Enhancing Nursing Education Through Affordable and Realistic Holographic Mixed Reality: The Virtual Standardized Patient for Clinical Simulation

Sean W. Hauze, Helina H. Hoyt, James P. Frazee, Philip A. Greiner, and James M. Marshall

Abstract

Nurses serve a valuable role in the healthcare industry. Nurses are trained with the skills and knowledge to thrive in a fast-paced, evolving environment. In order to meet the complex and diverse needs of patients, nurses must be able to assess and prioritize care to produce safe and high-quality outcomes. Simulation is an established method of educating nursing students and preparing nurses to respond appropriately to situations they are likely to encounter in practice. Traditional nursing simulation devices are prohibitively expensive for many nursing education institutions. The development of augmented, mixed, and virtual reality simulation delivery offers a new platform for simulation, known as *immersive simulation*. Immersive simulation can virtually place nursing students in situations that are difficult to arrange in actual clinical practicums or that occur rarely but for which nurses need to be prepared. Additionally, the hardware required to deliver immersive simulation is much cheaper than that of traditional nursing simulation devices. This chapter describes the virtual standardized patient application delivered via mixed reality immersive simulation. This chapter also discusses the research initiative currently underway to assess student perceptions to this modality of health training simulation.

Keywords

Nursing education · Technology · Mixed reality · Immersive simulation · Assessment

S. W. Hauze (✉) · H. H. Hoyt · J. P. Frazee
P. A. Greiner · J. M. Marshall
San Diego State University, San Diego, CA, USA
e-mail: shauze@sdsu.edu

1 Introduction

Simulation is an important aspect of training nursing students. Once education is complete and licensure is obtained, professional nurses function in an industry that is high-stakes, rapidly changing, and technology-driven (American Association of Colleges of Nursing 2016; National League for Nursing 2015). Pre-licensure nursing education encompasses both theoretical and clinical development. A debate exists about the best method for helping nursing students transition from a novice to a professional role that is safe for students and produces quality outcomes for students and future employers alike (American Association of Colleges of Nursing 2016; Benner et al. 2010; National League for Nursing 2015).

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Nursing educators have embraced simulation as a safe and realistic teaching methodology to help support the clinical development of nursing students for over a decade (National League for Nursing 2015). A study was conducted in the United States by the National Council of State Boards of Nursing (NCSBN) to explore the role and outcomes of simulation in pre-licensure nursing education. This landmark research provided substantial evidence to support simulation being used as a substitute for up to 50% of traditional clinical experiences when delivered through evidence-based methods (Hayden et al. 2014a; National League for Nursing 2015).

Guidelines by the National League for Nursing (2015) articulated that technology alone does not provide a realistic simulation experience. Evidence-based methods surrounding simulation should include a situation that is purposeful, requires student preparation, involves debriefing, and is related to student learning outcomes (National League for Nursing 2015). Well-designed simulation experiences are built upon concepts of active learning and student mastery. These concepts have repeatedly demonstrated the importance of aligning what is learned in theory to authentic, real-world scenarios (Bandura 1977; Benner et al. 2010; Bloom 1968; Dewey 1938; Ericsson et al. 1993; Freeman et al. 2014; Knowles 1973). A vast array of nursing and non-nursing educational research has shown that simulation can engage students in authentic active learning that is motivating, relevant, and builds confidence (Keller 1987; Larue et al. 2015; Vaughn et al. 2016; Weaver 2011).

1.1 Shortage of Nursing Faculty

Multiple competing forces are creating a need to transform the nursing educational system in the United States (American Association of Colleges of Nursing 2016; Benner et al. 2010). A current shortage of nurses is being compounded by an insufficient number of faculty (American Association of Colleges of Nursing 2016, 2017). According to the American Association of Colleges of Nursing (2017), the professional nursing workforce is expected to have more than one million job openings as 2020 approaches. The nursing faculty shortage is attributed as one of two critical reasons for the looming shortage (American Association of Colleges of Nursing 2016). The faculty shortage is complex and perpetuated by multiple factors. These include an aging faculty, looming retirements, non-competitive faculty salaries, burdensome workloads, and insufficient educational pathways for nurses to obtain the appropriate credentials to serve as nursing faculty (American Association of Colleges of Nursing 2016; National League for Nursing 2015).

Strategies to overcome the nursing faculty shortage have centered around both short- and long-term approaches to the problem. Short-term strategies involve the use of academic innovation that could increase the effectiveness of undergraduate nursing education through immersive and standardized simulation experiences (American Association of Colleges of Nursing 2016). The use of simulation to enhance teaching and clinical experiences despite a shortage of faculty could prove beneficial for regions that are especially hit hard by the shortage, such as rural communities.

1.2 Lack of Clinical Placements

A lack of undergraduate student nursing clinical placements is the second critical constraint to increasing student enrollment for nursing schools across the United States (National League for Nursing 2015). The National League for Nursing (NLN) and the American Association of Colleges of Nursing (AACN) are the two professional organizations that monitor pre-licensure nurse training programs and provide data about the obstacles to expanding educational capacity within the United States. A study among various types of pre-licensure nursing programs from 2012 to 2014 indicated 49% of Associate Degree Nursing programs and 41% of Bachelors of Science in Nursing programs have turned qualified applicants away because of the inability to provide appropriate clinical placements within their respective region (National League for Nursing 2015). Similarly, AACN conducts an annual survey of pre-licensure baccalaureate nursing programs. In their 2016 Report on Enrollment and Graduations in Baccalaureate and Graduate programs in Nursing, a majority (72.9%) of pre-licensure baccalaureate nursing programs reported insufficient clinical sites as a reason for not admitting more students (AACN 2016). Without alternative solutions to the clinical placement constraint, the impact will be potentially catastrophic (National League for Nursing 2015).

Simulation may provide a solution to this shortage in clinical placements. In a study by (Hayden et al. 2014b), findings concluded that simulation can be a successful substitute for traditional clinical experiences. This landmark study provided the basis for the National Council of State Boards of Nursing (NCSBN) to allow state boards and schools of nursing within the United States to substitute up to 50% of traditional clinical experiences when delivered through an evidence-based framework. The NLN has further developed a simulation framework that is widely used as the theoretical foundation for nursing simulation development and conducting research in the field around simulation use and its effectiveness (Jeffries 2005; Jeffries 2012; National League for Nursing 2015).

1.3 Potential for Immersive Simulation

Recent advances in immersive technologies makes possible a new kind of simulation, with potential to transform health education simulation. Virtual reality (VR), augmented reality (AR), and mixed reality (MR) technologies enable the user to interact with and control virtually-displayed components within virtual and physical environments. The combination of both physical and virtual components enables the user to practice low-frequency, high-risk scenarios within the safety of the classroom or clinical skills lab. While the research on such technologies is limited, early studies of immersive technology devices, such as Google Glass, showed positive effects on nursing student confidence (Vaughn et al. 2016).

Traditional simulation falls short in addressing the lack of available clinical placements due to the cost-prohibitive nature of high-fidelity manikin simulators, space and maintenance costs, and costs related to staffing. Innovation in the field of immersive technology provides a promising new alternative for high quality simulation at an affordable price. While this approach is attractive in terms of portability and affordability, the effectiveness of this immersive technology simulation to provide a motivating learning experience has not been thoroughly investigated.

2 Background

2.1 History of Simulation in Nursing Education

There is a rich history of simulation being used in nursing education. "Mrs. Chase" was the first patient simulator on record being used in the Hartford Hospital Training School for Nurses in 1911 (National League for Nursing 2015). Mrs. Chase was a life-sized adult doll with movable joints. Nurse educators used the doll to allow nursing students the ability to practice safely turning patients within a hospital bed. There was no interaction or realistic-feel to the original "Mrs. Chase."

Several advances have been made in technology and the use of simulation since Mrs. Chase. Nurse educators built upon previous simulation research that centers on student satisfaction and confidence to continually improve simulation so that it is more realistic and interactive (Hayden et al. 2014a). New methods provide not only learning opportunities for students but evaluation opportunities as well. There is a call for educators to continue to measure student satisfaction and confidence with simulation, as well as develop methods to measure knowledge and skill acquisition (Hyaden et al. 2014a; National League for Nursing 2015).

Currently, nurse educators utilize multiple modalities of simulation to enhance student learning and encourage skill mastery. A robust body of evidence exists surrounding use of traditional methods of simulation in nursing education. It showcases the rich learning opportunity for students to enhance assessment skills, develop the ability to become adept at clinical reasoning, work in teams, and receive immediate feedback on care provided during the simulation (National League for Nursing 2015).

Nursing simulation has helped bridge the gap between theory and real-time clinical decisions in an environment that is risk-free to patients and students. Evidence based methods of delivering simulation in an effective manner are rapidly changing. Not all schools have faculty who are experts in simulation or the ability to benefit from the latest equipment that offers better integration of simulation into the curriculum and to substitute for real-world clinical experiences (American Association of Colleges of Nursing 2016; National League for Nursing 2015).

The International Nursing Association for Clinical Simulation and Learning (INACSL) identified key concepts that guide simulation in nursing education. According to INACSL (2016), a consistent terminology is important to guide simulation experiences, research, and literature. The following definitions from INACSL (2016) are commonly used:

- AR technologies overlay digital objects into the real-world physical environment.
- Clinical relates to learning in a real or simulated environment and provides opportunities for students to apply knowledge, skills, and attitudes.
- Clinical judgement involves a process of making decisions and taking action.
- Clinical reasoning is identified as the capability of a person to gather and understand data while remembering certain knowledge, skills, and attitudes, about the situation as it develops.
- A clinical scenario gives the context for a particular simulation and can vary in length, difficulty, and design based on student learning outcomes.
- Clinical thinking is a disciplined process that allows an individual to be purposeful, goal-oriented, and scientific in methodology.
- Evaluation is the appraisal of data and involves a judgment that is based upon quality measures versus a standard measure.
- Fidelity is the degree to which a simulation experience is authentic. Creating fidelity that is realistic involves several dimensions (environment, equipment, psychological factors, social factors, culture) and an element of trust between participants.
- High-fidelity simulation involves large scale computer driven experiences such as patient simulators, virtual reality, or standardized patients. These experiences seem realistic and are highly interactive.
- Low-fidelity simulation involves experiences that are naturally static like manikins, use of case studies and role-playing.
- Mixed reality (MR) devices provide an ability to combine both the physical and virtual worlds and create a realistic and immersive experience.
- Pedagogy is the art and/or science of teaching.
- Simulated-based learning experience involves a combination of strategic activities that recreate real-world situations in a pretend environment with a case study that unfolds.
- A standardized patient is a person trained to act as a patient with a scripted scenario.
- Virtual reality (VR) is a term that can be used for virtual, augmented, and mixed reality. This technology is unique in that it transports the user into a constructed reality environment outside of the current physical environment.

2.2 Nursing Simulation Modalities

Nursing education relies heavily on simulation as a proven method for nursing students to master objectives to achieve safe, high quality care practices (McGaghie et al. 2011). These nursing sim-

Table 1 Nursing simulation modalities

Modality	Cost	Definition	Example
Partial task trainer	$500–$20,000	Low-tech simulation manikins and models used for specific scenario training	Plastic arm for intravenous procedures
High-Fidelity Manikin	$10,000–$200,000	Computerized patient simulation manikins used for a wide array of critical medical scenarios	SimMan simulation manikin
Standardized Patient	$20–$40 per hour	A patient actor trained to role-play specific medical scenarios	A patient actor with makeup displaying symptoms of anaphylaxis

ulation modalities are employed across all levels of nursing education, spanning the continuum of nursing fundamentals to advanced nursing courses. Along with coursework and clinical experience, simulation is a key component for transforming nursing students from novice to expert (Benner et al. 2010). Simulation requires nursing students to acquire knowledge, make sense of the learning, make use of the learning, assimilate learning, and transfer the learning into the patient care setting (Decker et al. 2008).

Table 1 outlines costs, definitions, and examples of commonly utilized nursing simulation modalities, including partial task trainers, high-fidelity computerized simulation manikins, and standardized patients (Decker et al. 2008; Jeffries et al. 2009).

The challenges nursing education faces to meet increasing demand with limited resources makes traditional simulation cost-prohibitive for many institutions, particularly those in rural areas (Lapkin and Levett-Jones 2011; National League for Nursing 2015). For example, nursing students at the San Diego State University – Imperial Valley campus do not have access to high-fidelity nursing simulation, with the nearest high-fidelity simulation center located over 100 miles away. The recent innovation in the field of immersive technology may provide a new modality for high quality simulation for institutions in need of high-quality simulation at an affordable price.

2.3 Immersive Technologies: Virtual, Augmented and Mixed

Immersive technology exists as a continuum of modalities ranging from fully virtual environments that transport the learner in time, space, and scale to holographic overlays on our real environment, enabling users to view digital content in immersive, real world contexts. Milgram and Kishino (1994) established a taxonomy for immersive technologies, defining the "virtuality continuum" as an array of immersive simulation modalities as shown in Fig. 1.

As shown in the diagram, one end of the virtuality continuum exists the real environment with the opposite end represented as a fully virtual environment. Within the real environment, AR simulation can bring anything to you in the form of simulated digital content, typically overlaid via a camera and digital display. In contrast, VR—referred to in continuum diagram as augmented virtuality (AV)—brings the users anywhere through immersion in a fully simulated reality that is entirely separate from the real environment. In the center of the virtuality continuum is MR, which blends virtual content with the real environment. Each of these modalities within the virtuality continuum relies on external hardware in the form of monitor-based displays, transparent head-mounted displays (HMDs), and fully immersive HMDs.

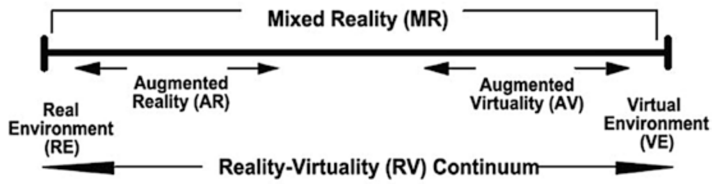

Fig. 1 The virtuality continuum. (Milgram and Kishino 1994, p. 3)

Table 2 Immersive technology modalities

Modality	Cost	Definition	Example
Virtual reality	$5–$800	A fully rendered representation of a virtual environment	Oculus Go
Augmented reality	$100–$1400	An overlay of virtual content onto the real environment	Apple iPhone
Mixed reality	$1000–$3000	A blend of a virtual environment with the real environment, in which virtual objects interact with the physical environment	Microsoft HoloLens

2.4 Recent Advances in Affordable Immersive Simulation

Innovation in the field of immersive technology has increased both the affordability and fidelity of commercially available devices. Recently released headsets include the Oculus Go, Lenovo Mirage Solo, Magic Leap One, and Microsoft HoloLens. Each of these devices enables realistic simulation in one or more of the following modalities, compared in Table 2.

3 Immersive Technology Modalities

Immersive technologies can be categorized into VR, AR, and MR depending on the degree to which the simulation environment is real versus digital. While VR is widely considered the generic term for all immersive technologies, there are many important and distinct functionalities that that differentiate each modality.

Virtual Reality The modality of VR transports the user into an entirely virtual environment outside of physical reality through a digitally constructed rendering (Barsom et al. 2016). The HMDs used for VR fully immerse users in the virtual environment. The leading VR HMDs are HTC Vive and Oculus Rift, both of which were released in the spring of 2016. Both HTC Vive and Oculus Rift require the processing power of a computer equipped with advanced graphics functionality and the Windows 10 operating system. Additionally, external infrared tracking systems devices are required to physically move within the virtual space. Since the release of Oculus Rift and HTC Vive, several standalone VR HMDs were made available at a fraction of the cost. Oculus Go and Lenovo Mirage Solo were released in the spring of 2018 for $199 and $399 respectively. Both the Oculus Go and Lenovo Mirage Solo operate without the need for external computing or tracking hardware. Other VR hardware includes smartphone auxiliary HMD devices, including Google Cardboard and Samsung Gear, that utilize existing computing power and display of smartphones.

The VR modality enables users to interact with simulations within a location or scale appropriate to the content. For example, The Body VR application enables the learner to travel virtually through a three-dimensional representation of the human body at the micro scale. Through the VR hardware functionality, the software enables the learner to navigate within the simulated human body to explore human biological systems.

Augmented Reality The AR modality overlays digital objects within the context of the learner's physical environment. This overlay of virtual content within the physical environment allows learners to visualize relationships between physical and virtual content, as well as simulate low-frequency, high-risk events (Akçayır and Akçayır 2016). AR software utilizes the location tracking, accelerometer, and camera hardware standard in smartphone and tablet devices to deliver immersive simulation through hardware many students already own.

One example of the use of AR simulation is the SkyView mobile application, which utilizes the user's location combined with the accelerometer and front-facing camera built into modern mobile devices to overlay planets, stars, and constellations over the night sky. SkyView provides graphical representations of celestial bodies, along with descriptive annotations.

Mixed Reality The MR modality combines the ability to use physical interactions to control and interact with virtual components (Chiu et al. 2015). As the term *mixed reality* implies, MR combines physical and virtual manipulates resulting in a mixed digital and physical experience. Commercially available MR HMDs include Microsoft HoloLens, Meta 2, and Magic Leap One, each of which enables the user to integrate holographic content within the physical components of the real environment through hand gestures. The hand gestures, as well as objects in the physical space, are mapped and recognized through infrared sensors on the front of the HMD. Simulation delivered via the MR modality enables learners to interact with virtual content integrated into the physical environment. This combination of virtual and physical elements enables MR to be particularly effective for scenarios in which the physical environment is important to the learning task, such as a clinical setting in which nursing students practice.

4 Economic Projections for Immersive Technology

The innovation in immersive technology is projected to generate major economic activity, with *Business Insider* projecting the immersive technology market to reach $162 billion by the end of 2019 (Blodget 2016). International educational content publishers recognize immersive technology is poised to become a dominant mode of information and knowledge transfer and are therefore investing in the development of educational content. Pearson and other publishers are currently investing heavily in these new technologies, with the potential to impact millions of students globally (Meyer 2016). The technological innovation in hardware, combined with the investment in educational immersive simulation software development, creates the potential for immersive simulation to transform education. There is therefore a strong need to empirically assess the efficacy of immersive technology through the scholarship of teaching and learning.

4.1 The NLN Simulation Framework

The National League for Nursing/Jeffries Simulation Theory (Jeffries 2005, 2012) is widely used as the theoretical foundation for implementation and evaluation of nursing simulation use and efficiency within the United States and beyond (Jeffries and Rogers 2007; Young and Shellenbarger 2012). The model blends experiential learning and technology as a method to enhance learning and skill performance for students. The framework helps articulate the unique experiences that exist within clinical simulation and offers a way to disseminate best practices. The framework builds upon perspectives of expert simulation researchers and is the foundation for future discoveries.

NLN Jeffries Simulation Theory identifies multiple variables that exist to produce desirable outcomes for the system, patient, and participant (Jeffries and Rogers 2007; National League for Nursing 2015). The framework identifies the importance of a process that begins with background and design leading to the simulation experience. The success of the simulation experience depends upon an environment of trust, leading to a learner centered experience that is collaborative, interactive, and experiential (National League for Nursing 2015). The dynamic interaction between the facilitator and student must be directed by strong educational strategies (National League for Nursing 2015).

4.2 Student Motivation and the ARCS Model

Several recent studies of augmented reality devices, such as Google Glass, showed positive effects on student confidence, satisfaction, and motivation (Akçayır and Akçayır 2016; Vaughn et al. 2016). One of the educational frameworks most used to evaluate student motivation to learn is John Keller's ARCS model (Keller 1987, 1999, 2010). The ARCS model asserts that motivation to learn is comprised of the degree to which the learner becomes engaged in the learning experience through elements of attention, relevance, confidence, and satisfaction. To measure the four constructs of the ARCS model, Keller (1993) developed the Instructional Materials Motivation Survey (IMMS). This instrument was created to measure and identify issues related to student motivation to learn with the use of self-directed learning materials, therefore the IMMS is an appropriate research instrument to measure nursing motivational attitudes toward the use a self-directed immersive simulation.

4.3 Educational Potential of Immersive Simulation

Immersive technologies offer a new simulation modality with the potential to transform education across the medical field. Several recent studies have explored the use of immersive simulation in medical education, particularly in the anatomy curriculum. Anatomy education presents challenges due to financial, ethical, and supervisory restraints with using human cadavers. Immersive technology provides an alternative through simulation of interactive, photorealistic anatomical representations of human anatomical systems. Immersive simulation also provides safe, realistic, and meaningful practice complex scenarios such as disaster relief, medication administration, and psychiatric care (Smith and Hamilton 2015; Ulrich et al. 2014; Vottero 2014).

The use cases for immersive simulation in education extend beyond the field of medicine. Studies across astronomy, chemistry, mathematics, and social sciences indicate immersive technology promotes both affective and cognitive student gains. This research includes the use of immersive simulation to promote science learning through hands-on interaction, virtual introduction to chemistry concepts, and increased astronomical knowledge retention (Cai et al. 2014; Chiu et al. 2015; Salmi et al. 2016; Zhang et al. 2014). As previously discussed, immersive technology is also shown to be effective in increasing student motivation (Vaughn et al. 2016; Akçayır and Akçayır 2016).

4.4 Use Cases Within Nursing Education

There are many opportunities for the use of virtual standardized patient simulations within undergraduate nursing education. According to Skiba (2016), the classroom lecture of today is waning as the primary teaching method in undergraduate nursing education. Interactive technologies provide more project-based, inquiry-driven learning experiences. Virtual simulation shows great promise when used in cases that deal with high-risk to patients involved (Skiba 2016). According to Decker et al. (2008), learning with simulation requires gaining knowledge, making sense of the knowledge, and then making use of the knowledge. Ultimately, the goal is for the assimilated learning to transfer into clinical readiness skills in a real-world setting. Best practices in simulation have been identified when it is integrated throughout the entire undergraduate nursing curriculum, increases in difficulty, aligns with student learning outcomes, and uses the appropriate tools for both teaching and measurement (Decker et al. 2008; National League for Nursing 2015).

The New Media Consortium (NMC) (2017), identified ten big picture themes that are positioned to impact teaching, learning, and innovation in higher education. The themes are a result of seventy-eight experts partnering with the EDUCAUSE Learning Initiative (ELI) to outline the 5-year impact of higher education innovation across the globe. The NMC Horizon Project is seen as education's longest-running exploration of new technology practices. The following ten themes outline what institutions should know about the use of technology to improve, support or extend teaching, learning, and creative inquiry: (1) Student success should be at the center of institutional learning approaches, (2) real-world skills are needed to ensure students are prepared for the workplace, (3) collaboration is key for scaling effective solutions, (4) inequity regarding student access to technology in education must be addressed, (5) educators must develop new ways to evaluate acquisition of individualized vocational skill, competencies, creativity, and critical thinking, (6) digital fluency is critical, (7) multiple strategies for integrating blended learning must showcase enriched learning outcomes, (8) learning ecosystems must be flexible enough to embrace the future practices, (9) higher education must be a developer of intuitive technology that responds to human interaction, and (10) lifelong learning must be fostered by higher education (Becker et al. 2017).

Recent undergraduate nursing studies showcase concepts of the EDUCAUSE movement and lay the foundation for immersive technologies to be safe, realistic, and meaningful. Limited studies exist, but there is promise for situations where teaching complex assessments are difficult to simulate such as a disaster (Ulrich et al. 2014), for administering medication within a busy environment (Vottero 2014), and when encountering a patient with psychiatric signs and symptoms (Smith and Hamilton 2015). Additionally, virtual technologies have been shown to be effective for technical skill acquisition for invasive procedures such as urinary catheter insertion (Smith and Hamilton 2015), hazardous chemical decontamination (Ulrich et al. 2014), and communicating with mentally ill patients (Kidd et al. 2012).

Discussion from individual studies within undergraduate nursing have identified four positive concepts regarding use of virtual simulation: (1) Virtual simulation is promising for knowledge and skill acquisition, (2) the technology creates an opportunity for student centered learning experiences, (3) the technology can be a safe and realistic evaluation method, and (4) the technology is user friendly and able to help save vital academic space. The main concern articulated by the initial researchers surrounds early coordination in the planning phase with instructional designers to ensure that the simulation experience is related to student learning outcomes, realistic, and not a distraction to the particular scenario or skill that should be the focus of the experience (Berndt 2014; De Gagne et al. 2013; Fisher and King 2013).

Immersive simulation is a new theme that shows promise for low-frequency, high-stakes scenarios that are difficult to replicate with current nursing simulation modalities. These modalities are sparking interest among nurse educators because they are less expensive and able to provide a standardized patient within a more immersive environment. The use of virtual simulation is changing rapidly and there is a need for research to assess this evolution (Doolen et al. 2016).

5 The Virtual Standardized Patient

5.1 Meeting the Need for Affordable, Realistic Nursing Simulation

In October of 2016, SDSU's Instructional Technology Services and School of Nursing partnered with Texas Tech University, Microsoft, and

Pearson to develop the virtual standardized patient (VSP) simulation. Our research is focused on the use of the Microsoft HoloLens as a simulation tool for nursing students to deliberately practice addressing such low-frequency, high-risk scenarios. A nursing student rarely witnesses a patient exhibiting the full array of symptoms related to anaphylactic shock, thus this clinical experience is currently supplemented using written case studies. In order to simulate anaphylaxis, a holographic video for the VSP captured a standardized patient actor portraying symptoms of anaphylaxis. The holographic video was recorded using an array of 25 infrared cameras and 100 video cameras. The holographic video was then built into a Microsoft HoloLens application using the Unity game development engine.

The VSP interactive functionality allows a nursing student to view the holographic video of the standardized patient exhibiting symptoms of anaphylaxis overlaid onto a physical hospital bed in a clinical teaching facility. The student can walk around the patient and observe the symptoms as they advance the application through the three stages of anaphylaxis. The development of simulation similar to the VSP provides a much more affordable and transportable simulation modality compared with traditional nursing simulation, however research is needed to determine the outcomes on nursing student skills, knowledge, and motivation to learn.

5.2 Description of the Study in Progress

The study currently in progress included baccalaureate nursing students (n = 161) enrolled in three levels of nursing courses at San Diego State University, both at the main campus and at the Imperial Valley satellite campus located 115 miles east of San Diego in Calexico, California. The three levels are defined as level 1 (n = 65), consisting of students familiar with reading case studies with no formal clinical experience; level 2 (n = 60), consisting of students with basic clinical experience; and level 3 (n = 36), consisting of students with extensive clinical experience. The research questions guiding the study include:

1. Does baccalaureate nursing student motivation to learn differ as a result of the modality of instruction employed among (a) a written case study; (b) a written case study plus two-dimensional video; and, (c) a written case study plus three-dimensional, mixed reality anaphylaxis simulation delivered via the Microsoft HoloLens?
2. What factors predict nursing student motivation to learn through mixed reality anaphylaxis simulation delivered via the Microsoft HoloLens?
3. Does baccalaureate nursing student knowledge, of anaphylaxis, differ as a result of the modality of instruction employed among (a) a written case study; (b) a written case study plus two-dimensional video; and (c) a written case study plus three-dimensional, mixed reality anaphylaxis simulation delivered via the Microsoft HoloLens?
4. Does baccalaureate nursing student intervention, for anaphylaxis, differ as a result of the modality of instruction employed among (a) a written case study; (b) a written case study plus two-dimensional video; and (c) a written case study plus three-dimensional, mixed reality anaphylaxis simulation delivered via the Microsoft HoloLens?
5. What variables predict nursing student knowledge and/or skill when the modality of instruction employed is mixed reality anaphylaxis simulation delivered via the Microsoft HoloLens?

All students enrolled in the three levels of courses during the Fall 2017 semester were invited to participate. Participating students were stratified and randomly assigned to one of the following groups: Research group 1, which provided students with an anaphylaxis written case study containing two-dimensional still images (n = 54); research group 2, which provided students with an two-dimensional video VSP anaphylaxis simulation via a computer monitor plus a written case study (n = 54); and research group 3, which provided students with a three-dimensional, MR VSP anaphylaxis simulation via the Microsoft HoloLens plus a written case study (n = 53).

All participants received written instructions accompanied by the anaphylaxis case study. Each student completed a pre-survey to collect data related to previous clinical and simulation experience. Upon finishing each anaphylaxis observation, participants completed a knowledge measure to determine understanding of the content conveyed in the corresponding observation. The data collection instruments are outlined below.

Pre-survey The pre-survey portion of the research instrument was used to determine demographic information (age and nursing level), previous clinical experience, previous immersive simulation experience, and previous nursing simulation experience.

Case Study The case study selected for the VSP was centered on anaphylaxis. Anaphylaxis is a severe, life-threatening allergic reaction. It can occur within seconds or minutes of exposure to an allergen. The VSP scenario for anaphylaxis involved three VSP observations. Each VSP observation showcased a scenario in which the patient demonstrated signs and symptoms of anaphylaxis and increased in severity rapidly. Students experienced the VSP observation through three different methods based upon their randomized research group assignment (video, Microsoft HoloLens, or written case study).

Observation Measures As the VSP scenario unfolded, there were three VSP observation periods that nursing students were prompted to respond to. Upon completion of each VSP observation period, students were asked to complete a set of questions to determine knowledge and skill regarding assessment and intervention in the low-frequency, high-stakes scenario. There was a total of three knowledge questions and two skill questions in observation period one. There was a total of three knowledge questions and two skill questions in observation period two. There was a total of three knowledge questions after observation period three and a total of four overall knowledge questions upon completion of the VSP scenario. Student responses were written on the research instrument scored dichotomously (1 = correct, 0 = incorrect) by the researchers. Knowledge and skill questions, with grading criteria created by the School of Nursing Director, Assistant Director, and the Medical-Surgical I and II Course Coordinator. Knowledge questions were added together to create a total knowledge score for observation period one, two, three, and overall. Skill questions were added together to create a total skill score for observation period one and two.

Post Survey Upon completion of the scenario and knowledge measure questions, each student completed a post-survey related to the simulation experience, focusing on their opinion of the simulation and the degree to which they felt it helped their confidence and motivation. The post-survey included the National League for Nursing (NLN) Student Satisfaction and Self-Confidence (SCLS) in Learning instrument and the Instructional Materials Motivation Survey (IMMS).

5.3 Planned Analysis

The planned quantitative analyses to address the research questions include comparisons of survey responses between the three research groups. Analysis of covariance (ANCOVA) will be used to determine if differences exist between research groups in terms of skills, knowledge, or student motivation to learn. Covariates will include age, digital quotient, clinical experience, simulation experience, and course in which the participant was enrolled at the time of data collection.

In addition to the ANCOVA, factor analysis, path analysis, and structural equation modeling will be used to determine which factors predicted increased skills, knowledge, and motivation to learn when the modality of instruction employed was mixed reality anaphylaxis simulation delivered via the Microsoft HoloLens. Confirmatory factor analysis will be used to determine which variables should be included within the factors.

5.4 Planned Discussion

Discussion of our future analysis will provide quantitative data not currently found in the literature regarding the effectiveness of using mixed reality simulation experience to address low-frequency, high-risk nursing clinical content. The results can be used by policymakers, educators, students, and clinical partners to make evidence-based decisions when contemplating use of simulation modalities to prepare student nurses and licensed nurses for the workforce. Additionally, the potential benefits of the study include determining if mixed reality is a viable means of providing simulation education to nursing students through devices much less expensive than using standardized patient human actors and/or high-fidelity manikin simulators.

References

Akçayır G, Akçayır M (2016) Research trends in social network sites' educational use: a review of publications in all SSCI journals to 2015. Rev Educ 4(3):293–319

American Association of Colleges of Nursing (2016) Advancing healthcare transformation: a new era for academic nursing. American Association of Colleges of Nursing

American Association of Colleges of Nursing (2017) Fact sheet: nursing shortage. American Association of Colleges of Nursing

Bandura A (1977) Self-efficacy: toward a unifying theory of behavioral change. Psychol Rev 84(2):191

Barsom EZ, Graafland M, Schijven MP (2016) Systematic review on the effectiveness of augmented reality applications in medical training. Surg Endosc 30(10):4174–4183

Becker SA, Cummins M, Davis A et al (2017) NMC horizon report: 2017 higher education edition. The New Media Consortium, Toronto, pp 1–60

Benner P, Sutphen M, Leonard V et al (2010) Educating nurses: A radical call for Transformation. Jossey-Bass, San Francisco

Berndt J (2014) Patient safety and simulation in prelicensure nursing education: an integrative review. Teach Learn Nurs 9(1):16–22

Blodget H (2016) The virtual and augmented reality market will reach $162 billion by 2020. http://www.businessinsider.com/virtual-and-augmented-reality-markets-will-reach-162-billion-by-2020-2016-8. Accessed 1 Oct 2018

Bloom BS (1968) Learning for mastery. Regional Education Laboratory for the Carolinas and Virginia, topical papers and reprints 1(2):2

Cai S, Wang X, Chiang FK (2014) A case study of augmented reality simulation system application in a chemistry course. Comput Hum Behav 37:31–40

Chiu JL, DeJaegher CJ, Chao J (2015) The effects of augmented virtual science laboratories on middle school students' understanding of gas properties. Comput Educ 85:59–73

De Gagne JC, Oh J, Kang J et al (2013) Virtual worlds in nursing education: a synthesis of the literature. J Nurs Educ 52(7):391–396

Decker S, Sportsman S, Puetz L et al (2008) The evolution of simulation and its contribution to competency. J Contin Educ Nurs 39(2):74–80

Dewey J (1938) Experience and education

Doolen J, Mariani B, Atz T et al (2016) High-fidelity simulation in undergraduate nursing education: a review of simulation reviews. Clin Simul Nurs 12(7):290–302

Ericsson KA, Krampe RT, Tesch-Römer C (1993) The role of deliberate practice in the acquisition of expert performance. Psychol Rev 100(3):363

Fisher D, King L (2013) An integrative literature review on preparing nursing students through simulation to recognize and respond to the deteriorating patient. J Adv Nurs 69(11):2375–2388

Freeman S, Eddy SL, McDonough M (2014) Active learning increases student performance in science, engineering, and mathematics. Proc Natl Acad Sci 111(23):8410–8415

Hayden JK, Smiley RA, Alexander M (2014a) The NCSBN national simulation study: a longitudinal, randomized, controlled study replacing clinical hours with simulation in prelicensure nursing education. J Nurs Regul 5(2):S3–S40

Hayden JK, Smiley RA, Gross L (2014b) Simulation in nursing education: current regulations and practices. J Nurs Regul 5(2):25–30

INACSL Standards Committee (2016) INACSL standards of best practice: simulation SM debriefing. Clin Simul Nurs 12:S21–S25

Jeffries PR (2005) A framework for designing, implementing, and evaluating: simulations used as teaching strategies in nursing. Nurs Educ Perspect 26(2):96–103

Jeffries PR (2012) Simulation in nursing education: from conceptualization to evaluation. National League for Nursing, New York

Jeffries PR, Rogers KJ (2007) Theoretical framework for simulation design. In: Simulation in nursing education: from conceptualization to evaluation. National League for Nursing, New York, pp 21–33

Jeffries PR, Bambini D, Hensel D et al (2009) Constructing maternal-child learning experiences using clinical simulations. J Obstet Gynecol Neonatal Nurs 38(5):613–623

Keller JM (1987) Development and use of the ARCS model of instructional design. J Instr Dev 10(3):2

Keller JM (1993) Manual for instructional materials motivational survey (IMMS). Unpublished manuscript, Tallahassee, Florida, 1999

Keller JM (1999) Using the ARCS motivational process in computer-based instruction and distance education. New Dir Teach Learn 1999(78):37–47

Keller JM (2010) The Arcs model of motivational design. In: Motivational design for learning and performance. Springer, Boston, pp 43–74

Kidd LI, Knisley SJ, Morgan KI (2012) Effectiveness of a second life® simulation as a teaching strategy for undergraduate mental health nursing students. J Psychosoc Nurs Ment Health Serv 50(7):28–37

Knowles M (1973) The adult learner: a neglected species. Gulf Publishing Company, Houston

Lapkin S, Levett-Jones T (2011) A cost–utility analysis of medium vs. high-fidelity human patient simulation manikins in nursing education. J Clin Nurs 20(23–24):3543–3552

Larue C, Pepin J, Allard É (2015) Simulation in preparation or substitution for clinical placement: a systematic review of the literature. J Nurs Educ Pract 5(9):132

McGaghie WC, Issenberg SB, Cohen MER et al (2011) Does simulation-based medical education with deliberate practice yield better results than traditional clinical education? A meta-analytic comparative review of the evidence. J Assoc Am Med Coll 86(6):706

Meyer L (2016) Pearson pilots mixed reality educational resources. https://thejournal.com/articles/2016/10/31/pearson-pilots-mixed-reality-educational-content.aspx. Accessed 1 Oct 2018

Milgram P, Kishino F (1994) A taxonomy of mixed reality visual displays. IEICE TRANSACTIONS Inf Syst 77(12):1321–1329

National League for Nursing (2015) A vision for teaching with simulation: a living document from the National League for Nursing NLN Board of Governors. http://www.nln.org/docs/default-source/about/nln-vision-series-(position-statements)/vision-statement-a-vision-for-teaching-with-simulation.pdf. Accessed 1 Oct 2018

Salmi H, Thuneberg H, Vainikainen MP (2016) How do engineering attitudes vary by gender and motivation? Attractiveness of outreach science exhibitions in four countries. Eur J Eng Educ 41(6):638–659

Skiba DJ (2016) On the horizon: trends, challenges, and educational technologies in higher education. Nurs Educ Perspect 37(3):183–185

Smith PC, Hamilton BK (2015) The effects of virtual reality simulation as a teaching strategy for skills preparation in nursing students. Clin Simul Nurs 11(1):52–58

Ulrich D, Farra S, Smith S et al (2014) The student experience using virtual reality simulation to teach decontamination. Clin Simul Nurs 10(11):546–553

Vaughn J, Lister M, Shaw RJ (2016) Piloting augmented reality technology to enhance realism in clinical simulation. CIN: Comput Inform Nurs 34(9):402–405

Vottero BA (2014) Proof of concept: virtual reality simulation of a Pyxis machine for medication administration. Clin Simul Nurs 10(6):e325–e331

Weaver A (2011) High-fidelity patient simulation in nursing education: an integrative review. Nurs Educ Perspect 32(1):37–40

Young PK, Shellenbarger T (2012) Interpreting the NLN Jeffries framework in the context of nurse educator preparation. J Nurs Educ 51(8):422–428

Zhang J, Sung YT, Hou HT (2014) The development and evaluation of an augmented reality-based armillary sphere for astronomical observation instruction. Comput Educ 73:178–188