-quality training, however, affordability can hamper their availability especially in low-income countries (Parham et al., 2019). Technological Pedagogical Content Knowledge (TPACK) cannot be achieved fully using virtual patients in place of the real clinical situation; however, the technological knowledge can be used in the development of clinical skills through practice in clinical decision making (Dafli et al., 2019).

STUDY LIMITATIONS

By focusing solely on the VR and SG, other components of technological advancement in clinical instructions may have been left out. There may be other terminologies that are used to describe VR and SG or their components, thus leading to some literature being overlooked. Secondly, while clinical teaching is an expected role of masters training in limited resource settings, this may not always be the case in endowed economies. Most of the studies reviewed were from developed economies, hence the results may not entirely apply to the less developed economies who may not be exposed to VR and SG in the same scale. Our study focused on clinical instructors' individual factors in determining adoption of VR and SG. This in itself is one sided as adoption of VR and SG occurs in an institutional, political, technological and economic complex ecosystem.

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

CONCLUSION

Clinical trainers have had fairly good experiences in the use of VR and SG. This has largely shaped their positive attitudes towards VR and SG and hence the higher chances of adoption of this technological advancement in clinical instruction. The potential for the usage of VR and SG in clinical instruction in situations requiring minimized human to human touch such as covid-19 is enormous. Their power to create realistic simulation, high fidelity and haptic experiences cannot be underestimated. It is inevitable for instructors to engage with virtual space in preparation for clinical instruction. The question is 'when' rather than 'if' clinical instructors perceive VR and SG as a vehicle in delivery of medical instruction. It is hoped that VR and SG can create a lasting positive impact on healthcare training. VR and SG have been integral to training in aviation and industry safety and have now become a proven force to reckon with in healthcare training since it increases safety, visibility, reproducibility of actions and cost reduction. This will therefore offer students new insights and refreshing perspectives but cannot replace human interactions' in totality. While VR and SG have been adopted across the medical field, there may be less adoption among allied health professional clinical trainers. This aspect needs to be explored in view of transferability. Similarity was only reported in one study from a low resource setting. There is a need to explore perceptions and adoption of VR and SG as clinical training modalities in low resource settings.

RECOMMENDATION

Serious gaming (SG) and virtual reality (VR) can be adopted to enhance learning among the novice and experienced learners. While VR is applicable to situations requiring hands on surgical skills, SG could be more appropriate in less complex off-site settings. We propose further analysis with the aim of contrasting the findings of this study with the students as well as institutional perspective as these dimensions are intertwined and will provide clarity in adoption of SG and VR in clinical training. There is a need to broaden the scope to other domains to enable cross-pollination between disciplines. This review did not discriminate against developers of the applications. There is a need for a more detailed study to contrast adoption levels based on user versus non users developed applications.

Data Availability Statement

Data analyzed in this study were a re-analysis of existing data, which are openly available at locations cited in the reference section.

Ethical Approval

Ethical approval was not required for this study as it did not involve direct interaction between the researchers and respondents. Anonymity was ensured in the analysis of secondary data.

Conflict of Interest

The authors declare no conflict of interest

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

REFERENCES

Aggarwal, Rajesh, Oliver T. Mytton, Milliard Derbrew, David Hananel, Mark Heydenburg, Barry Issenberg, Catherine MacAulay, et al. 2010. 'Training and Simulation for Patient Safety.' Quality& Safety in Health Care 19 Suppl 2 (Suppl 2). https://doi.org/10.1136/qshc.2009.038562.

Ahrq, Q. (2020) 'Healthcare Simulation Dictionary', Healthcare Simulation Dictionary. doi: 10.23970/simulationv2.

Alaker, Medhat, Greg R. Wynn, and Tan Arulampalam. 2016. "Virtual Reality Training in Laparoscopic Surgery: A Systematic Review & Meta-Analysis." International Journal of Surgery 29.

Alvarez, J. and Djaouti, D. (2012) 'An introduction to serious games', pp. 1–324. Available at: http://www.ludoscience.com.

Antoniou, Panagiotis E., Eleni Dafli, George Arfaras, and Panagiotis D. Bamidis. 2017. "Versatile Mixed Reality Medical Educational Spaces; Requirement Analysis from Expert

Ayodele, O. E. and Sciences, H. (2020) 'Residents-As-Teachers : Needs Assessment Of Residents ' Teaching Skills In A Clinical Setting Using Direct Observation Of Teaching', (March).

Ayodele, Olugbenga Edward, and Health Sciences. 2020. 'Residents-As-Teachers : Needs Assessment Of Residents ' Teaching Skills In A Clinical Setting Using Direct Observation Of Teaching', No. March.

Billinghurst, Mark, Adrian Clark, and Gun Lee. 2014. "A Survey of Augmented Reality." Foundations and Trends in Human-Computer Interaction 8(2–3).

Bing-You, R. G. and Sproul, M. S. (1992) 'Medical students' perceptions of themselves andresidents as teachers', Medical Teacher. Taylor & Francis, 14(2–3), pp. 133–138. doi: 10.3109/01421599209079479.

Bing-You, Robert G, and Marga S Sproul. 1992. 'Medical Students' Perceptions of Themselves And Residents as Teachers'. Medical Teacher 14 (2–3): 133–38. https://doi.org/10.3109/01421599209079479

Birt, James, Emma Moore, and Michael Cowling. 2017. "Improving Paramedic DistanceEducation through Mobile Mixed Reality Simulation." Australasian Journal of Educational Technology 33(6):69–83.

Barrado-Timón, D. A., & Hidalgo-Giralt, C. (2019). The historic city, its transmission and perception via augmented reality and virtual reality and the use of the past as a resource for the present: A new era for urban cultural heritage and tourism? Sustainability (Switzerland), 11(10). https://doi.org/10.3390/su11102835

Boeker, Martin, Peter Andel, Werner Vach, and Alexander Frankenschmidt. 2013. "Game-Based e-Learning Is More Effective than a Conventional Instructional Method: A RandomizedControlled Trial with Third-Year Medical Students." PLoS ONE 8(12):1–11.

Buttussi, Fabio, Tommaso Pellis, Alberto Cabas Vidani, Daniele Pausler, Elio Carchietti, and Luca Chittaro. 2013. "Evaluation of a 3D Serious Game for Advanced Life Support Retraining." International Journal of Medical Informatics 82(9):798–809.

Dafli, Eleni, Ioannis Fountoukidis, Chariklia Hatzisevastou-Loukidou, and Panagiotis D Bamidis. 2019. "Curricular Integration of Virtual Patients: A Unifying Perspective of Medical Teachers and Students." BMC Medical Education 19(1):1–11.

Davis, Fred D. 1989. "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

Information Technology." MIS Quarterly: Management Information Systems 13(3).

Deloitte (2018) ‘What can health systems do to encourage physicians to embrace virtual care?’,Deloitte Insights. Available at: https://www2.deloitte.com/content/dam/insights/us/articles/4407_Virtual-care-survey/DI_Virtual-care-survey.pdf.

Deloitte. 2018. ‘What Can Health Systems Do to Encourage Physicians to Embrace Virtual Care?’ Deloitte Insights. https://www2.deloitte.com/content/dam/insights/us/articles/4407_Virtual-care-survey/DI_Virtual-care-survey.pdf.

Dillard, Nancy, Stephanie Sideras, Marilyn Ryan, Kay Carlton Hodson, Kathie Lasater, and Linda Siktberg. 2009. "A Collaborative Project to Apply and Evaluate the Clinical Judgment Model through Simulation." Nursing Education Perspectives 30(2):99–104.

El-Beheiry, Mostafa, Greig McCreery, and Christopher M. Schlachta. 2017. "A Serious Game Skills Competition Increases Voluntary Usage and Proficiency of a Virtual Reality Laparoscopic Simulator during First-Year Surgical Residents' Simulation Curriculum." Surgical Endoscopy 31(4):1643–50.

Ferguson, Caleb, Patricia M. Davidson, Peter J. Scott, Debra Jackson, and Louise D. Hickman. 2015. ‘Augmented Reality, Virtual Reality and Gaming: An Integral Part of Nursing’. Contemporary Nurse 51(1):1–4. https://doi.org/10.1080/10376178.2015.1130360.

Fransson, G., Holmberg, J., & Westelius, C. (2020). The challenges of using head mounted virtual reality in K-12 schools from a teacher perspective. Education and Information Technologies, 25(4), 3383–3404. https://doi.org/10.1007/s10639-020-10119-1

Frøland, Tord Hettervik, Ilona Heldal, Gry Sjøholt, and Elisabeth Ersvær. 2020. ‘Games on Mobiles via Web or Virtual Reality Technologies: How to Support Learning for Biomedical Laboratory Science Education’. Information 11(4):195. https://doi.org/http://dx.doi.org/10.3390/info11040195.

Gauger, Virginia T., Deborah Rooney, Kevin J. Kovatch, Lauren Richey, Allison Powell, Hailesllassie Berhe, and David A. Zopf. 2018. "A Multidisciplinary International CollaborativeImplementing Low Cost, High Fidelity 3D Printed Airway Models to Enhance EthiopianAnesthesia Resident Emergency Cricothyroidotomy Skills." International Journal of Pediatric Otorhinolaryngology 114(July):124–28.

Gentry, Sarah Victoria, Andrea Gauthier, Beatrice L. Estrad. Ehrstrom, David Wortley,Anneliese Lilienthal, Lorainne Tudor Car, Shoko Dauwels-Okutsu, Charoula K. Nikolaou, Nabil Zary, James Campbell, and Josip Car. 2019. "Serious Gaming and Gamification Education in Health Professions: Systematic Review." Journal of Medical Internet Research21(3).

González-Yebra, Óscar, Manuel A. Aguilar, Fernando J. Aguilar, and Manuel Lucas. 2019. "Co Design of a 3D Virtual Campus for Synchronous Distance Teaching Based on Student Satisfaction: Experience at the University of Almería (Spain)." Education Sciences 9(1).

Gourishetti, Ravali, and M. Manivannan. 2019. "Improved Force JND in Immersive VirtualReality Needle Insertion Simulation." Virtual Reality 23(2):133–42.

Graafland, Maurits, Willem A. Bemelman, and Marlies P. Schijven. 2015. "Appraisal of Face and Content Validity of a Serious Game Improving Situational Awareness in Surgical Training." Journal of Laparoendoscopic and Advanced Surgical Techniques 25(1):43–49.

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

Han, D.-I. D., Weber, J., Bastiaansen, M., Mitas, O., & Lub, X. (2019). Virtual and Augmented Reality Technologies to Enhance the Visitor Experience in Cultural Tourism. 113–128. https://doi.org/10.1007/978-3-030-06246-0_9

Harden A, Thomas J. Using Mixed Methods Research Synthesis for Literature Reviews. 2010 2019/01/09. In: Handbook of Mixed Methods in Social & Behavioral Research [Internet]. Thousand Oaks, California: SAGE Publications, Inc.; [pages 265-92]. Available from: http://methods.sagepub.com/book/using-mixed-methods-research-synthesis-for-literature-reviews.

Hatta, M.H.; Sidi, H.; Sharip, S.; Das, S.; Saini, S.M. The Role of Virtual Reality as a Psychological Intervention for Mental Health Disturbances during the COVID-19 Pandemic:A Narrative Review. Int. J. Environ. Res. Public Health 2022, 19, 2390. https://doi.org/10.3390/ijerph19042390

Hong, Q. N., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., . . . O'Cathain, A. (2018). The Mixed Methods Appraisal Tool (MMAT) version 2018 for information professionals and researchers. Education for Information, 34(4), 285-291.

Izard, Santiago González, Juan A. Juanes, Francisco J. García Peñalvo, Jesús MGonçalvez Estella, M José Sánchez Ledesma, and Pablo Ruisoto. 2018. "Virtual Reality as an Educational and Training Tool for Medicine." Journal of Medical Systems 42(3):1–6.

Kardong-Edgren, S. (Suzie) et al. (2019) 'A Call to Unify Definitions of Virtual Reality', Clinical Simulation in Nursing, 31, pp. 28–34. doi: 10.1016/j.ecns.2019.02.006.

Koehler, Matthew J., Punya Mishra, and Kurnia Yahya. 2007. "Tracing the Development of Teacher Knowledge in a Design Seminar: Integrating Content, Pedagogy and Technology."Computers and Education 49(3).

Kolasinski, Eugenia M. 1995. "Simulator Sickness in Virtual Environments." United States Army Research Institute For the Behavioral and Social Sciences 1027(4).

Kowalewski, Karl Friedrich, Jonathan D. Hendrie, Mona W. Schmidt, Tanja Proctor, Sai Paul, Carly R. Garrow, Hannes G. Kenngott, Beat P. Müller-Stich, and Felix Nickel. 2017. "Validation of the Mobile Serious Game Application Touch Surgery™ for Cognitive Training and Assessment of Laparoscopic Cholecystectomy." Surgical Endoscopy 31(10):4058–66.

Krishnan, Dr. Divya G, Dr. Anukesh Vasu, D. S. U. (2015) 'Pros and cons of simulation in medical education: A review', European Journal of Clinical Nutrition, 68(7), pp. 799–803.

Kundra, P. and Cherian, A. (2014) 'Simulation based learning: Indian perspective', Journal of Anaesthesiology Clinical Pharmacology, 30(4), pp. 457–458. doi: 10.4103/0970-9185.142797.

Kundra, Pankaj, and Anusha Cherian. 2014. 'Simulation Based Learning: Indian Perspective'.Journal of Anaesthesiology Clinical Pharmacology 30(4):457–58. https://doi.org/10.4103/0970-9185.142797.

la Cour, Morten, Ann Sofia Skou Thomsen, Mark Alberti, and Lars Konge. 2019. "Simulators in the Training of Surgeons: Is It Worth the Investment in Money and Time? 2018 Jules Gonin Lecture of the Retina Research Foundation." Graefe's Archive for Clinical and Experimental Ophthalmology 257(5):877–81.

Lavoie, Raymond, Kelley Main, Corey King, and Danielle King. 2020. "Virtual Experience, Real Consequences: The Potential Negative Emotional Consequences of Virtual Reality Gameplay." Virtual Reality.

Levac, Danielle, Stephanie Glegg, Heather Colquhoun, Patricia Miller, and Farzad Noubary.2017. 'Virtual Reality and Active Videogame-Based Practice, Learning Needs, and Preferences: A Cross-Canada Survey of Physical Therapists and Occupational Therapists'. Games for Health Journal 6 (4): 217–28.

Liu, I. Fan, Meng Chang Chen, Yeali S. Sun, David Wible, and Chin Hwa Kuo. 2010. 'Extending the TAM Model to Explore the Factors That Affect Intention to Use an Online Learning Community'. Computers and Education 54(2):600–610. https://doi.org/10.1016/j.compedu.2009.09.009.

Ma, Minhua, and Huiru Zheng. 2011. 'Virtual Reality and Serious Games in Healthcare'. Studies in Computational Intelligence 337: 169–92. https://doi.org/10.1007/978-3-642-17824-5_9.

Mann, Steve, Tom Furness, Yu Yuan, Jay Iorio, and Zixin Wang. 2018. "All Reality: Values,Taxonomy, and Continuum, for Virtual, Augmented, EXtended/MiXed (X), Mediated (X,Y), and Multimediated Reality/Intelligence." Awe (X).

Mansoory, Meysam Siyah, Mohammad Rasool Khazaei, Seyyed Mohsen Azizi, and ElhamNiromand. 2021. 'Comparison of the Effectiveness of Lecture Instruction and Virtual Reality-Based Serious Gaming Instruction on the Medical Students' Learning Outcome about Approach to Coma'. BMC Medical Education 21 (1): 1–7. https://doi.org/10.1186/s12909-021-02771-z.

Milgram, Paul, and Fumio Kishino. 1994. "Taxonomy of Mixed Reality Visual Displays." IEICE Transactions on Information and Systems E77-D(12).

Mitrousia, V., and O. Giotakos. 2016. "Virtual Reality Therapy in Anxiety Disorders." Psychiatrike = Psychiatriki 27(4).

Moro, Christian, Zane Stromberga, and Allan Stirling. 2017. "Virtualisation Devices for Student Learning: Comparison between Desktop-Based (Oculus Rift) and Mobile-Based (Gear VR) Virtual Reality in Medical and Health Science Education." Australasian Journal of Educational Technology 33(6):1–10.

Moro, Christian, Zane Štromberga, Athanasios Raikos, and Allan Stirling. 2017. "The Effectiveness of Virtual and Augmented Reality in Health Sciences and Medical Anatomy."Anatomical Sciences Education 10(6):549–59.

Muhammad Mujtaba Asad, Aisha Naz, Prathamesh Churi, Mohammad Mehdi Tahanzadeh "Virtual Reality as Pedagogical Tool to Enhance Experiential Learning: A Systematic Literature Review", Education Research International, vol. 2021, Article ID 7061623, 17 pages, 2021. https://doi.org/10.1155/2021/7061623

Ofosu-Ampong, Kingsley, Richard Boateng, Thomas Anning-Dorson, and Emmanuel A. Kolog. 2020. "Are We Ready for Gamification? An Exploratory Analysis in a Developing Country."Education and Information Technologies 25(3):1723–42.

Ogbonna, Nicholas Onele. 2020. "Virtual Reality: A Tool for Improving the Teaching and Learning of Technology Education." in Virtual Reality [Working Title].

Olszewski, Aleksandra E., Dennis A. Daniel, Deborah R. Stein, Mignon I. McCulloch, Sharon W. Su, Daniel L. Hames, and Traci A. Wolbrink. 2018. "Teaching Pediatric Peritoneal Cardiopulmonary Resuscitation Education." SAGE Open Medicine 6:205031211879960.

Owolabi, M. O., Afolabi, A. O. and Omigbodun, A. O. (2014) 'Performance of ResidentsServing as Clinical Teachers: A Student-Based Assessment', Journal of Graduate Medical Education, 6(1), pp. 123–126. doi: 10.4300/jgme-d-13-00130.1.

Pantelidis, P., Chorti, A., Papagiouvanni, I., Paparoidamis, G., Drosos, C., Panagiotakopoulos, T., ... & Sideris, M. (2018). Virtual and augmented reality in medical education. Medical and Surgical Education-Past, Present and Future, 77-97.

Post, Robert E, R Glen Quattlebaum, and Joseph J Benich. 2009. 'Residents-as-Teachers Curricula : A Critical Review'. Academic Medicine 84 (3): 374–80.

Pottle, J. (2019). Virtual reality and the transformation of medical education. Future Healthcare Journal, 6(3), 181–185. https://doi.org/10.7861/fhj.2019-0036

Shao, X., Yuan, Q., Qian, D., Zheng, Y., Chen, G., Kang le, Z., … Di, Q. (2020). Virtual realitytechnology for teaching neurosurgery of skull base tumor. BMC Medical Education, 20, 1–7. Retrieved from https://search.proquest.com/docview/2341054723?accountid=10382 http://link.library.curtin.edu.au/openurl??url_ver=Z39.88-2004&rft_val_fmt=info:ofi/fmt:kev:mtx:journal&genre=article&sid=ProQ:ProQ%3Ahealthcompleteshell&atitle=Virtual+reality+technology+for+

Torraco, R. J. (2016) 'Writing Integrative Literature Reviews: Using the Past and Present to Explore the Future', Human Resource Development Review, 15(4), pp. 404–428. doi:10.1177/1534484316671606.

Velev, D. and Zlateva, P. (2017) 'Virtual Reality Challenges in Education and Training',International Journal of Learning, 3(1), pp. 33–37. doi: 10.18178/IJLT.3.1.33-37.

Wynn, Greg, Panagis Lykoudis, and Pasquale Berlingieri. 2018. "Development and Implementation of a Virtual Reality Laparoscopic Colorectal Training Curriculum." American Journal of Surgery 216(3):610–17.

Yoganathan, S., D. A. Finch, E. Parkin, and J. Pollard. 2018. "360° Virtual Reality Video for the Acquisition of Knot Tying Skills: A Randomised Controlled Trial." International Journal of Surgery 54(February):24–27.

Zweifach, S. M., & Triola, M. M. (2019). Extended Reality in Medical Education: Driving Adoption through Provider-Centered Design. Digita Biomarkers, 3(1)14–21. https://doi.org/10.1159/000498923

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

African Journal of Health, Nursing and Midwifery
ISSN: 2689-9418
Volume 6, Issue 2, 2023 (pp. 53-86)

APPENDIX

Table 1: Risk of Bias Table

	All studies			Randomized control trial						Non-randomized studies					Mixed methods				
	Are there clear research	Do the collected data allow to address the research	Further appraisal may not be feasible or appropriate when the answer is ' No' or ' Can' t tell' to one or both screening questions.	Appropriate statistical analysis	Is randomization appropriately	Are the groups comparable at	Are there complete	Are outcome assessors blinded to the intervention	Did the participants adhere to the assigned	Are the participants' representative of the target	Are measurements appropriate regarding both the outcome and intervention (or exposure)?	Are there complete outcome data?	Are the confounders accounted for in the design and	During the study period, is the intervention administered (or exposure occurred) as intended?	Is there an adequate rationale for using a mixed methods design to address the	Are the different components of the study effectively integrated to answer the research question?	Are the outputs of the integration of qualitative and quantitative components adequately interpreted?	Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?	Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?
Antoniou, (2017)	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	▲	—	▲	▲	—
Birt, (2017)	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	▲	—	▲	▲	—
Boeker (2013)	▲	▲	▲	▲	▲	▲	▲	—	▲	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

African Journal of Health, Nursing and Midwifery
ISSN: 2689-9418
Volume 6, Issue 2, 2023 (pp. 53-86)
www.abjournals.org

Buttussi, (2013)	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	▲	▲	▲	—	▲	n/a	n/a	n/a	n/a	n/a
Dafli, E., (2019)	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	▲	—	▲	▲	—
Dillard, (2009)	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	▲	▲	▲	▲	▲
El-Beheiry2017	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	▲	▲	▲	—	▲	n/a	n/a	n/a	n/a	n/a
Frøland, (2020).	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	▲	▲	▲	—	▲	n/a	n/a	n/a	n/a	n/a
Gauger (2018)	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	▲	▲	▲	—	▲	n/a	n/a	n/a	n/a	n/a
González-Yebra, (2019).	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	▲	▲	—	▲	▲	—
Gourishetti, (2019)	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	▲	▲	▲	—	▲	n/a	n/a	n/a	n/a	n/a
González-Yebra, (2019).	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	▲	—	▲	▲	—
Graafland, (2015)	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	▲	▲	▲	—	▲	n/a	n/a	n/a	n/a	n/a
Kowalewski, (2017).	▲	▲	▲	▲	▲	▲	▲	—	▲	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
la Cour, (2019).	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	▲	▲	▲	—	▲	n/a	n/a	n/a	n/a	n/a
Izard et al., 2018	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	▲	▲	▲	—	▲	n/a	n/a	n/a	n/a	n/a
Moro, (2017).	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	▲	—	▲	▲	—
Moro (2017)	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	▲	▲	▲	—	▲	n/a	n/a	n/a	n/a	n/a
Ofosu-Ampong, (2020)	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	▲	▲	▲	—	▲	n/a	n/a	n/a	n/a	n/a
Parham et al., 2019	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Salvetti, (2019).	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	▲	▲	▲	—	▲	n/a	n/a	n/a	n/a	n/a
Verdaasdonk, (2009).	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	▲	▲	▲	—	▲	n/a	n/a	n/a	n/a	n/a
Wang, (2017).	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	▲	▲	▲	—	▲	n/a	n/a	n/a	n/a	n/a
Wynn, (2018)	▲	▲	▲	n/a	n/a	n/a	n/a	n/a	n/a	▲	▲	▲	—	▲	n/a	n/a	n/a	n/a	n/a
Yoganathan, 2018	▲	▲	▲	▲	▲	▲	▲	—	▲	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Assessed risk of bias of included studies with a randomized control trial design; quantitative non-randomized and mixed-methods studies
Legend: Black triangle – the criterion was assessed as being met; grey dash - it was unclear whether or not this criterion was met; n/a – not applicable.

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

Table 2 – Study Characteristics

Author/Country	Study Design	Sample size	Age of participants	Target group
Antoniou, Dafli, Arfaras, & Bamidis, 2017 Italy	Qualitative cross- sectional study Post-test design one group only	Two resident cardiologists	Adults (not specified)	Postgraduate- Doctors
Birt, Moore, & Cowling, 2017 Australia	Mixed quantitative and qualitative study design. Post-test design one group only	159	Adult students - paramedics	Paramedicine - undergraduate
Boeker, Andel, Vach, & Frankenschmidt, 2013) Germany	Randomized controlled trial	145 (82 Game-based e-learning (GbEl) group and 69 conventional training)	Adults students - medical (not specified)	Undergraduate medical students
Buttussi et al., 2013 Italy	Quantitative - Action research. Pre-post-test design one group	40	Age 24 to 49 years, median - 36, mean 35.5 (SD = 6.4)	Unspecified ACLS providers
Dafli, Fountoukidis, Hatzisevastou-Loukidou, & P, 2019 Greece	Mixed method (unspecified) Post-test design one group only	252	Adults	Medical teachers and undergraduate doctors
Dillard et al., 2009 USA	Mixed quantitative and qualitative study design.	25	Adult nursing students	Nursing students

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

Author/Country	Study Design	Sample size	Age of participants	Target group
	Post-test design - one group only			
El-Beheiry, McCreery, & Schlachta, 2017 Canada	Prospective cohort study with a control group	49(24 C & 25 Int)	28 years ± 1.6 in the control cohort and 27 years ± 2.4 in the competition cohort.	Post-graduate - Medical doctors
Frøland, Heldal, Sjøholt, & Ersvær, 2020 Norway	Experimental study Pre-post-test design one group	17	teachers (average age 61), 3 students (average age 23), 3 inexperienced first-year students (average age 20)	Undergraduate - Biomedical students
Gauger et al., 2018 USA	Quasi experimental study Post-test design one group only	12	Adults	Post-graduate - Medical doctors
Gourishetti & Manivannan, 2019 India	Comparative cross-sectional study design	20	21 to 45 years	Not relevant
González-Yebra, Aguilar, Aguilar, & Lucas, 2019 Spain	Mixed quantitative and qualitative study design. Post-test design one group only	25	Adult post-graduates and undergraduates	Post-graduate - Unspecified
Graafland, Bemelman, & Schijven, 2015 Netherlands	Cross-sectional survey Pre-post-test design one group	45	25.8 years (SD=0.7) novice trainers, 31.9 years (SD=0.8) for intermediates, 44.6 years (SD=2.3) for experienced trainers.	Post-graduate – Medical doctors (clinical trainers)

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

African Journal of Health, Nursing and Midwifery
ISSN: 2689-9418
Volume 6, Issue 2, 2023 (pp. 53-86)
www.abjournals.org

Author/Country	Study Design	Sample size	Age of participants	Target group
Kowalewski et al., 2017 **Germany**	Quantitative study and Randomized pilot trial	105	23.9 ± 2.3 years and 23.4 ±2.1 years for TS and VR participants, respectively in the randomized pilot trial.	Postgraduate & undergraduate Drs
la Cour, Thomsen, Alberti, & Konge, 2019 **Denmark**	Descriptive quantitative action research. Cross-sectional study design. Pre-post test design one group	31	Adult surgeons and residents	Post-graduate- Medical doctors
Izard et al., 2018 **Spain**	Quantitative study – Pre- post test design one group	128	Health science students (not specified)	Health science students (Physiotherapy, 116 from Medicine, 56 from Nursing, 42 from Occupational therapy and 24 from Dentistry)
Moro, Stromberga, Raikos, & Stirling, 2017 **USA**	Mixed-method Triangulate comparative study. Randomized - control group	59	20.7 ± 5.5 years	Undergraduate - health science students
Moro, Štromberga, & Stirling, 2017 **USA**	Quantitative comparative study Post-test design - multiple groups	20	19.80 ± 2.9 years	undergraduate - mixed health science students

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

Author/Country	Study Design	Sample size	Age of participants	Target group
Ofosu-Ampong, Boateng, Thomas, & Kolog, 2020 **Ghana**	Descriptive cross- sectional study Post-test one group only	185	66.5% 17-23 years old. 16.2% were 24-30 years. 17.3% were 31 years and above.	Undergraduate - unspecified
Parham et al., 2019 **Zambia**	Descriptive study design	Not specified	Not specified	Post-graduate - Medical doctors
Salvetti, Gardner, Minehart, & Bertagni, 2019 **USA**	Descriptive study design Post-test one group only	Not specified	Not specified	Clinicians
Verdaasdonk et al., 2009 **Netherlands**	Quantitative correlational study design. Cross-sectional study design. Post-test one group only	31	The median age was 30 years (range, 23-56 years)	Post-graduate - Medical doctors
Wong, Chue, Jong, Wye, & Kei, 2018 **Singapore**	Qualitative and cross-sectional survey (Mixed method) Post-test one group only	30	Mean age - 40 years (SD 7.1)	Clinicians - Medical doctors & nurses
Wynn, Lykoudis, & Berlingieri, 2018 **UK**	Descriptive study design Post-test one group only	20	Adult (surgeons – not specified)	Post-graduate - Medical doctors
Yoganathan, Finch, Parkin, & Pollard, 2018 **UK**	Prospective randomized control trial	40	Adult (doctors not specified)	Undergraduate - medical students

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

Table 3: Studies Outcomes – TPACK Model

Author/year	Technology	Pedagogy	Content /Knowledge	Outcomes
(Antoniou, Dafli, Arfaras, & Bamidis, 2017)	Repurposed virtual patients in a living lab environment (mixed reality educational space)	Web based virtual patient (VP) Gamified educational approach	Content, functionality, and user engagement of repurposed VPs in the living lab.	Evaluators reported educational scenario, implemented through the LL VP case enhances decision-making and elicits clinical reasoning skills in trainees
(Birt, Moore, & Cowling, 2017)	Mobile mixed reality simulation using bring your own device (BYOD) technology	Traditional skills training	(airway management focusing on direct laryngoscopy with foreign body removal)	Significant improvement in test scores for students who were provided with the paramedic simulation tools (Mean=2.53; SD=1.45) than those who were not exposed (Mean=1.96; SD=1.51) prior to residential school.
(Boeker, Andel, Vach, & Frankenschmidt, 2013)	Game-based e-learning (GbEl) instruction with a conventional script-based instruction in the teaching of phase contrast microscopy urinalysis	Routine training conditions (Not explicitly described)	"Phase contrast microscopic urinalysis on native urine" in a conventional script-based approach, and the intervention group (GbEl) learned the topic with an electronic adventure-game.	Higher attitude scores in enjoyment of the learning experience, desire for further learning of this style, and self-assessment of achieved knowledge for the GbEl group (Wilcoxon-test: $p < 0.001$ for all three differences)
(Buttussi et al., 2013)	3D scenario-based simulation game	Not explicitly explained	Evaluation of a 3D serious game for advanced life support retraining.	Improved ALS knowledge and skills after using the 3D serious game. There was a decrease in ALS knowledge and skills after 3 months
(Dafli, Fountoukidis, Hatzisevastou-Loukidou, & P, 2019)	Virtual patients (VPs)	Not clearly explained	Evaluation of VP design process and curricular integration, learning and clinical reasoning experiences	Most participants (83.3%) approved that educational activities based on VPs are more interesting than traditional ones. All teachers (100%) agreed that VPs contribute to the development of clinical skills through practice in clinical decision making.

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

African Journal of Health, Nursing and Midwifery
ISSN: 2689-9418
Volume 6, Issue 2, 2023 (pp. 53-86)
www.abjournals.org

Author/year	Technology	Pedagogy	Content /Knowledge	Outcomes
(Dillard et al., 2009)	Tanner's model of clinical judgment and Lasater's Clinical judgment rubric in a simulation	Simulation Not explicitly specified	Simulation requiring provision of care to a patient with heart failure (HF)	Faculty were satisfied with the development workshop with implementation of workshop objectives. Students reported that they understood each of the concepts across the learning objectives in the simulation. Faculty could identify a student's clinical judgment skills from the written work, identify performance deficits and strengths and use these to modify the student's future learning goals.
(El-Beheiry, McCreery, & Schlachta, 2017)	Virtual reality laparoscopic simulator	Not explicitly described	Serious game skills competition on voluntary usage of a laparoscopic simulator	Residents in the competition cohort were significantly faster at peg transfer (194 ± 66 vs. 233 ± 53 s, 95 % CI of difference = 4–74 s; p = 0.03) and significantly decreased their completion time by 33 ± 54 s (95 % CI 10–56 s; paired t test, p = 0.007). Those in the competition cohort were significantly more likely to continue using the laparoscopic simulator voluntarily after completing their course requirements (50 vs. 7.7 %, p = 0.03; Fisher's exact test).
(Frøland, Heldal, Sjøholt, & Ersvær, 2020)	StikkApp(a gamified application for practicing the phlebotomy process) mStikk(mobile application) and wStikk(web version)	Not clearly explained	Games on mobiles via web or virtual reality technologies	Positive opinions for mobile-based learning games: 4.2.1. mStikk: User Experiences with Respect to Testing the Phlebotomy Learning Application on Mobiles They considered the application to be something they wished they could have had

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

Author/year	**Technology**	**Pedagogy**	**Content /Knowledge**	**Outcomes**
				available when they first learned the procedure. the opinions of teacher users were the most nuanced in relation to providing exact requirements for technical support and for other procedures that could be supported by SSGs.
(Gauger et al., 2018)	Virtual reality -3D printed laryngotracheal model produced with computer aided design	Not explicitly reported	Cricothyroidotomy skills maintenance program (CSMP) on needle cricothyroidotomy	Improved knowledge (pre=3.31, post=4.46, p=0.003), Improved procedural time (pre=96.64, post=72.82, p=0.12), Improved self-reported confidence (pre=1.69, post=3.08, p=0.001), Improved performance quality in the global test (pre=0.20, post=0.70, p=0.001) Checklist (pre=0.51, post=0.90, p=0.001)
(Gourishetti & Manivannan, 2019)	model for both the immersive virtual reality (IVR) and non-immersive virtual reality (NIVR)	Not clearly explained	IVR and NIVR needle insertion simulation	Just noticeable difference (JND) in the IVR is better than that of the NIVR Overall participants performance for both the experiments wad significantly different at the $p < 0.5$ level across four different forces (one- way repeated-measures ANOVA, $F(1, 38) = 4.09$, $p < 0.001$)
(González-Yebra, Aguilar, Aguilar, & Lucas, 2019)	3D Virtual Immersive Environment (Second life)	Synchronous distance learning in immersive 3D environments(I3DE)	satisfaction and perception with part-time classroom attendance in immersive 3D environments(I3DE)	Reported high degree of satisfaction with 13DE use of SL as a teaching–learning resource.

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

Author/year	Technology	Pedagogy	Content /Knowledge	Outcomes
(Graafland, Bemelman, & Schijven, 2015)	Serious game to optimize situation awareness in the Minimal Invasive Surgery (MIS) environment	Hands-on instruction. Off-site training environment	serious game on a laptop computer on to reduce misclassification of signals (major and minor problems) during MIS surgical theatre that originate outside of the direct line of sight	There were no significant differences among the groups (Operating room nurses, surgical residents, and licensed surgeons) Important medical constructs were represented realistically (64.4%–88.9%) and indicated the game to be particularly useful for training operating room nurses and surgical residents (75%–86%). Both educators and trainees found the game to be useful for surgical training (53%). Serious gaming was viewed as positive (78%) and challenging (60%), and 66% would play the game in their leisure time. Licensed surgeons perceived the game more frequently as boring than the intermediate- level and trainee groups (23.5% versus 6.7% and 8.3%; P = .045)
(Kowalewski et al., 2017)	Gaming application for laparascopy(TS), Virtual reality(VR) trainer for laparascopy	Not clearly described	Laparoscopic cholecystectomy (LC) module of Touch Surgery™ (TS). Used for basic knowledge training, visualization and multisensory learning	Surgeons outperformed students with TS: patient preparation (students = 45.0±19.1%; surgeons=57.3±15.2%; p<0.001), access and laparoscopy (students=70.2±10.9%; surgeons=75.9±9.7%; p=0.008) and LC (students=69.8±12.4%; surgeons=77.7±9.6%; p<0.001). The group that trained first on the VR trainer achieved significantly higher scores for cholecystectomy (module 3) compared to the TS group (TS group: 65.3±11.9%; VR group: 74.1±11.5%; p=0.010). Both groups required the same operation time (TS group: 764.7±373.7 s; VR group:

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

African Journal of Health, Nursing and Midwifery
ISSN: 2689-9418
Volume 6, Issue 2, 2023 (pp. 53-86)
www.abjournals.org

Author/year	Technology	Pedagogy	Content /Knowledge	Outcomes
				727.7±293.8 s; p=0.711) on the VR trainer to complete the first virtual LC operation.
(la Cour, Thomsen, Alberti, & Konge, 2019)	EyeSI virtual reality simulator of ophthalmic surgery	Not clearly described	transfer of skills from the EyeSI cataract module to the EyeSI vitreoretinal module.	EyeSI training statistically significantly ($P > 0.05$) improved the OR performance for emerging and intermediately experienced (0-75 cases) surgeons, but not for experienced (76-999 cases) surgeons and experts (1000+ cases). The group of cataract-trained residents did not perform significantly better on the vitreoretinal module than the EyeSI- naïve residents neither in starting score, time to reach maximum performance, and maximum performance score ($P > 0.2$).
(Izard et al., 2018)	virtual reality (VR) simulator for a scoliosis surgical procedure.	Not clearly explained	Interactive 360 content system and an Interactive virtual reality medical simulator 9 to teach different tools in surgery	The virtual simulator is a first step towards developing more complex and detailed simulations of surgeries to help medical professionals to better understand the surgical processes, and serve as a tool to practice in a virtual environment and become familiar with the different tools used in surgery.
(Moro, Stromberga, Raikos, & Stirling, 2017)	Virtual reality, Augmented reality and tablet-based application	? Face to face (Narration by the surgeon)	structural anatomy utilizing virtual reality (VR) or augmented reality (AR) - computerized interactive 3D model of a skull and a 10-minute audio-stream narrated by a specialist surgeon.	There was no significant difference observed in anatomical test scores between the three groups ($P = 0.874$). VR participants were more likely to exhibit adverse effects such as headaches (25% in VR $P < 0.05$), dizziness (40% in VR, $P < 0.001$), or blurred vision (35% in VR, $P < 0.01$).
(Moro, Štromberg a, & Stirling, 2017)	Virtual reality headsets, the Oculus Rift and Gear VR	Not clearly described	Comparison between desktop- based (Oculus Rift) and mobile- based (Gear VR) virtual reality	Participants in Gear VR group experienced a significant increase in the severity of two symptoms: disorientation and blurred vision

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

Author/year	Technology	Pedagogy	Content /Knowledge	Outcomes
		(Online questionnaire narrated by a surgeon)		(p = 0.029). Significantly more participants selected strongly agree when rating the user- friendliness (p = 0.024), instructions and labels (p = 0.007) and comfort using the module (p = 0.012)
(Ofosu-Ampong, Boateng, Thomas, & Kolog, 2020)	Gamification in learning management systems	Not clearly described	Gamification research in LMS and to test students' intentions to adopt gamification using an extended model	The internal consistency of the model was strong at 0.862 representing 86% reliability of the constructs with a p value of P<0.001 Individual reliabilities of the constructs were strong (Performance Expectancy – 0.85, Effort Expectancy – 0.84, Attitude – 0.84, Facilitating Conditions– 0.86, Trust – .87, Image – .86 and Behavioural Intention – 0.87).
(Parham et al., 2019)	Virtual reality surgical simulation (VRSS) for a total abdominal hysterectomy (TAH) with bilateral pelvic lymphadenectomy	Online didactic lectures plus Virtual reality surgical simulation plus a mentor	in-home computer gaming aimed at improvement in skills for conducting radical surgery for the treatment of invasive cervical cancer	A high-fidelity VRSS reflects the reality of the procedure developed with pre-set hardware technical specifications to ensure its affordability, portability and robustness in resource-limited environments is useful for rigorous pre-clinical and clinical research and testing.
(Salvetti, Gardner, Minehart, & Bertagni, 2019)	Augmented and virtual reality technology (eREAL) in a real classroom	Not clearly described	Interactive videos and visual storytelling on e-REAL with rapid cycle deliberate practice	Early findings showed that an interactive learning environment was an effective simulation tool for Labor and Delivery because it offers realistic scenarios that can be easily reconfigured to generate many different situations, including extreme and dangerous ones. Learners were able to rapidly cycle between deliberate practice and directed feedback within a high-fidelity simulation scenario until mastery was achieved.

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8

Author/year	Technology	Pedagogy	Content /Knowledge	Outcomes
(Verdaasdonk et al., 2009)	Laparascopic virtual reality simulator	Not clearly described	Serious gaming and voluntary laparoscopic skills training	More than 30 attempts resulted in a significantly higher final score than reached by participants who performed between ten and 30 attempts (Mann-Whitney, p=0.008). Motivation to learn score did not correlate with the final score on the simulator (Pearson correlation coefficient was 0.331, p = 0.088)
(Wong, Chue, Jong, Wye, & Kei, 2018)	CPR plus automated external defibrillator (AED) VR Simulation	Not clearly described	Cardiopulmonary resuscitation (CPR) using Virtual reality (VR)	VR was viewed as having potential as a blended learning tool, targeting both 'novice' and 'experienced' health professionals. CPR instructors in the study saw VR as having potential to manage the limitations of health professionals' CPR education such inadequate resources, insufficient practice opportunities, lack of motivation, sub-optimal frames of mind
(Wynn, Lykoudis, & Berlingieri, 2018)	Virtual reality simulator for laparoscopic colorectal resection	Not clearly described	A structured VR colorectal curriculum that describes the development of advanced laparoscopic skills	Time that participants needed to complete the task reduced significantly (p < .001). Time to complete the procedure (35 min for the expert's vs 69 min for the trainees; p < .001), Number of movements of right and left instrument (2581 vs. 4785; p < .001, and 849 vs. 2234; p < .001 respectively) and total path length (cm) of right and left instrument (4291 vs. 7072; p < .001 and 1599 vs. 3652; p=.003 respectively).
(Yoganathan, Finch, Parkin, & Pollard, 2018)	360 degrees Virtual reality (VR)video	Face to face teaching	Comparison of 360 degree VR video and conventional 2D video in the acquisition of knot tying skills	Using video teaching alone, knot tying scores were significantly better in the 360-degree. VR video arm (median knot score 5.0 vs 4.0 p=0.04) More people in the 360-degree VR video arm constructed a complete knot than in the 2D arm (17/20 vs 12/20). No difference between the groups existed in the time taken to construct a reef knot (median time 31.0s vs 30.5s p=0.89)

Article DOI: 10.52589/AJHNM-MFH6YYS8
DOI URL: https://doi.org/10.52589/AJHNM-MFH6YYS8