

Nursing Student Perceptions of Presence in a Virtual Learning Environment:

A Qualitative Description Study

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Jason R. Thrift

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By

Jason R. Thrift

Approved:

Lanell M. Bellury, PhD, RN, AOCNS, OCN
Dissertation Committee Chair

Date

Jennifer L. Bartlett, PhD, RN-BC, CNE, CHSE
Dissertation Committee Member

Date

Helen Hodges
Dissertation Committee Member

Date

Tammy Barbé, PhD, RN, CNE
Associate Dean, Graduate Programs

Date

Linda Streit, PhD, RN,
Dean, Georgia Baptist College of Nursing

Date

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DEDICATION

I dedicate this dissertation to my family. To my wife, Leslie, my children, Abby and Charlie, my parents, Rick and Debbie, and my father-in-law and mother-in-law, Jim and Brenda. They have supported me through thick and thin as I worked through this process, offering encouragement, strength, and love every step of the way. To my grandparents, Niney, Maw Maw, and Paw Paw, I miss you so much, but thank you for always encouraging me in all that I have ever done. “I can do all things through Christ who strengthens me.” Philippians 4:13

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ABSTRACT

JASON R. THRIFT

NURSING STUDENT PERCEPTIONS OF PRESENCE IN A VIRTUAL LEARNING ENVIRONMENT: A QUALITATIVE DESCRIPTION STUDY

Under the direction of DR. LANELL M. BELLURY

Multifaceted approaches to learning are used for educating student nurses. One common teaching modality in nursing education, simulation, provides hands-on experiences in a safe environment to prepare student nurses for professional roles. High quality simulation standards recommend an engaging immersive experience, with physical, emotional, and conceptual fidelity to clinical practice. Presence is the perception of *being there* in a simulation as if it were real. Studies have reported improved learning outcomes with increased sense of presence.

A simulation modality seldom used in nursing education is virtual reality simulation (VR-Sim) a three dimensional, immersive experience. VR-Sim with head mounted visual and haptic enhancements has the potential to increase presence and improve learning. Student perceptions of presence in VR-Sim is unknown.

The purpose of this study was to explore student nurses' perceptions of presence during simulation. A qualitative description design included a VR-Sim of a patient needing cardiopulmonary resuscitation (CPR). Each participant (N=11) performed two repetitions in the VR-Sim followed by debriefing and a guided interview.

The conceptual framework for the study was informed by extant literature including theoretical frameworks. Two research questions guided the study to 1) explore student perceptions of presence in VR-Sim and 2) align findings with current theories of simulation and presence. Braun and Clarke's (2006) steps for theme development and Saldaña's (2016) coding

informed the data analysis. For Research Question 1, three themes and eight subthemes described participants perceptions of *being there* in the VR-Sim environment. Findings showed all participants reported experiencing presence during the simulation (Theme: *What Brought Me In, What Brought Me Out*), but glitches, feel of compressions, and sensing the real physical environment outside the simulation interrupted the experience of presence (Theme: *Issues in VR-Sim*). Additionally, participants described the experience of learning CPR with the VR-Sim (Theme: *Higher Level of Learning*).

For Research Question 2, the main constructs from the extant theories aligned with the perceptions of participants including ideas about presence, fidelity, individual factors, learning outcomes, and collaboration. The study conceptual model provided a sound framework for continued research of the efficacy of VR-Sim in nursing education.

CHAPTER ONE

INTRODUCTION TO THE STUDY

Nursing education requires a multifaceted approach to help student nurses gain knowledge. Nursing knowledge and theory are applied in clinical learning experiences to achieve learning outcomes designed to prepare nursing professionals. These learning outcomes include experiential, contextual, and collaborative learning, incorporating critical thinking, professionalism, leadership, communication, nursing practice, and human understanding. Student nurses must obtain the knowledge needed to achieve designated learning outcomes to provide safe, quality care (Ballantrud et al., 2014; Beroz, 2017; Dahlke & Hannesson, 2016; Lee et al., 2011). A seamless transition from a student nurse to a licensed practitioner is the overall goal.

Historically, nursing education paired two learning environments, traditional didactic classroom teaching with clinical learning experiences in hospital settings, to achieve student learning and licensure outcomes. More recently, these two learning environments have responded to changes in nursing education. For example, traditional didactic teaching has been influenced by an increased interest in active learning, generational differences in student cohorts and faculty, online education, and computer-based educational tools (Johnsen et al., 2018; Roseberry-McKibbin, 2017; Shatto & Erwin, 2017). Clinical experiences have been impacted by the increased number of nursing programs and students, decreasing clinical placements, limitations on what students are allowed to do, and time-consuming credentialing requirements in many clinical environments (Dahlke & Hannesson, 2016; Ryan et al., 2017). The coronavirus pandemic recently resulted in changes to the hospital/facility-based setting, with virtual simulation replacing traditional experiences (Watties-Daniels, 2020).

Technological Influences on Learning Environments

One effect of the changes described above has been the increased use of technology to provide alternative clinical learning experiences for students. The increased use of technology resides in the growth of simulation as an adjunct to the two traditional learning environments. Simulation is a teaching strategy that attempts to duplicate the real-world clinical environment. Simulation creates a learning environment where faithful replications of real-world clinical practice settings occupy a learning space for student nurses (Saunders et al., 2017). This requirement of replicating actual clinical settings can take many forms and is key to the students' suspension of disbelief while participating in a simulation.

Current simulation practices in nursing education developed from advancements in personnel training in the aviation industry, education of healthcare professionals, and computer science training (Palaganas et al., 2014). For example, CAVE-based virtual reality simulation was designed to train individuals on the techniques needed to maneuver aircraft around a flight deck. The CAVE-based training allowed interaction in the immersive environment as if the users were on the vessel's flight deck, allowing for an authentic reenactment of necessary protocols and skills to provide the needed course of action (Yongliang et al., 2015). Modern simulation has been used for training in collaboration across healthcare professions, for communication development, and transition to practice experiences (Kron et al., 2017; Palaganas et al., 2014; Palmer & Ham, 2017). Simulation is used for specialty training, including, for example, obstetrics (Chang et al., 2019), resuscitation methods (American Heart Association, 2022), and anesthesia (Samosorn et al., 2020).

While language around simulation is not used consistently throughout healthcare literature (Agency for Healthcare Research and Design, 2020), Carey and Rossler (2021)

suggested simulations can be created using different modalities, equipment, and levels of fidelity. According to Carey and Rossler (2021), modality refers to the variety of simulation equipment and/or teaching strategies. The modalities range from standardized patients (trained actors as patients), task trainers (equipment designed for practicing a specific skill, like venous cannulation), manikins (equipment that resembles a human body), or computers (Carey & Rossler, 2021). Fidelity, or the amount of realism, was described by Choi et al. (2017) and the International Association for Clinical Simulation and Learning (INACSL, 2021) as incorporating realism in three domains: physical, conceptual, and emotional/experiential or psychological. High levels of fidelity create the most realistic simulations and support the suspension of disbelief in the student participants. According to INACSL Standards Committee (2021a), different modalities should incorporate appropriate levels of fidelity to promote student engagement in the simulation.

Common in nursing literature is a reference to high-fidelity human patient simulation (HF-HPS), which uses computer-programmed manikins to simulate human responses, allowing a student nurse to work through a hypothetical patient care scenario (NCSBN, 2021a; Vuuren et al., 2018). The setting around the manikins resembles the hospital/facility-based setting as much as possible (physical fidelity), having utensils, devices, and other necessary equipment at the student's disposal (Brady et al., 2015). High-fidelity human patient simulations are designed to allow students to practice various skills, tasks, and processes (Vuuren et al., 2018), with physical, conceptual, and psychological fidelity to aid the suspension of disbelief.

Recent research has assessed how simulation compares to traditional didactic and clinical education learning environments (Butt et al., 2018; Chang & Lai, 2021; Johnston et al., 2017; Khalaila, 2014; Palmer & Ham, 2017). Overall, these studies found active learning strategies

aided in building student self-confidence and knowledge and reduced anxiety for performing activities on eventual actual patients (Butt et al., 2018, Chang & Lai, 2021; Johnston et al., 2017; Khalaila, 2014; Palmer & Ham, 2017). The National Council of State Boards of Nursing (NCSBN) conducted a seminal study examining clinical competence and knowledge outcomes in groups of student nurses using up to 50% high-quality simulation compared to traditional clinical experiences. The study showed no significant differences in outcomes between the groups (Hayden et al., 2014). The Hayden et al. study substantiated the efficacy of replacing traditional clinical hours with simulation and propelled the adoption of increasing technological solutions for nursing education.

The coronavirus pandemic recently led to increased use of a computer or screen-based simulation, accelerating a growing trend of incorporating technological teaching strategies in nursing education (Richey, 2020). An advantage of screen-based modalities, or virtual simulation, is they are available anywhere a computer and internet connection exist. Virtual simulation is reality depicted on a computer screen (AHRQ, 2020). While the terminology is not yet standardized, Foronda et al. (2020) recommended using “virtual simulation” to mean a partially immersive, screen-based modality. The amount of fidelity (or realism) provided by virtual simulation can vary. For example, *Body Interact* is a two-dimensional (2-D) clinical problem simulation where students can interact with a simulated patient and respond to real-world patient situations requiring procedural skills, like blood glucose checks or respiratory assessment (Padilha et al., 2018; Body Interact, 2022). The National League for Nursing (NLN) product, *vSim for Nursing*, also features 2-D virtual simulation to provide student nurses with an interactive experience via a computer-based online platform (NLN, 2021).

With augmented reality simulation (AR-Sim), an artificial image or stimulus overlies a real-world object to enhance user experience with the simulation (McGrath et al., 2018). An AR-Sim example would be the *Human Anatomy Atlas* by *Visible Body* that users download on their mobile devices (Visible Body, 2022). Users can display the human body's interior on desks, the floor, or other parts of the natural world through their devices. Another immersive simulation modality with potential for nursing education is virtual reality simulation.

Virtual Reality Simulation in Nursing Education

Virtual reality simulation (VR-Sim) is a simulation modality that replicates real-world hospital/facility-based settings through computer-generated graphic images (AHRQ, 2020; Cant et al., 2022). VR-Sim uses three-dimensional headgear and haptic devices or other interfaces, including computer keyboards, motion sensors, or voice recognition (AHRQ, 2020; Cant et al., 2022). This form of simulation provides a high level of fidelity or realism because it presents the computer-generated environment as a three-dimensional hospital/facility setting. Little research has explored the utility of VR-Sim for nursing education. While VR-Sim is standard in other fields (e.g., aviation flight simulators), it is not widely available in nursing education. Therefore, little knowledge exists regarding the effectiveness of VR-Sim in nursing education, including understanding best practices and the cost, time, and resources needed to adopt this relatively new simulation modality.

One promising development for VR-Sim is that, the equipment needed for 3-D simulations (e.g., headgear, gaming computers, and hand controllers) is readily available and increasingly affordable. The equipment required for VR-Sim is affordable. Some evidence suggests screen-based simulation is significantly more cost-efficient than other simulation modalities. Haerling (2018) found manikin-based simulation costs were three times higher than

virtual simulation. VR-Sim has been associated with reduced costs when used as an alternative to hospital/facility-based experiences or simulation experiences (Carolan-Rees & Ray, 2015).

Standards for Effective Simulation Environments

Simulation standards have been established by the International Nursing Association for Clinical Simulation and Learning (INACSL), Society for Simulation in Healthcare (SSH), and the Association of Standardized Patient Educators (ASPE) (ASPE, 2022; Health Education Center, 2022; INACSL, 2021; SSH, 2022). The Healthcare Simulation Standards of Best Practice® (HSSOBP®) (INACSL Standards Committee, 2021a) address current INACSL standards for simulation, which were used for this study. High-quality simulations create a perception of reality, or fidelity, among participants. While high-quality simulations have demonstrated effectiveness using a wide range of modalities, learning was limited when students lacked engagement in the experience with less realistic patient encounters (e.g., McAlister et al., 2013; Power et al., 2016). A recent meta-analysis showed while simulation across different levels of fidelity demonstrated an effect (effect size = 0.70) on learning outcomes (cognitive, psychomotor, and affective), the result was not proportional to the level of fidelity (Kim et al., 2016). So, something besides fidelity is necessary to improve learning.

Another concept that may influence the perception of reality and suspension of disbelief may be the sense of presence perceived by the learner (Dunnington, 2015). Dubovi et al. (2017) demonstrated a correlation between higher conceptual and procedural knowledge of medication administration in a 3-D computer environment and a heightened sense of presence. Incorporating immersive virtual reality simulations has shown increased presence. For instance, Dang et al. (2018) found that student perceptions of presence were greater among those engaging in a VR-Sim observation with head-mounted displays than those observing through a computer monitor

like a television screen with similar content. When employing a television or computer-based simulation the experience is limited by the constraints of a 2-D interface, even if using a 3-D platform. Since 3-D is the recommended platform, VR-Sim may be the solution. VR-Sim allows for this 3-D experience using minimal extra equipment and promotes a person being in the environment with attention and presence. The phenomenon of presence needs greater exploration.

Presence

The perception of *being present* is a phenomenon of interest in simulation. MacLean et al. (2019) suggested presence has always been part of the nurse-patient relationship. For this reason, current simulation practice attempts to replicate the same sense of presence as that encountered in the real-world clinical setting. With HF-HPS, the recreation of a clinical situation attempts to foster the same sense of presence through technological means, to help student nurses believe they are immersed in and engaged with the patient scenario. Engagement is crucial to student learning and facilitated by the degree of presence the learner experiences within any learning environment. Presence is the learner's ability to perceive *being there* in the simulation while believing the experience is similar to the real world (Dang et al., 2020). Presence may depend on how well a person is immersed in and engaged with a simulation modality such as virtual simulation or VR-Sim (Servotte et al., 2020; Witmer & Singer, 1998).

Dunnington (2015) distinguished two types of presence, endocentric and exocentric. Endocentric presence is a first-person experience within the environment in which the user has lost all connection to the external or natural environment (Dang et al., 2020). The student nurse views the activity from their perspective and completely excludes awareness of the natural environment. Endocentric presence thus allows a user to perceive what they are experiencing as

real. Exocentric presence occurs when a student experiences the natural setting more substantially than the simulated environment.

Dunnington (2015) stated the primary goal of HF-HPS for nursing education is to recreate a realistic and dynamic patient care learning experience for student nurses. Excluding the natural environment from HF-HPS can be problematic with distractors, like ambient noise outside the lab, and limitations to the manikin's movements and capabilities reducing the suspension of disbelief. The natural environment intertwines with the HF-HPS experience, regardless of strategies undertaken by faculty to minimize the effect.

Virtual presence is defined as “the degree to which individuals experience a computer-generated environment rather than the physical locale” (Samosorn et al., 2020, p. 20). Concepts used to describe the feeling of being present in the learning environment include immersion, engagement, and presence (Bower et al., 2017; Dalgarno & Lee, 2010; Cho et al., 2015; Ip et al., 2017). Presence includes but is distinct from concepts of immersion and engagement. While these three terms have been used interchangeably in other contexts, they are different concepts in simulation. Immersion implies the degree to which the user is surrounded and enveloped in the simulation environment (Yildirim et al., 2019). Engagement focuses on the learner's actions and how “cognitively, behaviorally, and emotionally” involved they interact (Padgett et al., 2019, p. 819). Presence combines both immersion and engagement, allowing users to experience being in and engaging with the learning environment. In virtual environments, like VR-Sim, there is potential to more thoroughly exclude the natural environment, leaving the participants immersed in the situation, allowing for a greater perception of presence (Dunnington, 2015) and potentially improving learning outcomes.

Statement of the Problem

Investigation of the phenomenon of presence within different learning environments in nursing education is limited. Designing virtual environments that include 3-D elements may increase the immersive effects, exclude the natural environment, and ultimately increase presence. It is not clear how students generally perceive presence in simulation, including VR-Sim. Exploring presence may help us understand the intersections of faculty selection of simulation modalities and fidelity and student perceptions of simulation modality and fidelity.

Purpose of the Study

The purpose of this study is to explore student nurse perceptions of presence during simulation. A qualitative description design using semi-structured interviews will explore the phenomenon of presence within a virtual reality simulation.

Research Questions

The following related study questions will guide this research.

1. How do student nurses describe their sense of presence in a 3-D virtual reality simulation using a headset and haptic device?
2. How do student nurses' perceptions about presence align with theoretical models of simulation and presence?

Significance of the Study

The NLN (2021) has identified technology as a teaching and learning tool among their priorities for nursing education research. Exploring the connectivity and interoperability of any technology for application to the education of student nurses is needed. This technology research priority sets a standard for nurse researchers to develop integrative technological

learning solutions to reach educational goals within nursing school curricula. Integrating these solutions is critical in the current and rapidly evolving landscape of nursing education.

Criterion six of the HSSOBP® for simulation design requires simulation to include various levels of fidelity to promote the perception of realism (INACSL Standards Committee, 2021a). Simulation designs require development with “attention to physical, conceptual, and psychological aspects of fidelity” (INACSL Standards Committee, 2021b, p. 17) to help student nurses meet learning objectives through simulation experiences. Understanding the perception of presence may inform decisions made regarding fidelity and other simulation design elements, particularly related to the integration of VR-Sim, which is specifically designed to physically, conceptually, and psychologically stimulate a student. Ultimately, VR-Sim software programs could be designed to replicate multiple hospital/facility-based settings closely. The promise of the VR-Sim technology is a lower cost, lower-resourced, self-directed addendum to current simulation modalities in a virtual but authentic clinical environment for practice and learning.

Conceptual Basis of the Study

Four published models related to simulation informed the conceptual framework for this study. Jeffries’ Simulation Framework (2021), the foundation of most simulation research, is introduced. Next, Choi et al.’s three dimensions of simulation framework (2017); Dalgarno and Lee’s Three Dimensional Virtual Learning Environments model (2010); and Dunnington’s Centricity of Presence model for HF-HPS (2015) are summarized below.

Jeffries’ Simulation Framework

The Jeffries Simulation Theory is an established and extensively used framework of experiential learning in simulation (Cowperthwait, 2020; Hayden et al., 2014; Jeffries, 2021; Irwin, 2016; Yoo & Kim, 2018). This framework reflects the teacher and student's interaction

using various educational practices, noting important learner outcomes and simulation design considerations (Jeffries, 2021). Jeffries (2021) provided a model of components: background, design, simulation experience, facilitator, participant, and outcomes. The framework does not focus on the learner's perception of presence but contains concepts that affect the sense of presence in a simulated environment (Jeffries, 2021).

Three Dimensions of Simulation

Choi et al.'s work (2017) provided a framework to address ways to engage learners in simulation. The simple model describes simulation in terms of three dimensions: the modality, scope, and environment. Additionally, Choi et al. identify three dimensions of fidelity including physical, conceptual, and emotional fidelity leading to a sense of realism. Finally, realism is required for behavioral, emotional, and cognitive engagement in learning. This model links the key constructs in introducing simulation design, modalities, and fidelity with student engagement.

3-D VLE Model

Dalgarno and Lee (2010) proposed a model of the benefits of Three Dimensional Virtual Learning Environments (3-D VLE) in education, focusing on how virtual learning environments should be constructed to achieve learning benefits. The model includes realism or fidelity by representing the learner's simulated environment and realistic interactions within the experience. The model also describes a sense of presence (learner's perception of being in the virtual environment as if they are there in the virtual world) and co-presence (learner's perception of other users being present in the same environment). Finally, learning benefits or outcomes are identified, including spatial knowledge representation, experiential learning, engagement, contextual learning, and collaborative learning. The environment a learner enters can affect how

individuals achieve learning outcomes (Cho et al., 2015; Dalgarno & Lee, 2010; Ip et al., 2017). In the 3-D VLE model, the terms presence and student learning were connected. Specifically, the feeling of being within the virtual learning environment was proposed to allow greater understanding. Presence may help enhance learning, but more support is needed.

Centricity of Presence Model

The model by Dunnington (2015) includes Dalgarno and Lee's learning benefit of engagement and similar ideas of fidelity expressed by Choi et al., and the Jeffries' framework. Dunnington's (2015) Centricity of Presence model suggests that as students feel more present in the simulation setting, their perception of the simulated environment becomes more real. The natural environment in which the simulation exists fades to the background of the students' awareness.

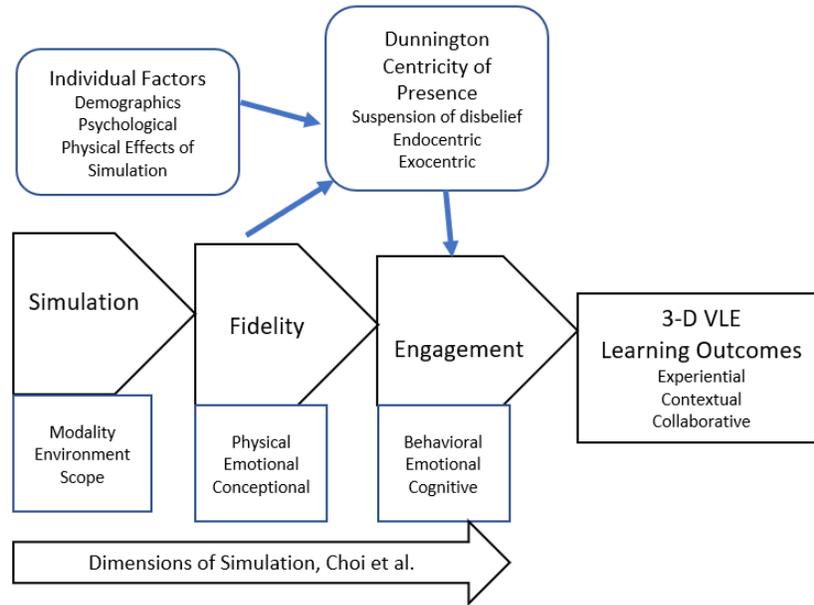
Dunnington's (2015) Centricity of Presence model includes two forms of presence in HF-HPS simulation. Exocentric presence occurs when a student experiences the natural setting more substantially than the simulated environment. Endocentric presence results when the user is fully present in the simulation. When progressing through an HF-HPS simulation experience, students experience a mix of natural and simulated environments. Initially, exocentric presence predominates the simulation. Later, endocentric presence gradually replaces this sensation as the simulation progresses. Dunnington (2015) noted, "gains in clinical knowledge, task competency, cue recognition, clinical reasoning, confidence, and perceived sense of responsibility and accountability for patient outcomes" (p. 72) were all linked to endocentric presence or a sense of *being there* in the simulation environment.

Model of Presence for this Study

The conceptual model created for this study, depicted in *Figure 1*, uses concepts from Choi and colleagues (2017), Dalgarno and Lee (2010), Dunnington (2015), and Jeffries (2021). The model incorporates the dimensions of simulation and implies the simulation design influences fidelity, leading to engagement and learning outcomes. Individual learner factors (demographics, psychological factors, and physical effects of simulation) are proposed to independently affect presence based on prior knowledge, age-related variations, and influences from the simulated environments. Fidelity influences presence which may moderate engagement. To successfully achieve endocentric presence, an individual must feel a sense of realism, brought on by immersion in the scenario unfolding. Greater engagement leads to the three learning outcomes on the far right side of the model: experiential, contextual, and collaborative learning. Experiential learning is what the user has gained from these interactions in the simulation learning experience. Contextual learning results from the individual comprehending the objectives and goals of the simulation. Collaborative learning results from a group understanding the same goals as the individual. The model proposes a simulation when suspension of disbelief and endocentric presence is achieved, leads to increased engagement and better learning outcomes.

Figure 1

Conceptual Model of Presence



Original Image

Researcher Assumptions and Biases

In exploring the phenomenon of presence related to simulation, particularly virtual reality simulation, it is also essential to understand my assumptions and biases related to the topic. I view this phenomenon from a pragmatic lens. Pragmatism focuses on the actions committed, a change to be considered, and how knowledge and action intersect (Goldkuhl, 2012). In this view, a researcher does not simply view what is happening but intervenes with research approaches. Simulation in nursing is firmly embedded in nursing education. Yet, more research is needed to develop simulation practices and modalities while maintaining high levels of fidelity and engagement to ensure the best educational outcomes. The limited research related to the presence phenomenon in nursing education may provide a direction to influence such improvements.

My experience and literature indicate student engagement is essential in HF-HPS, yet there may be missed opportunities to enhance student engagement. Presence is inherent in all simulated environments; therefore, exploring this phenomenon may provide insights into the student's perspective of presence to begin a research program to increase engagement and improve student outcomes with simulation, especially virtual simulation modalities.

My belief that VR-Sim has the potential to replace clinical hours is a bias. I will make every effort to set aside my biases and hear the voices of the students. Some students may genuinely not be engaged; my desire to engage students is clearly a simulation and educational mandate. The drive of my program of research is simple: I am interested in new technologies and desire to implement effective changes in nursing and nursing education. The cost, usability, effectiveness, and achievement of designated learning outcomes are all in question with the implementation of a new simulation modality like VR-Sim.

Implementing a new teaching strategy cannot just occur because I like or want a particular technology. Based on the NCSBN (2021a) guidelines, VR-Sim must replace or amplify real-world clinical experiences where students can fully interact in the simulation as they would in the natural clinical practice setting. Although VR-Sim has the potential to meet this guideline, showing this through research questions, methodologies, procedures, and analyses is essential to taking the first steps towards using VR-Sim as an educational strategy for student nurses.

Definition of Terms

Augmented reality simulation (AR-Sim) is an artificial image or stimulus overlying a real-world object to enhance a user experience with the simulation (McGrath et al., 2018). An AR-Sim example would be the *Human Anatomy Atlas* by *Visible Body* that users download on

their mobile devices (Visible Body, 2022). Users can display a digitized human body interior showing on their own device onto physical objects in the real natural environment such as desks, the floor, or tables.

Endocentric presence applies to users perceiving more presence as internal stimuli increase the user's perspective of the simulated situation (MacLean et al., 2019). With endocentric presence, the user engages in the first-person perspective, perceiving the encounter as realistic, diminishing any external input from the natural world (Dang et al., 2020).

Engagement is “a context-dependent state of dedicated focus towards a task wherein the learner is involved cognitively, behaviorally, and emotionally” (Padgett et al., 2019, p. 819). For simulated experiences like VR-Sim, engagement is a core component of immersion where the user can interact physically and control the environment (Miller & Bugnariu, 2016). Choi et al. (2017) separated engagement into three parts: behavioral, emotional, and cognitive.

- Behavioral engagement considers how involved a student is with the activity from an academic standpoint. Helping a learner understand what will take place in the simulation from a learning perspective will encourage engagement and suspension of disbelief as the student regards the experience as real to the extent to help with their education on a topic.
- Emotional engagement corresponds to a learner's attitude and interest in learning that create a response while actively working in the experience. The situation occurring may make the student feel happy, sad, or concerned for the well-being of the hypothetical patient.
- Cognitive engagement involves psychological effects motivating a student towards a goal. These individuals may be self-regulated to pursue an activity

towards an end goal. These cognitive pieces may also lead to frustrations and reduced motivation should difficulties occur in the simulated experience.

Environment is defined as the setting where simulations are performed (Choi et al, 2017).

Four distinct environments can be used for simulation: In situ in the actual clinical setting; simulated in a simulation lab; ad hoc in the classroom; virtual in a digital format with only the patient being recreated, such as with an augmented reality experience, or a digital environment immersing the learner where they can interact (Choi et al., 2017). No matter the modality, simulation environments are “experiential, interactive, collaborative, and learner centered” (Jeffries, 2005, p. 292).

Exocentric presence involves sensing the natural environment more than the simulated environment (Dunnington, 2015). Exocentric presence provides a third-person perspective to the experience of the user.

Fidelity refers to how realistic or exact a simulation is compared to the hospital/facility-based environment. The creators of the simulation use equipment, settings, and scenarios selected to resemble the natural environment of a hospital/facility-based setting. The believability of the experience is key to allowing students to perceive a sense of working through a healthcare situation through multi-dimensional concepts (Carey & Rossler, 2021). Choi et al. (2017) suggested fidelity in simulation has three components: physical, conceptual, and emotional or experiential. Physical fidelity corresponds to how elements are sensed in simulation based on what someone sees, hears, feels, or even smells. Conceptual fidelity considers plausibility, or whether the simulation is possible in a realistic manner. Emotional and experiential fidelity are combined as both generate feelings with similarities to what might happen in a real situation.

Haptic devices are a physical component applied to the VR-Sim experience, so users feel they interact with something real while immersed in the environment (Butt et al., 2018; Jung et al., 2012).

High-fidelity simulation uses computer-programmed manikins to simulate human responses, allowing a student nurse to work through a created patient care scenario (Vuuren et al., 2018). The setting around the manikins resembles the clinical setting as much as possible, having utensils, devices, and other necessary equipment at the student's disposal participating in the simulation (Brady et al., 2015). High-fidelity simulation allows students to practice various skills, tasks, and processes to complete a scenario (Vuuren et al., 2018).

High-quality simulation refers to a well-designed simulation experience incorporating the standards of best practice (INACSL Standards Committee, 2021a). INACSL has created a best practice standard HSSOBP® to guide educators in the development of simulated experiences. The criteria include prebriefing, simulation design, facilitation, the debriefing process, operations, objectives and outcomes, professional integrity, simulation-enhanced interprofessional education, and evaluation of learning and performance (INACSL Standards Committee, 2021a). The standards above are used in creating simulation experiences but require consistency and development over time to provide high-quality simulations for students.

Immersion applies to the technological change in the medium used, incorporating the five characteristics: inclusiveness, extensiveness, surrounding, vividness, and matching, providing a subjective perception of the experience (Miller & Bugnariu, 2016; Yildirim et al., 2019).

Inclusiveness relates to a VR-Sim environment eliminating signals suggesting connections to the physical world with the virtual world, like using joysticks or wearable devices (Miller & Bugnariu, 2016). Extensiveness involves how many sensory modalities have accommodations in

the environment, like eye tracking for visual cues. Surrounding encompasses the graphic design of the VR-Sim. The surrounding determines the field of view for the environment and how much of the natural world is eliminated. Vivid applies to how stimulating the environment is, such as the resolution of the graphics. Finally, matching describes how well the VR-Sim matches a user's perspective through the process of motion capture to ensure movements stay consistent onscreen with the user's (Miller & Bugnariu, 2016).

Individual Factors correspond variations in the participants. Each participant brings their own personality traits, motivations, prior experiences, and openness to ideas (Dunnington, 2015). Demographic characteristics correspond to the individual characteristics of each participant like those presented in this study that show age, gender, status in school. But the next two individual factors can play a role in the other traits listed above: psychological and physical factors. Psychological factors correspond to motivational variations, or a person's willingness to act on a particular event (Dunnington, 2015). Personality traits, prior experiences, and emotions encompass psychological factors that make an individual more or less susceptible to engaging in a simulated experience. Physical factors also correspond to the traits listed and may be manifested by how those traits are perceived. For instance, a person that is not motivated to perform in a simulated experience may choose not to perform certain tasks as they would in a real clinical situation. The lack of motivation psychologically inhibited their ability to perform physically (Dunnington, 2015).

Intermediate-fidelity simulation refers to a series of connected procedures to duplicate a potential scenario found in a clinical practice setting (Munshi et al., 2015). This type of scenario may incorporate low-fidelity simulation or even standardized patient encounters and follow-through with a straightforward training scenario (Munshi et al., 2015).

Learning affordances correspond to the relationship between “the properties of an educational intervention and the characteristics of the learner that enable certain kinds of learning to occur” (Dalgarno & Lee, 2010, p. 17). These learning affordances can be broken down into three components: experiential, contextual, and collaborative learning. Experiential learning concerns in performing tasks otherwise impractical or impossible to perform in a simulated environment, like visualizing the inside of the human body. Contextual learning implies learning with a connection to real-world activities, like foley catheter insertion and practicing this skill in a simulated environment to later apply to a real situation. Collaborative learning encompasses the previous two types of learning but uses a multi-person collaboration in the environment to assist with learning (Dalgarno & Lee, 2010).

Learning Outcomes is broadly defined for simulation as a learner’s reaction to the experience, learning that takes place resulting in a change, and behavior associated with the change leading to the use of that knowledge in the clinical setting (Jeffries, 2005). The reaction could be satisfaction or frustration, as well as increased or decreased self-confidence to perform actions or activities. Learning results from a change to the learner’s attitude, skill, or knowledge from the experience. Lastly, behavior means the learner takes that knowledge gained from simulation to apply to actions in the actual clinical setting (Jeffries, 2005).

Low-fidelity simulation refers to an experience in which student nurses demonstrate simple skills on partial task models, like foley catheter insertion on a pelvic exam trainer (Munshi et al., 2015; Johns Hopkins Medicine, n.d.; Stanford Medicine, 2022).

Modality refers to the type of simulation equipment or strategy used for the simulated experience. Types of modality may include, but are not limited to, task trainers, standardized

patient encounters, full-body manikins, computer screen-based virtual simulation, or virtual reality simulation (Carey & Rossler, 2021).

Partial task models, also known as partial task trainers, are devices designed to allow learners or students to practice one specified task, like foley catheter insertion, to develop psychomotor skills (Johns Hopkins Medicine, n.d.; Stanford Medicine, 2022).

Presence is the sense of *being there* with others or being present. It can also mean being present as a nurse with a patient or family members in a therapeutic, professional relationship (MacLean et al., 2019). For the context of this study, presence will be defined as *being there* within a virtual learning environment, as suggested by multiple studies (Dalgarno & Lee, 2010; Dang et al., 2020; De Leo et al., 2014; Dubovi et al., 2017; Dunnington, 2015; Liaw et al., 2020; MacLean et al., 2019; Shin et al., 2019; Shorey & Ng, 2021)

Scope relates to the choice of using one or multiple modalities and/or multiple environments in a specific simulation experience (Choi et al., 2017). This is set by the instructor based on the goal of the activity, which can range from a partial task training skill to full clinical episode requiring extensive time.

Simulation is a teaching modality replicating the real-world clinical environment in a learning space to educate student nurses on technical and behavioral skills. The simulation also provides an opportunity to evaluate student achievement of course and program outcomes in a controlled educational environment.

Simulation learning experience is an experience within an environment designed to mimic the natural world clinical setting providing the student with materials commonly used in the clinical practice environment (Palmer & Ham, 2017).

Three dimensional (3-D) Virtual Learning Environment (VLE) is a simulated virtual learning environment (VLE) with “three-dimensionality, smooth temporal changes, and interactivity,” allowing immersion of the user. The immersive aspect of VLE is one of the “most important features that distinguish 3-D VLEs from other types of VLEs, like those provided by a learning management system (e.g., Blackboard or Moodle)” (Dalgarno & Lee, 2010, p. 11).

Virtual learning environment (VLE) software that provides resources virtually through a computer-based, online, 2-D platform, but omits the “three-dimensionality, smooth temporal changes, and interactivity” seen in 3-D VLE (Dalgarno & Lee, 2010, p. 11). Software like Body Interact or *vSim for Nursing* use VLE technology to provide student nurses with an interactive experience via a computer-based online platform (Body Interact, 2022; National League for Nursing, 2022).

Virtual reality simulation (VR-Sim) is an immersive environment that duplicates real-world clinical settings through computer-generated graphic images. This form of simulation allows students to interact with the environment as if they are in a natural clinical environment. VR-Sim differs from high-fidelity simulation, which uses manikins predominantly for training purposes (Tilton et al., 2015). VR-Sim also differs from computer-based virtual simulation experiences. It uses haptic devices such as hand controllers and head-mounted displays, so the individual experiences a 360-degree representation of the 3-D environment while immersed in the scenario (AHRQ, 2020; Cant et al., 2022).

Summary

This chapter identified factors that have affected nursing education over time, particularly how technology continues to shape the ever-changing landscape of educating student nurses. Simulation establishes a foundation for engaging students with hospital/facility-based

experiences from the safety of a lab environment. Simulation, in general, has become a universally accepted experience, helping student nurses grow in their knowledge of nursing processes. VR-Sim is proposed as a teaching strategy in the education of healthcare students (Aebersold et al., 2018; Cant et al., 2022; Carolan-Rees & Ray, 2015; Lee & Lee, 2018; Padilha et al., 2018; Tilton et al., 2015), but few studies have shown how VR-Sim affects nursing education. Exploring the available literature about VR-Sim led to a phenomenon associated with varied learning environments—presence. Presence within the simulated environment can be of two types: exocentric presence or endocentric presence. Endocentric presence may enhance simulated learning experiences by promoting engagement in the learning environment. VR-Sim provides an environment potentially conducive to greater endocentric presence, but the phenomenon needs further exploration.

The conceptual framework provided a basis for the exploration of VR-Sim. Combining Choi's simulation model with 3-D VLE, Jeffries Framework and the Centricity of Presence model provided a perspective of how VR-Sim could become a practical teaching strategy to enhance students' knowledge and understanding of nursing processes. VR-Sim in nursing education is nascent. This study provided a basis for understanding presence, specifically endocentric presence, that is essential to all forms nursing simulation.

CHAPTER TWO

LITERATURE REVIEW

This chapter provides a review of the state of the science relevant to the current practices of simulation, an evaluation of virtual reality simulation (VR-Sim), and the phenomenon of presence. The main topics of the review include: (a) simulation and associated fidelity, modalities, and environments, (b) factors affecting learning environment effectiveness, and (c) the relationship among presence, immersion, engagement, and learning outcomes. This chapter provided supporting evidence for a qualitative study addressing student nurse perceptions of presence in virtual learning environments. Inferences for the current study will conclude the chapter.

Literature Searches

The literature search included the Cumulative Index to Nursing and Allied Health Literature (CINAHL) Plus with Full Text, PubMed, Google Scholar, and Google® using combinations of the following key terms: *simulation*, *virtual reality*, *virtual reality simulation*, *presence*, *education*, and *nursing education*. Inclusion criteria were the English language, publications within the last fourteen years, systematic reviews, meta-analyses, and original research addressing current simulation practice, virtual simulation, three-dimensional (3-D) simulation, and presence as a phenomenon. Exclusion criteria were gaming studies with no connection to learning outcomes, product investigations, and publications in non-academic resources (magazines, dissertations, and continuing education offerings). Specific, targeted searches and their results follow.

To establish a sense of the scope and general use of simulation in nursing education, a CINAHL search of *academic journals* published January 1, 2007-June 9, 2022 was performed

using the key terms *simulation* and *nursing education*. This initial search yielded 8016 results. Including the search term, *virtual reality* decreased the count to 392 results; including the search term, *virtual reality simulation* reduced the count to 47 results. Twenty-eight articles from CINAHL met the inclusion criteria and were not excluded based on exclusion criteria.

To consider virtual reality simulation in other health care disciplines, a CINAHL search of *academic journals* published January 1, 2007-June 9, 2022 was performed using the key terms *simulation*, *education*, and *virtual reality simulation*. This search yielded 140 results. The search was refined to include *healthcare* as a key term, producing 16 results. Fourteen articles met the inclusion criteria and were not excluded based on exclusion criteria.

The same process was followed in PubMed, with the parameters of meta-analysis, randomized controlled trial, review, or systematic review published January 1, 2007-June 9, 2022. The initial search using *simulation* and *nursing education* yielded 904 results. Including the search term, *virtual reality* or *virtual reality simulation* decreased the count to 64 results. After eliminating articles based on the exclusion criteria and eliminating articles already included in the review from the CINAHL search, there were an additional 28 unique articles that met the inclusion criteria.

To consider virtual reality simulation in other health care disciplines, I searched PubMed, with the parameters of meta-analysis, randomized controlled trial, review, or systematic review published January 1, 2007-May 15, 2022. The search used the key terms *simulation* and *education*, yielding 6702 results. Including the search term, *virtual reality* or *virtual reality simulation* decreased the count to 920 results. The additional key search terms of *healthcare disciplines* were added to determine other possible results not associated with nursing, yielding

five results. After eliminating articles based on the exclusion criteria, three additional unique articles met the inclusion criteria.

A CINAHL search of *academic journals* published January 1, 2007-June 9, 2022, was performed on the key terms *presence* and *nursing education*. This search yielded 255 results. Many of these articles referenced seminal work on presence and informed some key tenets of the concept of presence related to simulation and this project specifically. Including the search term *simulation* decreased the count to 29 results; including the search term, *virtual reality* reduced the count to 4 results. Two articles from CINAHL met the inclusion criteria and were not excluded based on exclusion criteria.

The same process was followed in PubMed with the parameters of *meta-analysis*, *randomized controlled trial*, *review*, or *systematic review* published January 1, 2007-June 9, 2022. The initial search using *presence* and *nursing education* yielded 298 results. Including the search term *simulation* decreased the count to 16 results; including the search term, *virtual reality simulation* reduced the count to 2 results. After eliminating articles based on the exclusion criteria, one additional unique article met the inclusion criteria.

A cursory Google® search using the search terms *nursing education* and *virtual reality simulation* yielded little in the way of scholarly works not previously discovered but provided links to products, platforms, and guidelines that provided varying levels of information. A cursory Google Scholar search using the search terms *nursing education* and *virtual reality simulation* yielded about 18,100 results – 17 of the top items were included in this literature review.

The articles found provided discussions of different learning environments or teaching strategies, such as simulation, virtual reality simulation, virtual simulation, and the faculty and

student perceptions of each type of learning. The articles explored individual or other factors (e.g., stress, fear) and how these concepts contribute to students' perceptions of the learning environment. The ideas of engagement, learning outcomes, nursing processes, and any associations with simulation development and debriefing were explored. Finally, articles described how presence, endocentric presence, and exocentric presence are related to engagement and learning outcomes.

In my review, I located seven recent and relevant meta-analyses covering 2007 through 2022. By extending my initial CINAHL and PubMed searches to fifteen years, I captured many of the studies included in those analyses in my original searches. Any of the 66 unique studies (eliminated duplications) referenced in those meta-analyses meeting my inclusion criteria were also included in this review of the literature. These studies from the meta-analyses focused on experimental designs, examining knowledge assessment or effectiveness of virtual reality simulation from the user experience. Seven of the quantitative studies included in the meta-analyses examined or explored the phenomenon of presence (Dubovi et al., 2017; Halfer & Rosenheck, 2014; Kleven et al., 2014; Liaw et al., 2019; Samosorn et al., 2020; Servotte et al., 2020; Tan et al., 2017). Although six of the studies included in the meta-analyses were qualitative, none of them focused on presence (Choi, 2019; Christensen et al., 2018; Davis et al., 2016; Liaw et al., 2020; Shoemaker et al., 2014; Williams et al., 2020).

Exploration of the Literature

This section reviews the state of the science relative to simulation modalities, including standardized patient encounters, various levels of fidelity, high fidelity-human patient simulation (HF-HPS), virtual simulation, and virtual reality simulation (VR-Sim). Following this review, factors affecting the environments are explored. Multiple articles reiterated the need for

knowledge transference to take place between didactic learning and practical clinical application (Cant & Cooper, 2017; Carr et al., 2018; Gu et al., 2017; Liaw et al., 2014; Liaw et al., 2020; Turkelson et al., 2020). Knowledge transference is a student nurse's ability to demonstrate knowledge, skills, decision capability, and confidence during clinical practice (Robinson & Dearmon, 2013). Applying knowledge in the clinical practice setting allows student nurses to build confidence, gain experience, and learn processes essential to their individual development. Students also demonstrate didactic learning with sound theoretical reasoning and knowledge transference. For example, effective communication requires clinical judgment to determine essential information when contacting other healthcare professionals (Turkelson et al., 2020). Students learn communication techniques in the classroom then transfer that knowledge to the clinical practice setting to communicate effectively.

Simulation

Nursing, the healthcare industry, and other professions such as aviation, military, and nuclear energy have used simulation for many years as an effective teaching strategy (Moreno et al., 2020). Nursing continuously increases technological approaches to facilitate student learning and achieve educational outcomes (Rim & Shin, 2021). The increasing use of technological approaches in nursing led to the Hayden et al. (2014) study with the NCSBN, examining simulation effectiveness. Hayden et al. (2014) examined ten prelicensure programs, 5 associate degree in nursing (AND) and five Bachelors of Science degree in nursing (BSN), to study the efficacy of replacing clinical hours with simulation experiences. In all 666 student nurses participated in the study. Three study groups were randomly assigned to a control (no more than 10% simulation), a 25% simulation group, and a 50% simulation group. The groups were compared validly reliable tools, such as the Global Assessment of Clinical Competency and

Readiness for Practice Scale and the New Graduate Performance Survey (Hayden et al., 2014). The participants were evaluated on clinical competency, technical performance, readiness for practice, critical thinking, learning needs, and NCLEX pass rates (Hayden, et al., 2014). Student knowledge of specific competencies showed no significant difference between groups using more simulation experiences compared to those using more clinical time in the hospital/facility-based setting. These competencies involved performing particular nursing processes for the care of patients in multiple nursing specialties. This result led to the recommendation by the NCSBN that up to 50% of simulation use can provide comparable learning compared to traditional clinical experiences (Hayden et al., 2014). Since this study's publication, simulation in nursing has continued to grow as a practice standard with widespread use in academia and the hospital/facility-based setting.

The literature has suggested high-quality simulation standards for nursing education (Alhaj & Musallam, 2018; Bogossian et al., 2018; Cant & Cooper, 2017; Kardong-Edgren & Fey, 2017). Educators work to provide a simulation mirroring the hospital/facility-based setting and making the experience of the highest quality possible, with consistent processes, equipment, and personnel in the simulated environment. In addition, simulations provide a safe environment where mistakes can happen, increasing students' self-confidence, knowledge, and attention to patient safety, as reported in previous studies (Jarvill et al., 2018; Lilly et al., 2016; Lynch et al., 2020; Miller et al., 2016; Palmer & Ham 2017; Robinson & Dearmon, 2013, Shinnick et al., 2011; Woda et al., 2016).

Simulation standards are established by ASPE, SSH, and INACSL (ASPE, 2022; HEC, 2022; INACSL, 2021; SSH, 2022). The ASPE establishes standards of best practice for Standardized Patient Encounters used in nursing simulation (Lewis et al., 2017). SSH not only is

associated with simulation standards and practices, but also is involved in accrediting simulation centers and credentialing for certifications, such as the Certified Healthcare Simulation Educator (CHSE) simulationists can apply for and earn (SSH, 2022). INACSL addresses simulation standards with the HSSOBP® (INACSL Standards Committee, 2021a). The standards stipulate simulation must use varying levels of fidelity to provide a sense of realism. Simulations should be structured by purpose, theory, and modality (INACSL Standards Committee, 2021a).

Simulationists and educators work together to select from various simulation modalities to provide a wide range of experiences to help student nurses learn and transfer knowledge. Although VR-Sim meets the criteria for inclusion in simulation modalities set forth by INACSL, it is currently not used widely in nursing simulation. The following sections will explore the various levels of fidelity, modalities, and equipment used in simulation.

Fidelity

Simulations are created with different levels of fidelity. Fidelity refers to how closely a simulation replicates an actual task or situation or how closely a simulated skill represents a real skill (Munshi et al., 2015). The different levels of fidelity include low-, intermediate-, and high-fidelity. Low-fidelity simulation uses task trainers or partial manikins to learn simple skills, such as foley catheter insertion (Munshi et al., 2015). Box trainers have also been constructed to educate surgeons on arthroscopic procedures as a form of low-fidelity simulation (Agyeman et al., 2020). Intermediate-fidelity simulation refers to a series of procedures connected to duplicate a scenario found in the clinical practice setting (Munshi et al., 2015). An intermediate-fidelity scenario can incorporate both low-fidelity and standardized patient encounters individually or combined.

Standardized patient (SP) encounters provide simulated patients portrayed by human actors. An SP provides students with an actual human to interact with during simulation. When performing a procedure, such as intravenous catheter insertion, a manikin arm would stand-in for the human actor's arm. Students would not complete the process on the SP's arm but instead perform the task on a manikin arm beside the actor (Munshi et al., 2015).

In nursing education, high fidelity is generally used synonymously with HF-HPS, which refers to the use of full-body, human-like manikins. These manikins are designed to imitate human anatomy with vital signs, both normal and abnormal body sounds, and a replicated clinical environment in the simulated environment (Brady et al., 2015). Students perform critical thinking skills throughout scenario-based interactions (Vuuren et al., 2018). High-fidelity simulation may incorporate multiple scenarios or manikins to achieve a specific learning outcome (Munshi et al., 2015).

Virtual learning environments also operate under a similar definition of fidelity in nursing education today. Immersion has been associated with fidelity in virtual reality and can equate to levels of fidelity for virtual learning experiences (Kardong-Edgren et al., 2019b). The classification of low, moderate, and high immersion is equivalent to low, intermediate, and high fidelity for VR-Sim. Three sensory components are stimulated in a VR-Sim environment, allowing the user to sense *being there*. Those components are visual (field of view), auditory (what can be heard), and proprioception (motion capture of specific movements) within the environment (Kardong-Edgren et al., 2019b; Miller & Bugnariu, 2016). A virtual simulation would correspond with the definition of low immersion/fidelity, primarily having a user focus on a computer screen for the interaction. Moderate immersion/intermediate fidelity would provide an experience that displays realistic components of a digitized environment but lacks interaction

with one of three sensory components stimulated in virtual learning experiences. High immersion/fidelity would be achieved with VR-Sim using a head-mounted display to stimulate all senses in the environment (Kardong-Edgren et al., 2019b; Miller & Bugnariu, 2016).

The range of realism and complexity of simulated experiences for nursing has been a concern (Bogossian et al., 2018). In one study, roughly 75% of participants reported using more low-fidelity simulation and rarely using HF-HPS or VR-Sim (Bogossian et al., 2018). Fidelity can affect perceptions of the realism of an experience. Fidelity can also affect the extent to which a user perceives themselves to be present within the environment (Piccione et al., 2019). Achieving learning outcomes have been associated with the level of fidelity involved in simulation (MacLean et al., 2019). Research indicated that when users perceive a simulation as realistic, they benefit from cognitive, affective, and psychomotor learning (MacLean et al., 2019; Shin et al., 2015; Shin et al., 2019).

Modality and Equipment

Modality and fidelity are interdependent. Modality refers to the type of equipment strategy, environment, and scope of a simulation. Creating simulations requires using different modalities, equipment, and levels of fidelity (Carey & Rossler, 2021). Modalities include traditional modalities (standardized patient encounters, task trainers, HF-HPS), virtual simulation, and virtual reality simulation.

Traditional Modalities

Standardized patient (SP) encounters, task trainers, and HF-HPS, as previously described related to levels of fidelity, also represent traditional modalities (Haerling, 2018). The student nurse must navigate the scenario to provide simulated care to an SP, a task trainer, or an HF-HPS manikin in a replicated hospital/facility-based setting, typically in a nursing school or college

lab. The cost and availability of these modalities can limit the usefulness of traditional modalities, as budgets can dictate supply and demand (Bryant et al., 2015). Partial task trainers, the body parts they represent, and simulation manikins, also termed mannequins, are combined with other replicated hospital room requirements. Those requirements in the environment include headboards, monitors, a hospital bed, and other healthcare equipment in a lab setting to allow students to interact as they would in the hospital/facility-based setting (Stanford Medicine, 2021).

Simulation educators typically combine these traditional modalities as a hybrid simulation (Giordano et al. 2020; Goldsworthy et al., 2022). Hybrid simulation combines two or more modalities into the same simulation experience (Giordano et al., 2020; Goldsworthy et al., 2022). For example, in a hybrid simulation using SP and HF-HPS, a standardized patient actor initially portrays the simulated patient. As the scenario unfolds, the simulated patient becomes unresponsive, requiring cardiopulmonary resuscitation (CPR). Once the standardized patient actor becomes unresponsive, a human patient simulation manikin is placed to allow students to perform CPR on the simulated patient. This type of hybrid simulation has been used routinely in traditional experiences for the education of student nurses.

It is important to note that the traditional simulation modalities listed above are accepted and integrated into most nursing curricula. Nurse educators and students have discovered limitations in the practice of traditional simulation experiences. In conjunction with NCSBN (2022) and INACSL (2021) standards for developing simulation experiences, these limitations or barriers provide a context for considering new ways of designing simulations in nursing.

Barriers to the Use of Simulation

Barriers related to adequate faculty development in simulation best practices, resources and cost, and debriefing practices have been reported in the literature. Bogossian et al. (2018) conducted a study in Australia and New Zealand to understand the current use of simulation and what standards are employed. This study also examined if any improvements to the quality and diversity of simulation occurred. Some concerns arose regarding barriers prohibiting effective simulation in nursing education (Bogossian et al., 2018). One such barrier was the adequacy of simulation resources used by faculty. From the study, many faculty developed scenarios but lacked formal training. Lack of training can increase workload and lead to more limited resources than commercially prepared simulations (Bogossian et al., 2018). Echoing the concern about training, Ryan et al. (2017) stated educators have sometimes felt overburdened with the responsibility of using simulation without formal training. Access to physical resources to conduct simulation and adequately prepared staff responsible for running simulation exercises are essential components of high-quality simulation experiences (Bogossian et al., 2018). Ryan et al. (2017) suggested a dedicated simulation team is needed to educate students via simulation.

In addition to a dedicated simulation team, the costs associated with the acquisition and maintenance of HF-HPS simulators can limit the use of this equipment (Gu et al., 2017). Lavoie and Clarke (2017) stated the expenses for traditional simulation experiences can be in the range of hundreds of thousands of dollars for initial purchases and maintenance. For instance, one human patient simulation vendor CAE Healthcare (2019), listed the price of one Apollo Pre-Hospital manikin, complete with Muse and Vivo operating software Lenovo PC, the simulated clinical experiences, licenses, service agreement, and training at \$42,995.00. This price is the cost of one human patient simulator and does not include associated costs for other healthcare

equipment or personnel involved in the simulation. A Google® search for the cost of the standard equipment used with an HF-HPS manikin returned the following results: Hill-Rom CareAssist ES Hospital Bed \$13,939.00 (Med Mart, 2021); Program for Nursing Curriculum Integration from CAE Healthcare (2019) \$25,994.80; promotional bundle for simulation equipment from CAE Healthcare (2019) \$98,579.14. These prices are for only a few pieces of equipment required. They do not include the costs for simulated medications, vital signs equipment, headboard equipment for monitoring, simulated oxygen, power, and personnel to operate, manage, and educate other individuals on the requirements of simulated experiences. These prices also do not include the learning management system used to record and debrief simulation experiences, such as CAE LearningSpace (CAE Healthcare, 2022) or SimCapture (Laerdal Medical, 2022).

Barriers related to debriefing also exist and require further faculty development (Beroz, 2017). Debriefing is a critical phase of simulation in which learners analyze and reflect on the experiences gained during simulation (Alhaj & Musallam, 2018). As Laschinger et al. (2008) reported, debriefing led by an instructor during and after the simulation is essential to avoid negative learning. Negative learning occurs, for example, when a student learns how to incorrectly complete a task during simulation because of a subpar performance that is not corrected. Several studies reiterated this same premise but suggested that debriefing must be substantial enough to refine student performance and enhance future simulation experiences (Hauber et al., 2010; Khalaila, 2014; Kardong-Edgren & Fey, 2017; Johnston et al., 2017).

Kardong-Edgren and Fey (2017) questioned how much time for debriefing needs to occur, with no firm indication of an adequate length of time. Other studies have suggested a debriefing time two to three times the simulation length; this is not always attainable (Roh &

Jang, 2017; Eisert & Geers, 2016; Wazonis, 2016). Bogossian et al. (2018) reflected some of these same findings in their study, indicating debriefing duration played a significant role in the effectiveness of simulation. In addition, they found that the consistency of debriefing was related to the duration of the simulation, the skill level of the educator debriefing students, and the time available for debriefing. Their data suggested more extended debriefing assists with students' critical analysis of the simulation experience (Bogossian et al., 2018). Johnston et al. (2017) demonstrated that debriefing highlighting practice deficits allowed learners to assess their gaps in knowledge and discuss how knowledge gained from the simulation might transfer to practice. Despite these barriers, Bogossian et al. (2018) also showed positive considerations regarding faculty perceptions of the impact of simulation in preparing student nurses for clinical practice. The benefits of simulation outweigh the disadvantages, especially regarding learning knowledge applied in the hospital/facility-based setting (Bogossian et al., 2018).

Although traditional modalities are generally accepted and widely used, guidelines for simulation practice denote a need to strive for the integration of new technologies capable of educating a large population of students (NCSBN, 2021a). The goal of simulation is to improve student understanding and to perform quality care on patients in the hospital/facility-based setting. Enhancing learning outcomes has been a focus of nursing education for some time, but as Shin and associates (2019) suggested, the effectiveness of virtual simulation modalities, including virtual simulation and VR-Sim, is currently minimally understood. An exploration of the characteristics, effectiveness, and learning benefits of VR-Sim is only beginning in nursing education.

Virtual Simulation

A screen-based modality, or virtual simulation, is available anywhere a computer and internet connection exist. Virtual simulation is a reality depicted on a computer screen (AHRQ, 2020; Shoemaker et al., 2014). While the terminology is not yet standardized, Foronda et al. (2017) recommended using *virtual simulation* to mean a partially immersive, screen-based modality.

Virtual simulation use varies, and what is identified as this modality in the research literature has not always aligned with the definition of simulation recommended by Foronda et al. (2017) and others (Leflore et al., 2012). Differentiating the types of virtual simulation is necessary to distinguish the simulation-based learning environments with terms used currently in the literature. In the following sections, several virtual simulation products are reviewed.

Body Interact. A key benefit of virtual simulation is that it offers a way for students to engage in simulation independently, at their own pace, on their personal computer, with a three-dimensional representation displayed on a two-dimensional screen, and with a level of confidentiality regarding the student's performance (Sapiano et al., 2018; Williams et al., 2020). Tilton et al. (2015) depicted the virtual simulation experience as a form of role-play in which students manage a situation through the actions of an avatar, immersing the participant in the reality of the scenario. Similarly, Padilha et al. (2018) used the clinical virtual simulation (CVS) software *Body Interact* for a study to examine its usefulness in enhancing student clinical reasoning skills. The *Body Interact* software provides users with a simulated case accessible from their personal computer through a web-based platform. Once logged into the virtual simulation software, a user can select a scenario (Williams et al., 2020). In *Body Interact* (2022), the scenario begins with a timer. It provides the user with various selections available to treat or

care for the patient appropriately. Examples of available scenarios include assessing a pediatric patient post-procedure or a deteriorating patient with choices for life-sustaining selections like defibrillation or administering life-saving medications (Verkuyl et al., 2017; National League for Nursing, 2022). Padilha et al. (2018) suggested that virtual simulation improves student knowledge transfer, even for highly complex experiences in hospital/facility-based settings. Padilha et al. (2018) found that virtual simulation aided in refining student understanding of deterioration scenarios.

vSim for Nursing. The software *vSim for Nursing* operates similarly to the *Body Interact* software allowing for a self-guided, interactive resource that student nurses can access online. Nurse educators can integrate this software into their courses or curricula (National League for Nursing, 2022). The *vSim for Nursing* software allows users to interact with a simulated patient in a virtual hospital/facility-based setting on an online platform the user can access from their personal computer. Unlike in *Body Interact*, the simulated patient onscreen reacts to actions by the nurse, attempting to simulate interactivity. The case provides choices for the user to treat the patient. The user may do a heart assessment with auscultation, administer medications, assess history information, or phone the doctor for other concerns. As with *Body Interact*, *vSim for Nursing* uses a self-guided resource or a proctored experience (National League for Nursing, 2022). Gu et al. (2017) noted *vSim for Nursing* closes the loop through a well-organized platform with cues prompting planning and complexity through the interaction. The *vSim for Nursing* introduces the scenario with clear objectives and specific guidance to direct a student's actions.

Following the activity, prompt feedback shows deficits and mastery to allow students an active learning experience (Gu et al., 2017). *Body Interact* provides a similar strategy with pre-briefing, followed by interactions with the virtual patient through dialogues, physiological

parameters, and observations (Padilha et al., 2019). After completing the scenario, through the resolution of the case or time, debriefing is provided through a simulation report, timeline, and performance, highlighting the individual's decisions made and how they affected the simulation outcome. (Padilha et al., 2019).

Other Virtual Simulation Software. Other virtual simulation software similar to Body Interact and vSim for Nursing are created by *Sentinel U* (Sentinel U, n.d.) and *ShadowHealth* (Bryant et al. 2015; Shadow Health, 2022; Shorey & Ng, 2021). *NurseThink* also created another form of virtual simulation known as *vClinical: Virtual Simulations* that provides a similar style to *Body Interact*, *Sentinel U*, *ShadowHealth*, and *vSim for Nursing*, but the unique feature of this product is the addition of distractions during the simulation (NurseThink, n.d.; Thrift, 2021). The student nurse may have a patient in the simulated experience as the primary patient but will be assigned to other patients for the scenario. As the scenario unfolds, the student would be interacting with one patient, and another patient may call requiring assistance. These additional patient distractions help develop prioritization for the student nurse in the virtual simulation (NurseThink, n.d.). All self-guided virtual simulations allow students to practice nursing concepts at a rate and pace conducive to them and before exposure to others' perspectives (Lapnum et al., 2019).

Although teaching technologies provided in a virtual simulation have potential for nursing education, studies have shown virtual teaching success is dependent on the selection process, integration of the technology, and implementation within the curriculum (Gu et al., 2017; Huun, 2018; Tan et al., 2017; Verkuyl et al., 2017). Virtual simulations create computer-based simulations to prepare student nurses for experiences in a hospital/facility-based setting (Body Interact, 2022; National League for Nursing, 2022; NurseThink, n.d.; Sentinel U, n.d.;

ShadowHealth, 2022). This additional resource enhances current simulation practice by reinforcing concepts presented in the simulation-based learning environment.

Virtual Reality Simulation

Dalgarno and Lee (2010) provided a means to distinguish a virtual simulation from a modality such as VR-Sim, or a three-dimensional virtual learning environment (3-D VLE). “Three-dimensionality, smooth temporal changes, and interactivity are the most important features that distinguish 3-D VLEs from other types of VLEs, like those provided by a learning management system (e.g., Blackboard or Moodle)” (Dalgarno & Lee, 2010, p. 11). Although learning management systems (LMS) are VLE software, they provide resources virtually through a computer-based, online, two-dimensional (2-D) platform and would not be considered 3D-VLE software (Dalgarno & Lee, 2010). Other virtual simulation programs, such as *Body Interact*, *Sentinel U*, *ShadowHealth*, *vClinical*, and *vSim for Nursing*, use VLE technology to provide student nurses with an interactive 3-D scenario via a 2-D computer-based online platform (Body Interact, 2022; National League for Nursing, 2022; NurseThink, n.d.; Sentinel U, n.d.; ShadowHealth, 2022). These virtual simulation programs qualify as 3D-VLE but lack the head-mounted displays for visualizing the virtual reality environment when working within a VR-Sim (Body Interact, 2022; Dalgarno & Lee, 2010; National League for Nursing, 2022).

VR-Sim provides an environment that prompts a sense of leaving the natural world and entering the virtual world as if physically there (Servotte et al., 2020). VR-Sim is a 3-D replication of the natural world in which a person is immersed within a digital environment through either projections or Head-Mounted Displays (HMDs), and movements are matched by motion sensor tracking gear through a computer (Bartlett et al., 2018; Cant et al., 2022; Dang et al., 2020; Wu et al., 2020; McGrath et al., 2018; Yongliang et al., 2015). The literature has

intertwined terms associated with virtual simulation and VR-Sim despite the two being distinctly different modalities. Cant et al. (2022) generally considered virtual simulation an umbrella term for simulation with any virtual component in their bibliometric analysis. Understanding those differences is critical to genuinely comprehending how the VR-Sim modality functions and what will occur during this study.

Virtual Reality. Virtual reality (VR) software has become ubiquitous in society, being used for everything from gaming, military training, and educational strategies for medical students. Virtual-world modalities have been around for decades but have progressed to more authentic mediums for simulation training (Dunne et al., 2010). The virtual platform *Second Life* VR software assisted in the education of first responders a decade ago (Foronda & Trybulski, 2013). Some software uses a two-dimensional environment for interactions in educational VR software in the same way as *Second Life* and *Body Interact*. The use of three-dimensional models has increased more recently to engage students in an immersive experience (Ma et al., 2017). A quick Google® search related to VR equipment and software for what is currently available to the average consumer returned 237,000,000 results. A few examples of VR-Sim products follow.

CAVE VR-Sim. Yongliang et al. (2015) suggested using a CAVE-based VR-Sim immersive aircraft carrier marshaling scenario to train individuals on the techniques needed to maneuver aircraft around a flight deck. CAVE VR-Sim is a projection form of the immersive environment where images of the real-life location are depicted on the walls of the room surrounding the participant (Jeong & Lee, 2019). The individual moves within the space as the images adjust on the walls, replicating a real-life environment. CAVE VR-Sim provides immersive, 3-D replication without the HMD haptic devices sometimes associated with VR-Sim (Jeong & Lee, 2019). Ruston et al., (2020) used an Octave VR-Sim software similar in scope to

the CAVE VR-Sim for Basic Life Support (BLS) training. CAVE VR-Sim is considered a medium fidelity, immersive version of VR-Sim. CAVE is different from the HMD VR-Sim which is more highly immersive.

Augmented Reality Simulation. Augmented Reality Simulation (AR-Sim) has similarities to the description Vottero (2014) presented for VR-Sim as a virtual 3-D environment with spatial perception generated through stereoscopic glasses, or goggles, allowing an individual to see the imagery with length, width, and depth. Stereoscopic glasses or goggles have been cited in the literature (Jeong & Lee, 2019; Kardong-Edgren et al., 2019b; Vottero, 2014), but there are other implications for using the HMDs for AR-Sim beyond the prototypical VR-Sim environment. AR-Sim applies computer-generated imagery to objects in the natural environment (Foronda et al., 2017). AR-Sim has revolutionized gaming software with overlaying natural environments in which the user resides with digital, interactive stimuli (McGrath et al., 2018). Mobile devices use AR-Sim by allowing an individual to tap on the screen of the phone or tablet to interact with the digital medium through an application, such as in the gaming software *The Walking Dead: Our World*, *Star Wars: Jedi Challenges*, or *Pokemon Go* to name a few (Crecente, 2018; Khan et al., 2019). Each of these applications overlays the natural environment with interactive, digitized media.

The natural environment interaction is the critical difference between AR-Sim and VR-Sim. For instance, Jensen and Forsyth (2012) studied student nurses experience of what the researchers referred to as a form of VR-Sim, namely AR-Sim, to insert an intravenous catheter (IV) in a self-directed, interactive environment using a computer program and haptic arm device (Jensen & Forsyth, 2012). Although this meets current criteria for AR-Sim, the researchers use VR-Sim in their description. Kardong-Edgren et al. (2019b) stated the definitions of VR-Sim

technology had been skewed at times, without consensus leading to misunderstandings in the technology and how it may be used. The nomenclature then combined VR-Sim and AR-Sim as one, despite the researchers specifically saying the experience augmented what the students could do in the simulation (Jensen & Forsyth, 2012). The haptic device and simulation allowed the user to perceive feeling for a vein and inserting a catheter as a real-life experience with a different feel from VR-Sim (Jensen & Forsyth, 2012). Clarity of the terms for AR-Sim and VR-Sim is needed (Kardong-Edgren et al., 2019b). Standardization of the terms currently associated with VR-Sim will continue to develop as more research progresses.

Mixed Reality Simulation. Another VR-Sim modality is mixed reality simulation (Kardong-Edgren et al., 2019b). AR-Sim and VR-Sim have shown enhanced learning environments and increased engagement among students using technology (McGrath et al., 2018). Enhancements to learning and engagement for AR-Sim and VR-Sim have led to the development of software and equipment that mixes the two simulation modalities into one experience. One such platform is the HoloLens® 2 by Microsoft® (2022), where a holographic image superimposes the natural environment through the HMD. To differentiate the AR-Sim parts from the VR-Sim parts, the user can interact with the digital aspects of the medium, like a holographic computer display that is not present in reality and has no connection to reality (Microsoft®, 2022). Cant and Cooper (2017) and Lilly et al. (2016) suggested using multimodal approaches to learning via simulation, such as combining a realistic simulation environment with a virtual simulation environment in augmented reality, to fill in gaps where clinical experiences cannot provide the same opportunities.

Three-dimensional interactivity with something not real can affect the presence phenomenon and how much individuals feel they are there within the environment (Kardong-

Edgren et al., 2019b). Immersion is another essential part of VR-Sim experiences, as greater immersion in the environment is achieved with sensory richness and the user's ability to influence the medium (Kardong-Edgren et al., 2019b). Presence and immersion will be explored later in the review, but both are central to how VR-Sim experiences work.

Types of Virtual Reality Hardware, Software, and Costs

Products such as Oculus Quest® 2, Sony PlayStation® VR, Valve Index® VR Kit, HTC Vive® Pro 2 are just a few of the available headset devices gaming consumers can readily purchase on the internet. On the PC (2022) website, a list of potential devices for use with a Windows 11 personal computer provided both the name and price of currently available headsets, ranging from \$299.00 to \$1399.00. Computer devices for use with VR-Sim, such as the Alienware® 17 laptop computer valued at \$1849.99, add the additional cost of setting up a virtual reality experience (Dell®, 2022). Many of these devices and software packages are used primarily for gaming purposes. A basic Dell® laptop, the company that designs Alienware®, would not run a VR-Sim experience, as the device's specifications may be limited (Dell®, 2022). For this study, Appendix H presents the specifications of the VR-Sim software and hardware. The increased accessibility of this equipment and software means a greater ability to use VR applications for education (Kritikos et al., 2020) but adds to the cost of the virtual education strategies. VR software for healthcare educational purposes takes considerable time and personnel resources to create activities suitable for the training of student nurses (Kardong-Edgren et al., 2019b).

In addition to the cost of the hardware presented above, it's necessary to understand the cost associated with the software of VR experiences, those that may be used for nursing education. Software such as *Oxford Medical Simulation: Virtual Reality Nursing Simulation*

(Oxford Medical Simulation, 2022b), *UbiSim* (D’Errico et al., 2021), and *Unity 5* (Liaw et al., 2019; Liaw et al., 2020) are explicitly designed for nursing-related procedures and scenarios. *UbiSim* and *Oxford Medical Simulation* come with additional costs and packages for schools and colleges of nursing to purchase. A search on Google® did not provide pricing information from the websites for either platform but did provide requests for demos suggesting pricing may be determined by other factors beyond the control of either company (Oxford Medical Simulation, 2022a; UbiSim, 2022). For instance, the number of students enrolled in a program may determine cost. For example, *Oxford Medical Simulation’s* virtual simulation platform provides the service for \$186 per student (Biros, 2022). For 220 students, as the report suggests, that would be an estimated cost of \$40,920 to implement the virtual simulation platform (Biros, 2022).

Pottle (2019) provided context with a cost comparison between setting up a traditional simulation experience with current modalities and a VR-Sim experience. The cost of traditional simulation, which the study called physical simulation, included a building renovation complete with manikins, a learning management system to record and debrief, medical equipment, and other simulated requirements, was a minimum of \$875,485 (Pottle, 2019). Annual costs for maintenance, licensing, and other contracts were a minimum of \$361,425, putting the value of traditional simulation experiences at over \$1 million US with start-up and continued expenses (Pottle, 2019).

The VR-Sim experiences provided under one-tenth the cost with start-up and running the modality compared to traditional simulation experiences (Pottle, 2019). Specific cost figures were not reported but showed a potentially reduced cost using VR-Sim experiences. The software used for this study is *Virtual Reality Cardiopulmonary Resuscitation* (VR CPR) to

provide a means to demonstrate a basic skill student nurses are required to learn during school for clinical placement (VR CPR, n.d.). The VR CPR software can be acquired as a one-time purchase from Steam (2022a), an online gaming platform allowing users to pay, play, and interact with others. The VR CPR software costs \$120 on Steam for an initial download and no subsequent cost.

VR-Sim Limitations

McGrath et al. (2018) suggested VR-Sim as a valuable teaching strategy for rarely encountered clinical events. VR-Sim can replicate challenging encounters not easily accessible for users. Kilmon et al. (2010) noted that to achieve the most significant level of realism training for health professionals in complex situations, VR-Sim should be combined with other simulation methods. Certain VR-Sim factors may promote users' stress, fear, and cybersickness (Servotte et al., 2020). As previously stated, the virtual environment prompts the sense of leaving the natural world and entering the virtual world as if physically *being there*. This change in the sense of location is desirable in a virtual environment. Users may be consciously aware of the natural environment, potentially negating the immersive response (Servotte et al., 2020). The other reviews noted concerns about effectiveness (Chen et al., 2020; Woon et al., 2021) and the need for more studies to show the capabilities of VR-Sim for use in nursing education.

Environment

Simulation aims to achieve an environment in which errors can occur without jeopardizing patient safety. Students can repeatedly practice a skill or task to increase nursing process knowledge (Lateef, 2010). Student nurses attempt to understand processes with simulation practice to prevent potential mistakes in hospital/facility-based settings. Harris et al. (2013) stated that student nurses could perform in a psychologically safe environment where

mistakes and failures have minimal consequences in simulation practice. Despite these advantages, Leigh et al. (2017) suggested future researchers should investigate teaching strategies, like simulation, that increase student engagement, learning, and participation. Other studies have cited the safe environment aspect of simulation, allowing for mistakes and consequent student learning to improve performance (Akhtar-Danesh et al., 2009; Ballangrud et al., 2014; Heard et al., 2011; Johnston et al., 2017; Khalaila, 2014; Wehbe-Janek et al., 2012). Simulation can reduce student anxiety about patient interactions in the hospital/facility-based setting (Khalaila, 2014).

Finally, the six meta-analyses of VR-Sim (Chen et al., 2020; Choi et al., 2022; Plotzky et al., 2021; Qiao et al., 2021; Shorey & Ng, 2021; Woon et al., 2021) showed students who engaged with virtual learning modalities reported improvements in knowledge and procedural understanding, but the environment was an add on experience to current simulation teaching strategies. Varied platforms for delivering the scenarios, situations, or environments were reported in VR-Sim studies. Some researchers developed their environments through the input of other educators and experts. For instance, Ulrich et al. (2014) developed a VR-Sim experience with a base platform in Microsoft Kinect®, adding VR equipment to make the scenario more interactive. The setting in the VR-Sim environment provided a realistic view of an emergency room complete with the patient, stretcher, and other equipment (Ulrich et al., 2014). A study on dental providers showing empathy developed the MPATHI (Making Professionals Able Through Immersion) VR-Sim experience (Amini et al., 2021). Others (Nicely & Farra, 2015) do not describe the VR-Sim software or equipment used, limiting what is known about available VR-Sim environments.

Medical VR-Sim studies have developed new platforms for virtual experiences and incorporated clinical assessment tools such as the Arthroscopic Surgery Skill Evaluation Tool (ASSET) scoring system (Aygeman et al., 2020; Hauschild et al., 2021). The Virtual Electrosurgery Skill Trainer (VEST) (Rossler et al., 2019) explored fire safety training in the operating room. A study on radiographic imaging used *Shaderware*, a virtual reality environment for medical imaging training (Russell & Spence, 2018).

These examples of VR-Sim software platforms provide direction on creating similar applications explicitly for nursing education. Many of these use animations resembling the natural environment or hospital/facility-based setting in the same manner as the *VR CPR* software used in this study (VR CPR, n.d.). Because of the animated nature of some VR-Sim platforms for nursing, applying the haptic devices to the simulation is essential to provide more realism.

Plotzky et al. (2021) suggested incorporating haptic components into VR-Sim to allow the experience to compete with the current learning environment of HF-HPS, which provides the hands-on capability. Plotzky et al. (2021) reviewed 22 studies that used computer keyboards, mice, and controllers as haptic devices in the literature. Plotzky et al. (2021) did not consider these devices immersive as they did not simulate haptics in the natural environment. For example, clicking the keyboard to make hands do chest compressions on a simulated patient in the virtual world is not the same as having the user physically press down on a manikin chest. Haptic devices are a physical component applied to the VR-Sim experience, so users feel they interact with something real while immersed in the environment (Butt et al., 2018; Jung et al., 2012).

Haptic feedback in VR-Sim environments that provides similar haptics as the actual interaction may be effective for nursing education (Komizunai et al., 2020). The *Geomagic Touch*, for example, presents a deep feeling the user recognizes by touching the object in the virtual environment allowing for a sensation of touching material like the skin on the surface of an arm (Chiba & Hamamoto, 2018). This type of haptic device is similar to those used in three studies in Plotzky et al.'s (2021) review. These studies used more sophisticated haptic devices to simulate auscultation with a stethoscope (Chiba & Hamamoto, 2018), a wrist-force-feedback module simulating catheter insertion for endotracheal suctioning (Komizunai et al., 2020), and tactile sensory gloves for inserting a foley catheter (Butt et al., 2018). Although VR-Sim can use hand controllers in the natural environment to reach for objects and pick up things within the virtual setting, hands-on interactions are more limited than current HF-HPS modalities. The hand controllers produce a vibration to provide feedback to the user as they interact, but no other stimuli are generated (Choi, 2019). Plotzky et al. (2021) only found three studies with more sophisticated haptic devices during their review, with no mention of the availability and cost associated with this equipment. This limited amount of sophisticated haptic devices could imply other intrinsic factors limit the use of such equipment.

Reviewing the literature regarding simulation from the standpoint of fidelity, modality, and environment provided context for how simulation has been used. The primary literature explored simulation availability, resourcefulness, and characteristics, explicitly focusing on VR-Sim in healthcare professional education. The application of VR-Sim in other disciplines provided evidence supporting the usefulness of this modality. Equipment cost and availability of various platforms of VR-Sim support the use of this teaching strategy. Barriers and limitations to

simulation and VR-Sim specifically require ongoing research of factors affecting this modality's inclusion within nursing educational curricula.

Factors Affecting Learning Environment Effectiveness

This section discusses the characteristics of the learners, various learning environments, barriers, and effectiveness clarifying how individuals gain knowledge from simulation. This review will show how individuals may perceive presence during an experience and how immersion affects learning environments. This review will also establish the relationships of immersion with engagement and learning outcomes.

Learner Characteristics

Generational differences among today's learners are changing nursing education strategies. Students classified as Generation Z, born in 1996 to 2012 (Roseberry-McKibbin, 2017) are digital natives and use digital platforms for communication, entertainment, shopping, and learning (Pront et al., 2018).

As Squire (2008) suggested, video gaming is a form of simulation typically for entertainment purposes with which digital natives are familiar (Gentry et al., 2019). In the context of learning for healthcare professions, this digital environment has also been called *serious games* (Gentry et al., 2019). Serious games apply the knowledge of healthcare professions, such as medicine or nursing, with critical implications to promote learning through a digital device (Gentry et al., 2019). Regular video gaming lacks this attribute shown in serious games. For instance, a serious game may be designed about blood administration, assessment of respiratory disease, or administering insulin (Gentry et al., 2019). Johnsen et al. (2018) said serious games allow students to engage actively with a case scenario similar to simulation. After using serious games, students found the use of such games valuable for educational purposes,

particularly in the care of patients with chronic conditions (Johnsen et al., 2018). Multiple innovative technologies and teaching strategies, as well as rapidly advancing technologies, that capitalize on generational preferences and skills are needed to fully engage today's students (Johston et al., 2018; Shatto & Erwin, 2017; Squire, 2008).

Chandrasekera and Yoon (2018) suggested learning style and preference for an environment could affect learning in individuals. Hands-on learning experiences, such as those representing reality, have shown effectiveness for learners (Yongliang et al., 2015). Tacgin (2020) suggested that learners should be familiar with the scenario unfolding in VR-Sim and the technology. Learners need to have prior knowledge of VR-Sim to adapt to this learning environment and work through the situation created for the experience (Tacgin, 2020).

Other individual characteristics that can impact the usefulness and effectiveness of VR-Sim and AR-Sim have been reported. For instance, Bayram and Caliskan (2019) reported virtual game play status, indicating a subject either played or did not play virtual gaming. Of the 43 subjects in the experimental group that used a virtual platform, only 29 listed themselves as having played virtual games (67.4%). Fourteen of the 43 subjects in the control group (53.5%) reported being game players. Based on these statistics, over half of the participants did not consider themselves virtual game players. The experimental group, which performed the activity on a phone-based application, showed a greater increase ($p = 0.022$) in knowledge than the control group in the study (Bayram & Caliskan, 2019). The lack of virtual gameplay did not seem to affect the results significantly. This intervention focused more on AR-Sim than VR-Sim. It did show gameplay status may not be a significant determinant of whether a participant can perform the desired intervention in a virtual simulation.

Multiple studies have also shown the predominance of female participants in nursing studies using VR-Sim modalities. Increased numbers of female participants are expected in nursing studies due to the composition of most nursing programs. Butt et al. (2018) reported 16 females between the control and experimental groups out of 20 total subjects. Dubovi et al. (2017) reported 97 female participants out of 129 subjects. Padilha et al. (2019) reported 40 females between the control and experimental groups and two males total between both groups. None of these studies mentioned the heavy female participation as a limitation or even difficulty generalizing the data to other populations. The studies show the participation as a descriptive statistic, but with little expansion on how the results may be affected, including how many participants were gamers.

Experience and Effect of Virtual Reality Simulation

Characteristics of effective teaching strategies are personalized, active, intense, and repetitive (Thompson-Butel et al., 2018). Dalgarno and Lee (2010) introduced the model of three-dimensional (3-D) virtual learning environments (VLEs) for the creation of VR-Sim experiences. Appropriately designed 3-D VLEs may provide value-added learning over 2-D technologies (Dalgarno & Lee, 2010). Some learning tasks may be more accessible or effective in 3-D VLE (Bower et al., 2017; Cho et al., 2015; Dalgarno & Lee, 2010). The 3D-VLE can allow the user to interact with the situation physically and psychologically (Bower et al., 2017; Cho et al., 2015; Dalgarno & Lee, 2010; Ismailoglu et al., 2020). For example, in the VR-Sim software *VR CPR* the user interacts physically by providing chest compressions using the two hand controllers to allow the user to experience compressions in the real world outside the simulated environment. For psychological stimulation in the environment, the user must consider the simulated patient's response. The user reacts to the situation to resuscitate the simulated

patient and responds to cues on screen for hand placement, compression statistics like rate and depth of compressions, and the simulated nurse directing actions such as pressing deeper on the patient's chest (VR CPR, n.d.).

Learner Experience

Although traditional simulation has multiple barriers such as faculty development, cost, debriefing concerns, and full use of the modality, other extraneous effects have been elicited with VR-Sim that differ from the traditional simulation. For instance, participants in a study by Adhikari et al. (2021) reported adverse effects of twisting the neck and body while engaged in a VR-Sim sepsis game. Drying of contact lenses was also reported (Adhikari et al., 2021). VR-Sim was used to educate patients on recovery measures from lumbar spine surgery, producing no side effects from the interaction (Chu et al., 2020). The Adhikari et al. (2021) study aimed to see how students navigate a VR-Sim to understand a process. The Chu et al. (2020) study provided patients knowledge about performing rehabilitative measures specific to their circumstances. Engagement may have been the key to the differences in adverse effects. If the exploration process was not beneficial to the user, perceiving adverse effects may be more prominent. Adverse effects may become less pronounced when users gain the knowledge they can use for their own needs, such as the patients learning rehabilitative measures. The user's perception may have adjusted how the individuals learn, based on how the individual uses the information following the experience.

Another less desirable effect elicited from VR-Sim is cybersickness (Bracq et al., 2019; Kleven et al., 2014; Samosorn et al., 2020; Servotte et al., 2020). Cybersickness refers to motion sickness caused by being immersed in the virtual learning environment with haptic devices and HMDs (Servotte et al., 2020). Discomfort, malaise, dizziness, dry eyes, and nausea have been

reported but typically resolve quickly (Kleven et al., 2014; Servotte et al., 2020). Users reported anxiety and stress surrounding the use of virtual learning environments (Cobbett & Snelgrove-Clarke, 2016; Menzel et al., 2014; Servotte et al., 2020).

Other stresses with virtual learning environments center around the use of the software itself. Both faculty and students reported preferences for face-to-face interactions in simulation or the clinical practice setting over virtual learning environments such as *Second Life* or virtual simulation (Cobbett & Snelgrove-Clark, 2016; Menzel et al., 2014). Simply using the virtual learning environment increased the participant's stress in the study because of lack of familiarity with the product (Cobbett & Snelgrove-Clark, 2016; Kardong-Edgren et al., 2019b; Menzel et al., 2014).

Learning outcomes from VR-Sim experiences have been compared to traditional simulation to ascertain the effectiveness of this learning environment. Loar (2007) suggested that knowledge used in different contexts and situations must be presented in multiple ways and noted that experiences differ from person to person and technology to technology. What worked for one modality might be slightly different for another. Understanding those varying perspectives is essential to determining how effective teaching is for the learner engaging in the experience. Observation continues to be a highly effective way to gain new knowledge. Chang et al. (2019) used a smartphone to deliver childbirth education. The participants observed the education in a virtual environment to improve learning procedures for childbirth (Chang et al., 2019). Chang et al. (2019) found students in the experimental group using VR showed significantly better learning achievement ($F = 20.30, p < 0.001$), motivation ($F = 8.37, p < 0.05$), and satisfaction ($F = 13.08, p < 0.01$) compared to those using conventional teaching strategies. There was no significant difference between the two groups for learning attitude ($F = 3.41, p >$

0.05) and critical thinking ($F = 0.81, p > 0.05$). The qualitative strand of the Chang et al. (2019) study corroborated the quantitative portion showing that students learned abstract issues more deeply with the VR approach before participating in clinical setting activities. Understanding how this modality improved knowledge acquisition can allow researchers to apply similar techniques to other modalities to facilitate goal-directed outcomes.

Effect of VR-Sim

The effect for VR-Sim pertains to how this software has been used in nursing education. But to understand the effect, a consistent definition of the modality is needed. Kardong-Edgren et al. (2019b) note the definition of virtual reality lacks consensus among scholars. As a result, blurred lines between virtual simulation, VR-Sim, ARSim, and other virtual environments can misconstrue the usefulness and effectiveness of specific virtual learning environments. This definitional confusion is seen throughout the literature. For example, Vidal et al. (2013) and William et al. (2016) consistently referred to the CathSim system as a virtual reality simulator when the CathSim description suggests a virtual simulation like *vSim for Nursing*. Using only the computer with no head-mounted display, no interactivity within the digital representations, no separation from the natural world and the virtual world, and no immersion into the environment are hallmarks of virtual simulation rather than VR-Sim. By contrast, some studies clearly defined virtual simulation based on a computer with the definition presented in the literature review (Padilha et al., 2019; Shoemaker et al., 2014). Cant et al. (2022) classified the term virtual simulation to refer to any virtual environment, including virtual worlds, virtual simulation, and virtual reality. The definition presented by Singleton et al. (2022) also has similarities with Cant et al. Although smartphone devices may use AR-Sim for many applications, devices like Google Cardboard® allow a three-dimensional representation consistent with the definition of VR-Sim

(Chang et al., 2019; Elliman et al., 2016; Permana et al., 2019). As VR-Sim usage increases, standardized definitions of virtual learning environments will help differentiate each type of software more effectively (Cant et al., 2022; Kardong-Edgren et al., 2019b).

Skill development has been a primary goal for using VR-Sim with student nurses. Ismailoglu and Zaybak (2018) conducted a study on intravenous catheterization training for student nurses using what they called VR-Sim, but not corresponding to the definition of VR-Sim in this review. The haptic elements had a digital overlay element that is more representative of AR-Sim. Nonetheless, the researchers compared pre-test and post-test results using a virtual intravenous simulator with a haptic element, including a plastic arm model. The results showed no significant difference in knowledge scores between the experimental VR-Sim and control groups ($p = 0.537$). The experimental VR-Sim group's satisfaction scores were significantly higher ($p = 0.000$) (Ismailoglu & Zaybak, 2018). Rushton et al. (2020) showed, in a VR-Sim investigating confidence and competence performing BLS skills, participants gained competence in the immersive environment (46.9, $P=.04$) compared to non-immersive. Yet non-immersive scores were higher for confidence (ventilation 29.2, $P < .001$, BLS guidelines 24.3, $P < .001$, leadership 27.7, $P = .163$) compared to the immersive suite and Octave environments. The researchers felt this lower scoring in the more immersive VR-Sim environments corresponds to a lack of familiarity with the experience (Rushton et al., 2020; Choi et al., 2022).

A refresher course in urinary catheterization using a VR-Sim gaming strategy (Kardong-Edgren et al., 2019a) allowed student nurses to practice the skill, reinforcing knowledge learned earlier in the semester. Results showed 75% of respondents felt the VR-Sim experience was positive, encouraging better hospital/facility-based performance (Kardong-Edgren et al., 2019a).

Despite the positive response, continued research looking beyond satisfaction for VR-Sim experiences is needed.

Another way to research VR-Sim is through serious gaming. Serious gaming allows educators to assess knowledge interactively with student nurses. Student nurses' level of knowledge has shown positive effects ($p < 0.05$) through gaming software in VR-Sim (Bayram & Caliskan, 2018). The experimental group who used VR-Sim showed significantly higher scores in this study with their final suctioning skill performance ($p = 0.017$) than the control group who received standard instruction (Bayram & Caliskan, 2018). Other VR-Sim experiences include decontamination training (Farra et al., 2015; Smith et al., 2016; Smith et al., 2018), disaster training (Farra et al., 2013), needle stick injury prevention (Wu et al., 2020), porta-a-cath education (Tsai et al., 2008), hypoglycemic intervention (Singleton et al., 2022), and wayfinding for nurses navigating a new hospital building (Halfer & Rosenheck, 2014).

Although VR-Sim has seen use in skills practice, it is not used widely in nursing education (Bogossian et al., 2018). Much of the lack of use corresponds to uncertainty with how to use VR-Sim. Educators have been concerned with how to understand and implement a new modality such as VR-Sim, making it difficult to integrate. Researchers have been attempting to provide uses for VR-Sim in nursing with various types of educational experiences. Multiple studies used VR-Sim for collaborative team efforts (Caylor et al., 2015; Christensen et al., 2018; Davis et al., 2016; King et al., 2012; Lee et al., 2020; Liaw et al., 2020; Seefeldt et al., 2012; Tschannen et al., 2018; Zook et al., 2018). These educational sessions using VR-Sim enabled the dynamics of working together towards a common goal in the virtual environment showing a sense of role understanding, performance in the experience, and teamwork.

Beyond skills and the team oriented ways to use VR-Sim, headsets are now making it easier to be mobile, allowing users to interact anywhere, anytime. Oculus Rift® uses human anatomy imaging in the Asteion computed tomography software to provide a virtual, three-dimensional image of the cranium, allowing the user to interact with the brain (Izard et al., 2017). The user interacting with the software can use a remote control device and a headset to visualize structures within the skull to understand specific structures. Wood et al. (2022) in their integrative review concluded fully immersive HMDs enhanced engagement and interactivity.

Mobility and interaction are shown to be beneficial to VR-Sim, but other studies looked at how behaviors impacted the experience. Giordano et al. (2020) concluded there was no significant difference ($p < 0.05$) between knowledge ($p = 0.229$) and attitude ($p = 0.002$) in VR-Sim and hybrid simulation groups. The hybrid simulation used traditional modalities. Goldsworthy et al. (2022) used a hybrid simulation with HF-HPS and virtual simulation showing statistically significant increases in competencies using both modalities ($p < .001$). DeLeo et al. (2014) stated users in virtual environments, such as VR-Sim, have thoughts, emotions, and behaviors consistent with real-life circumstances, such as in the clinical practice environment. Gromer et al. (2019) suggested when participants experienced emotional responses in VR-Sim, they felt a greater degree of *being there* in the scenario. Understanding what generates these emotional responses is needed to determine how VR-Sim genuinely effects users.

Impact of COVID-19

The coronavirus, or COVID-19, pandemic provided a dramatic example of limitations to clinical practice settings and the need for effective alternative learning strategies. During the pandemic, many clinical practice settings became limited or closed to student placements requiring nursing programs to find alternative clinical learning experiences. VR-Sim has the

potential to recreate the environments commonly used for nursing education purposes, like home care, operating rooms, or emergency rooms (Hirt & Beer, 2020). Time is needed to develop these environments in a VR-Sim experience, and currently, robust VR-Sim software are limited.

Like all face-to-face learning, VR-Sim was limited during the pandemic. Simulation centers with haptic devices and HMDs and HF-HPS simulators were no longer available to students due to university shutdowns caused by the pandemic. Students could not physically interact due to concerns of cross-contamination of devices and the spread of the coronavirus. Watties-Daniels (2020) noted that the Commission on Collegiate Nursing Education (CCNE) allowed flexibility in delivering clinical and simulated experiences for student nurses during the pandemic. This flexibility allowed the implementation of innovative teaching strategies. Therefore, virtual simulation, such as *vSim for Nursing*, was generally the alternative to clinical learning during the pandemic (Watties-Daniels, 2020).

One response to the need for virtual simulation during the pandemic was that companies began working together to solve problems rather than compete (Richey, 2020). Drager, GE Healthcare, Getinge, Hamilton Medical, Nihon Kohden, Philips, and Medtronic created the ventilator training alliance application to assist healthcare professionals in ventilator training exercises during the pandemic (Richey, 2020). Multiple universities, such as New York University, the Mayo Clinic, and Wake Forest University, partnered to create a VR workspace allowing clinicians to work together to train on airway management through Oculus headsets even while working remotely (Spear, 2022).

Although the current literature on the coronavirus and virtual learning environments is limited, the work conducted during the pandemic by educators, clinicians, and researchers will continue to progress and add to the body of knowledge. Scholars are beginning to incorporate

knowledge connected to the literature reviewed in this proposal to differentiate virtual learning environments and adequately implement virtual simulation. A brief search in CINAHL with the keywords “coronavirus” and “virtual” yielded 572 results. This literature focused on telehealth, fear, and experiences with coronavirus. Narrowing the search to virtual learning (21), virtual reality (96), or virtual simulation (6) produced a total of 123 results. Articles from the narrowed search dealt with implementing with some focusing on evaluating virtual simulation during the pandemic. This budding research paradigm will continue to grow and increase knowledge related to virtual learning environment use following the coronavirus pandemic.

How learners interact in simulated environments affects their perceptions and knowledge gained during the experience. These factors can change, but so can the effects of the simulation itself. The experience of a VR-Sim scenario can lead to adverse effects at times, such as cybersickness. It can also promote better behaviors like helping a patient work through their post-operative surgery. Extrinsic factors like the effects of COVID-19 on healthcare, in general, have impacted how simulation is delivered, but the simulations themselves, whether the traditional modalities or VR-Sim, complement one another to improve learning. Exploration of what promotes realism, immersion, and engagement in VR-Sim is required. A perception of *presence* or being in the situation influences immersion and engagement and affects how VR-Sim contributes to learning outcomes.

Relationship among Presence, Immersion, Engagement, and Learning Outcomes

Presence, immersion, and engagement are related phenomena. Studies show presence can influence student learning outcomes (Dubovi et al., 2017; Liaw et al., 2019; Tacgin, 2020).

Understanding presence may clarify how learning environments ranging from lecture and the

hospital/facility-based setting to virtual learning specifically can enhance student nurse educational experiences.

VR-Sim is a simulation scenario created using computer-generated graphics to mirror the natural world setting, fully immersing users in the environment and responding to their actions (Yildirim et al., 2019). Multiple studies support the definition of VR or VR-Sim as an interactive, three-dimensional, immersive tool recreating a realistic environment (Bartlett et al. 2018; Dang et al., 2020; Wu et al., 2020; Kritikos et al., 2020; MacLean et al., 2019; Piccione et al., 2019; Seabrook et al., 2020; Yildirim et al., 2019; Yongliang et al., 2014). Unfortunately, specific definitions for concepts frequently included in VR descriptions, such as *immersion* and *engagement*, are not well differentiated.

Presence

Presence is a learner's ability to perceive *being there* (MacLean et al., 2019). Multiple studies, theoretical frameworks, and meta-analyses incorporate this simple definition as the primary meaning of presence in virtual learning environments (Dalgarno & Lee, 2010; Dang et al., 2020; De Leo et al., 2014; Dubovi et al., 2017; Dunnington, 2015; Liaw et al., 2020; MacLean et al., 2019; Shin et al., 2019; Shorey & Ng, 2021). Dunnington (2015) suggested an extension of this definition by adding that a learner uses judgment and critical thinking to remain accountable and responsible for responding to the circumstances unfolding in the environment. When fully immersed in a virtual environment, the VR-Sim participant may forget the natural world and adapt to the new environment (Weibel et al., 2015). This forgetting of the natural world embodies the state of being present within the environment.

Presence not only characterizes simulation or virtual learning environments but can be experienced in such pursuits as online gaming, reading, television viewing, conferencing via

video platforms, and watching movies in a movie theater (Dang et al., 2018; Dang et al., 2020; Weibel et al., 2015). When individuals are present in a medium, their primary egocentric frame of reference (PERF) is controlled by that environment (Weibel et al., 2015). PERF means the individual's subjective frame of reference is captured by their environment, with total loss of the sense of the natural environment (Weibel et al., 2015). VR-Sim attempts to achieve this change in perspective, allowing an individual user to interact in an environment (Izard et al., 2017). Presence goes beyond the simple definition and may be classified as either exocentric or endocentric.

Exocentric Presence

Being more involved with the natural environment than the simulated environment is termed *exocentric presence* (Dunnington, 2015). For example, exocentric presence could correspond to television viewing (Dang et al., 2020). The viewer is not fully immersed in the situation but watches television in a standard room. Exocentric presence provides a third-person perspective to the experience of the user. This perspective can result in more or less engagement in a scenario. Exocentric presence is also associated with a generalized, abstract understanding of concepts (Dang et al., 2020). With this form of presence, the big picture is the primary focus of learning.

Endocentric Presence

Endocentric presence occurs when the student nurse attends to and engages more with the simulated environment than the natural world (Dunnington, 2015). Dang et al. (2020) referred to this type of interaction as *egocentric presence*, similar to Weibel et al.'s (2015) PERF. Endocentric presence involves being immersed in a reality while physically being in another location. I used endocentric presence as the primary term for this phenomenon.

Learners who display more endocentric presence were found to have more positive learning experiences, and faculty discerned links between engagement in clinical reasoning and problem solving (Dunnington, 2015). This same positive link between endocentric presence and engagement appears in other studies as highly influential in achieving learning outcomes (Dang et al., 2020; De Leo et al., 2014; MacLean et al., 2019). MacLean et al. (2019) suggested users perceive more presence as internal stimuli increase the user's perspective of the simulation. This means the user engages in the first-person perspective perceiving the encounter as realistic, diminishing external input from the natural world (Dang et al., 2020). Reduced external stimuli lead to an experience in the simulation that is more directed at learning outcomes than at how the environment works.

The intensity of the experience also influences the perception of presence and, thus, endocentric presence (Samosorn et al., 2020). Miller and Bugnariu (2016) suggested that high-fidelity in virtual learning environments allows for complete user immersion when more than two sensory modalities are stimulated (visual, auditory, and proprioception). The proximity of the representation to the real world can allow for full-body motion, with haptic devices including hand controllers and head-mounted displays, to match the movements commonly seen in the actual clinical environment. The high fidelity virtual learning scenario can increase intensity based on the user's situation, such as a collaborative interdisciplinary modality where multiple professionals must provide a holistic approach to the patient's care (Liaw et al., 2020). The intensity, in this case, is being able to work with other professionals, represented as individual avatars, in a VR-Sim environment suitable to understanding roles in the hospital/facility-based setting.

Presence increases with greater fidelity, intensity, and immersion and propels users toward interaction with greater perceived engagement. Although presence and engagement are desired for all learning environments, how learning outcomes for student nurses are affected by presence and engagement, especially in virtual learning, needs exploration.

Levels of Immersion

The goal of VR-Sim is to create an environment in which the user feels a sense of immersion and being present within the simulation experience (Jorissen & De Boi, 2018). Presence, or the perception of *being there*, is affected by immersion (Miller & Bugnariu, 2016; Samosorn et al., 2020). A user can perceive varying levels of immersion in a VR-Sim environment (Farra et al., 2018). Levels of immersion can be divided as low, moderate, or high categories based on five characteristics: inclusiveness, extensiveness, surroundings, vividness, and matching (Kardong-Edgren et al., 2019b; Miller & Bugnariu, 2016).

Inclusiveness means a VR-Sim environment eliminates signals suggesting connections to the physical world by using joysticks or wearable devices. Extensiveness refers to the number of senses accommodated in the environment, like eye tracking for visual cues, sound, or smell. Surrounding encompasses the graphic design of the VR-Sim. This determines the field of view for the environment and how much of the natural world is eliminated. Vivid applies to how stimulating the environment is, such as the resolution of the graphics. Finally, matching describes how well the VR-Sim matches a user's perspective through the process of motion capture to ensure movements stay consistent onscreen with the user's actions (Miller & Bugnariu, 2016).

Immersion and presence are two distinct components in a virtual environment (Miller & Bugnariu, 2016). Immersion is a technical change imposed through equipment and software,

while presence signifies an individual's experience or perception within the environment. Both concepts must work together to achieve a realistic learning experience (Farra et al., 2018; Kardong-Edgren et al., 2019b; Miller & Bugnariu, 2016). Kardong-Edgren et al. (2019b) provide examples of the varying levels of immersion in VR-Sim. Low immersion has numerous signals associated with the presence of a device, such as a computer monitor with a mouse in the natural world, stimulating only one sense, with minimal details and no motion capture. Moderate immersion provides signals of a natural world device, such as a large projection screen used in CAVE, stimulating one to two senses, with some details simulated and body segments displayed in motion capture. High immersion shows limited signals from the natural world, where the user has on an HMD, accommodating more than two senses, with full-body motion capture and high-resolution detail. The levels of immersion are a standard classification system the researchers believe will help add clarity to VR-Sim experiences and provide unified definitions of the modality (Kardong-Edgren et al., 2019b).

Engagement

The term engagement has associations with other terms such as *attention* (Vorderer et al., 2004), *interactivity* (Farra et al., 2012; Yildirim et al., 2019), *actions of the operator* (Dunnington, 2015; Smith & Hamilton, 2015), *arousal* (Gromer et al., 2019), and simply how the user responds in the environment. Arousal, associated with activation of the fear structure in the brain regulating individual factors such as emotional responses, has been associated with a heightened sense of presence (Diemer et al., 2016; Gromer et al., 2019). The Gromer et al. (2019) study applied to engagement and essentially suggested higher levels of presence correspond to behaviors allowing a user to feel more interactivity with the environment. VR-Sim provides an immersive environment in which students can achieve designated learning outcomes.

Because of the immersive nature of VR-Sim, presence becomes essential within this environment (Yildirim et al., 2019).

Effects on Presence

Levels of immersion in simulation vary with the type of technology used, with VR-Sim considered more immersive than HF-HPS (Yildirim et al., 2019). Vorderer et al. (2004) designed a presence instrument known as the Measurement, Effects, Conditions-Spatial Presence Questionnaire (MEC-SPQ) to measure six components of presence, determining the degree of presence a participant perceives in different learning environments. These components of presence addressed in the instrument include attention allocation, spatial presence self-location and possible actions, suspension of disbelief, high cognitive involvement, and domain of specific interest.

Attention Allocation

Attention allocation has been associated with engagement and represented as a process of interaction with the environment (Vorderer et al., 2004). As users work within a virtual environment, they pay attention to events in the natural world (Cho et al., 2015). Haptic and audio sounds provide a stimulus to focus a user's attention on the virtual environment interactions, tuning out the natural world around them (Dalgarno & Lee, 2010). Stimuli in virtual environments help to reduce distractors from the natural world.

Spatial Presence

Spatial presence self-location and possible actions are the processes associated with the user's subjective perception of VRSim (Vorderer et al., 2004). If a user present in a virtual environment perceives higher levels of representation fidelity, their spatial knowledge will be enhanced (Ip et al., 2017). Representation fidelity involves the user having immediate control of

or in the environment while also being familiar with the virtual surroundings (Dalgarno & Lee, 2010). Representation fidelity also includes presence as part of the user's ability to feel within the environment (Dalgarno & Lee, 2010; Ip et al., 2017).

Suspension of Disbelief

Suspension of disbelief and high cognitive involvement are considered actions within the virtual environment (Vorderer et al., 2004). An individual's interest in the specific content of the VR-Sim may also increase presence. The user may perceive errors, inconsistencies, and contradictions in the environment that can alter how the experience affects the user (Yildirim et al., 2019). Suspension of disbelief allows users to feel a sense of realism from an emotional, psychological, conceptual, or physical standpoint that encourages exploration of the experience (Dalgarno & Lee, 2010; Vuuren et al., 2018).

Gromer et al. (2019) measured subjects' suspension of disbelief using the MEC-SPQ during a height exposure study using VR-Sim height. Subjects in the high condition for sensory realism report significantly higher presence than those in the low condition. High sensory realism scored $M=60$, $SD=23.9$, and low sensory realism scored $M=43.6$, $SD=25.9$ (Gromer et al., 2019). When the VR-Sim is highly detailed for visual stimuli, such as texture quality and sound, presence increased compared to low fidelity. With a fear variable incorporated, emotional responses in VR-Sim led to a strong sense of being present (Gromer et al., 2019). Padgett et al. (2019) suggested realism begins with developing engaging simulations rather than focusing on achieving engagement. Engagement may be achieved through realism that stimulates a user's emotional responses (Padgett et al., 2019). Petukhov et al. (2020) used an electroencephalogram (EEG) in an attempt to measure presence with downhill skiers to better understand the phenomenon in VR. There was similar brain activity, the researchers called neuropatterns, in

both the virtual and physical environments while conducting the activity. Comparing the physical environment to a desktop simulation lacked the same neuropatterns (Petukhov et al., 2020).

Exploring presence and endocentric presence may explain students' perceptions within the learning environments and variances in learning outcomes. Presence has not been explored extensively in nursing education, necessitating more research about the phenomena.

Learning Outcomes

Presence has been associated with positive learning outcomes (Dunnington, 2015). Some studies have shown the application of prior knowledge and haptic devices provides an increased sense of presence. For example, Smith et al. (2016) looked at learning and retention in virtual environments to understand the cognitive aspects of working through the procedures for a decontamination scenario related to a hazardous materials incident. The researchers found participants were faster with each attempt to show skill and understanding. Other factors contributing to the participants' performance allowed for this increase in speed, resulting in positive learning outcomes. Factors aiding participants during the VR-Sim interaction were prior knowledge, familiarity, and experience with the modality (Smith et al., 2016). Prior knowledge, familiarity, and experience factored into educating individuals in other VR-Sim experiences like aircraft carrier marshaling (Yongliang et al., 2015), serious games for blood transfusions (Tan et al., 2017), dementia interactions (Adefila et al., 2016; Elliman et al., 2016), and intravenous catheter insertion (Jung et al., 2012). The addition of haptic devices, the physical component used in tandem with VR-Sim, also helps achieve learning outcomes and increases interaction within the environment. Haptics can increase the sense of presence in helping the user feel a

greater perception of being in and controlling the environment. An increased sense of presence has been found to enhance learning outcomes in VR-Sim (Dubovi et al., 2017).

The presence phenomenon provides the context of understanding how VR-Sim experiences enhance learning. Learning outcomes have increased related to an increased perception of presence an individual achieves when working in a VR-Sim environment. Two different forms of presence, exocentric and endocentric, potentially occur. Continued study of this phenomenon is needed. The purpose of this study is to explore student nurse perceptions of presence during simulation. This study will explore student's perceptions of presence within VR-Sim specifically.

Summary

Learning environments are dynamic and ever-changing in nursing education. Simulation is a teaching strategy encompassing various modalities from standardized patients, to HF-HPS, to VR-Sim. Exploring the literature on VR-Sim showed the multifaceted approaches that have been used to facilitate this modality in the education of healthcare professionals and other disciplines, including the aviation industry. Cost, mobility, barriers, and limitations influence the feasibility of learning environments, including VR-Sim. For example, certain types of VR-Sim may be more effective than others when comparing virtual simulation, AR-Sim, and VR-Sim. Factors influencing learning environment effectiveness show how learner characteristics, the overall experience in virtual learning, effects from simulation, and the COVID-19 pandemic have all impacted simulation use, specifically VR-Sim.

The associated fidelity or realism of a simulation modality has been important in the literature. Fidelity of a modality that closely resembles the actual clinical environment promotes suspension of disbelief allowing a user to engage with the environment. Each modality of

simulation, from HF-HPS, to standardized patient encounters, to VR-Sim have challenges with regard to realism. Exploring how realistic a simulation modality is from a participant perspective can only help to understand how a modality benefits student learning. Another concern found in this review related to lack of standardized definitions for virtual simulation. Multiple studies in the review identified virtual simulation, based on a 2D laptop computer, and VR-Sim, which is 3-D based and fully immerses a user in a digital environment, as the same modality. This distinction between the two modalities is not clear, and the study may help differentiate the two for future research.

Presence is a component of multiple learning environments, but particularly VR-Sim. Presence is an overarching perception of *being there* for a patient in a didactic, clinical, or simulated learning experience. An association of higher levels of endocentric presence with greater engagement and better learning outcomes for student nurses has been shown in simulations such as HF-HPS. It has not been explored adequately in VR-Sim. Providing a strategy where students can gain knowledge and transfer the knowledge to practice is essential for all nurse educators. Although VR-Sim has not been explored or examined extensively in nursing education, presence in that environment has been explored even less. Conducting a study exploring the presence phenomenon through the VR-Sim modality may add knowledge to this substantial gap in the literature of how perceptions of presence impact the use and effectiveness of VR-Sim for educating student nurses.

CHAPTER THREE

METHODOLOGY

This chapter discusses the research methodology, starting with the study design. In addition, the chapter addresses the setting, sample, instrumentation, and data collection procedures of the study. Finally, the data analysis plan is presented, along with ethical considerations for study participation.

Research Design

The purpose of this study is to explore student nurses' perceptions of presence during simulation. A qualitative description design using semi-structured interviews will explore the phenomenon of presence during a virtual reality simulation. As suggested by Dunnington (2015), "*being there*" (p. 64) is inherent in VR-Sim, virtual simulation, HF-HPS, and clinical learning experiences. Exploring presence from the perspective of those experiencing it allows for understanding the experience of presence as it occurs in different simulation modalities and different levels of fidelity. The VR-Sim design attempts to suspend the sense of *being in* the natural physical environment, so the participant's focus and reactions are solely engaged in a virtual digital environment as if it were real. The VR-Sim experience contrasts to HF-HPS, a simulation residing in the natural world which mimics the hospital/facility setting through physical props, manikins, actors, and other healthcare equipment set in a school or clinical learning lab environment (Dunnington, 2015). Nurse educators want student nurses to be present and focused on the patients they care for during clinical experiences. Exploring the presence phenomenon can help nurse educators determine the best ways to provide experiences for student nurses that foster feelings of being present in the situation and facilitate the achievement of desired learning outcomes.

The study design was qualitative description (QD) to explore perceptions of a person working through a virtual experience and understanding how the individual was affected by the encounter through feelings, senses, and thoughts (Sandelowski, 2000; Sandelowski, 2010). Using qualitative description, the investigator seeks to determine associations, relationships, and patterns, exploring participants' perceptions of the phenomenon being studied and puts those perspectives into everyday language (Kim et al., 2017; Sandelowski, 2000). Participants described what they saw, heard, and felt in the experience.

According to Sandelowski (2010), flexibility is key to conducting research. Textbook descriptions provide a blueprint of a design. As the investigation unfolds in qualitative methods, the data gathered can be messy, requiring careful iterative analysis to understand the phenomenon sufficiently. A researcher using QD will use purposive sampling, generally with maximum variation. Maximum variation allows the researcher to pursue greater diversity in the sample of individuals (Sandelowski, 2010). As an example, related to this study, a participant who identifies as regularly playing video games or a 'gamer' might experience virtual learning in ways quite differently from participants who are not as familiar with video games. Therefore, I attempted to recruit participants with a variety of gaming experience. The QD design uses a minimally structured or semi-structured interview guide to gather data from individual or focus group interviews. Finally, content analysis occurs as the data is coded and themes emerge to help understand the phenomenon of interest (Sandelowski, 2010).

The qualitative description method is like the interpretive description described by Thorne (2008) as essentially reporting what someone observed. A difference between these two types of qualitative inquiry lies in the data analysis (Neergaard et al., 2009). Interpretive description seeks to go beyond description alone, exploring a more in-depth interpretation of the

meaning of the phenomenon. Qualitative description remains close to the data obtained in the study (data-near) (Kim et al., 2017; Neergaard et al., 2009; Sandelowski, 2010), upholding the participant's voice to directly describe the phenomenon rather than the description being retold and interpreted by the researcher (Bradshaw et al., 2017). The literal description of what is taking place is a vital component of the QD design and supports the naturalistic approach to the QD research design. Understanding the phenomenon comes from the participants' perspective as the researcher attempts to understand the VR-Sim experience from the participant's point of view (Bradshaw et al., 2017; Lincoln & Guba, 1985).

The qualitative description method's theoretical or conceptual underpinnings do not commit to any formal theory (Davis et al., 2016; Sandelowski, 2010). This lack of commitment does not mean the qualitative description method has no preconceived theoretical notions. Instead, it means a study using qualitative description method can be open-ended—the study can begin with a theory or framework, but as the research progresses, the researcher's understanding of the framework may evolve (Colorafi & Evans, 2016; Sandelowski, 2010). The presence model in Chapter 1 represents a beginning framework to aid understanding the phenomenon for this study.

QD design does employ the tenets of naturalistic inquiry (Sandelowski, 2000; Sandelowski, 2010). Naturalistic inquiry consists of a commitment to studying anything in its natural state or context (Lincoln & Guba, 1985; Sandelowski, 2000). This context means the term *natural* represents the setting occurring naturally for that phenomenon, whether physical, psychological, social, chemical, or biological (Lincoln & Guba, 1985). For VR-Sim, the goal is that the digital environment temporarily becomes the world in which a participant is immersed. The participant described what appeared real within the computerized VR-Sim environment.

Qualitative description differs from traditional qualitative methods like phenomenology, ethnography, and grounded theory, each based on distinctive philosophies. Qualitative description as a method stands on its own. It does not focus on culture as ethnography does, theory development like grounded theory, or even the meaning of lived experience as phenomenology does (Bradshaw et al., 2017). QD can adopt components of these more philosophically oriented designs (Sandelowski, 2000; Neergaard et al., 2009; Thorne, 2008). Thorne (2008) suggested qualitative description allows for exploring a clinical case bearing similarities to other topics and may move a phenomenon toward a general understanding for application in different situations. This definition is also suggested by Bradshaw et al. (2017) that QD discovers and attempts to understand a phenomenon and the participant's worldviews. Many interpretations of reality exist from everyone's perspective, and QD accepts this notion built on the strength of subjective interpretations referencing verbatim quotes from participants in a study (Bradshaw et al., 2017).

Qualitative description uses inductive reasoning to explore a phenomenon from a specific point of view and then broaden that viewpoint to develop generalizations related to the observed phenomenon (Thorne, 2008). The descriptions obtained depend on the participant's perceptions and sensibilities describing the phenomenon (Neergaard et al., 2009). Using qualitative description, the researcher seeks to move beyond what has been described and interpret the data without moving too far away from the literal phrasing by the participant (Bradshaw et al., 2017). There is no highly abstract interpretation of the findings like other qualitative designs. Thus, findings from a QD study have been essential for practitioners starting a new process or leaders implementing new policies (Bradshaw et al., 2017).

Several studies have used the qualitative description method. For example, Toguri et al. (2020) used qualitative description to investigate how advanced care planning was perceived by families, patients, and physicians to enhance care. Barlott et al. (2020) used qualitative description to research intellectual disabilities because information and communication technologies used with this population were poorly understood before the study. Exploring the experiences of those with intellectual disabilities and using information and communication technologies through the qualitative description method provided the rich insight needed to make the phenomenon more understandable to others in the healthcare field (Barlott et al., 2020). Davis et al. (2016) used qualitative description for an interprofessional collaboration project involving *Second Life's* virtual environment. Lastly, while investigating orthorexia nervosa, an eating disorder described as “clean” eating, Greville-Harris et al. (2020) used qualitative description to understand the phenomenon more accurately.

The qualitative description method lends itself to practical health education environment research (Bradshaw et al., 2017; Colorafi & Evans, 2016). It is appropriate for exploring simulation modalities because participants' perceptions generate data to understand simulation experiences in nursing education. Multiple forms of data are generated through simulated experiences, questionnaires, observations, and interviews. Understanding how participants describe presence in simulation and what may facilitate or hinder learning in a simulation helped advance the science of nursing education (Colorafi & Evans, 2016; Kim et al., 2017).

Research Setting and Context

The selected setting was a large land-grant university in the southeastern United States. This University has two instruction sites devoted to educating student nurses across various undergraduate and graduate program tracks. One site is located on the main University campus,

and the second is an off-campus site associated with a large hospital system. The main campus offers nursing education primarily to traditional baccalaureate (BSN) students. The off-campus site offers two accelerated BSN programs and one registered nurse (RN) completion program plus graduate programs. The two accelerated BSN programs are comprised of second degree students and traditional students. Second degree students have completed a previous degree in another major and are now pursuing a nursing degree for the first time. The other accelerated program's traditional students start after high school and are accepted as baccalaureate students like those at the main campus. These students then transition to the off-campus site to complete the BSN program in consecutive semesters, including summer, graduating sooner than those on the main campus.

The main campus and off-campus sites have a combined total of 661 student nurses enrolled across the various programs. Two hundred twenty-four students are in the traditional BSN program on the main campus, and 224 are in the accelerated traditional baccalaureate programs on the off-campus site. The traditional and accelerated traditional program tracks comprise students from high school, beginning college as first-year students and concluding with the senior year. The accelerated traditional track includes a summer semester allowing for an earlier completion time for the cohort.

Both sites have simulation centers with the same types of rooms available: a skills lab, simulation rooms for use with HF-HPS or Standardized Patients (SP) encounters, a birthing simulation room with an HF-HPS birthing simulator, simulation control rooms, and debriefing rooms. The off-campus location was the primary site for this study. Due to lack of space in the simulation center, it was necessary to use another area within the facility to conduct the study. The off-campus facility has a large auditorium, three lecture classrooms with tiered seating, one

large classroom divided into two as needs permit, five small conference rooms, and an Information Technology (IT) office studio. Because the VR-Sim equipment is portable, and due to space availability, the IT office studio with partitions was used to conduct the study. The requirement for VR-Sim is to have a large enough open area to allow students to work in the virtual environment without the potential of walking into objects present in the natural world. Although the IT office was smaller than most other areas, it was the only area exclusively available for the study for the six-week duration. Although VR-Sim is not currently used at either instruction site, the simulation centers have conducted small VR-Sim studies at both locations with various researchers. In addition to the virtual reality equipment, a low fidelity patient simulator for correct placement of the haptic hand controller devices was needed and was available.

Hardware for VR-Sim Experience

The laptop used for the VR-Sim experience is the Alienware® 17 Laptop from *Dell*® (2022). The HTC Vive® Head Mounted Display (HMD) will provide the VR experience with total immersion into the environment (Vive, 2022). Full tracking and earphones speakers on the HMD will allow the user to see and hear things in the environment. The hand controllers and base stations connect via Bluetooth to the laptop and HMD to create the room environment (Vive, 2022). Once all this equipment is turned on and connected, the software is ready to be used.

Software for VR-Sim Experience

The Steam (2022b) gaming platform was the software used to access the VR-Sim experience. Access to Steam was through my private account. SteamVR (2022b) allows users to interact in VR with any gaming software available and compatible with the appropriate

equipment. The HTC Vive® is compatible with Steam. Through SteamVR, *Virtual Reality Cardiopulmonary Resuscitation* (VR CPR) will serve as the VR-Sim experience for this study. The VR CPR software allows users to simulate the functions of resuscitating a person who has succumbed to cardio-pulmonary collapse. Three scenarios are available: hospital setting, out-of-hospital setting, and school setting (VR CPR, n.d.). All the experiences offer the same situation of resuscitating a simulated patient with cardio-pulmonary collapse. For this study, the hospital setting scenario was selected as the most applicable to student learning.

Sample Strategy and Sampling

The study sample included students from the undergraduate baccalaureate nursing traditional and accelerated traditional programs. Students in the traditional and accelerated traditional programs are introduced to VR-Sim in a nursing-based computer course during their first year. Milne and Oberle (2005) suggest purposeful sampling as a strategy to select participants who can provide in-depth knowledge of the information relevant to the research purpose of the study. Since students generally have had the same experience with and exposure to simulation in the existing nursing program, I used convenience and purposive sampling with maximum variation. Convenience sampling considered the scheduling availability of both the student participants and the researcher. I purposely sought out participants from various gender, race and ethnicity, and gaming (headset/haptic) experiences.

It was necessary for participants to have prior experiences with various simulation modalities to understand the simulated scenario for the study. The participants must have completed cardiopulmonary resuscitation (CPR) training. The VR-Sim software VR CPR, a simulated resuscitation scenario, was the primary means of creating the virtual simulation environment for this study. Students must understand the basics of CPR to maneuver through the

experience. Therefore, eligibility for the study included baccalaureate students in the traditional and accelerated traditional undergraduate tracks, who have first-semester junior through second-semester senior standing.

Data saturation is defined as reaching a point in data collection where "no new properties, dimensions, conditions, actions/interactions, or consequences are seen in the data" (Strauss & Corbin, 1998, p. 136 as stated in Saldaña). A predetermined number of participants cannot determine data saturation, but from multiple factors, including study design, heterogeneity of the sample related to maximum variation sampling, and opportunity for triangulation (Majid et al., 2018). A diminishing number of codes may indicate the saturation point is approaching (Majid et al., 2018).

In reviewing the literature, most qualitative description studies reported a range of 6-15 participants (Barlott et al., 2020; Davis et al., 2016; Greville-Harris et al., 2020; Toguri et al., 2020). Greater ranges have been reported ranging from 8 to 1932 participants (Kim et al., 2017). I proposed an estimated sample range of 8-12 participants. Majid et al. (2018) suggested saturation occurred in their study with 12 participants, but 13 interviews were conducted, with the final one verifying saturation had already occurred. Majid et al. (2018) demonstrated a method of counting the number of new codes per interview to track saturation. Reaching data saturation is never certain. Due to limitations of time, and student nurse interest in the study, recruitment ceased after reaching the proposed number of participants.

Data Sources

This section describes the sources of data and data collection strategies for the study. An informed consent form (Appendix A) was discussed before any data collection began. Data sources included an individual characteristics form (Appendix B) and semi-structured interviews

using the interview guide (Appendix C). Additional data sources were recorded interviews via Zoom®, a phone call screening tool for determining eligibility (Appendix D), field notes and journaling from observing the participants during the VR-Sim experience, and other observations during the interviews.

Screening Tool for Recruitment

The screening tool for recruitment (Appendix D) was used to identify participants who met inclusion criteria for the study during a phone call conversation prior to setting an appointment. The primary data points included the inclusion criteria of program track, status level, CPR training, and if the student completed the prior nursing course with VR experiences.

Individual Characteristics Form

The individual characteristics (Appendix B) form includes self-reported demographics (age, gender, race, and ethnicity) and personal characteristics of the participant based on information found in the literature that potentially influences experiences within the VR-Sim environment. Three questions asked about their identity. The remaining questions asked about potential attributes impacting experiences in various forms of simulation. For example, individuals may be core gamers, casual gamers, or non-gamers. Core gamers are experts on computerized gaming content who expect an evolving depth and range of development and spend countless hours playing and strategizing various computerized gaming content (Meredith et al., 2012; Pront et al., 2018). Whereas casual gamers only play occasionally, finding enjoyment in the experience but lacking the same devotion to the medium (Meredith et al., 2012). Non-gamers have little to no experience engaging with computerized gaming. Understanding the nuance of behaviors presented by the individuals helped gain knowledge of the processes of thinking exhibited by individuals participating in the study. The next question

addressed what types of gaming platforms individuals have used prior to this experience. These other platforms were gaming consoles like Nintendo®, mobile apps, and other programs using haptic devices ranging from laptops to other VR software and hardware. These prior experiences offered insights into how participants perceived the VR-Sim experience. Finally, sensations such as dizziness or motion sickness correspond to cybersickness that can occur during VR-Sim experiences (Servotte et al., 2020). Although safety was a primary consideration for all participants in the study as they navigate the room for the VR-Sim, people with more susceptibility to cybersickness may warrant greater precautions during the scenario.

Interview Guide

In reviewing the literature and developing questions for the interview guide, the *Measurement Effects Conditions Spatial Presence Questionnaire* (MEC-SPQ), a survey tool for analyzing presence in VR-Sim environments, provided a framework for exploring participant feelings, emotions, and actions experienced during the scenario (Vorderer et al., 2004). The MEC-SPQ includes three components explored here: attention allocation, spatial presence, and suspension of disbelief. Attention allocation is the idea of engagement or the process of interacting with the environment. Spatial presence is the sense of self-location and possible actions associated with the subjective perception of the users' experience in VR-Sim. Spatial presence corresponds to the user sensing a first-person perspective in the environment. Suspension of disbelief considers actions within virtual environments. With minimal to no distractions, the user loses the sense of the physical environment outside of the VR-Sim experience (Vorderer et al., 2004; Yildirim et al., 2019).

The MEC-SPQ has demonstrated validity and internal consistency reliability with Cronbach's alpha ranged from .90 to .93 for attention allocation, .92 to .93 for spatial presence:

self-location, .81 to .88 for spatial presence: possible actions, and .80 to .83 for suspension of disbelief (Vorderer et al., 2004). Example items for attention allocation, spatial presence, and suspension of disbelief concepts are presented in *Table 1*.

Table 1

Sample Questions From MEC-SPQ Questionnaire, With 4-item Configuration

Attention Allocation	Spatial Presence	Suspension of Disbelief
I devoted my whole attention to the VR-Sim.	I felt like I was a part of the environment in the presentation.	I concentrated on whether there were any inconsistencies in the VR-Sim.
The VR-Sim captured my senses.	I felt like I was actually there in the environment of the presentation.	I didn't really pay attention to the existence of errors or inconsistencies in the VR-Sim.
I dedicated myself completely to the VR-Sim.	It was as though my true location had shifted into the environment in the presentation.	I took a critical viewpoint of the VR-Sim presentation.
My perception focused on the VR-Sim almost automatically.	It seemed as though I actually took part in the action of the presentation.	It was not important for me whether the VR-Sim contained errors or contradictions.

Adapted (public domain) from Vorderer et al., (2004)

The MEC-SPQ questionnaire provided a basis for understanding how an individual may perceive presence and thus informed question construction for the interview guide. The interview guide was generated from the literature related to the sense of presence and simulation. The interview will begin with two broad, grand tour questions. The first question was, “What was it like working through the VR CPR resuscitation scenario just now?” The second question was, “You’ve used various forms of simulation, like High-Fidelity Human Patient Simulation, virtual

simulation, and VR-Sim. What was your experience like being in those environments?” These questions allowed participants to tell their stories of their perceptions of reality and presence in those environments. Follow-up questions were based on the responses to the initial questions, for example, “What was it like working with the haptic devices as you resuscitated the patient?” A corresponding probe was, “What, if anything, captured your attention?”

Examples included: “How much did you feel like you were actually there in that environment or part of it?” “At what point did that happen for you?” “What did it feel like?” “How real did the VR-Sim experience feel to you?” Probe: “Did anything in the VR-Sim feel more real than to you than other things? Explain.” The remaining questions are listed, with corresponding probes, in Appendix C.

Field Notes and Journaling

Field notes are impressions of what the researcher sees while observing the participant. Field notes can assist a researcher in developing themes and understanding impressions derived from the participant's interactions during the experience and what the researcher may have observed. These impressions can also be recorded in a journal to provide reflective commentary on the participant's performance during the experience. A field note may prompt a different way to phrase a probe question as the researcher continues through the interview. For example, the researcher may assume the student participant's reaction to performing CPR was related to how present they felt during the activity. But, in interviewing the participant, the researcher may discover the issue was more technology-related than any perceived reaction the user had while in VR-Sim. These differences in perception from the participant to the researcher may also help understand some potential research biases active in the study. Reflective journaling also provides a means for a researcher to consider their biases, thoughts, and feelings about observations of the

participants. In the reflective journaling, the researcher might state they were confused by a participant's response to a question believing the response meant one thing from actions observed, only to have a conflicting response from the participant during the interview. Writing these thoughts down provides a researcher another important data source during the analysis phase of the study.

Data Collection Procedures

This section explains the data collection methods for the study. This section addresses the procedure followed with each participant. First, informed consent was obtained using the approved form and answering questions that arose (Appendix A). Secondly, participants completed the individual characteristics form (Appendix B) before the VR-Sim experience. All forms were completed in-person, via provided iPad, and secured so only the individual participant and I accessed the responses. I then uploaded the documents and stored them in a secured online Box account folder. The Box folders are part of my university account in a secure cloud management system. After the VR-Sim experience, I conducted semi-structured recorded interviews via Zoom® using a researcher-developed interview guide described above, and I documented field notes and observations. Transcripts were automatically generated from the recorded interviews within Zoom®. Upon completing the interview, the appointment was concluded, and each participant received a \$15 cash payment for being part of the study. Each participant signed a receipt for research study participation payment (Appendix E).

Recruitment

Recruitment began upon IRB approval. Initially, I obtained a listing of all available students in each undergraduate program who met inclusion criteria (junior one to senior two standing). Next, the student services coordinator emailed potential participants the email

message (Appendix F) and flyer (Appendix G) which explained the study and the next step of contacting the researcher. The email (Appendix F) outlined the purpose of the study and what was used during the experience with VR-Sim. Interested individuals called me, and I screened potential participants to determine if they met the inclusion criteria.

As part of inclusion criteria, the students were junior one to senior two levels in the program, having completed CPR training, and the nursing course introducing them to VR experiences. After screening I sent eligible students a SignUpGenius link to set up a study appointment, an email confirmation, and follow up with a reminder of the participant's upcoming appointment date, time, and location.

Appointment Start and Debriefing

Upon arrival, the informed consent was signed, and individual characteristics form was completed. I gathered information to allow maximum variation based on level in the program, age, gaming experience, and cybersickness concerns. I aimed to have at least three participants from each year in the program, junior through senior standing. In addition, I aimed to have a variety of ages and self-classification as a gamer. Diversifying based on these three variables were planned for the maximum variation and heterogeneity of the sample. I reviewed the range of ages and gaming experience and aimed to have at least three variations for both variables. For example, for age at least one age twenty, twenty-one, and twenty-two. Gaming status I also aimed to have at least one with gamer status and three with non-gamer status. For safety concerns, I asked if participants ever experienced dizziness or the effect of motion sickness.

Following brief instructions about the VR CPR software and hardware, I guided the participant through applying the equipment and interactions. Each participant made two attempts at using the VR CPR simulation. In the first attempt, I guided the participant through performing

the VR CPR simulation, helping them understand how the software works by visualizing prompts for actions in the scenario, interacting with the simulated patient, completing the resuscitation measures, and viewing the results. Following the first attempt in the VR CPR simulation, I conducted a debrief of technology session to explore how the participant felt working through the scenario. Immediately upon completion of the debriefing of technology session, the second attempt began as the participant completed two cycles in the VR CPR simulation with a focus on presence. Following the second attempt in the VR CPR simulation, the interview commenced. *Table 2* outlines the time intervals for completion of all parts of the study appointment.

Table 2

Parts of the Study Appointment with Durations

Parts of the Appointment	Duration
Complete Informed Consent and Individual Characteristics Form	10 minutes
Explain use of VR CPR software and hardware	15 minutes
The first attempt of the VR CPR simulation guided experience through unresponsive patient assessment, initial compressions, AED setup, resuscitative measure with CPR, and performance assessment at the conclusion	6 minutes
Debriefing of technology following first attempt of the VR CPR simulation.	6 minutes
The second attempt of the VR CPR simulation without guidance	3 minutes
The VR CPR simulation Resuscitative Measures with CPR	4 minutes 10 seconds
Performance Assessment following the VR CPR simulation	25 seconds
Interview following the second attempt of the VR CPR simulation	30 minutes
Total	74 minutes, 35 seconds

Semi-Structured Zoom® Interviews

The interviews followed the semi-structured interview guide described above and were recorded via Zoom®. Participants agreed to being both audio and video recorded. The benefits of recording via Zoom® are that the laptop used for the VR CPR simulation experience can also use Zoom®, allowing transcripts to be created automatically following the meeting. The initial interview questions presented in Appendix C were asked during the interview, with corresponding probes as needed to explore responses by the participants.

Field Notes and Observations

During the VR CPR simulation experience, I observed the participants' non-verbal responses and recorded field notes. Immediately following each interview, I summarized my impressions in summary notes and reviewed the Zoom® video recordings, adding additional observations of the participant responses and visual cues to my initial field notes. For instance, hearing the tone of voice about a part of an answer provided insight that a specific aspect of the experience was important to the participant. In addition to the tone of voice, non-verbal cues, such as hand gestures, facial expressions, and eye contact were recorded. The interviews were in-person and recorded via Zoom®, so I saw each participant's reactions, both in-person and visually through the laptop as they completed the VR CPR simulation scenario.

Researcher bias can occur in the form of presumptions the researcher has about what the study may produce. I believe VR-Sim to be a viable simulation modality for nursing education and that students experienced presence when working within the VR CPR simulation environment. These results are outlined in Chapter 4 and the discussion in Chapter 5. I worked with participants who are students affiliated with the University where I am employed. Some participants had already interacted with me in a prior teaching/learning experience, which was

taken into consideration to maintain the study's objectivity and integrity. Maintaining objectivity applied to ethical considerations for the research and minimizing harm due to participation, which I ensured.

VR CPR Simulation Experience

Initially, I needed to be sure all devices were charged and plugged into the laptop and that they were not likely to be stepped on or tripped over. A wide-open space was necessary for the VR-Sim experience to ensure adequate room for a participant to maneuver around the scenario. The IT office studio was used which allowed a large enough area to promote the safety of the participants. I also ensured all equipment was disinfected between uses. The HMD and hand controllers were the primary devices the participant used and were cleaned with a disinfectant wipe suitable for use on the devices. Proper sanitization made sure the equipment had minimal germs after use, including COVID-19. Sani-Cloth wipes, or another derivative, were used for disinfecting the equipment.

I set up the hospital-based scenario for the participant in VR CPR simulation. After starting the scenario, the participant placed the HMD on their head to visualize the virtual environment. Next, the researcher pre-set the length of time (2 minutes and 5 seconds) and the number of cycles (1 cycle) for the VR CPR software. Each participant engaged in the VR CPR simulation for the same length of time and two attempts working in the software: a guided attempt and a focus on presence attempt. The researcher guided the participant first by applying the equipment and helping them understand how the software worked by visualizing prompts for actions in the scenario, interacting with the simulated patient and the manikin, completing the VR CPR simulation resuscitation measures, and viewing the video results. This initial guidance attempt through the VR CPR simulation took approximately 6 minutes to complete. Following

this experience, the researcher conducted a 6 minute debriefing of technology session to explore how the participant felt working through the scenario. Immediately upon completion of the debriefing session, the participant completed a second attempt of two cycles through the VR CPR simulation, focusing on how present they were in the scenario. This attempt lasted approximately 7 minutes 35 seconds. Three minutes of the scenario was initially assessing, performing rescue compressions, and applying the AED. The VR CPR simulation resuscitative measures took 4 minutes and 10 seconds (two 2 minute and 5 second cycles) to complete, as pre-set by the researcher. Twenty-five seconds was allotted to review results from the experience in the VR CPR simulation. Following the VR CPR simulation, the researcher conducted a 30-minute Zoom® recorded interview using the above interview guide. Following the interview, the data management and analysis plan commenced.

Data Management and Analysis Procedures

The following presents the data management and analysis plan of the study. Data management entailed gathering consent forms, individual characteristics forms, recorded VR-Sim experiences, and audio and video recorded interviews for synthesis and storage. Zoom® recordings were cleaned and then analyzed (Creswell & Plano Clark, 2011).

Data Management

Data management shows how data were stored, cataloged, and secured. After signing the consent and individual characteristics forms, all participants received a number assignment to ensure confidentiality of the data. A three-character numeric code was used for each participant and their related forms. For example, the first participant was labeled 001, with all participants following in succession. Labels contained no identifiable information that could jeopardize the

confidentiality of the participant. The electronic folders in my Box account housed all the documents for each participant from the study.

Each participant had six documents stored in Box folders. Data collection documents included 1) informed consent, 2) individual characteristics form, 3) phone call screening tool, 4) interview transcription, 5) audio and video recording of Zoom® interview, and 6) field notes and observations made by me. These documents represented the parts of the study with direct participant interaction by either completing the tasks or having questions asked or observations being made of them by me. These documents were uploaded to Box via the provided iPad. Only my committee, and I had access to this data through Box, with all data residing there.

Once the appointment ended, only my committee and I had access to the Box folder containing the study data. The laptop accessing Box was password protected known only to me. Zoom® recordings were loaded into the cloud database to generate automatic transcriptions. Following transcription completion, I uploaded the recordings and associated transcripts to Box. Next, I compared the audio-video recordings to transcripts and made corrections as needed before beginning the analysis. This data cleaning provided a clear version of the transcripts for analysis.

Data Analysis for Research Question One

The first research question provided a basis for much of the data analysis of the study. Research Question 1: *How do student nurses describe their sense of presence in a 3-D virtual reality simulation using a headset and haptic device?*

Content analysis is a typical analytic method used whereby coding data occurs, reflecting on the data collected, identifying themes and patterns, and exploring any generalizations attributed (Neergaard et al., 2009). With the qualitative description method, a quasi-statistical

analysis may also be employed. Because the data collected stays close to the description of the individual observing the phenomenon, interpretation of data bits can occur. Quasi-statistical analysis can only supplement the more traditional content analysis associated with the qualitative description method (Neergaard et al., 2009). For example, to provide validity, descriptive statistics could be used as a quasi-statistical analysis by summarizing, such as counting how many participants are gamers. These numbers are descriptions remaining close to the data obtained (Neergaard et al., 2009).

Theme development took place after coding the data. One plan for data analysis used in other studies is the Braun and Clarke (2006) framework for theme analysis (Greville-Harris et al., 2020; Liaw et al., 2020). There is flexibility with thematic analysis, which allows for exploring meaningful patterns in the data (Greville-Harris et al., 2020). Flexibility means everything from the theory to research questions, sample size, and data collection methods to generate meaning from the participants' experiences (Clarke & Braun, 2014). The qualitative description method is flexible in how theory is used with the design, using an iterative process of participants' responses to interview questions with the researcher's observations to understand new insights (Bradshaw et al., 2017). Thematic analysis by Braun and Clarke (2006) allows for an organic approach to theme development. This method may be used if there is consistency in my use of the framework. I also employed this analytical framework for the study.

Braun and Clarke (2006) outline a step-by-step process for thematic analysis in qualitative studies. Other qualitative studies have recently used this coding and theme development process successfully (Aloweni et al., 2021; Clarke & Braun, 2014; Goh et al., 2021; Greville-Harris et al., 2020; Kerman et al., 2021; Liaw et al., 2020). The six-step process allows the researcher to follow a consistent approach in theme generation (Braun & Clarke, 2006).

These guidelines are not rules but a way of refining and enhancing the credibility of the analysis (Aloweni et al., 2021). The six steps are as follows.

Familiarize Yourself with Your Data

Researchers should first familiarize themselves with the data to understand the breadth and depth of the content (Braun & Clark, 2006). Immersing yourself in the data involves the repeated reading of transcripts while searching for common elements before coding begins. It is crucial to have a transcript with a verbatim account that is true to what the participant said in the initial encounter. The researcher can then discover what is interesting about the transcripts, generating an initial list of ideas (Braun & Clarke, 2006).

Generate Initial Codes

In this step, the researcher created initial codes identifying data features of significant interest (Braun & Clarke, 2006; Saldana, 2016). This step contains the most basic elements of the raw information, allowing the researcher to assign descriptive labels to ideas. Coding may be data-driven or theory-driven, depending on if the codes the researcher created are based on the raw data or if the researcher wants to answer specific theoretical questions to code around (Braun & Clarke, 2006). This study will use data-driven coding, using the information obtained by the participants to generate codes about the phenomenon. The crucial part of this step is to code for significant elements and ideas. Code for extracts or the surrounding relevant data and translate the data to fit into as many different themes as possible for generating patterns, categorizations, assertions, propositions, theories, or any other analytic processes the researcher considers (Braun & Clarke, 2006; Saldana, 2016). These possibilities could also entail having uncoded data, data coded once, or data coded many times (Braun & Clarke, 2006).

Search for Themes

Following coding, the researcher organizes the information in a long list of codes across all data sets. The researcher broadens the codes by combining them into potential overarching themes. Some codes will form main themes, while some will form sub-themes. Other codes may have potential relevance but do not fit into a particular group. It is essential not to eliminate anything in this phase until reviewing all the themes generated (Braun & Clarke, 2006).

Review Themes

Once participant themes are generated, refinement by reviewing begins. Reviewing starts with reading through the coded extracts to find a coherent pattern. This is when codes may be discarded or reworked to fit into another potential theme. The second part of reviewing involves validating the accuracy of the participant theme. Reviewing the themes, led to the recoding of some data sets. Recoding is an expected process for the analysis. Thematic mapping is developing the themes from the codes in a brainstorming map of potential vital concepts. The researcher determines if the themes fit or require adjustment to the data set (Braun & Clarke, 2006).

Define and Name Themes

Once the thematic map accurately portrays the data, the researcher defines and refines the themes for the analysis. Defining means identification of what the theme is about and what parts of the data the theme represents. Each theme requires a detailed analysis, along with telling the story each theme embodies. The researcher will describe an overarching theme, followed by the number of sub-themes also generated. The naming of the themes also needs to be specific so the reader can easily understand what each represents (Braun & Clarke, 2006).

Produce the Report

Finally, the researcher provides the final analysis and report once all themes have been created, refined, defined, collated, and set. The report should have vivid examples highlighting enough evidence of the themes developed from the data. The report should also take the reader beyond the data, providing the essence of the argument from the research questions generated by the researcher (Braun & Clarke, 2006).

Coding Plan

Based on Saldaña's (2016) work, the coding plan for the study will be to analyze the data extensively to get a clear picture of what has been said by each participant. I will familiarize myself with the data generated reading through each transcript to identify any critical elements that may show up. For each transcript, I reflected on the most interesting or relevant text to the purpose of the study, essentially how present the students felt in the VR-Sim environment. This form of coding is In Vivo coding and has been known as literal coding (Saldaña, 2016). After highlighting, I will take those interesting parts and use the words or phrases verbatim as descriptors for processing theme development. Using In Vivo coding is also suitable for newer researchers beginning in qualitative inquiry (Saldaña, 2016).

Once recurring codes or patterns emerge between and among transcripts, field notes, and observations, I began to combine codes into broader categories of codes to address specific insights from the participants. In Vivo coding captures behaviors and processes the participant used to resolve the problem while maintaining the meaning of the individual's views and actions (Saldaña, 2016). Using In Vivo coding is beneficial in capturing behaviors participants describe during the interaction in the VR-Sim experience. For example, if a participant states they began to feel dizzy during the experience, this could be coded as dizziness. If a participant's

concentration breaks during the experience because of issues related to the software, this could be coded as a distraction or lacking suspension of disbelief. In addition to In Vivo coding, first-cycle coding may also include other coding processes. Process coding utilizes gerunds denoting actions like things that emerge or change with time. The participant may describe how it feels to perform chest compressions during the VR-Sim experience and may relate that to other experiences they have encountered. Emotion coding infers “a feeling and its distinctive thoughts, psychological and biological state, and (motives) to act” (Goleman, 1995, as cited by Sandana, p. 125). The participant describes emotions elicited during the experience, like fear and anxiety, which could lead to another set of codes for theme development.

The first-cycle codes of extracts helped triangulate other data sets from the data collection methods besides the interviews, such as individual characteristics form. Coding themes were discussed among committee members for consensus, a typical approach in qualitative studies where authors collaborate on theme development (Colorafi & Evans, 2016; Toguri et al., 2020). Repeating first-cycle coding was necessary until all possible categories applicable to the data were identified.

Following first-cycle coding, second-cycle occurred to reorganize the data codes (Saldaña, 2016). Second-cycle coding reorganizes and reanalyzes codes from the first cycle. The primary purpose of second-cycle coding is to develop a categorical, conceptual, and theoretical organization of the first-cycle codes. In the above example, dizziness is referenced as a first-cycle coding label for a particular experience the participant reported. In performing second-cycle coding, codes were expanded to distinguish other effects generated by participants. For example, First-cycle coding may have had labels like lightheadedness, nausea, or disorientation. In second-cycle coding, those varied effects would have been categorized under the code of

cybersickness. Cybersickness, in this case, would have been a coding category label in second-cycle coding for various effects coded individually in first-cycle coding based on a theme identified during the review of the transcripts or even field notes. In this case, cybersickness did not occur for any participants, nor did lightheadedness, nausea, or dizziness. Those codes were never generated. Focus coding followed In Vivo coding to help categorize the data (Saldaña, 2016). As an example of focus coding, taking the first-cycle codes, the investigator might take those coded data with similarities and cluster them together. This clustering creates a new category the data codes can be classified under, such as excerpts from a transcript showing codes for dizziness or stress that are later categorized as cybersickness. Refining codes allowed themes to be focused more on the experience, allowing for a rich understanding of what took place during the experience. Second-cycle coding is not always required, but key terms may help refine the codes, allowing for better data categorization. This coding process was exhaustive and immersive to optimize an accurate understanding of the participants' interactions.

Data Analysis for Research Question Two

Research question two provided insights into how theories aligned with the study findings. Research Question 2: How do student nurses' perceptions about presence align with theoretical models of simulation and presence?

The conceptual model combined the information from the literature and theoretical frameworks of Jeffries Simulation Framework (2021), the Choi et al. (2017) model Three Dimensions of Simulation, Dalgarno and Lee's (2010) Three Dimensional Learning Environments model, and Dunnington's (2015) Centricity of Presence model. To answer research question 2, interview data were analyzed a second time to determine how the students' perceptions aligned with the study conceptual model and these four models of simulation. The

primary and secondary concepts found in the four models are identified in *Table 3*. Definitions used for these concepts are located in Chapter 1 and were used to explain these concepts for coding purposes. I re-analyzed the codes and themes from research question one to determine how those themes aligned with these models. Finally, I addressed the concepts found in the models that are missing in my data. The table below illustrates how the concepts were analyzed.

Table 3

Concepts from Conceptual Model and Extant Theories

Study Conceptual Framework	Dunnington (2015)	Choi et al. (2017)	Dalgarno & Lee (2010)	Jeffries (2021)
Individual Factors	Individual Factors	Fidelity	Active Learner	Participant Context
Demographics	Openness	Physical	Participant	
Psychological Effects	Motivation	Conceptual		
Physical Effects	Emotional Response			
	Referential Experience			
Simulation Fidelity	Presence in simulation	Simulation Modality	Virtual Learning Environment	Simulation experience
Engagement	Endocentric Presence	Scope Environment		Design
	Exocentric Presence			
Presence and Learning outcomes	Learning Outcomes	Engagement Behavioral	Learning Affordances	Outcomes
		Emotional Cognitive	Experiential Contextual Collaborative Learning	

Trustworthiness and Rigor

As Bradshaw et al. (2017) said, “the researcher is implicit in safeguarding the integrity of the study by demonstrating the study’s trustworthiness” (p. 6). The qualitative description approach has been criticized due to a lack of rigor by some researchers, leading to questions about the method's credibility (Neergaard, 2009). Attending to established qualitative criteria throughout the study for the qualitative description method enhanced both trustworthiness and rigor.

Guba (1981) initially proposed four evaluative criteria regarding truth value, applicability, consistency, and neutrality. Later, these four criteria were developed more by Lincoln and Guba (1985) as credibility, transferability, dependability, and confirmability and are widely used to demonstrate rigorous qualitative inquiry. Krefling (1991) identified how these four criteria compare, allowing for more depth in understanding the process and application for researchers conducting a qualitative inquiry. Shenton (2004) described ways to ensure a researcher shows trustworthiness in a qualitative study by proposing qualitative strategies for demonstrating the four criteria refined by Lincoln and Guba (1985)

Ensuring credibility, comparable to truth value and internal validity, is one of the most important ways to promote trustworthiness in a qualitative study (Lincoln & Guba, 1985). The method used in this study stayed close to the data, maintaining the participant’s voice in describing the phenomenon, consistent with qualitative description design (Bradshaw et al., 2017; Kim et al., 2017; Neergaard et al., 2009; Sandelowski, 2010). Using iterative questions and probing allowed me to obtain a greater depth of responses by participants, providing for a rich description of the experience (Milne & Oberle, 2005). Iterative questioning allows the researcher to return to responses earlier during the interview (Shenton, 2004) to explore more deeply or

clarify. Purposeful sampling allowed me to select participants who can provide an in-depth description and understanding of the phenomenon and information relevant to the purpose of the study (Milne & Oberle, 2005). Within purposeful sampling, I had hoped to have maximum variation in characteristics of study participants who meet inclusion criteria (Sandelowski, 2010). Maximum variation in the sample contributes to a broader perspective of the phenomenon under study. Maximum variation was only partially achieved with specific variables in the participants, which is addressed in Chapter 4. Peer debriefing and scrutiny by reviewing and reaching consensus with my dissertation committee minimized the influence of my biases on the study (Shenton, 2004). I also used reflective commentary through journaling as I reviewed field notes, visual recordings, and observations during and after coding data. Reflection promoted prolonged engagement with the data, immersing myself in the fine detail of the experience the participants described. Triangulation then occurred as I assessed not only the transcripts but also the individual characteristics of the participants based on age, gender, and other video gaming or simulation experiences.

Transferability is comparable to applicability and external validity, meaning the extent to which study findings may be applied to other circumstances (Krefting, 1991; Shenton, 2004). Using journaling for the study provided me with an audit trail from which another researcher may duplicate the results. It was my responsibility to provide accurate research logs, audit trails, and thick descriptions with rich contextual details for the reader to determine.

Dependability is comparable to consistency and reliability, suggesting the results would be similar if the same work were done with the same methods and participants (Krefting, 1991; Shenton, 2004). I addressed the design, data gathering, and analysis with the expert panel, my dissertation committee, and thoroughly documented the results. Finally, confirmability, relating

to neutrality and objectivity, uses the audit trail to confirm the participants' experiences are authentic and free of the researcher's biases (Neergaard et al., 2009; Milne & Oberle, 2005). By reflecting on my assumptions and biases from journaling, observation, and field notes and reviewing with my dissertation committee, I reduced the risk of influencing the experiences described by participants.

Protection of Human Subjects

The study had Institutional Review Board (IRB) approval before commencing. IRB approval was for two separate institutions. The University where I am enrolled in the Ph.D. program approved the initial study. Next the University where the study was conducted completed the IRB Authorization Agreement form to accept the approval of the prior institution. Once both institutions had approved, the study was ready to commence, and recruitment began.

A packet containing a consent form, an explanation of the study purpose, and individual characteristics form was completed by eligible students before participating in the study. All participation was voluntary, with complete information about the research provided before consent to participate was given. I maintained confidentiality for all information obtained during the study, per the consent materials presented to each participant. Before participants signed the informed consent, I noted they understood the voluntary nature of the study and that they may withdraw at any time. None of the participants were under 18 years of age, so authorization by a parent legal guardian was not necessary. Although all participants were students enrolled in the undergraduate nursing program where I am employed, and the study occurred, no students were taking my courses during the timeframe of the study. This reduced opportunities for coercion and any concerns were minimized as much as possible. Additionally, my status as a certified healthcare simulation educator enables me to conduct a study based on simulation, as I am

knowledgeable of the required standards for simulation practice. My expertise with conducting a simulation and debriefing were used extensively during the study providing a means to focus on the phenomenon of interest with minimal technical issues.

All data gathered during the study were kept confidential, available only to me and my dissertation committee members. All participants in the study had a number with no other personal identifiers recorded on the individual characteristic form, interview guides, or other documents used during the study, other than the screening tool and consent form. These documents were secured so only the researcher and dissertation committee had access to them. My laptop stored all participant forms electronically and under the protection of a password. Participants required no login information for the VR-Sim experience. This program was entirely under the researcher's control at the time of participation. Individual quotes from participants are reported in numeric form to protect the identity of the participants.

In using the VR-Sim software, unknown effects may occur due to the nature of the virtual environment, and I took necessary measures to reduce potential harm as much as possible during the study. These effects include but are not limited to stress, fear, and cybersickness effects like dizziness (Servotte et al., 2020). In the event of any unusual effects from the VR-Sim experience, a nearby seating area was available that allowed participants to sit down or they could cease all VR-Sim activities. I was available to monitor, and counsel as needed.

Following the VR-Sim experience, I conducted the individual interviews using Zoom® to record. All Zoom® files were password protected and saved to the cloud for video processing and transcript creation through the University's Zoom® database. Upon completion of Zoom® video processing, I stored the videos and transcriptions, along with all other data sources, in Box through my password-protected laptop deleting all files from the Zoom® cloud database to

ensure continued confidentiality. The Box folder was only accessible by me and my dissertation committee. No third party interacted with the processing of the videos other than my committee. Participants could refuse video recordings of their likeness via Zoom® during the interview, but none requested not to be video recorded. Had these instances occurred, I would have shut off the webcam and noted participant observations during the discussion in the field notes. Had the participant not allowed video recording, their assigned number would have been displayed on the Zoom® screen during recording. No other identifiers were visible.

Summary

This chapter described the methodology for the study, including the design, sample, setting, and procedures. The instruments used for data collection have been explained in detail and described how data collection and analysis would be conducted. The process for human subject's protection was also described.

CHAPTER FOUR

RESULTS

This chapter presents the findings related to the two research questions. The data analysis for research question one was conducted using the Braun and Clarke (2006) framework for theme development and Saldaña's (2016) process for coding. Braun and Clarke (2006) were appropriate for the qualitative description study design, allowing for flexibility in using theory and an organic approach to theme development. Saldaña's (2016) process worked well with the Braun and Clarke (2006) framework allowing for data-driven coding to identify the most significant elements and ideas of the participants' responses to interview questions. In the data analysis for research question two, the interview data were re-analyzed to compare, and contrast perceptions aligned with the study conceptual model and four extant simulation theories/models. Complications that arose, data management and analysis, sample characteristics, and the findings of the themes and subthemes generated are presented. Explanations for In Vivo, process, and emotion coding are provided in detail for emergent themes.

Complications

As the study commenced, minor and significant changes were needed to provide the best opportunity for study participation and data collection. Minor changes included revisions to data collection forms and one major change eliminated the manikin in the VR-Sim protocol. To reflect inclusion criteria for the study during the screening protocol, the screening phone call tool and individual characteristics forms were revised. Three questions were moved from the screening phone call tool (Appendix D) to the individual characteristics form (Appendix B) to be addressed when the participant arrived for the study and signed the consent. The following questions were added to the individual characteristics form:

"What is your date of birth?"

"Do you classify yourself as any of the following? Core Game___; Casual
gamer___non-Gamer."

"Have you ever experienced motion sickness, or do you experience dizziness easily?"

Yes___ No___

This change was due to limited interest, providing and responses, providing no means to eliminate potential participants from consideration. Additionally, one question was added to the screening phone call tool to verify eligibility for inclusion in the study. The additional question, "Have you completed the nursing computer course that introduces you to virtual reality? Yes___ No___", was incorporated into the tool to confirm eligibility. These changes were approved by IRB prior to recruitment.

Another complication arose with the first participant related to the use of the half manikin torso for chest compressions. This manikin was included in the VR CPR simulation experience to offer a realistic tactile experience during compressions because the hand controllers offered no tactical sensation like real CPR. There were multiple issues using the half manikin torso. First, it was not possible to press down into the manikin while holding the hand controllers the way the VR CPR software required. One hand controller had to rest on top of the manikin chest, flipped upside down. For the second hand controller, the participant had to continuously hold that device in their hand and move the controller up and down to simulate compressions. In the VR CPR simulation, this up and down motion showed the compressions being performed on the simulated patient in the virtual environment. But, in the actual physical environment, the participant was not compressing into the manikin's chest. The participant was only moving one hand, and stopping on top of the chest, thus no compression inward occurred, and no resistance was being

felt. The next issue with the compressions on the manikin, the participant was trying to do compressions as they would on the manikin causing issues in the VR CPR simulation. The participant was not able to get a feel for performing compressions on the half manikin torso and making sure compressions were being recorded correctly in the VR CPR software.

Next, the half manikin torso was resting on a rolling cart, with lockable wheels, for the activity. The height of the manikin off the ground was not adjustable, and the IT location could not accommodate a stretcher or other hospital device that could allow for height adjustments. This also created an issue with compressions as the participant was unable to get their hands with the controllers in the best position to simulate compressions. Neither a stretcher nor table were required for the VR CPR simulation. The half manikin torso was shown on a setup screen in the VR CPR software as an option, but also was not required. Using these devices was an attempt to provide some realism in the actual physical environment for the participant to aid them in not only performing the activity but offer a way to make the experience seem realistic in the actual physical environment.

The thought for using the half manikin torso was if the participant felt compressions were similar to a real situation, perhaps the sense of presence would be affected. The logistics of this process with the half manikin torso were difficult and observing the participant struggle concerned me. My concern was the participant, and all subsequent participants, would become fixated on working with the equipment and distracted from experiencing the VR CPR simulation environment. After reflecting on the difficulty experienced by the first participant, I opted to remove the half manikin torso and rolling cart from the VR CPR simulation protocol. Ten subsequent participants performed compressions in mid-air.

Data Collection, Management, and Analysis

Recruitment began with an email sent out to all potential students at the research location, followed by a screening phone call to determine eligibility for the study. The data for the study were collected from February 14, 2022, until March 15, 2022. A SignUpGenius link was used to allow participants to set an appointment date and time. The average total length an appointment was 1 hour and 15 minutes from the start to conclusion. The VR CPR software and simulation environment were consistently delivered to each participant except for the use of the half manikin torso as mentioned as a complication. The same semi-structured interview guide (Appendix C) was used for all participants. Interviews were conducted in person using Zoom® recordings with transcription generation. The length of interview sessions depended on each participant's answers, lasting approximately 18-39 minutes in length. Each interview was downloaded into a Word document from the recorded interview and then assessed for accuracy. Data cleaning included a word-by-word comparison of the Zoom® transcript with the audio recording to ensure accuracy of the transcript. I met with the committee members at regular intervals to debrief on the study's progress and discuss needs for data management and analysis.

After completing the first two interviews, the interview process and questions were reviewed. The committee noted some leading questions and unnecessary dialogue from the researcher. This extra dialogue was due mainly to receiving minimal responses to my interview questions from one participant. My interview technique was adjusted to minimize bias potentially created by leading questions and excess dialogue. The remaining interviews were conducted with minimal dialogue from me to allow for an uninterrupted description by all participants. Minimal participant responses were addressed with the proposed probes.

No additional questions were added to the interview guide, as the questions were reflective of the desired focus of the research study. Participant responses provided a rich description of the experiences within the VR CPR simulation. The responses by the participants also described concerns or issues experienced, which included technical problems with the hardware.

The data analysis followed the Braun and Clarke (2006) framework of theme development within the scope of the qualitative description method proposed by Sandelowski (2000; 2010) and described in Chapter Three. The qualitative description (QD) method stays as close to the data as possible, true to what the participant describes during the experience. The first step involved becoming familiar with the data. Each transcript was read through fully, followed by rereading multiple times to clearly understand the participant's view with no attempt at analysis. The next step was to generate initial or preliminary codes (Braun and Clarke, 2006). Preliminary codes were data-driven, generated from the transcripts and were established with no focus on analysis.

Next, first and second cycle coding were conducted. Coding commenced on all interviews as each was completed. Contact with the committee occurred throughout as coding was conducted. *In vivo*, process, and emotion coding were used for first cycle coding, where general codes were developed for categorization and data analysis (Saldaña, 2016). First cycle coding was completed independently for each transcript, then second cycle coding began using pattern coding. Reflection took place through second cycle coding to generate codes that could be collapsed into categories and grouped based on patterns. Patterns became clear as interviews and analysis progressed.

Based on Braun and Clarke's (2006) third step, themes were then defined and named from these patterns. In searching for themes, some codes became main themes while others formed subthemes (Saldaña, 2016). Upon determining themes and subthemes, the researcher and committee refined the potential themes and began defining and naming the themes (Braun & Clarke, 2006). Three main themes and eight subthemes were developed.

Description of Participants

A sample of 8-12 student nurses was estimated. During the study, 12 nursing students were recruited for participation, reaching the estimated goal. All 12 participants met the study's eligibility criteria, which included being Junior 1 to Senior 2 status, enrolled in the Traditional Baccalaureate or Accelerated Traditional Baccalaureate programs, with Cardiopulmonary Resuscitation (CPR) certification, and having completed the computer course introducing the respondents to virtual reality. One student initially contacted me to participate in the study but could not do so due to an inability to reach the study site and when contacted later was no longer interested in participating. A total of 11 eligible students enrolled in the study. After 6 interviews, I began to assess for data saturation. In assessing the data, codes began to become similar with fewer codes being generated. Guest and Namey (2020) suggested information threshold to assess data saturation. Information threshold corresponds to determining the initial number of codes generated and reassessing new codes with subsequent interviews to reach less than or equal to 5% new information (Guest & Namey, 2020). I began to see what new information was obtained in the next five interviews. After 11 interviews each had similar perceptions and codes shown. I believed I was approaching data saturation. The number of codes were declining and using the information threshold data saturation was nearing less than or equal

to 5%, but further interviews may have been needed to determine if data saturation was achieved.

All participants provided informed consent and completed the individual characteristics form. Maximum variation was partially met. Maximum variation was met related to program track with five participants in the accelerated traditional track, and six in the traditional track. Variation by level was partially met with at least one participant from each level but the aim for having at least three participants from each program level was not obtained. The largest group of participants was Junior 2 (N=8), with one participant each in the Junior 1, Senior 1, and Senior 2 statuses. The Junior 1 student also did not have as much experience in simulation compared to Junior 2 through Senior 2 status participants.

Additionally, variation partially occurred in gamer status with three participants reported being a casual gamer with the remainder reporting being non-gamer (N=8). This met the aim of having at least one participant identifying as a gamer and three with non-gamer status. No participants identified as core gamers. Despite these statuses, the participants used various gaming devices, with five using all forms of gaming devices listed, including virtual reality experiences allowing for some variation on types of gaming used prior to the study. All 11 participants had used mobile game apps, and a large majority had used gaming consoles (N=9), laptop games (N=9), and games with haptic devices (N=8). Less than half (N=5) had experiences with headsets or head-mounted displays. While maximum variation as proposed was not obtained relative to gamer status, there was adequate variation in that both non-gamers and casual gamers participated and reported experience with all five gaming devices. Individual characteristics for program, status, gamer, sickness, and devices are shown in *Table 4*.

Table 4*Individual Characteristics for Program, Status, Gamer, Devices, and Sickness (N=11)*

Characteristics	n	Range	Mean
Program:			
Accelerated Traditional	5		
Traditional	6		
Status:			
Junior 2	8		
Junior 1	1		
Senior 1	1		
Senior 2	1		
Gamer:			
Non-Gamer	8		
Casual Gamer	3		
Devices:			
Gaming consoles (Atari®, Nintendo®, Playstation®, Xbox®)	9		
Games with headsets or head-mounted displays	5		
Games with haptic devices (hand controllers/mouse/motion capture)	8		
Laptop games	9		
Mobile app** games	11		
Sickness-Motion or Dizziness:			
None reported	11		

**app=application

Gender identification and age, as expected, showed little variation. Despite offering four gender options, only one participant identified as male with the rest identifying as female (N=10). Age did not show maximum variation as all participants were in the age range of 20-22 years old. But, at least one participant was 20, 21, and 22 years old meeting the aim of three variations. The individual characteristics of the participants' age, gender identification, race, and ethnicity are shown in *Table 5*.

Table 5*Individual Characteristics for Age, Gender, Race, and Ethnicity (N=11)*

Characteristics	n	Range	Mean
Age	11	20-22	20.6 years
Gender Identification:			
Female	10		
Male	1		
Non-binary	0		
Race:			
White	11		
Ethnicity:			
Non-Hispanic	11		

Findings

The VR CPR simulation allowed participants to see what could take place in a hypothetical patient situation. Everything from initiating the encounter, to evaluating performance was provided through the VR CPR software. The participants performed two attempts in the VR CPR simulation. The first attempt was the orientation with the researcher commenting and instructing throughout the attempt followed by a debrief of the technology. The debrief of the technology was to understand initial impressions of the software and hardware, as well as any sensations perceived while using the VR CPR simulation for the first time. No participants had used the VR CPR simulation prior to this attempt, and it was important to learn initial thoughts of how the software worked. Most participants found the software interesting, fun, or “really cool.” None experienced anything stressful, other than understanding compressions and how the environment worked. About the first attempt, Participant 003 said, “I think it took me a second to see where everything was...the rate was up top, the depths over

there, the time is on the bottom and so it took me a second to look around and see everything, while I'm also trying to resuscitate the patient.”

The second attempt was on their own. Participant 010 stated initially about the second attempt, “I think figuring out the lay of the land was really enjoyable. I thought that was really cool.” Similar statements such as these were made from multiple participants during both the first and second attempts, as many had minimal experience with virtual reality. Participant 011 went on to describe their initial impressions of the second attempt in the VR CPR simulation:

I took a second to look around the room again and noted the two chairs are in the corner of the room. The other bed that was behind me and the skyline through the window. That's one of my favorite details in the simulation is the skyline. It could very well just be a blank window, with nothing outside of it, but I thought that was really descriptive. It made me feel like I was in some kind of city in the hospital and really set the scene.

To provide an overview of a participant's experience of VR CPR simulation, Participant 011's description was particularly comprehensive:

The patient goes into distress and falls over. And then I was expecting just to push the emergency button, but I had to wait for the voice over head for me to initiate the emergency sequence and then push call for help. So, I did call for help, and then I had to listen or I had to arouse the patient or try or attempt to rouse the patient, a couple of times and no response, and then I had to tilt his head back and listen for breaths and I heard, I think this time it was just two gasps it might have been more...and then initiating CPR. So, the first time I noticed that they didn't have the 30 counter so I wasn't necessarily counting in my head. I was kind of practicing the movement of CPR and waiting for the lady nurse to come in. And so, I was doing that and trying to get it in between the green lines, and I think that's a good way to first do it because it takes a second to sense where your hands are and where your compressions are because it starts out a little red and then it gets your rhythm. I understand now. The nurse came in and she said, "Oh I'll start compressions if you get the AED hooked up." I put the AED where it's supposed to be. I opened it and turned it on. And used the scissors to cut the chest [shirt]. I actually had to manually do that, this time, rather than just [motions like she's pretending to cut the shirt open]. I did that, and then I had to select the language as well. Selected English and then you have to put the pads on the bare chest...and then you had to hold your hand out and stand clear of the patient and then deliver the shock. Then I continued doing CPR. So, this is my first round of CPR with the nurse, who was helping me with the bag valve mask with the respirations. So, I did my CPR. I was staring at the circle the whole time because it told me all my stats that I needed to know and it was kind of hard to

simultaneously look at your rate and try to get your rate into the green. Look at your depth. Try and get that in the green, at the same time, and also keep track of the 30 at the bottom. I tried my best to hit 30 but I don't think I hit exactly 30 every single time. And then once I saw that I'd hit her 30 I took my hands off and she gave it the two respirations. Then I continued and that went on for a couple of minutes or so. I did get the hang of it a little more and I understood. It was a lot. I did my run of CPR and we delivered another shock, staying clear of the patient, delivering the shock. I came back down and then I did my second round of CPR. But overall, I think I did better than the first time because I knew I was anticipating things rather than waiting for them to happen. And I remember hearing your voice in my head you have to press this and you know the green spot where you put the AED, take it put it over there, and that made sense, and all the little guiding hands were perfect. I knew exactly what to do. But then, it stopped. It gave me a little newspaper of the results, which I thought was a fun touch too. It tells you the story of the patient, and here's your percentage.

Research Question 1 Findings

The first research question was: How do student nurses describe their sense of presence in a 3-D virtual reality simulation using a headset and haptic device? It was essential to ask how the participants felt about being in the environment and how real it was to them. Each interview began with the grand tour questions: “How much did it feel like you were actually in that environment?” and “You’ve used various forms of simulation, like High-Fidelity Human Patient Simulation, virtual simulation, and VR-Sim. What was your experience like being in those environments.” Three themes and eight subthemes were derived from the data to answer this research question and are shown in *Table 6*.

Table 6*Themes and Subthemes*

Themes	Subthemes
What Brought Me In, What Brought Me Out	It Felt Real or It Felt Fake You're Here Suspension of Disbelief
Issues in Virtual Reality Simulation	Nothing to Ground Balancing Hardware and Software Authentic Approaches to Simulated Learning
Higher Level of Learning	Performance Improvement Influencing Background Factors

Theme One: What Brought Me In, What Brought Me Out

The first theme, *What Brought Me In, What Brought Me Out*, refers to participants' experiences within the VR CPR simulation and with the hardware producing effects triggering a perception of either being within the simulation (what brought me in) or feeling as if they were a bystander, not able to focus on the simulation (what brought me out). A common phrase shared by almost all participants was that aspects of the VR CPR simulation “felt real.” By contrast, participants described the real physical environment (cords, walls, chairs, and tables) as obstacles while working through the VR CPR simulation. Glitches, sounds, and visual imagery from the software would give the participant reason to believe what was happening in the VR CPR simulation was real or not real to them. Participant 009 drew a comparison of the VR CPR simulation to other simulation modalities to understand what brought them in or out of the experience:

I think the standardized patient you can't physically do tons of things to them because a lot of people don't necessarily want a nursing student coming and sticking them with an IV that they don't need. But they can talk back to you, and you can physically see what's going on with them. So, I think that the sim or I think that the VR is a very interesting

combination of the two because with the manikin you have something where you can listen to their heart and lungs and they don't sound correct, but they have no facial expressions, and you won't see the real-time reaction to things. You have the simple patient [Standardized Patient] where you can physically see them make faces or make breathing sounds, but they can't force their heart or lungs to sound wrong because they're not incorrect. And then you have...the VR where you can physically see things happening to them, you can hear the things happening, and you just can't physically touch them, but you can virtually touch them.

The subtheme *It Felt Real or It Felt Fake* suggested there were moments during the VR-Sim scenario that brought participants in or out of the situation presented. Participants would describe certain objects, such as the bedside table, patient bed, and the patient themselves, as authentic (fidelity) that brought them in the environment. They would show empathy for the patient and would look at and engage with the nurse assisting them (engagement). They would reach across the table or bed for objects, contorting their bodies to adjust to an object that did not exist in the real physical environment (immersion). Participant 010 offered what added to the fidelity, engagement, and immersion:

For this [VR-Sim], it was gestures and I needed to know to look for the call light so I'm using that knowledge and that I need to hit the call light, but then it's obviously there where I know it would be in the real world. So, it's not that I have to look through a tab and hit the call light. I'm actually doing the thing. So, I really enjoyed that, and it just got me in the process.

Conversely, haptic devices malfunction, software glitches, and focusing on the graphics were described as distractions. The software itself would glitch resulting in positions requiring movement to be in errant locations, even outside the grid boundary that protects the participant from objects in the real physical world. These actions detracted from realism and reduced the fidelity, engagement, and immersion of the experience. These distractions made the participant feel the scenario wasn't as real and brought them out of the simulation. Participant 003 described a moment where the prompts on screen confused her:

So, there was at least once where I noticed that I had been doing it, and then I looked down and the little hand symbol, whatever telling me where it was, was going crazy. I was thinking, "Oh, is it going right now, or do I need to put my hand back or something?" But for the most part, I wasn't really watching the patient, I was watching the monitor.

Participant 001 expressed this concern over watching the evaluation graphics, such as the monitor mentioned above, stating, "I was playing for the computer, as opposed to trying to do it correctly, for the patient." These expressions showed concerns where the participants lost their sense of being within the environment and either being confused by a glitch in the software or focusing entirely on graphics in the VR CPR simulation rather than the patient, both of which are contrary to what would occur during real CPR encounters. Participant 005 stated another concern suggested by multiple participants related to the handheld haptic devices:

I also felt like the patient was really low and so maybe I should have moved my body more so that it would have made more sense and I could have fully felt that motion. Because a lot of times, I felt like my hands were just kind of moving. To satisfy the hands that I'm seeing [in the VR-Sim], but that wouldn't be how it would be in real life.

The subtheme *You're There* was defined as endocentric presence reported throughout the VR CPR simulation experiences. When a participant felt endocentric presence, they saw nothing but the scenario in front of them. The situation felt completely real to them as if they were in a real hospital. Many participants described being in the scenario as if it was very real, urgent, and intense. Most participants felt a second nurse *being there* helped make them feel in the environment. Participant 001 said, "It was nice to have the ability to feel like you're in a hospital with a different nurse, as opposed to doing it by yourself." Participant 001 went on to say:

It felt more like you had an actual patient because they had an actual face, and so, instead of just being a beige piece of plastic it felt like there was an actual patient or an actual kind of person in front of you. And I did think the visuals were good enough where you could really put yourself into the setting. Nothing distracted from the realism of that in my opinion. I thought it helped that you had another nurse there, and she was in scrubs, and she was in a mask and so it's not what I was used to practicing it with just the manikin.

Participants worked diligently to master hand controllers and perform CPR adequately to save the patient's life. None wanted to give up or stop short of having better outcomes for the patient, showing a high degree of endocentric presence where they were engaged with the VR CPR simulation. Participant 005 was brought into the VR-Sim by a sense of urgency. "I think the dialogue added to the intensity of it. [The virtual nurse would say] keep your hands straight. There's definitely a sense of urgency, through the dialogue." Participant 009 reiterated this statement describing that sense of urgency:

I did feel a certain sense of urgency though because, when your partner is taking the time to do the bag [bag valve mask] I'm thinking come on, we need to go. This man's going to die. It's a simulation but we've got to save him. Come on, why are you taking so long. Why am I taking so long?

Urgency was stated as a reason for two participants to work as well as they could to perform CPR and save the patient. Dunnington (2015) also suggested urgency helped to create endocentric presence helping with knowledge gains. All participants experienced urgency in various ways, with an overarching statement implying wanting to save the patient. Their emotions and efforts performing CPR showed a desire to keep the patient in the VR CPR simulation from dying.

The subtheme *Suspension of Disbelief* refers to the necessity of VR users knowing something can feel real even when they know it has been faked, whether in a movie, play, or simulated experience. Suspension of Disbelief allows a sense of realism from an emotional, psychological, conceptual, or physical standpoint that encourages exploration of the experience (Dalgarno & Lee, 2010; Vuuren et al., 2018). For the duration of the event, a participant engaging in the activity perceives the actions demonstrated as realistic despite the knowledge the scenario is completely fake. Grounding in reality with realistic locations, people, objects, utensils, and other things can allow a participant to suspend their disbelief and perceive realism

in that encounter. Participant 001 stated, “Having a little bit of time to look around, see your hands. I think helps you adjust and kind of change your location in your brain to being in the hospital room with the patient.” Suspending disbelief made some participants believe a life was at stake, as in the case of Participant 009:

It just makes you think this is a person with a life and kids just like any other patient you talk to. That you want them to be okay. You don't want to see your patients do poorly and you're responsible for their life, you want to see them be okay, and I think you do that so often with humans that even when it comes to fake humans or fake things you want them to be okay and go back to their fake life.

Theme Two: Issues in Virtual Reality Simulation (VR-Sim)

The theme *Issues in Virtual Reality Simulation* refers to concerns participants had with the haptics of VR-Sim that add a sense of interaction to the experience, providing a medium to promote realism in the situation. Haptics can include hand controllers in VR-Sim, a computer interface such as a laptop running the VR CPR software, or a head-mounted display providing the 360-degree reference of the virtual environment. Haptics are an essential technology to make any simulation plausible and assist with realism. Haptics are necessary for VR-Sim experiences to promote realism and authenticity of the environment. The haptics can allow a participant to feel present in the situation as they interact with the environment and believe the scenario is realistic. The software and hardware in VR-Sim sometimes have issues. These issues detract from the experience and lessen the realism and affect the sense of *being there* in the environment. The subthemes within this theme are *Nothing to Ground*, *Balancing Hardware and Software*, and *Authentic Approaches to Simulated Learning*. All participants experienced concerns related to haptics within the VR CPR simulation and expressed ways in which to enhance the experience going forward.

Nothing to Ground related to the concerns created by the haptics of compressions in the VR CPR simulation environment. Compressions were problematic with every participant. The main reason for these problems revolved around the need to simultaneously get the depth and rate correct. This is the same process used in real CPR situations in the hospital and in manikin training. The haptic feel of the VR CPR simulation did not provide the same resistance exhibited in the encounters. Therefore, participants were simply compressing in mid-air with no resistance to their movements. Participant 010 said:

The only unusual thing I think was that I wasn't actually compressing or touching anything. There were sometimes I thought don't think too much about it. But initially I thought I'm just hovering my hands in the air. There's nothing to ground my arms or my hands. I didn't know if I was moving my hands up too far. I didn't know if, I needed to bend over more because I'm tall, something like that. I think I just kind of hung my arms out in the middle of nowhere. That was kind of a weird sensation at first.

This created a difficulty in understanding the appropriate depth, even if they correctly did the rate.

Secondly, the subtheme *Balancing Hardware and Software* related to coordinating the rate and depth of compressions using the hand controllers (hardware), and the monitor displayed in the VR CPR software. This was a virtual monitor that appeared showing a participant the amount of time that had elapsed, the rate and depth of compressions, and counted the number of compressions delivered. All participants felt the head mounted display and bases that created the virtual room worked flawlessly, save for one participant with blurriness due to an adjustment issue. No participant consistently used the hand controllers correctly. With the participants trying to balance out the depth and rate recorded through their movements with the hand controllers, and the metrics reported on the monitor in the VR CPR software, many had issues correctly delivering compressions. Participant 010 said:

Seeing your compression depth go up and down [motions like the waveform on the monitor with hand]. I feel like in most stuff that I've gotten for [BLS] or the ACLS class that I did, [the manikin] would just beep at you if you're not going deep enough. Or it beeped at you if you weren't going fast enough or going too slow. This [in the VR-Sim] was a very visual thing. You can see the two high up [numbers for compressions and rate] and too low [time and count]. So, it's like another variable to see, not just wrong, but it's telling you you're pushing too much.

There was confusion over flipping one controller over to help simulated compressions, with some never performing the action and putting the hand controllers side-by-side instead. This side-by-side motion sometimes disrupted the VR CPR simulation leading to “flying hands” where the virtual hands flew off the patient making it impossible to do compressions. This only lasted for a few split seconds, but it was enough to cause issues for participants in a few cases.

Participant 005 said the issues corrected themselves:

There was one point in the CPR I was holding my hands the same, but it was like the hands released [the simulated hands in the VR CPR simulation], and I guess I moved without realizing it. And then the compressions weren't going, and I was thinking, ‘Oh no.’ So, then I just went like that [motions swinging her hands off to the sides], and then once I redid it, it reset. So, that was good, because at first, I thought, ‘Oh no what am I doing wrong?’ But then it reset so that was good.

Participant 003 had similar issues and said:

I was a little stressed because I knew I wasn't doing it properly. So, I was trying to figure out how to hold the controllers properly while keeping that correct rate and rhythm, and while making sure that the hand controllers sensed it correctly. I saw that the depth was in and red. I didn't really know what to do to change that because I'm assuming that meant that I was doing the wrong depth. But I didn't really know because I felt like I tried to do it deeper or shallower I feel like nothing that I did kind of made it not bright red anymore, so I just ignored that, and I was just trying to do the right rate, then the right rhythm.

Pressing certain buttons or pulling triggers was required for some actions in the VR CPR simulation. Participant 010 stated, “I don't think I felt awkward using the controllers or anything like that. I think maybe knowing should I pull the triggers on the thing or should I just grab and gesture?” Other times, participants only had to reach with a controller in the direction of an

object to interact with it, such as the call light in the VR CPR simulation. This led to confusion. Prompts for actions were displayed throughout for participants, which all found helpful, but some actions could not be performed unless the participant followed the prompt correctly. This was an easily remedied issue when participants encountered it. Participant 005 stated:

When I got the AED I knew cutting off the shirt, well cutting it on and then cutting off the shirt would be it, and so I was thinking...cut it on and I was grabbing for the scissors, but I had to wait for the hand, and then I had to wait for my hand to go like this [motions hand going horizontally across], but the hand had not cut the shirt yet. So, then I had to redo it. But they [the prompts] were pretty easy to follow.

Another issue that arose dealt with participants trying to balance out doing compressions while watching the monitor keeping track of depth, rate, count, and time of compressions. Most participants did not count out loud while performing chest compressions, choosing to watch the monitor on screen. A thumping sound was heard during the VR CPR simulation by all participants, which was designed to assist those doing CPR in the software, but at times that was overlooked, misinterpreted, or required time for adjustment. This caused issues with timing and at times revealed issues with the VR CPR simulation itself. Participant 003 described these concerns:

Once I started thinking about it, I thought I probably should have been doing that [counting out loud] the whole time. And so, then by the end, I started thinking, "Okay [whispers] 1-2-3-4 [nodding]." Going with it [the thumping]. But I hadn't really been thinking about it before. I kind of looked at where the number was, go back to what I was doing. Check the rate. I kind of think that was distracting because it was big right there and I kept looking up at that to see where I was in terms of rhythm, in terms of how many I had left [compressions] so I kept going, and then I realized I had gotten to 31 or 32 . That's when I put my hands up [to stop compressions]. That was another thing because then she does the air and then I'd go back down and before I started it [the compression counter on the screen] was on two or three. I don't know if that was because I wasn't getting back fast enough or if it thought I was pushing down, but I would go back to push, and it already started counting up. So, I fell off the count. I kind of waited and saw that it showed five, six and that's when I started counting so that I could get on where it was.

The subtheme *Authentic Approaches to Simulated Learning* suggested how the VR CPR simulation could be used for future research and education. Most felt combining the software with other forms of simulation, such as Standardized Patient Encounters or High Fidelity-Human Patient Simulation, would allow for an authentic form of experience. Participant 011 suggested, “If you had virtual reality plus the real live person that might have been the ideal simulation.” The main reason for these combinations is to allow for a physical feel with the virtual elements that allow you to see behaviors, such as a patient becoming unresponsive. The haptic feel of compressions on a chest, like that with a manikin, could only enhance the feel of performing these actions in the VR CPR simulation, providing a realistic approach to understanding the technique. Participant 011 suggested haptic gloves:

If there was some kind of technology where you could wear gloves or something and then you can use your hands so it's still the same kind of tactile movements that would be a little easier to navigate just because you're trying to make it as close to reality as you can. I feel like that way you can almost get your hands more into the position of where would be for CPR itself and I don't know if this is possible but having maybe a chest device to be able to feel the person behind the CPR rather than just the air. Because the resistance on that is a lot more real than just the air and CPR. Because, this is a very helpful tool but you're not on a physical person and that's a different sensation.

Several participants felt the VR CPR simulation would be a supplement to current simulation practice, but not a replacement for sim or clinical practice. The realism is what interested them with the intricate details used by the creators of the VR CPR software to provide an authentic approach to understanding healthcare processes essential to saving lives. Participant 003 had this to add:

I have never done anything like that, before like I've never done anything that I have to be active and, my movements are dependent on what I'm trying to complete is dependent on what I'm doing. I'm usually I'm just walking around and clicking on stuff, so I've never done something that I have to actually do a certain movement at a certain rate or whatever, in order to do the tasks that I'm trying to do. It was interesting.

Dunnington (2015) also mentioned extraneous factors influencing perceptions of the experience, and in this study prior knowledge contributed to issues with how realistic the VR CPR simulation was to participants. Participant 001 stated quietness was a factor influencing the sense of realism in the VR CPR simulation experience:

I felt like the thing that brought me out of it the most was how quiet it was because when you're in an actual hospital room there are monitors. That patient wasn't hooked up to anything. And so, if I was actually in a patient's room and I was having difficulty I would be able to hear the person across the hallway yelling about something. I'd be able to hear the nurses in the hallway going to get something. Something's happening over the intercom. There's a different code somewhere else in the hospital. I thought the one thing that kind of brought me out of feeling like it was realistic, more than anything else was how it was me and that other nurse, and it was the patient, and that was it because in the real hospital it's so crazy and loud which, I think, maybe that would be helpful.

This participant's perspective of what happens in a busy hospital was influencing how they felt about the VR CPR simulation. Quietness did not seem authentic. Whereas one participant perceived relaxation from less verbal communication, this participant felt the lack of communication, other people, noises all seemed to diminish the experience. The chaos was needed for them to feel part of the scenario. This point about quietness was brought up by other participants, with some agreeing while others did not consider quietness in the VR CPR simulation a concern.

Prior experience played a factor in emotional responses that also impacted the VR CPR simulation as participants compared modalities. The modality of virtual simulation on a 2D laptop computer based program was shown to be disliked by all participants having used the platform. Participant 001 had this to say about virtual simulation:

The virtual sim on the computer I don't care for at all. I think it's very difficult to get a lot out of it because it's so easy to just go through the motions and on the computer. I've been lucky I haven't had a rotation that's virtual yet, but I've seen other people doing it and I've had to do one or two before now. So, I very much don't care for it, just the straight-up virtual.

In discussions about virtual simulation a participant even stated they “hated” virtual simulation. This emotional response about a prior experience clearly can affect motivation to perform in any activity with similarities to the virtual simulation platform. As addressed in this study in the literature review, there is incongruency over the definitions of virtual simulation and what distinguishes virtual reality simulation and virtual simulation as separate modalities. Because of this dislike for virtual simulation being in the VR CPR simulation may have had an affect similar to that experience and thus negated potential learning outcomes for the participants. Fortunately, participants were distinguishing the VR CPR simulation from virtual simulation during this study as wholly separate, but prior experiences were shown to affect perceptions during the study. Therefore, it is possible that the impact of virtual simulation affected perceptions in the VR CPR simulation experience initially. This initial perception before the study may have contributed to lower interest from emails sent out to potential participants, but no follow-up occurred to determine if this was a causative factor during recruitment.

Other factors also began to emerge from prior experiences, whether in VR, clinical, or other simulation modalities to inform how participants worked through the study. Participant 008 in describing what bad stress could be also stated the VR CPR simulation environment felt “relaxed.”

Personally, not having a speaking part I guess in this simulation kind of made it more relaxed...another person talking for you, it kind of took that level of stress away, and it was kind of like I had to do the compressions basically.

This feeling of relaxation goes into the emotion response part of presence, that can be both good and bad. Dunnington (2015) suggested stress and anxiety can be related the evaluation of performance, such as being watched by an instructor as someone works through a simulation, or from the perception that the situation is real and requires real effort to perform. In this case,

aspects of the VR CPR simulation allowed participants to focus solely on compressions, which resulted in Participant 008 suggesting the experience was relaxing to them. They focused on what they perceived to be the main premise of the situation, performing CPR and saving the patient. Therefore, relaxation acted as a double-edged sword in allowing a participant to focus on the task but reduced the realism and thus fidelity may have been affected.

Theme Three: Higher Level of Learning

The theme *Higher Level of Learning* related to participants' descriptions provided regarding learning outcomes, knowledge gains, and suggested educational pathways with virtual reality simulation. Participants engaged with the software and hardware to learn, to explore being within the environment, and to understand the practical and educational purposes of the VR CPR simulation. They described both advantages and disadvantages associated with VR-Sim in nursing education and ways to use the VR CPR simulation for future educational and research purposes. Participant 003 described those practical purposes by how it actually felt:

At the beginning, when I was really listening for the breath sounds, trying to get the rate. That felt more like I was actually doing it because I had to lean over and actually try to listen. And then, with the pads, I knew I would actually do that. That was the most that I felt I could feel like how I actually would in that situation. It's a simulation, so I try to think of it as more real and try to do it correctly because I'm trying to save the virtual patient.

The participants felt the experience allowed for understanding steps following initial training in CPR certification, as well as a viable option for re-certification. The situation mattered to many of the participants, sensing it was important to understand the process of CPR should the event arise even while working in clinicals at school. Evaluating their performance and understanding the consequences of their actions to the patient being resuscitated also allowed for an understanding of how important it is to develop adequate knowledge on the CPR process for use

in any capacity in the nursing workforce. Participant 002 offered this statement about the VR CPR simulation from a learning standpoint:

I think it's a higher level of learning for sure. But it's also fine motor skills, with technical things like this [CPR knowledge]. I'm not exactly going to learn how to do the head tilt and chin lift off this. I'm going to learn to do it and I'm going to know to do it and know how to do it, but as far as practicing it, it's got to be paired with the real thing.

Participant 005 reiterated a statement Participant 002 suggested when it comes to the VR CPR simulation and motor skills mixed with technical skills above, “muscle memory.” From their perspective the VR CPR simulation offered the ability to perform tasks in CPR that were not always available in other modalities because the prompting in the experience allowed for memory recall from tasks learned in BLS classes. Participant 005 went on to say:

A CPR class can be done like that and how you would walk through it first so you get a feel for it, and then you would just perform it on your own. Maybe just add to it...something else, where you could actually see how your hands would be and how hard you'd have to push because I know that was one thing that I struggled with in a simulation with the manikins that I didn't really experience here...

The subtheme *Performance Improvement* showed participants were able to adjust to the feel, work flow, and needs of the VR CPR simulation throughout their experience in the VR-Sim. Only one participant did not improve performance as reported by the VR CPR simulation after the first attempt walk-through with the researcher. In many cases the improvement was only minimal from the first to the second attempt. Some of this lack of improvement was the result of participants attempting to understand how to work the haptic controls properly in order to perform CPR. But each participant was pleased that their performance improved from the first attempt to the second, even if the improvement was minimal. In several cases the adaptation to the environment led to outcomes where patients were alive and well, residing on a medical-surgical unit with no further injuries. While others had patients with severe neurological deficits

and remained on an intensive care unit following resuscitation efforts. Participant 001 stated, “I was competing against myself. I thought, all right, my patient had serious brain damage last time so let’s go for a normal function.” Participant 007 added that the realism made the experience matter to them:

I think it felt real in the way that it's a serious thing that we have to do. When you do CPR you're not just doing it for fun. But in other situations, like, with the manikins that you just go in there, and you give medicines. I know that's important but CPR and physically saving someone's life is more important and we don't really see that with the real patients or how it resolves.

The subtheme *Influencing Background Factors* related to individual characteristics of the participants that may have impacted the VR CPR simulation experiences. Six of the participants identified as non-gamers, while five identified as casual gamers. No one identified as core gamers demonstrating the minimal amount of gaming experience needed to perform and learn effectively in the VR CPR simulation. Only three participants thought of the VR CPR simulation as a gaming application. For many, the act of performing CPR was too serious to think of as a game. Motivation is an individual factor Dunnington (2015) cites as an individual’s desire to act. Choi et al. (2017) suggested achievable benchmarks for skill levels is needed so a learner can remain motivated. Motivation also needs to be coupled with stress to perform (Dunnington, 2015). Participants considered the experience stressful but described it as good stress that motivates you to work through the situation. Participant 002 had this to say about perceived good stress:

When you're doing it in a regular class you always have to go in and it's like you know you're running through the scenario, but you never actually have. It just feels more real than a manikin to be able to see facial reactions and check, you see him going down. That felt more real. It felt more in a way stressful but not like bad stress.

Bad stress would have been the feeling of being completely overwhelmed by the experience. An

example of bad stress came from Participant 008 saying, “that’s what stresses me out about interacting with patients. Knowing what to say in certain circumstance.” Good stress motivated participants to perform better and provide a better outcome for the simulated patient in the VR CPR simulation. As Participant 004 summed up for all participants, “I just wanted to save the patient. Even though he’s not real.” As they worked on practicing what was needed to perform in the VR CPR simulation, their confidence grew to allow most of them to finish with a higher percentage on the second attempt than had occurred on the first attempt. The good stress motivated each participant to perform at optimum capacity to achieve confidence in performing the skill.

But this wasn’t the case with every participant. One participant's motivation was lower, and it came from prior experiences in VR environments. Dunnington (2015) stated learners will draw from prior simulation and clinical experiences to help perform. But in the case of Participant 004 prior experience seemed to hinder than help:

It felt more like a game I’d say. The way I had to position my hands and stuff. But I feel like in real life situation there would be a lot more commotion. More people in there and I know I wouldn't have to be the one doing the compressions the whole time. So, I was trying to compare it to what I know real life would be like but that's still as real as it's gotten for me.

The implication from this participant is that the VR CPR simulation felt no different than any prior VR game they had experienced. Some did feel the evaluation method at the end allowed them to compete against themselves, but not for the purposes of winning a game. The competition with themselves related to their learning and the participant’s desire for better outcomes for the patient in the VR CPR simulation scenario. Participant 001 stated about the final evaluation results:

I liked the newspaper. I liked how it showed you how you did. I thought it made it more

fun, not like a game because it's CPR training, but I found myself the second time I did it I was competing against myself. I thought, all right, my patient had serious brain damage last time so let's go for a normal function. Let's hope he's okay, and so that almost made it more competitive with yourself and so it's not just a number score it's more you think this is about the patient.

Research Question 2 Findings

The data was also used to answer the second research question: How do student nurses' perceptions about presence align with theoretical models of simulation and presence? Four existing simulation theoretical models were described in Chapter 1 and outlined in Table 3. These frameworks informed the conceptual model, and I was interested in whether the experience of my participants aligned with these theories. A discussion of the usefulness and applicability of my conceptual model is presented in Chapter 5.

All four theories referred to a similar definition of fidelity that is inherent in making a simulation experience realistic to engage a learner in understanding learning objectives and concepts (Choi et al., 2017; Dalgarno & Lee, 2010; Dunnington, 2015; Jeffries, 2021). Based on fidelity, all participants stated the VR CPR simulation felt real to them, at different points during the experience. For example, participants described physical fidelity when they noted the room fixtures and window seemed to represent a real hospital room, and they reported emotional fidelity when describing the urgency of saving the patient.

Presence is not included for Choi et al. (2017) and Jeffries (2021) as these two theories focused on design concepts for simulation. However, the factors affecting presence are there in both models as these same concepts for design appear in both Dalgarno and Lee (2010) and Dunnington (2015). The design of the VR CPR simulation helped participants feel like they were there, thus it was important to have theories adequately supporting both the design and sense of presence to facilitate a better understanding of student perceptions in the environment.

Aligned with Dunnington's (2015) model of endocentric and exocentric presence, participants described going in and out of *being there* as they performed in the VR CPR simulation. My data suggested individual factors seemed to affect how much presence a participant felt more than the design. Individual characteristics were not impacting the sense of presence in the VR CPR simulation as much as other factors associated with the individual participant. Prior experiences, motivation, and emotions contributed to how present participants were during the VR CPR simulation. These factors interlink all four theories as an individual learner's experiences can greatly influence how they perform within a simulation. Modality varies, but a statement from various participants suggested that if a modality had realism or fidelity that engaged them, they felt a sense of realism similar to clinical setting situations.

Learning was a benefit of the VR CPR simulation, allowing participants to gain knowledge on the processes of CPR. The theoretical models provided concepts affecting learning in simulated experiences. Cognitive engagement, learning experience, and learning outcomes were part of all of the theories, and participants in this study responded with statements suggesting the VR CPR simulation experience was a higher level of learning. This experience allowed them to test their skills in an environment they had not used before. Each participant adapted to the environment to perform CPR adequately and improve their efforts from the first to the second attempt.

Collaborative interactions were part of Dalgarno and Lee's (2010) and Dunnington's (2015) models. The literature has shown VR-Sim experiences can be beneficial for interdisciplinary collaborative simulations. With the VR CPR simulation, collaboration somewhat occurred when a participant interacted with the virtual nurse in the scenario. The nurse in the VR CPR simulation assisted the participant with obtaining an AED, providing ventilations,

and instructions to aid in performing CPR. Although this interaction with the virtual nurse took place, participants also suggested more individuals are needed to provide realism to the environment similar to what would occur during CPR in the hospital/facility-based setting.

In using simulations, pedagogical constructs are essential in framing how a simulation will be used for student learning. All of the theories include pedagogical constructs, but these concepts were not relevant to participants during the study from a student nurse perspective. Pedagogical constructs would be important when faculty are considering ways to develop simulations for specific learning outcomes. Faculty considering research in simulation would focus on these pedagogical constructs to design a simulation to study a student nurse's perceptions of presence in future research.

The theoretical concepts of Choi et al. (2017), Dalgarno and Lee (2010), Dunnington (2015), and Jeffries (2021) were presented to see how participants' perceptions of presence informed the theoretical components of the study. Aspects of the model confirmed the themes and subthemes from the analysis of the research question one, and offered other insights and perceptions garnered during the study to address the conceptual model. At times parts of the theories seemed to both align and misalign with the same concept.

Summary

This chapter described the analytic results answering the researcher questions. Data management and analyses were reported. Complications, sample characteristics, and the process of theme development were presented. Braun and Clarke's (2006) procedures and Saldaña's (2016) first and second cycle coding methods guided the data analysis. In Vivo, process, and emotion coding were used for first cycle coding, then condensed for second cycle pattern coding.

Categorization allowed for groupings of codes for the creation of themes and illustrated with participants comments throughout the chapter.

For research question one, three themes and eight subthemes described the findings. The theme *What Brought Me In, What Brought Me Out* described how participants perceived being in or out of the VR-Sim experience through the subthemes *It Felt Real or It Felt Fake, You're There*, and *Suspension of Disbelief*. This theme and subthemes described moments where the accuracy (fidelity) of the experience engaged participants in ways they felt completely part of the simulation (immersion), but also moments where the realism was lacking. Participants sensed endocentric presence through feelings like urgency, while exocentric presence was shown when they adjusted their body to a real object. These sensations were being triggered all while participants focused their belief on the activity being realistic enough they wanted to perform and help save the simulated patient in the scenario.

The theme *Issues in Virtual Reality Simulation* referred to concerns over the haptics with the environment. The subthemes *Nothing to Ground, Balancing Hardware and Software*, and *Authentic Approaches to Simulated Learning* provided understanding for the difficulties inherent with the VR CPR simulation experience. Not having resistance to push on a manikin chest was common concern amongst participants, with no way to simulate that sensation in the real physical environment. All participants struggled with simultaneously working with the hand controllers and watching the activity in the VR CPR software to guide their actions. Most felt that the VR CPR simulation could be useful when coupled with other modalities to provide the needed tactile sensations for learning.

The final theme *Higher Level of Learning* related to how knowledge was gained from the VR CPR simulation. The subthemes *Performance Improvement* and *Influencing Background*

Factors provided context for how a learner desires to increase their knowledge based on how they perceive the experience. Participants competed against themselves and took the results of the experience as incentive to perform better. Prior experiences both helped and hindered how participants perceived the environment, with most finding it beneficial for learning.

For research question two, how extant simulation theories aligned with perceptions of participants was discussed. These theories provided a base framework for the study. Most concepts of the models coincided with participant perceptions of the environment.

CHAPTER FIVE

DISCUSSION

Simulation modalities have become commonplace over the past decade, but current changes in healthcare have suggested an expansion of simulation practice will be needed going forward. With the increasing number of student nurses, in more nursing programs, clinical sites have diminished prompting increases in simulation as a learning modality. The coronavirus pandemic disrupted clinical and didactic education significantly and revealed both strengths and weaknesses in simulation practice. Expanding simulation suggests a need to understand all potential modalities available for the education of student nurses. VR-Sim is a new modality that has had little use in nursing education. The ability of immersive VR-Sim to generate a sense of presence may be a key contribution this modality brings to nursing education. This qualitative description study explored the concept of presence in simulation, specifically, the simulation modality of VR-Sim. The first research question was: How do student nurses describe their sense of presence in a 3-D virtual reality simulation using a headset and haptic device? Exploring student perceptions can help educators understand how the VR-Sim modality worked and the potential of VR-Sim in nursing education. The second research question was: How do student nurses' perceptions about presence align with theoretical models of simulation and presence? The answer to this question was aimed to expand the theoretical understanding of presence by comparing my findings with extant theoretical models.

VR-Sim has not been widely used in nursing education. Until recently, research on the topic of VR-Sim in the nursing literature has also been limited. Analyzing student perception of the VR-Sim environment provided a better understanding of how students experience this

modality and future potential for VR simulation, resources, and designs. Additionally, theoretical models of simulation have multiple and divergent approaches to the value of presence.

In this chapter I will situate my findings within recent literature and discuss how the findings diverge and converge with that literature. Interesting and novel findings from this study are also described in the context of current literature. I also reflect on and relate my findings to the conceptual model created for this study. This chapter also discusses the rigor, trustworthiness, and limitations of the study. Implications for research are presented. Finally, my reflections of the research process and outcomes are shared.

Discussion of Findings

Because little is known about student nurse experiences of presence in simulation, this study was to our knowledge a first attempt to characterize the experience of presence in VR-Sim from a student nurse perspective. Additionally, little theoretical work has been empirically explored related to presence in simulation, therefore the model created from the literature and based on four prominent theoretical perspectives was novel and useful.

Research Question 1

The three themes and eight subthemes summarized the experience of presence among student nurses while working in the VR CPR simulation. Participants were recruited from two cohorts at a southeastern United States university with 448 eligible students available to participate. Themes and subthemes were developed as experiences showed consistencies between participants working in the VR CPR simulation.

Theme One: What Brought Me In, What Brought Me Out

The first theme is *What Brought Me In, What Brought Me Out* with three subthemes *It Felt Real or It Felt Fake*, *You're There*, and *Suspension of Disbelief*. This theme and subtheme

can be summed up by the phrase it felt real. The sense of *being there* is presence (Dunnington, 2015). The more present someone feels in a situation, the more they engage with it. The first subtheme *It Felt Real or It Felt Fake* focuses on how real the simulation is to the participant allowing them to feel part of it and thus respond the way a nurse might in that situation. Singleton et al. (2022) suggested engagement and immersion work synergistically to promote better learning outcomes. Some participants in this study described high levels of immersion, not only with the VR CPR simulation, but other simulation modalities. Participants felt they needed to “save this man’s life” indicated they were perceiving the virtual patient as real and they were engaged in the simulation. Others commented the scenario felt like a game. This shows participants at times were going in and out of the perception of realism during the VR CPR simulation scenario. It is unknown if lapses in immersion or engagement led to the decreases in presence.

When participants felt like *You’re There*, they were experiencing endocentric presence. Petukhov et al. (2020) reported a connection between purposeful activities and brain activity in virtual and physical environments. This brain activity was associated with psychophysiological parameters the researchers called neuropatterns that stimulated the brain when engaging in activities. For practical application of an activity, a perceived risk or need provided context for a realistic experience a participant worked through in a VR modality allowing them to feel present in that situation (Petukhov et al., 2020). When participants felt they were present in the VR CPR simulation, they perceived a risk or need associated with the experience. A need to save the patient and risk involved if the participants did not perform CPR adequately for a good performance and patient outcome. The participants’ actions had a risk or need involved making them engage with the experience. Petukhov et al. (2020) stated the realism of the VR experience

reproduced the same cognitive connections and motor functions present when engaged with the real activity. Therefore, the participants felt the VR CPR simulation experience was real enough to take the interaction seriously. This was particularly interesting when participants simultaneously acknowledged the patient was not real. The participants found purpose in the VR CPR simulation activities and wanted to perform at an optimum level. One participant thought of the VR CPR simulation experience as a game. They could save the patient, but the feel of the experience was like any other VR gaming software they had encountered.

Suspension of Disbelief is another important part of the conceptual framework for the study and presence. Emotional, psychological, conceptual, and physical realism encourages exploration of an experience (Dalgarno & Lee, 2010). One way to possibly increase suspension of disbelief in an individual working through a VR-Sim is to help them feel at ease in the environment (Singleton et al., 2022). As someone uses VR-Sim, they become at ease with that modality. At times it was difficult for participants to become at ease in the environment, particularly after seeing their performance evaluation on the first attempt and thus wanting to improve. Each participant handled that stress in their own way, but each worked towards a better outcome for the simulated patient in the VR CPR simulation experience.

Theme Two: Issues in VR Simulation

The second theme is *Issues in VR Simulation* with three subthemes *Nothing to Ground*, *Balancing Hardware and Software*, and *Authentic Approaches to Simulated Learning*. Issues in VR Simulation corresponds to any concerns brought up by participants, particularly with the haptics of the environment. All participants had concerns, and even reservations, about the feel of compressions while performing CPR in the VR CPR simulation. The feeling was different, awkward, hard to gauge, difficult to manage, or it felt off. Although all participants felt the

experience in the VR CPR simulation was quite real, the lack of tactile realism during compressions was a dominant distraction affecting their sense of *being there*. The participants were no longer focusing on being in the environment, but instead focused on the difficulties they were experiencing with the compressions.

Hite et al. (2022) suggested haptic feedback improves an individual's learning ability by offering real-time responsivity. Responsivity refers to touch feedback, or the sensation of feeling accurate chest compressions (Hite et al., 2022). My plan to provide haptic feedback using the half manikin torso was ineffective and problematic. The VR CPR simulation did not include haptics with a manikin connected to the software. Only visual feedback for compressions was available in the VR CPR simulation. A lack of resistance, the sensation of pressing on the chest, ribs breaking, and confirming correct hand placement made the experience less real. There was *Nothing to Ground* their hands. Real time responsivity was missing and future similar studies with the VR CPR simulation should explore alternatives to the half manikin. Perhaps a sim lab environment and practice improvements on the controllers would provide the haptic feedback Hite et al. recommends.

Balancing the software and hardware was another difficulty during the study, as participants had issues focusing on both the monitor tracking their rate and depth of compressions and performing the compressions simultaneously. Bracq et al. (2019) suggested similar concerns as participants reported difficulty understanding how the VR-Sim system worked. This difficulty maneuvering through the unfamiliar software and hardware was also shown by Tacgin (2020). Ismailoglu and Zaybak (2018) suggested more time is needed for preparation to use technology like VR-Sim. These studies were grounds for having two attempts in the VR CPR simulation experience. For the VR-Sim study here, time for preparation was the

reason for the walk-through attempt to allow participants to familiarize themselves with the VR CPR simulation technology first. This first attempt helped participants manage the second attempt more effectively. One attempt allowed participants to familiarize themselves with the software, while the other allowed them to explore being in the software. There was also a perceived learning benefit to the two attempts for the participants using the VR CPR simulation. Repetition is a key concept Singleton et al. (2022) pointed out as participants in that study completed the VR exercise three times, helping benefit the learners. Additionally, repetitions should be planned for replications of this study.

Rushton et al. (2020) used the Octave immersive VR system to allow participants to perform CPR on manikins in a digitized environment. The Octave VR system has similarities to the CAVE virtual reality interaction used by Yongliang et al. (2015). The Octave system provides VR through projections in a physical room space rather than a head-mounted display like the VR CPR simulation environment. Both types are immersive, but the physical body of the participant is present and visible in the environment, as well as other equipment like a manikin. This provides the participant with the suggested sense of feeling a body and having resistance many wanted, but without the fully 3-D immersive head-mounted display offered by the VR CPR simulation. These two types of VR-Sim show continuing development of this modality, and the need to offer haptic devices that provide the realistic hands-on sensations.

Theme Three: Higher Level of Learning

The third theme is *Higher Level of Learning* with subthemes *Performance Improvement* and *Influencing Background Factors*. A higher level of learning applies to the descriptions participants provided regarding learning outcomes, knowledge gains, and suggested educational pathways with virtual reality simulation. Individuals participating in the study offered

descriptions of what helped them understand processes with the VR CPR simulation throughout the experience. They even suggested ways to enhance or alter the VR CPR simulation experience to benefit future resources, studies, and participants.

The systematic review by Choi et al. (2022) suggested immersive VR-Sim, like the VR CPR simulation, is an effective tool for the education of student nurses because VR-Sim helps visualize, reinforce, and expose students to skills and patient care performances. The review showed VR-Sim improves cognitive and learning performance, and psychomotor skills (Choi et al. 2022). One of the included studies found a VR-Sim provided the opportunity to visualize a skill and reinforce technique (Ismailoglu & Zaybak, 2018). The VR-Sim used a headset and haptic devices with a 3-D visualization (Ismailoglu & Zaybak, 2018) much the same as the VR CPR simulation equipment used in this study. Satisfaction scores for the study suggested participants found the instructional method useful. Lee et al. (2020) found participants perceived benefits of their VR-Sim, one of which was seeing symptoms presented by the virtual patient they may not see in clinical. Participants using the VR CPR simulation suggested similar points having seen the patient go into distress and collapse, which they seldom see in clinical.

Knowledge gains result in confidence and *Performance Improvement*. Rushton et al. (2020) showed increased confidence in participants for using the VR-Sim software, despite initial anxiety. The study equated this anxiety to fearing the unknown, as anxiety increases when doing something new, like VR-Sim (Rushton et al., 2020). After using the Octave VR-Sim, the participants had more confidence than they did prior to using it. The VR CPR simulation did help participants feel more confident and their performance showed this from the first to the second attempt. All but one participant improved on the second attempt in the VR CPR simulation.

Influencing Background Factors, identified in the literature such as individual characteristics were not found in this study. Other studies concurred suggesting age, and prior computer experience, and demographics have little effect on learning in VR-Sim (Bracq et al., 2019; Singleton, et al., 2022; Smith et al., 2018). In this study, nearly all participants improved their performance, but no individual differences were found in my findings.

Research Question 2

The second research question was answered using perceptions from participants to explore how their experiences aligned with extant theoretical models. The 11 participants offered insights supporting the conceptual model for the study design with some perceptions misaligning minimally.

Conceptual Model

The conceptual model of the study showed alignment with perceptions from participants based on the concepts for how simulation, fidelity, and engagement work together to progress learners toward educational outcomes (Choi et al., 2017; Dalgarno & Lee, 2010; Dunnington, 2015; Jeffries, 2021). Participants felt the experience was real and would be a valued educational commodity. But, the primary focus of the study, presence, was missing from two of the theories. Two theories focused predominantly on design of simulations (Choi et al., 2017; Jeffries, 2021). The other two theories incorporated concepts from both design and presence (Dalgarno & Lee, 2010; Dunnington, 2015). However, the design concepts can assist with the perception of presence. The main concepts linking all four theories—fidelity and immersion.

For instance, a participant described the simulated patient as being real to them, suggesting they wanted to save the patient and get them back safely to their family. Later in the interview, the same participant admitted they knew the whole experience was not real. This

indicated suspension of disbelief shifted back and forth and produced some of the responses seen in Dunnington's (2015) theory regarding endocentric and exocentric presence. Most participants felt completely immersed in the VR CPR simulation, but then something would bring them back out, such as quietness, cords, or movements. This shifting back and forth between endocentric and exocentric presence happens as a learner's attention shifts (Dunnington, 2015). Capturing that attention and holding it is the essential part of presence. What held participants attention in this study was the visual, interactive elements of the VR CPR simulation. The monitor maintaining statistics for compressions, or the patient becoming unresponsive and having to act were engaging and realistic to the participants. That's why some of the focus of the study seemed to shift from presence to realism and back again, because the realism shifted as well. Every time a participant encountered something that brought them out of the simulation, such as quietness, the realism was lacking. The effects of the VR CPR simulation having a quiet environment made the participant question the realism, and thus their presence shifted from endocentric to exocentric in those moments. Despite being fully immersed in the VR CPR simulation, the effects of shifting realism and presence still took place, suggesting the levels of immersion had little to no effect on the participant.

Immersion was high in this study using the VR CPR simulation (Kardong-Edgren et al., 2019b). Three of the five senses of the participants were being stimulated, except for smell and taste, but all five characteristics of immersion were being used with the VR CPR simulation. These characteristics contributed to the sense of presence making some participants feel as though they had entered another world. What also affected presence were individual factors: physical and psychological. Prior experience led at least one participant to view the VR CPR simulation as less than beneficial and more like a game. But, regardless of prior experience with

VR-Sim and learning needs, participants confidence improved (Singleton et al., 2022) as they perceived the VR CPR simulation as real, urgent, and intense. As participants gained knowledge on performing activities in the VR CPR simulation, they improved from one attempt to the next showing a beneficial learning need. Most also did not look at the experience as game-like, but instead suspended disbelief long enough to feel that the situation mattered and warranted their full attention. The multiple repetitions in VR-Sim were not included in the conceptual model and would be a beneficial addition to the framework in future iterations of this study.

One of the other factors not represented in the model was individual motivation. Although the participants all appeared motivated, there was also some uneasiness present initially as the study began inhibiting motivation. The VR CPR simulation was not as familiar to them. However, doing two attempts seemed to ease any anxieties or stress of the unfamiliar. Being at ease let participants perform in the simulation. This easiness allowed them to become relaxed and willing to immerse themselves into the VR CPR simulation (Singleton et al., 2022). Multiple participants suggested feeling relaxed, or lack of stress, while working in the environment aided their performance as they completed the scenarios. One participant did express how the relaxed feel took away from the experience, making it not seem as real to them. Although this participant was still motivated to work in the scenario, their posture, movements, and full effort appeared relaxed from an observation standpoint from start to finish. Motivation did not seem to be affected by becoming familiar with the VR CPR software and hardware. Familiarity may not have played a factor for this individual, as it did with other participants. It is worth noting that relaxation does not always equate familiarity for all individuals.

The conceptual model of this study worked well as most of the concepts within were represented in the VR-Sim experience for participants. Concepts such as presence, fidelity, and

immersion showed incongruency, but may have been affected by individual factors requiring further investigation. The motivations of participants were not a primary focus but should be looked at closely in subsequent iterations. Although immersion for the study was high, this did not stop participants from being brought in and out of the VR CPR simulation, warranting continued exploration of the phenomenon of presence and associated levels of immersion.

Trustworthiness and Rigor

Four techniques are used to aid trustworthiness in qualitative research: credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985). Credibility in this study was promoted by iterative questioning, peer debriefing, and reflective commentary. As participants were interviewed questions focused on the VR CPR simulation experience, their sense of presence, and comparing other simulated and clinical experiences to provide a baseline. Probing and following up on concepts discussed in the interviews stimulated detailed descriptions of the environment (Shenton, 2004). All of the transcripts generated were then reviewed by the dissertation committee, as we worked together to a consensus agreement of how effective the questions were during the interview, what codes had emerged, and that research bias was minimized as much as possible (Shenton, 2004). For example, I adjusted my interview technique after feedback on the initial two participants to reduce bias and promote a natural response from later participants. Following peer debriefing, I also used journaling for reflection and to collect my thoughts on the interviews while sifting through the transcripts to determine what was said by each participant and provide the most accurate representation of their interactions in the VR CPR simulation experience. Triangulation occurred as I went through individual characteristics, transcripts, reflective commentary, and journaling to fully understand each participant experience in the VR CPR simulation.

As I journaled, I ensured transferability of the study with rich contextual details of what I observed in relation to participant responses. I later discussed both the data in the transcripts and my observations with my committee to help with reduce research bias. This made the descriptions of the participants authentic, allowing me to have a rich descriptive understanding of the phenomenon. Future readers will determine the transferability of the findings to their studies, but it was my responsibility to provide the findings needed to allow those subsequent determinations (Krefting, 1991; Shenton, 2004). Reducing biases also promotes confirmability, which the findings were confirmed by reviewing repeatedly with my committee and addressing my own assumptions in the journaling and reflective commentary (Milne & Oberle, 2005). Finally, dependability was demonstrated with the frequent meetings with members of my committee, who supervised all aspects of the study being conducted (Krefting, 1991; Shenton, 2004). Through these discussions I remained consistent with the study design, attempting to adhere to the plan of action throughout the study implementation.

Limitations

Study limitations included a convenience sample, few affordable available options in VR-Sim software, and limited time, expertise, and resources. A convenience sample was used to recruit participants. Although purposeful sampling applies to inclusion criteria associated with junior to senior two status, available students lacked heterogeneity. Up to 75% of the cohorts at the University were female, making it difficult to recruit diverse genders. The sample of 11 participants while adequate in number based on prior literature, did not allow for proposed maximum variation (Toguri et al., 2020). It was not possible to achieve the desired variation in the sample population as originally planned. The largest population of students for the semester at the study site was Junior 2, making it harder to diversify based on level in the program.

Participant experience in VR-Sim was another limitation. The VR-Sim experience is relatively new to nursing, and there were limited VR experiences with the technology for students at the study site prior to this encounter. Most of the participants' prior experiences in VR were as a gaming software. Status in the program also limited experiences participants had in other simulations prior to using the VR CPR simulation. The Junior 1 level student did not have as much simulation experience as Junior 2 through Senior 2, making their responses during the interview limited.

Another potential limitation arose from the VR CPR software and hardware, as the only scenarios available are resuscitation measures. To fully integrate a learning environment like VR-Sim into the nursing curriculum, the software needs various types of scenarios ranging from basic skills to complex situations. For the purposes of this study, the VR CPR simulation was a way to see how students engage in the learning environment, with a haptic interaction allowing for a sense of being within the setting. The haptics of the VR CPR simulation were mentioned many times related to compressions by all participants. Trying to develop a way to provide a physical sensation to the compressions, with resistance like that felt on a real patient or manikin, would be the next step in developing the VR CPR simulation. Some of the suggestions offered by the participants, such as the glove, may be available on other platforms or already under development.

Available time and resources to conduct the study was a limitation. In this study, resources were limited to what the researcher used for a virtual reality experience based on the funding. Ideally, a VR-Sim developed de novo representing familiar clinical environments with realistic haptic compressions technology, would have been the best way to explore presence. Developing a VR-Sim experience from scratch would have taken considerable programming

expertise, time, and money. Potential VR-Sim platforms created by vendors are unavailable at the institution where the study was conducted. This study used software and equipment that students can access at minimal cost and at any time. In the VR CPR simulation, the environment in the digital virtual world where student nurses have had minimal experiences, was distinctly separate from their familiar physical world and was appropriate for an exploratory, descriptive study.

Space for the study was also limited as a resource. Although it would have been ideal to conduct the study in the simulation lab, or even a larger classroom, these areas were not available consistently during the timeframe of the study. An IT office suite allowed for adequate space to conduct the study, but in a smaller area. This required the researcher to watch the participants closely to promote safety in the environment while performing in the VR CPR simulation. Resources like a stretcher were not available for use, and the half manikin torso did not facilitate the needs of the study as originally planned.

The final limitation concerned data saturation. Although the data was approaching saturation, it was never shown conclusively to be achieved. Some factors corresponding to this regarded my own expertise in the research process and learning as I worked through the study. Additionally, no other recruitment emails or messages were distributed after the scheduled participants had all been interviewed. The timeframe of the semester factored into this limitation. A scheduled break and the busy end of the semester for students began competing for time availability. A participant that had been interested prior to the break no longer was afterward. I also had time constraints on the availability of the space for conducting the study, as the IT office studio could not be used indefinitely. Despite any of these limitations, the study progressed to

conclusion providing novel understanding of how presence is perceived in a VR-Sim environment.

Implications for Research

Although VR-Sim has not been used much in nursing education, it is used frequently in other disciplines. Due to the lack empirical research related to presence within simulation, additional research on the phenomenon of presence is needed. The study showed that VR-Sim can be useful in the education of student nurses, and what issues might arise. From these issues, future directions can be deduced for changes advancing VR-Sim to facilitate learning. Investigations into neuropatterns suggested by Petukhov et al. (2020) is a potential research direction to better understand what makes an individual feel more present.

Understanding presence would be an essential component not only of VR-Sim, but any learning experience implemented in a curriculum. Presence could be investigated in the classroom, clinical, skills lab, or simulation. Understanding what motivates a student to engage with simulated experiences and the impact it has on presence would be beneficial for future research. Prior experiences and emotions affect motivation and thus impact a sense of presence in simulation (Dunnington, 2015). Participants suggested VR-Sim is a necessary commodity for educating student nurses moving forward. A comparative study between VR-Sim and HF-HPS focusing on presence would be beneficial to determine if any greater sense of presence, especially endocentric presence, occurs between two modalities. Multiple participants suggested combining VR-Sim with other modalities could be the ideal situation. Hybrid simulation has been a longstanding element in nursing simulation for decades where multiple modalities have been combined to facilitate learning skills or clinical reasoning. For example, when a Standardized Patient encounter requires an intravenous insertion, a manikin arm prop is

put in place to allow a student to practice the skill. Some participants felt the hybrid strategy at times brought them out of other simulation scenarios in prior experiences due to the lack of realism. Studies combining VR-Sim with another modality are needed to determine if the hybrid strategy generates not only a better learning experience, but great presence. The other modality would have to be integrated to work with the VR-Sim and allow for the hands-on capability that limited the VR CPR simulation in this study.

The promise of VR-Sim suggests a low-cost, low-resource, self-directed addendum to currently simulation practice. Researching how learning outcomes are impacted by both VR-Sim and presence is essential. Studies on the connection between presence, fidelity, and immersion need to be conducted to determine if all three concepts complement one another, or if little effect occurs from one or all. The shifting between endocentric and exocentric presence that occurred at times during this study was consistent with the theory regarding presence, but investigating what factors promote greater presence and what can promote greater fidelity are needed. A quantifiable relationship needs to be shown to better understand the experiences suggested from this study. Expanding of this study into a mixed-methods design would also be a beneficial research initiative, as parts of this study could have been quantified using the MEC-SPQ questionnaire.

Implications for Education and Technology Development

Many of the participants felt the VR CPR simulation offered an incentive to perform with the results screen at the end of the experience. The evaluation of the participants' performance was a motivator to help them improve, and generated focus on the scenario unfolding. This focus provided a sense of presence in the VR-Sim, because each participant wanted to do better the second time. Providing further development of evaluation methods in VR-Sim would be another

direction to pursue. Providing instant feedback like the rate and depth display that keep a participant engaged may contribute to greater presence and would be another potential feature for simulations.

Standardized definitions of what constitutes virtual learning environments are needed and have been proposed by Carey & Rossler among others but are not currently used accurately in the literature. Distinguishing between virtual simulation and virtual reality simulation is essential to help simulationists understand the differences between the modalities so a clear understanding of modalities and their potential can be studied. Multiple studies were shown to incorporate various virtual modalities under singular terms, such as virtual simulation. This term does not encompass all of the possibilities present in virtual learning platforms available. A conceptual definition is needed to distinguish each modality and classify them under a singular term more representative of virtual learning platforms. To go along with a conceptual definition, more work into learning outcomes associated with presence various modalities of simulation is needed. This study only touched on learning aspects, but the feedback methods of the VR CPR simulation were beneficial to participants and could help develop other simulation modalities providing a basis for the integration of lesser used strategies such as VR-Sim.

Determining where best to put VR-Sim in the curriculum was not the purpose of this study but understanding what takes place in the experience to determine if the modality can be used was the focus. Part of what took place in these experiences was exploring presence. All participants felt present in the environment, as if they were in a real hospital, allowing the actual physical environment to fade from recognition. One participant suggested providing different levels of VR-Sim education. Having varied levels would provide younger student nurses, such as freshman, inexperienced in simulation a chance to practice in a simple VR-Sim scenario. Starting

a freshman with a simple assessment skill, VR-Sim would allow them to not only practice that skill but develop a sense of presence working in the scenario as if they are in an actual hospital. Later, an ACLS scenario in VR-Sim could assist a senior student nurse to refine their sense of presence and how that impacts team approaches to caring and treating patients in critical situations.

Much of the research to date on VR-Sim involves collaborative experiences, and those should continue particularly with regard to interdisciplinary simulations. Enhancing VR-Sim with an interdisciplinary Advanced Cardiac Life Support (ACLS) algorithm, involving multiple individuals, both virtual and real, may enhance realism. Enhanced realism, or fidelity, has been shown to promote a sense of presence. The participants felt adding other people to the VR CPR simulation experience, virtual or real, would have made the scenario feel like an actual hospital.

Technology developments need to focus on improving haptics in VR-Sim to allow greater ease of interaction in the environment. The hand controllers were problematic throughout the VR CPR simulation, but this is the current state in which VR resides. Hand controllers are evolving each year and are adapting to mimic reality more than prior devices. Development of a glove controller would be ideal and require collaboration with computer science engineers to create a device capable of producing the effect participants request. A better hand interface, like the glove controller, could enhance the realism to a point a learner may perceive being in the environment more than the current design of the VR CPR simulation, as the learner could place their hands on a real object to administer compressions on in the real physical environment while doing the same action in the software.

Fidelity is another part to VR-Sim that helps participants feel not only part of the scenario, but that it is real to them. Singleton et al. (2022) had the VR-Sim modeled after a local

hospital ward. The visuals of the VR CPR simulation reminded participants of the hospitals in the area adding to the realism and their sense of presence. However, the environment was not a match for the local hospitals. Having a VR-Sim experience with a hospital room designed from the local hospitals for the University may enhance the sense of presence in the VR-Sim with a more authentic look to the environment.

Another concern with fidelity involved quietness in the VR CPR simulation. The VR CPR simulation currently was designed to allow for practice with minimal interruptions. The quietness of the environment brought some participants out of the simulation, suggesting a lack of realism comparable to a real hospital setting. Comparing the distinct sounds exhibited between a hospital setting and a VR-Sim could be a follow-up to understanding how sounds affect the sense of presence in that situation.

Researcher Reflections

I was very pleased with how this study progressed and concluded. Having the opportunity to share a newer technological educational strategy with students fulfills many of the goals I have had for my professional career both as a nurse and in nursing education. The students participating in the study were genuinely curious and interested in understanding how the VR-Sim modality worked and how presence corresponded to the experience. I am greatly appreciative of their efforts working through this study. I'm looking forward to taking their perceptions and expanding on this information with future research to develop VR-Sim and the understanding the phenomenon of presence in various simulation modalities.

The first time I had the opportunity as a nurse to work with technological advancements, I knew I had found my niche. Whether I was learning to document in a new Electronic Health Record (EHR) or learning to do compressions myself in the same VR-Sim I used for the study, I

have never grown tired of trying something new that helps myself and others learn. I knew teaching my first informatics class at the hospital that my calling was to become an educator, and when I had my first opportunity as an educator the position was a Simulation Coordinator at a local university. At that time, working with HF-HPS was new, as was the coordinator position I was in, helping me feel as though I was on the leading edge of what nursing education had to offer. Leading edge, from a technology standpoint, means having the most advanced part or position in that area (Cambridge University Press, 2022). Any time I have had the opportunity to try new technology, I wanted to be on the leading edge. I feel that is where I am with my career now as both an educator and a nurse. I have the opportunity to add knowledge about presence, applicable to all simulation modalities, helping others understand this phenomenon and how it can develop the modality of VR-Sim in future research. Small steps are needed, but the journey has only just begun.

Conclusions

The purpose of this study was to explore student nurse perceptions of presence in a virtual learning environment. A qualitative description study was conducted answering the first research question: How do student nurses describe their sense of presence in a 3-D virtual reality simulation using a headset and haptic device? From the data, three themes and nine subthemes emerged. The themes were *What Brought Me In*, *What Brought Me Out*, *Issues in VR Simulation*, and *Higher Level of Learning*. The themes and subthemes captured the perceptions of student nurses working through a VR-Sim software known as VR CPR for the purposes of understanding how it felt to be in that environment and what learning outcomes might be achieved through this experience. The second research question was: How do student nurses' perceptions about presence align with theoretical models of simulation and presence? The conceptual model

constructed for the study was supported by the perceptions from participants, with some misalignment regarding individual factors from psychological effects related to motivation and prior experiences.

This chapter discussed the findings from Chapter Four comparing findings from other studies, understanding the trustworthiness of the data collected, the rigor used to conduct the study, and any limitations there within. Research implications were provided. A final reflection from the researcher allowed for an understanding of the processes involved in developing and performing the study.

Some of the most interesting findings revealed that student nurses do feel the sense of presence being in a VR-Sim environment, as the interaction with the simulated world made them feel part of the experience. From an educational standpoint, the VR-Sim experience has potential to become an enriching teaching and learning strategy for student nurses. These findings work within the conceptual framework composed for the study, as fidelity, immersion, and engagement were factors in helping student nurses become part of the experience. But, some concerns did arise with how the haptics of the VR CPR simulation functioned, leading many participants to suggest other ways VR-Sim could be enhanced to provide the best experience possible for educating student nurses. Those suggestions will help build a new nursing educational paradigm, investigating both VR-Sim and presence in the years to come for preparing student nurses for the clinical practice setting.

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APPENDICES

APPENDIX A
INFORMED CONSENT

Nursing Student Perceptions of Presence in a Virtual Learning Environment: A Qualitative Description Study

Informed Consent

You are being asked to participate in a research study. Before you give your consent to volunteer, it is important that you read the following information and ask as many questions as necessary to be sure you understand what you will be asked to do.

Investigators

Jason Thrift, MS, RN Mercer University PhD Student, Georgia Baptist College of Nursing
3001 Mercer University Drive, Atlanta, GA 30341, jasont@clemson.edu or
Jason.R.Thrift@live.mercer.edu 864-940-8536

Lanell Bellury, PhD, RN, AOCNS, OCN Professor Mercer University Georgia Baptist College of
Nursing
3001 Mercer University Drive, Atlanta, GA 30341, bellury_lm@mercerc.edu 678-547-6772

Purpose of the Research

This research study is designed to explore student nurse perceptions of presence during simulation, specifically virtual reality simulation (VR-Sim).

The data from this research will be used to understand the phenomenon of presence in relation to nursing simulation and VR-Sim.

While VR-Sim programs have been developed in other fields, like the education of pilots and surgeons, there is limited research related to the use of VR-Sim in the education of student nurses. Some research has found that student learning is enhanced when simulation seems real to students and when students perceive being present during the simulation. Exploring presence in the VR-Sim environment may help us understand the role of presence in nursing education and the potential use of VR-Sim in nursing education. I am interested in finding ways to improve nursing education using technology, and this study may provide evidence for acceptable technology applications and use in nursing education.

Procedures

If you volunteer to participate in this study, you will schedule an appointment at the college, complete required forms, be oriented to the VR-Sim equipment (head mounted display and hand held controllers) and the CPR program, complete the short VR-Sim for CPR simulation twice, and be interviewed after the VR-Sim.

Your participation will take approximately 2 hours

Potential Risks or Discomforts

Some individuals report dizziness or motion sickness, also known as cybersickness, while using immersive virtual reality equipment. Should you encounter any cybersickness during the study, you will be able to withdraw immediately, and the researcher will guide you to a place to sit or lie down. There are also minor safety risks of tripping on cords or bumping into equipment while using the head mounted

display as you will be minimally aware of the real environment. Safety precautions, including a clutter-free open space ensuring cables and other devices are out of your path, will be taken. Additionally, I will be in close proximity and carefully monitoring safety throughout the simulation.

Potential Benefits of the Research

You may gain some insight and skill related to CPR through participation in this study. Your participation will also help develop better understanding of presence for the emerging field of virtual reality simulation in nursing.

Confidentiality and Data Storage

You will be given a participant identification number to maintain confidentiality of your data. Your name and corresponding identification number will be stored separately from the data in a secure electronic file.

All documents will first be completed on an iPad and saved to Box, which is a secure cloud storage online platform, password protected by the researcher. From Box, all files will be downloaded to the researcher's password protected laptop, and then deleted from Box. You will not be required to login to any applications. Only the researcher and the researcher's dissertation committee will have access to the documents on the laptop.

Interviews will be conducted using Zoom® to record and transcribe the interviews. All Zoom® recordings will be password protected and saved to the cloud for video processing and transcription creation through the University's Zoom® database. Upon completion of video processing, I will store the videos and transcripts on the password-protected laptop deleting all files from the cloud database to ensure continued confidentiality for a minimum of three years. Identifiable data will be destroyed three years after completion of this study.

The deidentified information collected during the study could be used for future research studies or shared with other investigators for future research studies without additional informed consent from you or a legally authorized representative. Only de-identified data will be published or used for future studies.

Participation and Withdrawal

Your participation in this research study is voluntary. You may refuse to participate in the study at any time. To withdraw from the study please contact Jason Thrift via email at jasont@clemson.edu or Jason.R.Thrift@live.mercer.edu, or via mobile device number 864-940-8536.

Questions about the Research

If you have any questions about the research, please speak with Jason Thrift via email at jasont@clemson.edu or Jason.R.Thrift@live.mercer.edu, or via mobile device number 864-940-8536.

In Case of Injury

It is unlikely that participation in this project will result in harm to subjects. If an injury to a subject does occur, they may be seen at a local or regional medical facility, such as Prisma Health in Greenville, SC adjacent to the facility where the research is being conducted. All expenses associated with care will be the responsibility of you and your insurance.

Incentives to Participate

You will be given a \$15 gift card after completing the study.

Audio or Video Taping

All interviews during the study will be video and/or audio recorded. You have the right to waive video recording, but audio recording is necessary for data analysis. If you do not want to be audio recorded, you can decide to not participate in the study. By signing this consent, you agree to audio and video recording. If you decline video recording, please initial here:

Reasons for Exclusion from this Study

Individuals under the age of 18, and who do not maintain an enrolled status at the university of junior to senior level in the nursing program, will be excluded from the study.

This project has been reviewed and approved by Mercer University’s IRB. If you believe there is any infringement upon your rights as a research subject, you may contact the IRB Chair, at (478) 301-4101.

You have been given the opportunity to ask questions and these have been answered to your satisfaction. Your signature below indicates your voluntary agreement to participate in this research study.

Research Participant Name (Print)

Name of Person Obtaining Consent (Print)

Research Participant Signature

Person Obtaining Consent Signature

Date

Date

APPENDIX B
INDIVIDUAL CHARACTERISTICS FORM

Individual Characteristics Form

Instructions to participant: Please complete each item on this form. All information will remain confidential and used only for the purposes of this study.

1. What is your date of birth?

2. Identify your gender.
Female____ Male____ Non Binary____ Prefer not to answer____
3. With which racial group do you identify? (Select one or more)
American Indian or Alaska Native____ Asian____ Black or African American____
Native Hawaiian or Other Pacific Islander____ White____
4. What is your ethnicity?
Hispanic or Latino____ Not Hispanic or Latino____
5. Have you ever used any of the following devices? (Select one or more)
Gaming consoles (Atari®/Nintendo®/Playstation®/Xbox®)____ Games with headsets or
head mounted displays____ Games with haptic devices (hand
controllers/mouses/motion capture)____ Laptop games____ Mobile App Games____
6. Do you classify yourself as any of the following?
Core Gamer____ Casual Gamer ____ Non-Gamer____
7. Have you ever experienced motion sickness, or do you experience dizziness easily?
Yes___ No ___

APPENDIX C
INTERVIEW GUIDE

Interview Guide

Participant Identification Number _____

Debriefing Questions

1. Tell how you felt about this experience as you worked through it just now.
2. What was it like to use this technology?
3. Was there anything stressful during this experience?

Now I'm going to have you go through the experience again. This time, I would like for you to focus on being in the environment and working through the resuscitation measures from start to finish for 2 cycles of CPR. Once you complete this, we'll conduct an interview of the experience and how you perceived being in this environment for the resuscitation of the patient.

Interview Questions

1. Grand tour question #1 "What was it like working through the VR CPR resuscitation scenario just now?"
2. Grand tour question #2 "You've used various forms of simulation, like High-Fidelity Human Patient Simulation, virtual simulation, and VR-Sim. What was your experience like being in those environments."
3. "What was it like working with the haptic devices as you resuscitated the patient?"
Probe: "What, if anything, captured your attention?"
4. "How much did you feel like you were actually there in that environment or part of it?"

Probe: "At what point did that happen for you?" "What did it feel like?"
5. "How real did the VR-Sim experience feel to you?"
Probe: "Did anything in the VR-Sim feel more real to you than other things? Explain.."
6. "Did you feel any unexpected sensations while in the VR environment? Would you describe what they were like?"

Probe: "Another participant described feeling dizzy at some point during the VR-Sim. Did anything like that happen to you?"

Probe: "Did anything distract you in the environment? Describe what happened."

Closing question: "Is there anything else you'd like to add that might help me better understand how you experienced this as a learning simulation?"

APPENDIX D
SCREENING TOOL FOR RECRUITMENT PHONE CALL

Screening tool for Recruitment Phone Call

Participant Identification Number _____

Thank you for calling about the study, and I hope you'll be able to participate. I need to check your eligibility for participating in the study. If you will please tell me your name so I can record that for my records.

And if you will provide me with the best contact information for you, should any questions or other information be needed.

Email: _____ Phone: _____

What program tract are you currently enrolled?

Traditional Baccalaureate Program Accelerated Traditional Baccalaureate Program

What is your current status in the program?

Junior 1 Junior 2 Senior 1 Senior 2

When did you complete CPR training?

Have you completed the nursing computer course that introduces you to virtual reality?

Yes ___ No ___

APPENDIX E
RECEIPT FOR RESEARCH STUDENT PARTICIPATION PAYMENT

Receipt for Research Study Participation Payment

The following invoice outlines payment to the subject voluntarily participating in the research study: *Nursing Student Perceptions of Presence in a Virtual Learning Environment: A Qualitative Description Study*.

Payment for participation in the study \$15.00

Total \$15.00

Participant acknowledgement of payment received

On _____ I received payment for participating in the study above.

Signed: _____

Witnessed: _____

APPENDIX F

EMAIL TO POTENTIAL PARTICIPANTS FOR THE STUDY

Dear students,

You are invited to participate in a study led by Jason Thrift, an Instructor in the School of Nursing and College of Behavior, Social and Health Sciences at Clemson University and PhD student in the Georgia Baptist College of Nursing at Mercer University. I am interested in your perceptions of being present in a virtual learning environment. The findings of this study will help improve nursing education.

Your participation is completely voluntary and will have no effect on your nursing courses. You will be able to use a fully immersive virtual reality simulation (VR-Sim), with head mounted display and wireless controllers in a virtual setting. In the simulation you will get to perform lifesaving measures on an unresponsive virtual simulated patient using Cardiopulmonary Resuscitation (CPR). After the simulations, you will be interviewed so I can learn about your experience with the VR-Sim. The study should last no more than two hours.

To be eligible for the study, you must be enrolled in the traditional baccalaureate (BST) or accelerated traditional baccalaureate (BSA) nursing program with a junior 1 to senior 2 standing and have completed CPR training.

The study will be conducted in the Clemson University Nursing building in Greenville, SC. If you would like to know more about this study, please contact **Jason Thrift at 864-940-8536** for more information.

Every participant will receive a \$15 Visa gift card.

If you: 1) have prior experience with motion sickness during virtual reality exposure or 2) are extremely susceptible to motion sickness (e.g. car, boat, air), please consider not participating in this study.

Thank you very much for your time and interest. If you have any questions, please do not hesitate to contact me by the phone number listed above or via email at jason@clermson.edu.

Sincerely,

Jason R. Thrift, MS, RN
PhD student at Mercer University
Instructor at the Clemson University School of Nursing

APPENDIX G

FLYER FOR INFORMATION TO PARTICIPANTS

ATTENTION NURSING STUDENTS!

**You are invited to participate in a study about
Nursing Student Perceptions of Presence in a Virtual
Learning Environment**

If you are a Junior 1-Senior 2, enrolled in BST or BSA, and have had CPR training

Please consider this opportunity!

This study will only take 2 hours and you will:

- **Get to try a 3-D Virtual Reality CPR Simulation**
- **Be interviewed to contribute your experiences of the sim**
 - **Be part of a study to improve nursing education**
 - **Be given a \$15 gift card after completing the study.**

Your participation is completely voluntary and your data will be kept confidential.

**If you are interested in participating, please contact
Jason Thrift at 864-940-8536 or via email at jasont@clemsont.edu.**

**Jason R. Thrift, MS, RN
PhD Student and Principal Investigator**

APPENDIX H
EQUIPMENT FOR VIRTUAL LEARNING STUDY

Equipment for Virtual Learning Study

This study will use the Alienware® 17 R4 Gaming Laptop from Dell® (Back Market, 2022), equipped with Windows® 10 Home Edition. The laptop uses an Intel Core® i7-8750H CPU @ 2.20 GHz and a 64-bit operating system (Back Market, 2022). The specifications of this laptop allow for smooth and efficient use of any compatible Virtual Reality (VR) software available, with greater portability than a desktop personal computer. The laptop comes with one HDMI port, two USB 2.0 ports, power cord and is set up to run VR software immediately. The HTC Vive® Pre Head Mounted Display (HMD) will provide the VR experience with complete immersion into the environment (Road to VR, 2016). The HMD has full tracking and earphone speakers resting outside the user's ears to apply it to their head. The HTC Vive® has a dual AMOLED® 3.6" diagonal screen, allowing a 110-degree view in one direction, but it rotates 360 degrees when the user moves (eBay, n.d.). The HMD is complete with SteamVR Tracking, G-sensor, gyroscope, and proximity capability. The HMD connects to the Alienware® 17 laptop via a tether cable, HDMI, USB 2.0, and power connections. Bluetooth capability allows the two hand controllers and base stations to connect to the laptop and HMD (eBay, n.d.). The base stations create the room environment after the researcher programs in the needed proximity features before use.

Alienware® 17 R4 Gaming Laptop https://www.backmarket.com/tested-and-certified-used-dell-alienware-m17-173-core-i7-8750h-22ghz-ssd-512gb-ram-16gb-qwerty/93123.html?shopping=gmc&gclid=CjwKCAjwIaVBhBkEiwAsr7-c719g5sEGdb15wqV2sNFGiGm7x-p9Co8tIQYwcjrQHVZwwhr8-YZIBoCjIUQAvD_BwE

HTC Vive Pre

https://www.ebay.com/itm/234580279447?_trkparms=amclsrc%3DITM%26aid%3D1110006%26algo%3DHOMESPLICE.SIM%26ao%3D1%26asc%3D239178%26meid%3D00b93fee27c46779ad20f4e5cd23556%26pid%3D101195%26rk%3D3%26rkt%3D12%26sd%3D284810658901%26itm%3D234580279447%26pmt%3D1%26noa%3D0%26pg%3D2047675%26algv%3DSimplAMLv9PairwiseWebMskuAspectsV202110NoVariantSeedWithRevOpt90NoRelevance%26

brand%3DHTC&_trksid=p2047675.c101195.m1851&amdata=cksum%3A23458027944700b93f
eee27c46779ad20f4e5cd23556%7Cenc%3AAQAHAABMFVvFeUTQhL4KP79koL%252B4
Ydgokeb2CQrAyC%252BOWbdpQetV2qAC7C3Vu0XLY04JD2173LYnMyfSHCKvxS7d%252
F15SZlydoOOGTzprPO8qZrjfCQtI0gA2no6R7ieR119DJKT51GOJyf8Cs1I1oMlvcQxHJAu69tff
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8btom8IfH7AJziwdVOr5aDDBFDw0Ruy%252BFAd4upjxE58TCX%252BAi9MJZFOx1U11V
9ZwQxnuBm2nBOaW2sD5pQI%253D%7Campid%3APLX_CLK%7Cclp%3A2047675

APPENDIX I
THEME DEVELOPMENT GUIDE

Theme Development Guide

First Cycle Coding-Preliminary Codes (Taking parts of transcripts verbatim)

Transcript response from participant:

I thought, having the other nurse there helps. If you look at me in the video you can see when she starts doing the Ambu-bag, I looked up at her because she was so high up. But **whenever it was her turn I would look at her** to go or when she would say something I would look at her, and I think **that kind of brought me in** because it was something or someone who was interacting with me and the patient.

From the response I separated parts by lines:

P001 Line 233 having the other nurse there helps (Effect of VR-Sim-added to the sense of realism)

P001 Line 235 whenever it was her turn I would look at her (Engagement-with simulated nurse)

P001 Line 236 that kind of brought me in (It Felt Real-engaging with a virtual nurse made the interaction more real to them and they wanted to continue to engage in the VR-Sim as if it was real)

Labels provided me with organization of the responses to determine how the perceptions informed their sense of presence while working in the VR

The participant's sense of presence perceived the interaction as real, moving and adjusting to the environment as they would in real life.

In Vivo code: that kind of brought me in because it was something or someone who was interacting with me and the patient.

Emotion code: other nurse helps

Process code: look at her

Second Cycle Coding-looking for patterns

I took the preliminary codes and began coding for chunks of data

This entire transcript response above was coded as **What brought me in or out of VR-Sim**

I then put all the codes for this participant together with the codes from the remaining 10 to begin categorization of the codes.

What brought you in or out of the VR-Sim

Throughout the experience, participants stated moments where the VR CPR software and/or hardware did something that led them to either believe the interaction to be more real or less real as they perceived it.

What brought me in or out of the VR-Sim became a major category, and had other codes connected that were clustered under this category in the list below:

- Concerns over glitching in software
- Visual stimulation added to realism
- Concerns over things in the real world
- Things that grabbed my attention; Audio and Visual Stimulation
- Visual and Audio Stimulation grabbing your attention
- Headset adjustment issue
- Concerns over physical objects outside VR-Sim
- Feeling Part of the Scenario
- Treating the computer not the patient

The pattern that emerged for this category led to the creation of a primary theme

What Brought me in, What Brought me out

All participants had described experiences in the VR CPR simulation that either brought them into the scenario or took them out, based on individual occurrences within the VR-Sim.

From here the clustered codes took specific phrases and responses that informed the theme and created the sub-themes that followed:

Fidelity, engagement, immersion – Later this became *It Felt Real or It Felt Fake*
“You’re there”
Suspension of disbelief

These sub-themes all described how the participants felt they were in the VR-Sim, as if it were real, what pieces felt real to them more so than others, and also how their cognitive processes like motivation, emotions, and prior experiences helped them to stay focused or even lose focus as times while working through the scenario.

APPENDIX J
IRB APPROVAL LETTER MERCER



*Institutional Review Board
For Research Involving Human Subjects*

Sunday, December 5, 2021

Jason Thrift
3001 Mercer University Drive, Suite 214
Georgia Baptist College of Nursing
Atlanta, GA 30341

RE: Nursing Student Perceptions of Presence in a Virtual Learning Environment: A Qualitative Description Study [H2112275]

Dear Thrift:

On behalf of Mercer University's Institutional Review Board for Human Subjects Research, your application submitted on 30-Nov-2021 for the above referenced protocol was reviewed in accordance with the 2018 Federal Regulations [21 CFR 56.110\(h\)](#) and [45 CFR 46.110\(h\)](#) (for expedited review) and was approved under category(ies) 5, 7 per 63 FR 60364.

Your application was approved for one year of study on 05-Dec-2021. The protocol expires on 04-Dec-2022. If the study continues beyond one year, it must be re-evaluated by the IRB Committee.

Item(s) Approved:

The purpose of this study is to explore nursing student perceptions of presence during virtual reality simulation.

NOTE: You **MUST** report to the committee when the protocol is initiated. Report to the Committee immediately any changes in the protocol or consent form and **ALL** accidents, injuries, and serious or unexpected adverse events that occur to your subjects as a result of this study.

We at the IRB and the Office of Research Compliance are dedicated to providing the best service to our research community. As one of our investigators, we value your feedback and ask that you please take a moment to complete our [Satisfaction Survey](#) and help us to improve the quality of our service.

It has been a pleasure working with you and we wish you much success with your project! If you need any further assistance, please feel free to contact our office.

Respectfully,

Ava Chambliss-Richardson, Ph.D., CIP, CIM.
Director of Research Compliance
Member
Institutional Review Board

Mercer University has adopted and agrees to conduct its clinical research studies in accordance with the International Conference on Harmonization's (ICH) Guidelines for Good Clinical Practice.

Mercer University IRB & Office of Research Compliance
Phone: 478-301-4101 | Email: ORC_Mercer@Mercer.edu | Fax: 478-301-2329
1501 Mercer University Drive, Macon, Georgia 31207-0001