EXPLORING UNDERGRADUATE NURSING STUDENTS' EXPERIENCES WITH INTERRUPTIONS: THE IMPACT OF COMPUTER-BASED SIMULATION ON THEIR KNOWLEDGE AND SATISFACTION

Lisa M. Otto, MSN, RN, CHSE, CNE

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APPROVED:

J. Michael Spector, Major Professor
Scott J. Warren, Committee Member
Cathleen A. Norris, Committee Member
Yunjo An, Chair of the Department of Learning Technologies
Kinshuk, Dean of the College of Information
Victor Prybutok, Dean of the Toulouse Graduate School

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The purpose of this study was to evaluate the impact of computer-based simulation on prelicensure senior second semester undergraduate baccalaureate nursing students' knowledge and satisfaction. The goal was to explore the current state of nursing education in relation to the nursing student's experience with interruptions and interruption management as interruptions and interruption management are an underexplored area of the nursing education experience, yet interruptions impact nursing performance and patient safety. Including effective interruption management in nursing education is the ultimate aim of this effort. The design of the study was a descriptive case study with mixed methods including quantitative and qualitative data collection and analysis. The quantitative analysis encompassed pretest and posttest drug calculation knowledge tests and a satisfaction survey. The qualitative portion of the study involved a focus group discussion relating to the nursing student's experience with interruptions and interruption management. The study results demonstrated that the participants were satisfied with the computer-based simulation. Furthermore, the results demonstrated that the professional nursing education of the study participants was devoid of interruption and interruption management education in the classroom, lab, and high-fidelity simulation. The themes that emerged from this study describe the current state of the second semester nursing student's experience with interruptions and interruption management and inform the need for interruption and interruption management education in professional nursing educational programs.

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CHAPTER 1

INTRODUCTION

1.1 Statement of the Problem

The purpose of this study was to evaluate the impact of computer-based simulation on prelicensure senior second semester undergraduate baccalaureate nursing students' knowledge and satisfaction. The goal was to explore the current state of nursing education in relation to the nursing student's experience with interruptions and interruption management as interruptions and interruption management are an underexplored area of the nursing education experience, yet interruptions impact nursing performance and patient safety. Including effective interruption management in nursing education is the ultimate aim of this effort.

The growing demand for nurses, the current nursing faculty shortage, and technological advances in education are driving forces for changes in nursing educational programs (Bureau of Labor Statistics (BLS), 2020). The BLS (2020) projects that the number of career registered nurse will grow 7% from 2019 to 2029, representing an increase in the workforce from 3 million to 3.3 million. The expected growth may worsen the nursing gap and put further pressure on nursing education (American Association of Colleges of Nursing (AACN), 2020). The BLS (2020) also predicts 194, 500 job openings for registered nurses each year between 2019 and 2029. The increase in registered nurse jobs is fueled in part by an increasing demand for health services in multiple care levels and settings, such as acute care, rehabilitation, outpatient, and home care (BLS, 2020). Zhang et al. (2018) predict that the national registered nurse shortage will continue to grow between 2015 and 2030 with varying effects on the different regions and states within the United States. Zhang et al. (2018) predict the shortage of registered nurses by 2030 to be 510,394 with the greatest registered nurse job shortages in the South and West at

248,964 and 241,434 respectively. Furthermore, Zhang et al. (2018) report that significant nursing shortages will occur by 2030 in 37 of the 50 states included in the study. Specifically, the greatest job shortages of registered nurses will be in California, Florida, and Texas at 141,348, 77,527, and 62,235 respectively (Zhang et al., 2018).

Major factors contributing to the growing nursing shortage involve nursing education, including limitations imposed on nursing school admissions by a shortage of nurse faculty, a reduced number of available clinical sites for training, limitations in classroom space, an insufficient number of clinical preceptors, and educational program budget constraints (AACN, 2020; Foronda & Bauman, 2014). In 2019 nursing schools, including undergraduate and graduate programs, report turning away 80,407 qualified applicants (AACN, 2020). Benner et al. (2009), based on the Carnegie National Nursing Educational Study, called for “radical changes in nursing education” (p. 8) relating to curriculum, pedagogy, and pathways to licensure. This effort focuses on the impact of using advanced technologies such as interactive simulations on the situation of growing demand for nurses and current limitations of nurse education programs.

The registered nurse shortage coupled with other nursing education issues, such as admission limitations of nursing programs, limited clinical site availability, and patient safety initiatives, propels nurse educators to develop and implement creative learning strategies to meet the workforce demands (Foronda & Bauman, 2014; Hayden et al., 2014; Simpson, 2002). Low-cost virtual reality technologies are the “next largest stepping stone in technological innovation” (Cipresso et al., 2018, p. 1) and may be a solution to these educational challenges (Simpson, 2002). The idea of virtual reality dates back to 1965 from a presentation by Ivan Sutherland at an International Federation for Information Processing (IFIP) conference (Grabowski & Jach, 2021; Mandal, 2013; Mazuryk & Gervautz, 1996) when he stated to “make that (virtual) world in the window look real, sound real, feel real, and respond realistically to the viewer's actions" (Sutherland, 1965). While virtual reality began in the computer graphics field (Cipresso et al., 2018), it is now used in training systems in many fields.

Since the introduction of virtual reality, a variety of virtual environments, computer-based simulations, and virtual simulations have been developed as pedagogical approaches in nursing programs. Some examples of nursing concepts taught with virtual simulation are disaster training (Farra et al., 2012), multipatient care (Josephsen & Butt, 2014), communication with the healthcare team (Foronda et al., 2014), assessment and management of a deteriorating patient (Liaw et al., 2014), emergency room triage (Weatherspoon & Wyatt, 2012), disaster triage (Foronda et al., 2016a), inclusivity awareness (Tiffany et al., 2016), maternal-newborn nursing (Cobbett & Snelgrove-Clarke, 2016), decontamination practices (Smith et al., 2016), fundamentals of nursing (Gu et al., 2017), medication administration (Dubovi et al., 2017), mental health care (Soccio, 2017), pharmacology (Hanson et al., 2019), and neonatal resuscitation (Williams et al., 2018). These are all complex demanding situations that are difficult or impossible to train without new technologies. The increasing use and development of virtual simulations demonstrates that nursing education embraces the relatively new educational technologies such as interactive simulations and virtual/augmented realities. The best practices and impacts of technology-enhanced nurse training continue to be explored and defined through research (Foronda et al., 2020). This effort is an attempt to contribute to this important and expanding field of nurse education. An underexplored area involves such training and education being implemented while educating nurses.

A major focus of nursing education and one of the primary responsibilities of the registered nurse is medication administration (Harris et al., 2014; Zahara-Such, 2013). According to Koehane et al. (2008), nurses spend 26.9% of their time completing medication activities and this places the nurse in a position to make medication administration errors that compromise patient safety. High numbers of medication errors (Institute of Medicine (IOM), 2000; Muroi et al., 2017) necessitate that nurse educators implement effective approaches to teach drug calculation and medication administration procedures (Donaldson, 2017; Harris et al., 2014).

The vast research relating to numbers of medication administration errors and the resulting impact on patient outcomes and financial cost examines interruptions as a primary cause (Bower et al., 2015; Hall et al., 2010; Hayes, et al., 2015,). However, little is known about how nurses learn about interruptions and interruption management. Colligan and Bass (2012) contend that "healthcare interruptions are here to stay" (p. 5) and highlight the need for education about interruptions and handling of interruptions by both the interruptees and the interrupters. The interruptees need training on management of interruptions, while the interrupters need training on timing of their interruptions (Colligan & Bass, 2012). The specific focus of this effort was on using the aforementioned advanced technologies to learn about and manage interruptions.

Hayes et al. (2015) recommend nurse educators teach interruption reduction, management, and prioritization techniques and contend this education is necessary to improve medication administration and patient safety. Hayes et al. (2015) call for nurse faculty to educate nurses about the connection between interruptions and risk of medication error and equip nurses to handle distraction and interruptions. Thomas et al. (2017) reiterate the need to educate undergraduate nursing students about interruption management and call for a radical change in how medication administration is taught in nursing programs, stating:

> The teaching of medication administration in prelicensure programs should be radically transformed to encompass an awareness of organizational systems as well as personal and professional responsibility. The long-held emphasis on medication knowledge

> competence for students and new graduates must widen to include interruption and distraction management skills. (p. 316)

The call for radical change and inclusion of interruption management skills as a part of teaching medication administration by Thomas et al. (2017) is consistent with the call by Hayes et al. (2015) for nurse faculty to prepare nurses to manage distractions and interruptions.

1.2 Purpose and Significance of the Study

The purpose of this study was to (a) explore the current state of nursing education in relation to the nursing student's experiences with interruptions and interruption management and (b) evaluate the impact of computer-based simulation on senior second semester undergraduate baccalaureate nursing students' knowledge and satisfaction. The study aims to provide information about the impact of computer-based simulation on student knowledge relating to drug calculation accuracy and satisfaction including debrief and reflection, clinical reasoning, and clinical learning. The knowledge and satisfaction data can help guide nurse educators in the use of computer-based simulation as an adjunct to or replacement for clinical hours. In addition, the study aims to provide information about nursing students' education and experience relating to interruptions and interruption management that will inform decisions about the need for interruption and interruption management education in undergraduate baccalaureate nursing programs. The data analysis will identify how and when nursing students learn about interruptions, as well as identify gaps in what is taught about interruptions and interruption management in undergraduate baccalaureate nursing programs.

1.3 Research Questions

This descriptive case study investigated through mixed methods the impact of computer-based simulation on senior second semester undergraduate baccalaureate nursing student's knowledge and satisfaction. Emphasis was placed on debrief and reflection skills, clinical reasoning, and clinical learning. The qualitative portion of the study examined the students' experience with interruptions. The following research questions were explored:

1. How do senior second semester undergraduate baccalaureate nursing students experience and manage interruptions?
2. What impact does computer-based simulation have on the senior second semester undergraduate baccalaureate nursing student's knowledge and satisfaction including debrief and reflection skills, clinical reasoning, and clinical learning?

1.4 Conceptual Framework

The conceptual framework for this study is experiential learning theory which postulates that "learning is the process whereby knowledge is created through the transformation of experience" (Kolb, 2015, p. 75). Experiential learning occurs in a cycle comprised of four stages with four adaptive learning modes: concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb, 2015). The four stages of the cycle are further organized into two dimensions that are dialectically opposed adaptive orientations including first concrete experience/abstract conceptualization, the processes of grasping experience, and second, active experimentation/reflective observation, the processes of transforming the experience (Kolb, 2015). According to Kolb (2015), "the structural bases of the learning process lie in the transactions among these four adaptive modes and the way in which the adaptive dialectics get resolved" (p. 92). The result is divergent, assimilative, convergent, or accommodative knowledge (Kolb, 2015).

Simulation is an active learning experience that embodies experiential learning theory by facilitating students through the stages of the experiential learning cycle and combining the active simulation experience and reflection for the purpose of applying knowledge to practice (Fanning & Gaba, 2007). Computer-based simulation is a screen-based simulation that provides the learner real-time clinical situations or scenarios (Bonnetain et al., 2010) with a continuous feed of problems (Weatherspoon & Wyatt, 2012). The computer-based simulation places the learner in a central role requiring decision-making skills and provides feedback on learner actions and decisions. (Bonnetain et al., 2010; Weatherspoon & Wyatt, 2012). The learner reflects on the simulation scenario experience and forms abstract conceptualizations upon which they will experiment and form new concrete experiences (Foronda & Bauman, 2014). The process of reflection assists the learner to make sense of the simulation experience through abstract comprehension forming the basis of decision making and clinical judgement (Weatherspoon & Wyatt, 2012). Repeated exposure to simulation situations or scenarios builds past experiences that the student can draw from and apply to future clinical practice situations (Foronda & Bauman, 2014). The computer-based simulation provides an opportunity for learners to create knowledge through the transformation of experience that can be applied to future situations. The building of past experiences through computer-based simulation promotes the development of clinical decision-making skills that ultimately may translate to reduced errors, safe patient care, and improved patient outcomes.

1.5 Definition of Terms

Researchers, nurse faculty, and simulation educators lack clarity and consistency in the use of simulation definitions (Foronda et al., 2020). Foronda et al. (2020) contend "no single terminology is used consistently within the literature of games, serious games, virtual worlds, virtual patients, and virtual reality" (p. 46). Cant et al. (2019) clarify terms and definitions for virtual simulation modalities. Cant et al. (2019) explain that "computer-based simulation may include virtual worlds, virtual environments, virtual patients, virtual reality task trainers, and serious games" (p. 27). The terms virtual reality, virtual world, virtual environment, augmented reality, and virtual simulation refer to different types of educational technologies. Cant et al. (2019) distinguish between these terms by referring to virtual environments and virtual worlds as the setting for a virtual reality experience. Another term that lacks clarity in the literature is virtual simulation (Foronda et al., 2020). Foronda et al. (2020) further delineated the term virtual simulation to include "clinical simulation offered on a computer, the internet, or in a digital learning environment including single or multiuser platforms" (Foronda et al., 2018, p. 27). The landmark document Healthcare Simulation Dictionary (Lioce et al., 2020) provides clarity relating to simulation terminology and serves as a key reference for simulationists and the simulation community at large for education and research (Foronda et al., 2020). The simulation definitions included in this research study are from the reputable resource Healthcare Simulation Dictionary (Lioce et al., 2020) and established simulation literature.

- *Augmented reality*. "A technology that overlays digital computer-generated information on objects or places in the real-world for the purpose of enhancing the user experience" (Lioce et al., 2020, p. 9).
- *Clinical judgement.* "Skill of recognizing cues about a clinical situation, generating and weighing hypothesis, taking action and evaluating outcomes for the purpose of arriving at a satisfactory clinical outcome. Clinical judgement is the observed outcome of two unobserved underlying mental processes, critical thinking and decision making" (National Council State Boards of Nursing (NCSB), 2018, p. 3).
- *Clinical reasoning*. "Thought processes that allow healthcare providers to arrive at a conclusion" (American Association of Colleges of Nursing (AACN), 2021, p. 62).
- *Clinical scenario.* "The plan of an expected and potential course of events for a simulated clinical experience. A scenario usually includes the context for the simulation (hospital

ward, emergency room, operating room, clinic, out of hospital, etc.). Scenarios can vary in length and complexity, depending on the learning objectives" (Lioce et al., 2020, p. 11).

- *Computer-based simulation*. "The modeling of real-life processes with inputs and outputs exclusively confined to a computer, usually associated with a monitor and a keyboard or other simple assistive device" (Textbook of Simulation, as cited in Lioce et al., 2020, p. 12).
- *Debriefing*. "To encourage participants' reflective thinking and provide feedback about their performance, while various aspects of the completed simulation are discussed" (Lioce et al., 2020, p. 13).
- *Feedback*. "Information transferred between participants, facilitator, simulator, or peer with intention of improving the understanding of concepts or aspects of performance (International Nursing Association of Clinical Simulation Learning (INACSL), 2013 as cited in Lioce et al., 2020, p. 18). Feedback can be delivered by an instructor, a machine, a computer, a patient (or simulated person), or by other learners as long as it is part of the learning process" (Lioce et al., 2020, p. 18).
- *Guided reflection*. "The process encouraged by the instructor during debriefing that reinforces the critical aspects of the experience and encourages insightful learning, allowing the participant to link theory with practice and research" (INACSL, 2013 as cited in Lioce et al., 2020, p. 20).
- *Interruption*. "A break in the performance of a human activity initiated by a source internal or external to the recipient, with occurrence situated within the context of a setting or location. This break results in the suspension of the initial task by initiating the performance of an unplanned task with the assumption that the initial task will be resumed" (Brixey et al., 2007, p. e38).

- *Modality*. "A term used to refer to the type(s) of simulation being used as part of the simulation activity, for example, task trainers, manikin-based, standardized/simulated patients, computer-based, virtual reality, and hybrid" (Society for Simulation in Healthcare (SSH), as cited in Lioce et al., 2020, p. 31).
- *Prebriefing*. "An information or orientation session held prior to the start of a simulation activity in which instructions or preparatory information is given to the participants. The purpose of the prebriefing is to set the stage for a scenario, and assist participants in achieving scenario objectives" (Lioce et al., 2020, p. 37).
- *Screen-based simulation/screen-based simulator*. "A simulation presented on a computer screen using graphical images and text, similar to popular gaming format, where the operator interacts with the interface using keyboard, mouse, joystick, or other input device" (Lioce et al., 2020, p. 41).
- *Simulation*. "A technique that creates a situation or environment to allow persons to experience a representation of a real event for the purpose of practice, learning, evaluation, testing, or to gain understanding of systems or human actions" (Lioce et al., 2020, p. 44).
- *Virtual environment (VE)*. "A simulated environment rendered by a computer, mobile device, or virtual reality/augmented reality/mixed reality device" (Schwebel et al., 2017, as cited in Lioce et al., 2020, p. 55).
- *Virtual reality*. "A computer-generated three-dimensional environment that gives an immersion effect" (Lioce et al., 2020, p. 55).
- *Virtual simulation*. "The recreation of reality depicted on a computer screen" (McGovern, 1994, as cited in Lioce et al., 2020, p. 56).

- *Virtual world.* “Similar to virtual environment, though implies multiple characters, learners, or participants and potentially a larger scale than a virtual environment” (Chang & Weiner, 2016, as cited in Lioce et al., 2020, p. 56).

1.6 Assumptions, Limitations, and Delimitations

Some assumptions were made in the research study. It was assumed that the participants would be able to use the computer-based simulation after the technology orientation. It was also assumed that the participants would answer the knowledge pretest and posttest questions, survey questions, and focus group discussion questions honestly and to the best of their ability.

Limitations of the study include number of participants; selection bias; location; generalizability; some variation in nursing practices, education, and expectations; Zoom meeting distractions; and researcher bias. The convenience sampling method, small sample size, and a location that may or may not be representative limits the generalizability of the study results. The education practices were held as consistent as possible between the two course sections as the sections had the same course syllabus, objectives, assignments, exams, grading criteria, number of clinical hours, simulation assignments and didactic teacher. The clinical course sections shared the same didactic course information, objectives, and clinical evaluation tool, but had different clinical instructors and the clinical site placements varied among the groups.

The debriefing sessions and focus group discussions were conducted through Zoom. One limitation of the study was that the researcher could not control participant distractions or interruptions during the Zoom debriefing sessions or focus group discussions. The study participants joined the group discussions from a location of their choosing through Zoom, and there could have been distractions or events in the environment that interrupted the participant during the group discussions. Researcher bias may affect the analyzing of utterances, assigning of codes, reviewing of codes, merging and elimination of codes, creating categories of codes, and the process of developing related categories and themes or patterns.

A delimitation of the study was excluding registered nurses and licensed vocational nurses pursuing a Bachelor of Science degree in nursing. A licensed nurse's previous work history with drug calculation, medication administration, and exposure to interruptions would introduce bias into the study. Another delimitation of the study was the collection of data in one semester of the nursing program. The study included only fourth semester nursing students and, thus, did not examine the impact of computer-based simulation on nursing students earlier in the program, such as junior students. Furthermore, the study was delimited by the focus on the senior second semester student's experience with interruptions. The study did not seek to explore the junior level student's experience with interruptions, which may be different due to their experience with a lower number of computer-based simulations, clinical simulations, and clinical rotations.

1.7 Summary

Nurse educators must prepare nursing students to enter the workforce ready for the challenges of today's hospital including increasing complexity of patient care, medication administration, high patient acuity levels, and a fast-paced environment with interruptions (Colligan & Bass, 2012). Computer-based simulation offers standardized teaching of curricular concepts (Foronda & Bauman, 2014; National League for Nursing (NLN), 2015) with deliberate and focused instruction on essential nursing competencies (Josephsen & Butt, 2014). Computer-based simulations provide the student access to convenient learning opportunities; anywhere anytime learning; immediate feedback; self-remediation; and flexible debriefing options, such as asynchronous discussion boards, synchronous group meetings, or both (Foronda et al., 2018;

Foronda & Bauman, 2014; Josephsen & Butt, 2014). Furthermore, the advantages of computer-based simulation, such as less classroom and lab space usage, less resource usage, and less need for faculty and staff support, make it a cost-effective alternative to high-fidelity simulation (Foronda et al., 2018). This study aims to contribute to the research about learning technology use in nursing education by assessing the impact of computer-based simulation on knowledge and satisfaction including debrief and reflection, clinical reasoning, and clinical learning, and aims to explore the nursing students' education and experience relating to interruptions and interruption management. The data about the impacts on knowledge and satisfaction may help to inform nurse educators about the use of computer-based simulation. The assessment of the nursing student's experience with interruptions and interruption management may help to better understand the need for interruption and interruption management education in undergraduate baccalaureate nursing programs. Furthermore, the data may guide nurse educators on how, when, and what to teach nursing students about interruptions and interruption management to reduce errors and promote safe patient care.

CHAPTER 2

LITERATURE REVIEW

The study addresses a gap in the nursing education literature by studying computer-based simulation as a mechanism to connect theory and practice (Simpson, 2002) and explores the nursing students' experience with interruptions and interruption management. Interruptions during the medication administration process are a leading cause of medication error (Hayes et al., 2015). The overarching question is how do nursing students learn about interruptions in order to prepare for clinical practice (Hayes et al., 2015) According to Hayes et al. (2015) "a significant gap in the literature exists in relation to innovative sustainable strategies that assist undergraduate nurses to learn how to safely and confidently manage interruptions in the clinical environment" (p. 3063). This chapter presents the literature review including an overview of simulation, virtual simulation, medication errors, role of interruptions, and the computer-based simulation implemented in the study.

2.1 Simulation

Simulation is "a technique—not a technology—to replace or amplify real experiences with guided experiences that evoke or replicate substantial aspects of the real world in a fully interactive manner" (Gaba, 2004, p. i2). Simulation in nursing education replicates real life clinical situations providing an opportunity for nursing students to apply knowledge gained in theory classes to the care of a simulated patient. Jeffries (2005) defined simulation as "activities that mimic the reality of a clinical environment and are designed to demonstrate procedures, decision-making, and critical thinking through techniques such as role playing and the use of devises such as interactive videos and mannequins" (p. 97). The NLN (2015) further expanded the definition of simulation, stating:

> Simulation is more than a way to teach and practice psychomotor skills. It is an evidence-based strategy to facilitate high-quality experiences that foster thinking and clinical reasoning skills for students. The emphasis is on creating contextual learning environments that replicate crucial practice situations. (p. 3)

Simulation-based learning experiences consist of three phases: prebriefing, the patient care or clinical scenario, and debriefing (Cato 2012; International Nursing Association of Clinical Simulation Learning [INACSL] Standards Committee, 2016). The prebrief phase occurs before the clinical scenario and consists of a structured orientation to participant and facilitator expectations, objectives, equipment, fiction contract, time allotment, and the evaluation method (INACSL Standards Committee, 2016). The clinical scenario encompasses the course of events and context or setting of the simulation (Lioce et al., 2020). The clinical scenario can take place in any simulation modality. The debriefing or feedback sessions follow the simulation-based experience (INACSL Standards Committee, 2016).

In 2014, the National Council of State Boards of Nursing (NCSBN) conducted a seminal work examining simulation as a substitute for required traditional clinical hours at 25% and 50% replacement in prelicensure nursing programs (Hayden et al., 2014). Jeffries (2015) hales this landmark study as "the most rigorous educational study ever done in the history of nursing education" (p. 278). The NCSBN National Simulation Study "was a comparison study using a randomized, controlled, longitudinal, multisite design" (Hayden et al., 2014, p. S6). The outcome measurements of the study were students' (a) knowledge using the ATI RN Comprehensive Predictor® 2010; (b) clinical competency using the Creighton Competency Evaluation Instrument (CCEI), New Graduate Nurse Performance Survey (NGNPS), Global Assessment of Clinical Competency and Readiness for Practice, and National Council Licensure Examination (NCLEX®); (c) critical thinking using the Critical Thinking Diagnostic©; and (d) perceptions about learning needs being met using The Clinical Learning Environment Comparison Survey

(CLECS) (Hayden et al., 2014). The study had a two-part experimental design consisting of three nursing student participant groups and a sample size of 847. The control group included nursing students attending traditional clinical experiences not exceeding 10% of the time in simulation. The other two participant groups included 25% and 50% of traditional clinical time replaced with simulation time.

Part 1 of the study focused on educational outcomes, while Part 2 assessed the long-term impact of substituting clinical simulation for traditional clinical experiences on performance and acclimation to the professional role of the nurse (Hayden et al., 2014). Hayden et al. (2014) reported no statistically significant difference ($p = 0.478$) in overall student knowledge on the ATI RN Comprehensive Predictor® 2010 exam total score including the control group (M = 69.1%), 25% group (M = 69.5%), and 50% group (M = 70.1). Furthermore, the first time NCLEX examination pass rate for the entire study participant cohort was 86.3% and the control group, 25% participant group, and 50% participant group first time NCLEX pass rates were 88.4%, 85.5%, and 87.1% respectively and higher than the national average at the time of the study (Hayden et al., 2014). The CCEI final ratings for fundamentals, medical-surgical, advanced medical-surgical, maternal-newborn, pediatric, mental health, and community health clinical competency ratings were above 90% for all three study groups. Hayden et al. (2014) reported that at the end of the nursing program clinical preceptors and instructors indicated the students in all three study groups were clinically competent through ratings on the NGNPS.

According to Hayden et al. (2014), "this study provides substantial evidence that up to 50% simulation can be effectively substituted for traditional clinical experience in all prelicensure core nursing courses under conditions comparable to those described in the study" (p. S38). The Hayden et al. (2014) study results support nursing programs substituting time and activities in the simulation lab up to 50% of clinical educational hours, thus assisting to alleviate clinical placement issues, limited direct patient care experiences, and concerns about the quality of clinical experiences at clinical sites.

Cobbett and Snelgrove-Clarke (2016) examined nursing student's knowledge, self-confidence, and anxiety using two methods of simulation, virtual clinical simulation (VCS) and face-to-face simulation, over two different topics, pregnant women experiencing preeclampsia and Group B Streptococcus (GBS). Cobbett and Snelgrove-Clarke (2016) reported there was no significant difference in knowledge scores between the two different modalities of simulation. The preeclampsia knowledge scores for face-to-face simulation were $M = 4.80$ and $SD = 1.19$ as compared to VCS knowledge scores of $M = 4.12$ and $SD = 1.54$ with $t\ (48) = 1.75$ and $p = 0.09$ (two-tailed) (Cobbett et al., 2016). The GBS knowledge scores for face-to-face simulation were $M = 6.82$ and $SD = 1.25$ as compared to VCS knowledge scores of $M = 6.40$ and $SD = 1.73$ with $t\ (51) = 1.02$ and $p = 0.31$ (two-tailed) (Cobbett & Snelgrove-Clarke, 2016). In addition, there was no statistically significant difference ($t = 1.93$, $p = 0.059$) in the student's self-confidence scores relating to the method of simulation face-to-face ($M = 115.25$, $SD = 21.95$) versus VCS ($M = 104.89$, $SD = 17.52$) (Cobbett et al., 2016). Cobbett and Snelgrove-Clarke (2016) demonstrated the important finding that VCS learning outcomes relating to knowledge and self-confidence are equivalent to face-to-face simulation. However, the authors found that the VCS group anxiety level ($M = 73.26$) demonstrated a statistically significant ($t = -3.2$, $p = 0.002$) higher level of anxiety than the fact-to-face group (M = 57.75) (Cobbett & Snelgrove-Clarke, 2016). In addition, Cobbett and Snelgrove-Clarke (2016) reported that about half of the participants disliked the VCS due to technology issues. Cobbett and Snelgrove-Clarke (2016) highlight the importance of student orientation to learning technologies such as VCS prior to use.

2.2 Virtual Simulation

Virtual simulation is an active learning modality that provides learning opportunities for nursing students to practice and apply knowledge and skills learned in theory classes without the possibility of patient harm (Foronda et al., 2017; Simpson, 2002). Active learning strategies promote the development of clinical reasoning (Herron et al., 2019) through experiential learning and learner engagement in knowledge clarification, application, and expression of thought (Hicks Russel et al., 2013). Some learner outcomes associated with virtual simulation are improved satisfaction (Foronda et al., 2016b; Herron et al., 2019; Liaw et al., 2014), knowledge (Dubovi et al., 2017, Gu et al., 2017; Herron et al., 2019), knowledge retention (Dubovi et al., 2017, Farra et al., 2012; Liaw et al., 2014), skills performance scores (Gu et al., 2017; Smith et al., 2016), and skill performance time (Smith et al., 2016). The combined educational challenges of limited clinical practice for nursing students and the need to ensure patient safety drive the use of virtual simulation technologies as a complementary learning strategy to traditional and other simulation strategies (Bonnetain et al., 2010; Foronda & Bauman, 2014).

Several studies document the use of virtual simulation in nursing education. Dubovi et al. (2017) conducted a pretest/posttest quasi-experimental study with two nursing student participant groups for comparison. The control group (n = 47) received a lecture-based curriculum as the format to learn medication administration, while the experimental group (n = 82) received medication administration instruction with the Pharmacology Inter-Leaved Learning Virtual Reality (PILL-VR) program in place of the normative lecture-based curriculum. Dubovi et al. (2017) reported that the post knowledge scores for the experimental group (M = 93, SD = 7) were significantly higher than the comparison group (M = 52, SD = 25). The medication administration sequence scores for the experimental group (M = 83, SD = 19) were also higher than the comparison group (*M* = 41, *SD* = 24). Lastly, the basic procedural concepts scores for the experimental group (*M* = 98, *SD* = 5) were higher than the comparison group (*M* = 57, *SD* = 31). Moreover, Dubovi et al. (2017) reported the difference in results between the pretest and the posttest (taken two months after the experiment) for the experimental group was statistically significant ($p < 0.0010$). Dubovi et al. (2017) also reported that the results from the delayed posttest (taken five months after the experiment) were not different at a statistically significant level when compared with the first posttest, thus demonstrating medication administration knowledge retention for five months. The results from Dubovi et al. (2017) relating to knowledge retention are consistent with Farra et al. (2012) demonstrating improved knowledge retention over time with use of virtual simulation as a teaching strategy.

Farra et al. (2012) explored the effect of a disaster virtual reality 3-D Second Life computer keyboard and mouse simulation on nursing student's knowledge gains and retention. The study design was quasi experimental with 47 participants randomly assigned to one of two study groups, the intervention group or standard care group. The intervention group received disaster training through the web-based teaching method only. The standard care group received the web-based teaching and virtual simulation disaster training. Farra et al. (2012) reported "overall, the main effect of the virtual simulation was strongly significant (p <0.0001)" (p. 664). The post assessment knowledge scores for the web-based teaching and virtual simulation group (*n* = 22, *M* = 17.68, *SD* = 1.729) were higher than the web-based teaching only group (*n* = 25, *M* = 16.24, *SD* = 2.134). The 2-month knowledge scores for the web-based teaching and virtual simulation group (*n* = 21, *M* = 16.95, *SD* = 1.910) were higher than the web-based teaching only group (*n* = 20, *M* = 14.10, *SD* = 2.490), and the differences were significant ($p < .0001$). Farra et al. (2012) concluded that “the VRS had a strong positive effect on retention of disaster training” (p. 665).

Herron et al. (2019) compared student satisfaction, self-confidence, and knowledge between two different types of in class case studies: a video simulated unfolding case study using a standardized patient versus a traditional written unfolding case study. Herron et al. (2019) reported that overall satisfaction was higher for the video simulation group (22.03) as compared to the case study group (21.47), but the difference was not statistically significant ($p = 0.32$). Similarly, the self-confidence results demonstrated higher scores for the video simulation group (33.75) than the case study group (33.70); the difference was not statistically significant ($p = 0.95$). The pretest and posttest results showed that participants in the video simulation group answered a higher percentage of the questions correctly, with a 5% higher score on 3 of the questions. Furthermore, Herron et al. (2019) reported 0.19-5.09% higher knowledge scores for the video simulation group over the case study group, indicating the possibility of a deeper understanding of the content by the video simulation group.

2.3 Medication Errors

The Institute of Medicine (IOM) (2000) landmark study indicates that the deaths caused by medical errors range between 44,000 and 98,000 Americans per year as compared to other leading causes of death, such as motor vehicle accident, breast cancer, and AIDS at 43,458, 42,297, and 16,516 respectively. Furthermore, the IOM (2000) reports that “preventable adverse events are a leading cause of death in the United States” (p. 26). The IOM (2000) report highlighted the frequency of medication errors and the escalating cost of errors, reporting an associated cost of $2.8 million for a hospital with approximately 700 beds and $2 billion dollars nationally.

Muroi et al. (2017) investigated medication errors by examining incident reports at five hospitals from a previous research study with a total of 2,336 observations including 1,276 medication error case reports and 1,060 in the control group. The researchers utilized the 1,276 medication error case reports to further explore medication errors by drug classification and consequences to patients. Muroi et al. (2017) found that 74% of the medication errors involved cardiovascular drugs (*n* = 315, 24.7%), antimicrobials (*n* = 243, 19.1%), electrolytes (*n* =144, 11.3%), endocrine drugs (*n* = 131, 8.8%), and analgesics (*n* = 112, 8.8%). Vancomycin and heparin were the two most frequent drugs with a medication error report, and heparin was the most common drug involved in a medication error excluding pediatrics. Muroi et al. (2017) reported that "approximately 10% of medication errors reached the patients with harm" (p. 182). The four most common drugs found to cause patient harm as a result of medication error were furosemide, enoxaparin, insulin, and vancomycin (Muroi et al., 2017). Muroi et al. (2017) contend that their findings are consist with previous studies and contribute the errors to high patient volume, frequent distractions, and interruptions.

The Global WHO Patient Safety Challenge is Medication Without Harm (Donaldson, 2017). The goal of the challenge is "to reduce the level of severe, avoidable harm related to medications by 50% over 5 years, globally" (Donaldson, 2017, p. 1681). Havens and Boroughs (2000) brought forth the notion that the entire healthcare enterprise is responsible for the state of medical errors. Donaldson (2017) furthered the notion that the entire healthcare team is responsible for medical errors by calling on the entire healthcare field, including researchers and academic institutions, to accept responsibility for reducing medication errors and engage in strategies to actively reduce medication errors. Nursing faculty, an important role in educational institutions and the healthcare enterprise, prepare new baccalaureate nurses to enter the workforce practice ready. Medication administration is a critical aspect of the registered nurses' role requiring knowledge of the five rights of medication administration, pharmacology, assessment, nursing considerations, potential adverse effects, and critical thinking skills that nursing programs must teach effectively (Harris et al., 2014; Pauly-O'Neil, 2009; Shanks, 2021; Zahara-Such, 2013).

Numerous studies point to nurses' poor drug calculation skills as a cause of medication errors (Harris et al., 2014; Shanks, 2021; Wright, 2004). Zahara-Such (2013) conducted an integrative review of the nursing education literature on teaching strategies relating to improving student nurses' math and medication calculation skills. The analysis supported four recommendations for teaching nursing students' math calculation skills:

> (a) Math skills must be early and reinforced often throughout the nursing curriculum; (b) simulation with real, practical problem solving provided the best learning outcomes; (c) accurate ways to assess math competency must be developed; and (d) nursing students' confidence can be increased by improving math calculation skills. (p. e382)

Nurse educators have an obligation to implement validated teaching methodologies that focus on math calculations and real-life situations to teach medication calculation skills. Furthermore, validated teaching methodologies involving math calculations and the mimicking of real-life situations result in increased student confidence, increased critical thinking, and fewer medication errors (Zahara-Such, 2013).

In order to enable student nurses to gain the required skills to perform safe medication administration, nurse educators need to develop and implement effective strategies to teach nursing students drug calculation skills (Pauly-O'Neil, 2009; Wright, 2004). A three-stage approach including mathematical concepts, drug calculation formulas, and practicing the skills in a clinical setting is an effective method for teaching drug calculation (Wright, 2004). Furthermore, the teaching needs to be multifaceted and comprehensive, including requiring students to interpret clinical information, apply math skills, conceptualize drug dosages, and determine if the drug dosage is appropriate (Wright, 2004). Additional strategies that promote success are teaching calculation skills early in the program, repeating drug calculations often, and practicing in realistic simulated environments (Zahara-Such, 2013).

The literature supports simulation as an effective strategy to teach drug calculation and safe medication administration (Harris et al., 2014; Pauly-O'Neill, 2009; Pauly-O'Neill & Prion, 2013; Shanks, 2021; Wright, 2004; Zahara-Such, 2013). Harris et al. (2014) conducted a quasi-experimental pilot study to compare simulation and traditional didactic teaching methods in improving drug calculation and medication administration skills. The sample was 158 Bachelor of Science in Nursing (BSN) students with the 79 students in the control group offered the traditional didactic review and the 79 students in the experimental group offered the simulation review. The medication administration exam results for the simulation review group (M = 95, SD = 6.8) was significantly higher (p = .004, t = 2.92, df = 118) than the traditional didactic group (M = 90, SD = 12.9). The simulation teaching method incorporated supplies and equipment that represented the clinical environment, such as ampules and syringes to calculate dosages, complex conversions, and intravenous drip rates for manual and pump administration.

Pauly-O'Neill (2009) also researched simulation as a strategy to teach medication administration procedures. The author conducted a pre-intervention and post-intervention observational study with medication administration practice in the simulation center as the intervention. The comparison of pre-training and post-training observational data demonstrated student improvement in many aspects of medication administration after the simulation training including assessment of allergy pre-training 0% as compared to post-training 97%; assessment of right patient and right medication pre-training 95% and 30% respectively as compared to right patient, right medication, and right route post-training 100%; safely dilute drug pre-training 29% as compared to post-training 96%; and set the correct IV pump rate pre-training 85% as compared to post-training 88%. Furthermore, Pauly-O'Neill (2009) expanded the safety aspects of medication administration to include concepts such as medication administration rate, IV pump settings, choosing the correct equipment, drug reconstitution, and medication dilution.

2.3 Role of Interruptions

Brixey et al. (2007) explored and clarified the concept of interruption using the Walker and Avant concept analysis method. Brixey et al. (2007) defined five attributes for an interruption: "(1) a human experience; (2) an intrusion of a secondary, unplanned, and unexpected task; (3) discontinuity; (4) externally or internally initiated; and (5) situated within a context" (p. E30). The attribute of human experience refers to the notion that it is the human being interrupted (Brixey et al., 2007). The intrusion task can occur at any time and results in discontinuity, such as the primary task not being completed (Brixey et al., 2007). Interruptions to an individual or recipient may stem from an internal or external source (Brixey et al., 2007). Internal interruptions occur privately within an individual's thought process, like a daydream or intrusive thought (Brixey et al., 2007). External interruptions are observable and come from another person or device (Brixey et al., 2007). Examples of external sources are other healthcare team members; patients; family members; and technical devices, such as the telephone, infusion pump, and missing equipment (Biron et al., 2009; Bower et al., 2015, Brixey et al., 2007; Hall et al., 2010, Tucker & Spear, 2006). The final attribute, context, refers to interruptions taking place within a context or location, such as healthcare organizations; hospitals; and specific departments, like emergency or intensive care units (Brixey et al., 2007).

The literature depicts a four-level taxonomy for managing interruptions: (a) engaging a higher priority secondary task immediately by suspending a primary task; (b) multitasking resulting in both tasks being done simultaneously by splitting attention; (c) mediation involving prospective memory, deflection, or delegation of a task; and (d) blocking the secondary task due to the higher priority of the primary task (Colligan & Bass, 2012). In addition, Li et al. (2011) recommend minimizing interruptions, practicing tasks repeatedly, training on interruption handling, and providing environmental cues for recovering from interruptions as strategies to reduce the disruption effects of interruptions. Personal experience is a factor in managing interruptions and prioritizing a task (Colligan & Bass, 2012). Therefore, the novice nurse needs to be taught by an experienced nurse how to manage interruptions based on the processes of prioritization and timing of interruptions (Colligan & Bass, 2012). Colligan and Bass (2012) highlight the need for education about interruptions as a strategy for resiliency of the healthcare system.

Numerous studies support the negative impact of interruptions on medication errors (Hall et al., 2010; Thomas et al., 2017; Westbrook et al., 2010). Hall et al. (2010) examined interruptions through a mixed method approach using observation and focus group interviews across three Canadian providences, nine hospitals, and 36 medical and surgical units. The authors identified the primary source of interruptions as healthcare workers, other nurses, and the individual nurse himself or herself as *n* = 3419 (26 %), *n* = 2903 (22.3%), and *n* = 2865 (22.0%) respectively. Furthermore, Hall et al. (2010) reported the majority of interruptions observed in the study resulted in negative consequences (*n* = 1170 or 90%), while only a few interruptions resulted in a positive outcome (*n* = 1315 or 10%). Hall et al. (2010) also identified the time of documenting, providing direct patient care, and administering medications as the time periods or aspects of the nurse's shift when interruptions mainly occur, highlighting the potential for critical consequences.

Westbrook et al. (2010) conducted an observational study of 98 nurses preparing and administering medication to 720 adult patients at two hospitals in Sydney, Australia. The researchers observed 4271 drug administrations for 720 patients in the two hospitals combined. The authors found that the clinical errors increased with each interruption. Westbrook et al. (2010) reported that the mean procedural failures increased by 12.1% and the mean clinical errors increased by 12.7% with every interruption. Westbrook et al.'s (2010) logistic regression demonstrated two important risk factors for failures and errors. First, interruptions increase the risk for at least one failure or error. Second, excessive interruptions such as five interruptions during medication administration result in almost certain procedural failure (Westbrook et al., 2010). Furthermore, Westbrook et al. (2010) found that the risk of major error doubled when interruptions increased from zero to four. Overall, Westbrook et al. (2010) reported a significant relationship between interruptions and procedure failures and medication administration errors.

Kalisch and Aebersold (2010) examined the nursing work environment with a focus on interruptions, multitasking, and associated patient errors. Kalisch and Aebersold (2010) conducted an observational study with 36 nurses from two different hospitals spanning three hospital unit types including four medical-surgical units, one intensive care unit, and one progressive care unit. Kalisch and Aebersold (2010) reported that overall, the registered nurses (RN) encountered 10 interruptions per hour or 1 per 6 minutes. The interruptions at Hospital 1 were significantly higher (14.2 interruptions per hour or 1 every 4.5 minutes) as compared to Hospital 2 (3.9 interruptions per hour or 1 every 13.3 minutes). Furthermore, the interruptions were subdivided into occurrences when the RN was doing a single task/activity or occurrences when the RN was doing two or more task/activities simultaneously. Kalisch and Aebersold (2010) found that Hospital 1 had 55% and Hospital 2 had 39% of the interruptions occur when the nurse was completing a single task. However, Hospital 1 had 45% and Hospital 2 had 61% of the interruptions occur when the nurse was already doing two or more tasks. Kalisch and Aebersold (2010) reported that overall "interruptions were interrupted again 92 times in Hospital 1 and 32 times in Hospital 2" (p. 128). Kalisch and Aebersold (2010) explain this further, stating "in other words, when an RN was responding to one interruption, he or she was interrupted again" (p. 128).

Kalisch and Aebersold (2010) reported overall 200 errors or 1.5 errors per hour encompassing hand washing, patient identification, donning gloves and gowns, medication administration, isolation procedures, order transcription, incorrect diet order and not using the correct needleless system. The largest number of interruptions were RNs interrupting other RNs, indicating an opportunity to develop methods to reduce these types of interruptions. Kalisch and Aebersold (2010) concluded "this kind of interruptive and multitask-driven environment is conducive to errors" (p. 130). Kalisch and Aebersold's (2010) research demonstrates the need to teach nursing student how to manage interruptions in order to prepare the next nursing workforce for a complex interruption laden healthcare clinical environment.

2.4 Description of Technology

The computer-based simulation used in the study is Swift River™ Virtual Hospital (ATI Assessment Technologies Institute, LLC) consisting of Math Refresher, Dosage Calculation, Med-Pass (Medication Administration), Mental Health, Medical-Surgical, and Emergency Room (ER) Leadership (see Table 1). Math Refresher includes various types of math problems covering calculation concepts, such as intake and output, intravenous drips, and weight-based dosages (Swift River Virtual Clinicals, 2021d). Dosage Calculation uses patient scenarios in a virtual hospital for students to practice and test their ability to calculate medication dosages, gather needed supplies, and administer medications (Swift River Virtual Clinicals, 2021a).

Table 1

Computer-Based Simulation

Math Refresher	**Drug Calculation**	**Med-Pass**
• Math problems • Immediate student feedback and scoring	• Patient scenarios with drug calculations • Immediate student feedback and scoring	• Medication administration • Interruptions • Immediate student feedback and scoring
Medical-Surgical	**Mental Health**	**ER Leadership**
• Patient assessments • Priority interventions • Interruptions • Immediate student feedback and scoring	• Psychiatric diagnosis • Medication administration • Immediate student feedback and scoring	• Triage • Admit, discharge, and divert patients • Background noise • Immediate student feedback and scoring

Source: Swift River Virtual Clinicals (2021h).

Med-Pass (Medication Administration) allows the student to practice medication administration in a virtual hospital. The medication administration procedure encompasses identification of the patient, drug classification, and the rights of medication administration (Swift River Virtual Clinicals, 2021f). The learner assesses for nursing considerations to determine if the medication should be administered or held (Swift River Virtual Clinicals, 2021f). Med-Pass (Medication Administration) replicates reality by presenting multiple opportunities for the student to implement safe medication calculation and administration procedures or to make drug calculation and procedural errors (Swift River Virtual Clinicals, 2021f).

Medical-Surgical is a real time clinical simulation experience that encompasses an audio recording of shift report followed by opportunities for students to complete patient assessments and implement priority patient care interventions (Swift River Virtual Clinicals, 2021e). Mental Health focuses on psychiatric diagnosis and medication administration (Swift River Virtual Clinicals, 2021gc). The Emergency Room (ER) Leadership provides an opportunity for students to triage virtual patients, assign and adjust staffing, discharge patients, admit patients, and divert patients (Swift River Virtual Clinicals, 2021b). The Math Refresher, Dosage Calculation, Med-Pass (Medication Administration), Medical-Surgical, Mental Health, and ER Leadership computer-based simulations provide immediate student feedback and scoring (Swift River Virtual Clinicals, 2021c).

The computer-based simulations Med-Pass (Medication Administration) and Medical-Surgical incorporate random call light distractors as interruptions for students to respond to during the simulation (Swift River Virtual Clinicals, 2021e, 2021f). The students must assess the patient issue associated with the call light and determine the best response action. The ER Leadership simulation mimics the clinical environment by including background hospital noises (Swift River Virtual Clinicals, 2021b). The incorporation of call light distractors and background hospital noises into simulations is an approach to clinical education that allows students to practice managing interruptions while completing routine nursing care activities. The call light and background noise distractors expose nursing students to the reality of interruptions and the associated challenges of prioritizing, delegating, and completing tasks and procedures without errors in the clinical setting.

CHAPTER 3

METHODOLOGY

Computer-based simulation is a learning strategy to facilitate the application of theory and knowledge to patient care situations. The purpose of this study was to evaluate the impact of computer-based simulation on senior second semester undergraduate baccalaureate nursing students and explore the nursing students' experience with interruptions. This research study utilized both quantitative and qualitative research approaches including knowledge tests and a satisfaction survey to evaluate the computer-based simulation impact on nursing students and a focus group discussion to explore the nursing student's experience with interruptions and interruption management. This chapter presents the research design, research questions, settings, participants, data collection methods, and data collection instruments.

3.1 Research Design

The design of the study was a descriptive case study with mixed methods including quantitative and qualitative data collection and analysis. The quantitative analysis encompassed pretest and posttest knowledge tests and a satisfaction survey. The qualitative portion of the study involved a focus group discussion relating to the nursing student's experience with interruptions and interruption management.

3.2 Research Questions

1. How do senior second semester undergraduate baccalaureate nursing students experience and manage interruptions?
2. What impact does computer-based simulation have on the senior second semester undergraduate baccalaureate nursing student's knowledge and satisfaction including debrief and reflection skills, clinical reasoning, and clinical learning?

3.3 Setting

The study was conducted at a four-year university school of nursing located in the southwestern portion of the United States. The setting for the computer-based simulation was the student's personal or school computer. The study pretest and posttest knowledge tests, participant survey, group discussion debriefing session, and focus group discussions were administered in a classroom, online, or through a remote or virtual meeting over a period of fifteen weeks.

3.4 Participants

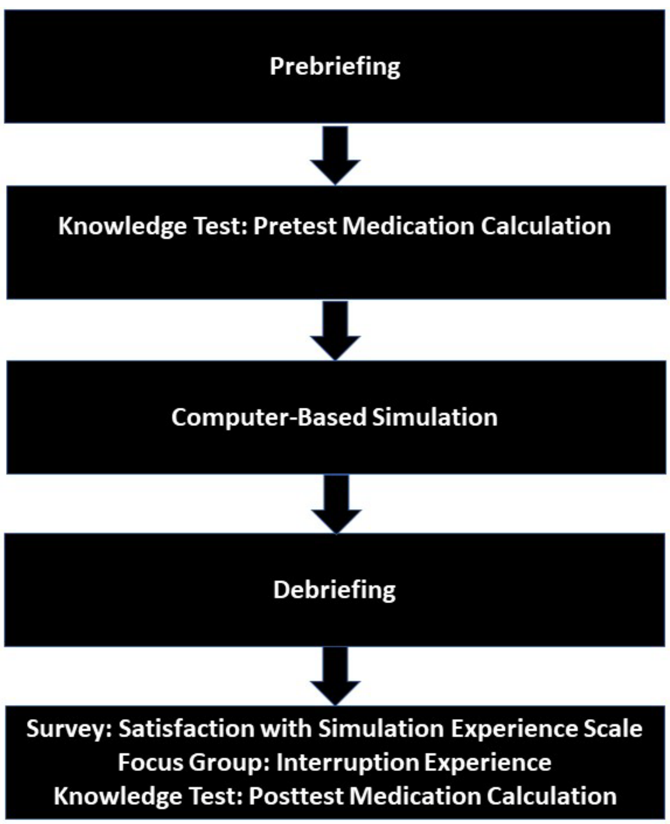
A convenience sampling method was used to obtain a sample of volunteers from the senior second semester cohort of an undergraduate baccalaureate nursing program. The inclusion criteria included the participant's successful completion of all pre-nursing courses, enrollment in a specific senior second level course, and concurrent enrollment in all senior second semester nursing program courses. Participants had to be above 18 years of age or older and speak English.

3.5 Data Collection Methods

The principal investigator sought and received institutional review board (IRB) exemption status for the study. After receipt of IRB approval of exemption status, the principal investigator distributed a study flyer at a class meeting of eligible study participants. The principal investigator explained the participant eligibility requirements, purpose of the study, research procedure, potential benefits, and potential risk and discomforts, and then signed up volunteers to participate in the study. An announcement was made informing all potential study participants that participation or nonparticipation in the study would not affect the course grade or program progression in any way and that participants could withdraw from the study at any time without consequences. Informed consent (see Appendix A) and demographic data (see Appendix B) were obtained from all participant volunteers. The principal investigator maintained confidentiality of the participant data by storing the data on a password protected computer. After the focus group Zoom recordings were transcribed, the recordings were destroyed. The typed transcriptions were stored on a password-protected computer and any printed copies were kept in a locked office. The principal investigator was transparent regarding all aspects of the research including purpose, procedures, data, results, and outcomes.

Figure 1

Research Procedure



The students participating in the study completed a prebrief, computer-based simulations, and discussion board debriefing assignments as part of their regular course work. Study participants also completed a written medication calculation knowledge pretest and posttest, attended a group debriefing session, completed the Satisfaction with Simulation Experience (SSE) Scale (Levett-Jones et al., 2011), and attended a focus group discussion. The steps of the research study procedure are outlined in Figure 1.

The exact same medication calculation knowledge exam was administered prior to participation in the computer-based simulations and a second time after completion of the computer-based simulations. The study participants received a prebriefing session and orientation to the computer-based simulation program technology prior to starting the simulation hours as part of the course orientation. The participants completed the computer-based simulations on a personal or school computer and debriefing sessions within a semester timeframe. The computer-based simulation included Math Refresher, Dosage Calculation, Med-Pass (medication administration), Medical-Surgical, Mental Health, and Emergency Room (ER) Leadership. Students were allowed to use a drug reference for all Med-Pass simulations. The ER Leadership simulator included background noise distractions (Swift River Virtual Clinicals, 2021b). The Med-Pass and Medical-Surgical simulators included random call light distractors as interruptions, an approach to clinical education that allows nursing students to practice managing interruptions while completing routine nursing care activities.

The group discussion debriefing was conducted through a Zoom meeting. The debriefing sessions were conducted by the same simulation instructor with a certification as a Certified Healthcare Simulation Educator (CHSE). The debriefing questions for the discussion board and group discussion are outlined in Table 2. After completion of the computer-based simulation and all debriefing sessions the students filled out the SSE Scale including one open-ended question asking for further comments about the simulation experience. Participants also participated in a focus group discussion about the student's experience with interruptions and interruption management.

Table 2

Debriefing Questions

Discussion Board
1. What was the priority nursing assessment(s)? Did you obtain the pertinent data?
2. Give two examples of communication components that were necessary to take care of the client(s). How did these components help you (rationale)?
3. What was the priority issues with the client(s)? Did you prioritize appropriately and what would you do differently?
4. What patient safety issues did you encounter? How did you navigate these?
Group Discussion
1. Did you get any interruption? How did it impact your patient care and passing of medications?
2. How did you prioritize and delegate in the presence of call light distractors?
3. How can you reduce or minimize interruptions?
4. Did you confront any medication or classifications with which you are unfamiliar? What did you do?
5. How did you demonstrate safety rights when administering medications?
6. Did you need to get another RN witness for any medication? Why?
7. Did you need to hold any medications? Why?
8. How will you use the information you gained in your virtual clinical experience in future nursing practice?

3.6 Data Collection Instruments

The quantitative data were collected using the medication calculation knowledge exam and the SSE Scale (Levett-Jones et al., 2011). The knowledge exam consisted of 10 medication calculation questions the participants. The 10-question drug calculation test comprised five 1-factor problems, three 2-factor problems, one 3-factor problem, and one safe dosage problem (Table 3). The knowledge exam was reviewed for content validity by two certified nurse educators with experience writing National Council Licensure Examination for Registered Nurses (NCLEX-RN) style questions.

Table 3

Knowledge Exam Questions and Type of Drug Calculation Problem

Question	Drug Calculation Problem Type
Q1	One-Factor
Q2	One-Factor
Q3	One-Factor
Q4	One-Factor
Q5	One-Factor
Q6	Two-Factor
Q7	Two-Factor
Q8	Two-Factor
Q9	Three-Factor
Q10	Safe Dose Calculation

The SSE Scale (Levett-Jones et al., 2011) was adopted and used in this study without modifications. The SSE Scale is composed of 18 questions divided into three subscales with a 5-point Likert rating scale for each question. The SSE Scale subscales are Debrief and Reflection (Questions 1-9), Clinical Reasoning (Questions 10-14), and Clinical Learning (Questions 15-18). The SSE Scale (Levett-Jones et al., 2011) is a valid and reliable tool. The SSE Scale internal consistency was established with the Cronbach alpha coefficient demonstrating 0.776, thus meeting a satisfactory internal consistency level (Levett-Jones et al., 2011). Levett-Jones et al. (2011) conducted an exploratory factor analysis to identify the three subscales: debriefing and reflection, clinical reasoning, and clinical learning. The Cronbach alpha coefficient for the three subscales were debriefing and reflection 0.935, clinical reasoning 0.855, and clinical learning 0.850, demonstrating high internal consistency (Levett-Jones et al., 2011). Further data relating to student nurses experience with interruptions and interruption management were collected through focus group discussions encompassing 11 open-ended questions (Table 4). The focus group questions were developed by the researcher and piloted with three nurse educators for critical feedback and validity.

Table 4

Focus Group Interruption Discussion Questions

1.	Please share your experience regarding interruptions during the Med-Pass or Medical-Surgical Simulator virtual clinical(s).
2.	Describe how the interruption(s) effected your passing of medications or virtual clinical patient assignments.
3.	Describe what you think are interruptions during patient care.
4.	Describe strategies you have used to manage interruptions.
5.	Describe how you get experience with interruptions.
6.	Tell me about a time when you learned about interruptions.
7.	Tell me about a time when you successfully handled an interruption.
8.	What are the differences between practicing interruptions in clinical simulation and the interruptions in the clinical setting?
9.	How does experiencing interruptions in clinical simulation assist your learning?
10.	How will you use the experience you gained in your Med-Pass or virtual clinical patient assignments with interruptions in future nursing practice?
11.	Do you wish to make further comments about interruptions and interruption management?

CHAPTER 4

FINDINGS

The methodology of this study included both quantitative and qualitative research methods. The quantitative portion of the study encompassed a knowledge pretest, knowledge posttest, and a satisfaction survey. The pretest and posttest examined the effect of computer-based simulation on knowledge. The SSE Scale survey assessed the impact of computer-based simulation on satisfaction including debrief and reflection, clinical reasoning, and clinical learning. The qualitative portion of this study consisted of focus group interviews that explored the state of interruptions in nursing education. The qualitative data analysis included identifying emergent patterns, creating categories of codes, and identifying related themes regarding how senior second semester undergraduate baccalaureate nursing students describe interruptions, experience interruptions, manage interruptions, and learn about interruptions.

4.1 Quantitative Data Analysis

The quantitative data analysis was done using R version 4.1.0. The data analysis includes (a) demographics; (b) pretest and posttest comparison of correct answers and score data; (c) a two-sided paired t-test of the percentage of using units of measure in the answer; (d) pretest and posttest number incorrect without using units of measure in the answer; (e) SSE Scale survey questions, subscales, and overall scale mean and sum; (f) SSE Scale subscale ANOVA results; and (g) Tukey's HSD for the SSE Scale subscales. The study sample size was 48 participants with 34 participants completing the pretest and posttest and 31 participants completing the SSE Scale survey. Table 5 depicts the demographics of the study participants. The age of the participants ranged from 18-30 with one participant (3%) 18-20 years of age and 33 participants (97%) 20-30 years of age. The majority of participants were female (n = 24, 73%), and the remaining participants were male (*n* = 6, 18%) or did not report gender (*n* = 3, 9%). Participants reported ethnicity was white or Caucasian (*n* = 23, 71%), black or African American (*n* = 1, 3%), and Hispanic or (*n* = 9, 26%).

Table 5

Demographic Frequency

Question	Response	*n*	%
Age	18-20 years	1	3
	20-30 years	33	97
Gender	Female	24	73
	Male	6	18
	Prefer not to say	0	0
	Not reported	3	9
Ethnicity	White or Caucasian	23	71
	Black or African American	1	3
	Hispanic or Latino	9	26

The first aspect of the quantitative data was the pretest and posttest analysis. The pretest and posttest were given to 48 participants; however, four participants did not complete the pretest and 12 participants did not complete the posttest. The total number of participants that completed both the pretest and posttest were 34. The participants' records with missing data were eliminated from the study. The pretest and posttest were exactly the same and contained 10 drug calculation questions with five 1-factor problems, three 2-factor problems, one 3-factor problem, and one safe dose calculation problem with a yes or no answer (Table 3). The participants completed the drug calculation pretest and posttest using common calculation methods such as basic formula, ratio and proportion/fractional equation, or dimensional analysis (McCuistion, DiMaggio, Winton, & Yeager, 2021). Table 6 exhibits how the participants answered the pretest and posttest questions including the number of correct responses, percentage of correct responses, and the number of responses using units of measure in the answer. The participants performed better on posttest Questions 3 and 4, but performed worse on posttest Questions 6, 9, and 10. The percentage of participant pretest and posttest responses using units of measure in the answer decreased from the pretest to posttest.

Table 6

Pretest and Posttest Question Statistics

Question	Pretest				Posttest			
	Correct Responses		Correct Responses with Units of Measure		Correct Responses		Correct Responses with Units of Measure	
	n	%	*n*	%	*n*	%	*n*	%
Q1	34	100	15	44.1	34	100	9	26.5
Q2	34	100	19	55.9	34	100	10	29.4
Q3	33	97.1	22	64.71	34	100	10	29.4
Q4	25	73.5	19	55.9	28	82.4	11	39.3
Q5	34	100	23	67.6	34	100	11	32.4
Q6	26	76.5	22	64.7	23	67.6	10	43.5
Q7	29	85.3	23	67.6	29	85.3	10	34.5
Q8	32	94.1	22	64.7	32	94.1	10	31.3
Q9	34	100	23	67.6	24	70.6	10	41.7
Q10	14	41.2	NA	NA	12	35.3	NA	NA

A two-sided paired *t*-test of the percentage of using units of measure in the answer (Table 7) was conducted where the mean difference between posttest and pretest (posttest-pretest) is -0.272, the standard deviation of difference is 0.0249 with a 95% confidence interval (-0.329, -0.215). The *p*-value is less than 0.001 and significant, demonstrating strong evidence that the mean *p*-value is less than 0.001 and significant, demonstrating strong evidence that the mean difference of using units of measure in the answer between the pretest and posttest is not equal to zero. The confidence interval includes only negative values; thus, the data are consistent with the mean difference of using units of measure in the answer between the posttest and pretest (posttest-pretest) being negative.

Table 7

Two-Sided Paired t-*Test for Percentage Using Units of Measure in the Answer Between Pretest and Posttest*

Mean Diff	**Std. Dev.**	**Std. Error**	**95% CI**		***t***	***df***	***p-value***
			Lower	**Upper**			
-.0272	0.746	0.249	-0.329	-0.215	-10.934	8	<0.001

Table 8 compares the pretest and posttest number of incorrect answers and the number of incorrect answers without units of measure given in the answer for each question. Questions 6 and 9 both demonstrate higher percentages of incorrect answers on the posttest and a higher percentage of incorrect answers on the posttest without units of measure given in the answer. On the pretest Question 6 is answered incorrectly by 8 participants where 3 (37.5%) of the incorrect answers were without units of measure given in the answer. As compared to the posttest where 11 participants answered Question 6 incorrect and 9 (81.8%) of the incorrect answers were without units of measure given in the answer. In addition, pretest Question 9 is answered incorrectly by 0 participants where 0 (0%) of the incorrect answers were without units of measure given. As compared to the posttest where 10 participants answered Question 9 incorrect and 8 (80%) of the incorrect answers were without units of measure given in the answer.

The calculation methods basic formula, ratio and proportion/fractional equation, and dimensional analysis require the identification and use of units of measure in the math operations (McCuistion et. al., 2021). The decreasing use of units in the posttest answers may represent a decreasing use of units in the drug calculation operations by participants, resulting in more missed drug calculation questions on the posttest. The participants' worse posttest performance on the more complex two-factor, three-factor, and safe dose type drug calculation problems (Questions 6, 9, and 10) may be a result of the lack of use of units in the calculation process and indicate less than full understanding of units of measure by some of the participants.

Table 8

Pretest and Posttest Number Incorrect Without Using Units of Measurement in the Answer

Question	Pretest				Posttest			
	Incorrect Responses		Incorrect Responses without Units of Measure		Incorrect Responses		Incorrect Responses without Units of Measure	
	n	%	*n*	%	*n*	%	*n*	%
Q1	0	0.0	NA	NA	0	0.0	NA	NA
Q2	0	0.0	NA	NA	0	0.0	NA	NA
Q3	1	2.9	0	0.0	0	0.0	NA	NA
Q4	9	26.5	6	66.7	6	17.6	4	66.7
Q5	0	0.0	NA	NA	0	0.0	NA	NA
Q6	8	23.5	3	37.5	11	32.4	9	81.8
Q7	5	14.7	0	0.0	5	14.7	4	80.0
Q8	2	5.9	0	0.0	2	5.9	1	50.0
Q9	0	0.0	NA	NA	10	29.4	8	80.0
Q10	20	58.8	NA	NA	24	70.6	NA	NA

Table 9 exhibits the pretest and posttest scores including the mean, median, mode, standard deviation, and range. A two-sided paired *t*-test was conducted to compare the pretest and posttest mean values. The mean difference is -3.235, and the standard deviation of mean difference is 2.301 with a 95% confidence interval (-1.4448, 7.918). The *p*-value is 0.17, therefore there is not sufficient evidence to say that the mean difference differs from zero.

The drug calculation knowledge pretest scores may have been affected by the normal course work of the class in which the participants were enrolled. The normal course work included a required drug calculation test at the beginning of the semester, prior to students going to the clinical environment. Participant preparation and drug calculation practice early in the semester for this required course drug calculation exam may have positively affected the pretest drug calculation knowledge exam results.

Table 9

Pretest and Posttest Score Statistics

	Pretest	**Posttest**	**Posttest - Pretest**
Mean	86.76	83.53	-3.24
Median	90	80	0
Mode	90	80	0
Standard Deviation	10.65	13.46	13.42
Range	40	50	50
Minimum	60	50	-30
Maximum	100	100	20
Count	34	34	34

The second aspect of the quantitative data analysis was the satisfaction survey. The principal investigator conducted 10 debriefing discussion groups with a total of 31 participants. The SSE Scale survey was administered to the debriefing group participants after each meeting. All debriefing group participants (n = 31) completed the SSE Scale survey. The SSE Scale question items are rated on a 5-point Likert scale including 1 = *strongly disagree*, 2 = *disagree*, 3 = *unsure,* 4 = *agree*, and 5 = *strongly agree*.

Table 10 presents the summary statistics for the SSE Scale including the subscales. The sum scores for each question item ranged from 125-151. The mean score for each question is $\geq$ 4.03 with a range of 4.03 to 4.87. The mean for the debrief and reflection, clinical reasoning, and clinical learning subscales are 4.74, 4.39, and 4.49 respectively. The mean score for all questions on the SSE Scale is 4.59. The mean scores for all questions on the SSE Scale and the subscales indicate a high level of satisfaction as all mean scores are above the agree level on the

Likert scale. According to Levett-Jones et al. (2015), "the scores for the three subscales and overall scale are calculated by summing responses; higher scores indicate a higher degree of satisfaction with the simulation experience" (p. 350). Table 11 shows the ANOVA test conducted to investigate whether the mean values of all the subscales are equal.

Table 10

Satisfaction with Simulation Experience (SSE) Scale and Subscale Statistics

	Mean	Median	Highest	Lowest	Sum
Debrief and Reflection Subscale					
Q1	4.58	5	5	4	142
Q2	4.87	5	5	4	151
Q3	4.81	5	5	4	149
Q4	4.87	5	5	4	151
Q5	4.61	5	5	3	143
Q6	4.68	5	5	3	145
Q7	4.58	5	5	3	142
Q8	4.77	5	5	3	148
Q9	4.9	5	5	4	152
Subscale Combined	4.74	5	5	3	1323
Clinical Reasoning Subscale					
Q10	4.48	5	5	2	139
Q11	4.39	5	5	2	136
Q12	4.48	5	5	3	139
Q13	4.03	4	5	2	125
Q14	4.55	5	5	2	141
Subscale Combined	4.39	5	5	2	680
Clinical Learning Subscale					
Q15	4.52	5	5	3	140
Q16	4.45	5	5	2	138
Q17	4.45	5	5	1	137
Q18	4.52	5	5	2	140
Subscale Combined	4.49	5	5	1	555
SSE Scale Combined	4.59	5	5	1	2558

Table 11

ANOVA Results Satisfaction with Simulation Experience (SSE) Scale Subscales

	df	**Sum square**	**Mean square**	***F* value**	***p* value**
Subscale	2	0.457	0.229	10.96	0.00117
Residuals	15	0.313	0.021		

The ANOVA result demonstrates a *p*-value of 0.00117 that indicates at least one pair of mean values for the three subscales are different. Therefore, a Tukey's HSD test was conducted to explore the subscales and determine which subscales are different. Table 12 presents the results from the Tukey's HSD test that demonstrated a comparison of all pairs of the SSE Scale subscales. The difference in the mean of the SSE Scale subscales clinical reasoning and debrief and reflection is significant at a *p*-value of 0.001. The mean of the SSE Scale for the subscale clinical reasoning is significantly different from that for debriefing and reflection. The difference in the mean of the SSE Scale subscales clinical learning and debriefing and reflection is significant at a *p*-value of 0.025. The mean value of the SSE Scale subscale clinical learning is also significantly different from that for debrief and reflection. The difference in the SSE Scale subscales clinical learning and clinical reasoning scores is not significant at a *p*-value of 0.575.

Table 12

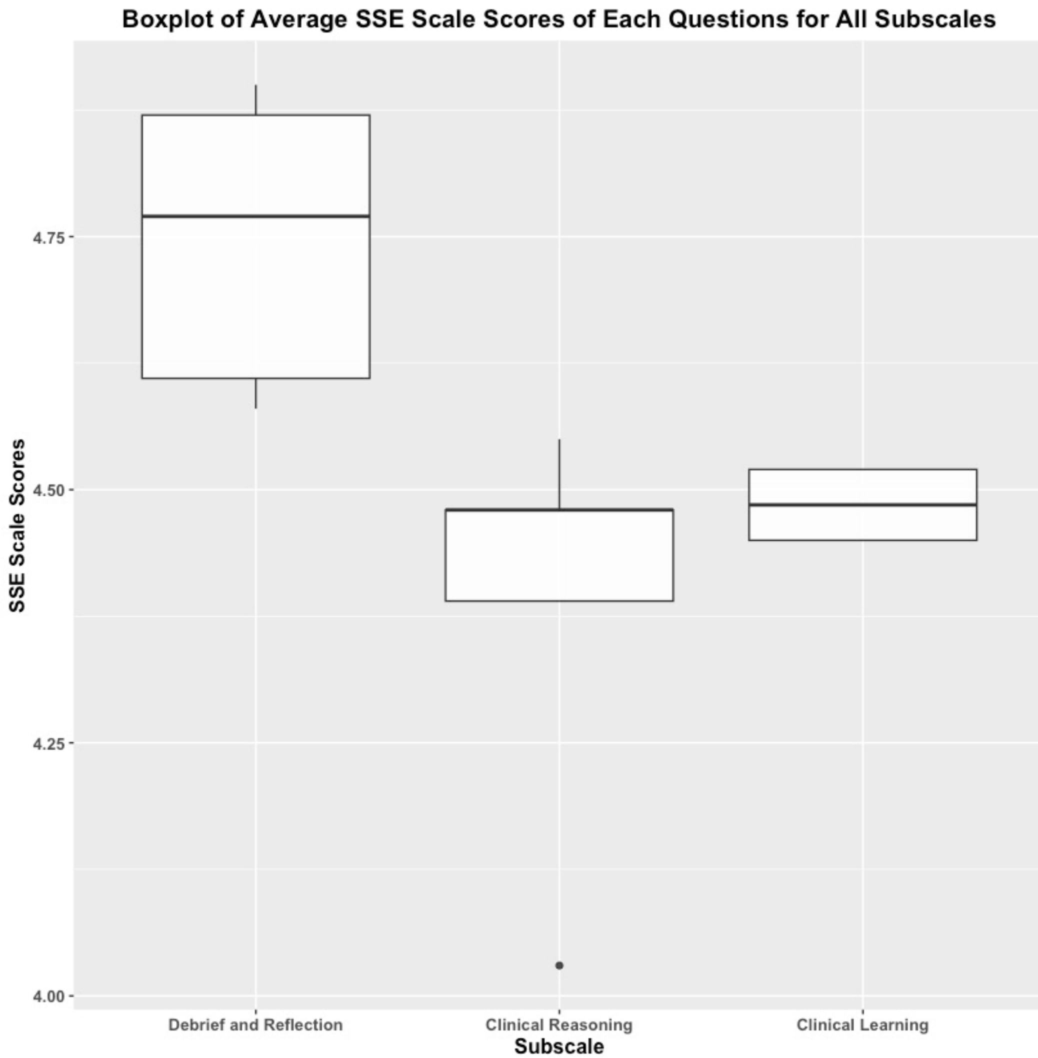
Tukey's HSD Results Satisfaction with Simulation Experience (SSE) Scale

Subscale	**Difference**	**Lower Bound**	**Upper Bound**	**p values**
Clinical Reasoning/Debrief and Reflection	-0.355	-0.564	-0.146	0.001
Clinical Learning/Debrief and Reflection	-0.256	-0.482	-0.031	0.025
Clinical Learning/Clinical Reasoning	0.099	-0.153	0.351	0.575

Figure 2 is a boxplot that illustrates the Tukey's HSD result. The boxplot shows the differences in the subscales debrief and reflection, clinical reasoning, and clinical learning.

Figure 2

Boxplot Satisfaction with Simulation Experience Scale (SSE) Scale Subscales



4.2 Qualitative Data Analysis

This chapter presents findings from the quantitative and qualitative data analysis. The quantitative data analysis focused on the impact of the computer-based simulation on knowledge and satisfaction. The qualitative portion of the study explored the current state of nursing education in relation to the nursing student's experiences with interruptions and interruption management. The qualitative data analysis methods for the focus group interviews were based on constant-comparative analysis (Ravitch & Mittenfelner Carl, 2016). The process of analysis included jotting and field notes, audio and video Zoom recording, transcription, and coding. The researcher's jotted notes were reviewed and completed creating complete field notes within 24 hours of the focus group interview experience to promote validity and reliability. The focus group discussions were audio and video recorded in Zoom, then transcribed to establish validity and reliability of the data obtained from the interviews (Ravitch & Mittenfelner Carl, 2016). The focus group data analysis process included analyzing the utterances, assigning codes, reviewing the codes, merging and eliminating codes, a second person reviewing the codes, creating categories of codes, and developing related categories and themes or patterns. The utterances were entered into an excel spreadsheet and patterns in the interviews were identified, then a coding scheme was identified. A second person reviewed the codes and data to agree there is 100% intersubjective agreement, and there was final agreement on the codes, categories, and themes that emerged.

The validity of the qualitative portion of the study was enhanced through triangulation including dialogical engagement strategies in the form of peer debriefer, structured reflexivity practices, and mixed method research (Ravitch & Mittenfelner Carl, 2016). The qualitative data analysis process included a peer debrief as an integral part of the coding process to provide feedback on codes, themes, and interpretations of the focus group data. The researcher engaged in reflexivity practice through monitoring, challenging, and engaging with personal biases by writing a personal bias statement before data analysis. The mixed-methods research design combines both qualitative methods including a focus group and quantitative methods including knowledge assessments and a satisfaction survey. The mixed-methods design supports improved qualitative rigor because the study provides multiple data sources and data points that can be compared to each other (Ravitch & Mittenfelner Carl, 2016). Credibility of the study was enhanced through the use of simulation practices and student assignments that were consistent with the developer recommendations.

The confidentiality of the research records was protected by the principal investigator storing the data on a computer with access protected by a password. The research data were coded so that no data can be linked back to the participant. Participant names were replaced with participant numbers and pseudonyms so no participant names were used. The Zoom recordings of the focus group discussions were saved on the University portion of the cloud and the transcriptions were downloaded to a password-protected computer. After the focus group Zoom recording was transcribed, the recording was deleted. Any identifying information on the transcript was removed and replaced with the participant's number. The typed focus group transcription was kept on a password-protected computer and printed copies were kept in a locked office. Information collected during this project may be shared with other researchers or used for future research studies. However, no information that can identify a participant will be shared. Study participants could request that the recording be paused at any time during the focus group. The data will be kept for three years after the study is complete, then the data will be destroyed. The results of the study may be published or presented in professional journals or conferences. Table 13 introduces the identified themes resulting from the research outcomes, both quantitative and qualitative.

The study sample size was 48 participants with 31 participants completing the focus group discussion. Throughout the process of analyzing utterances, assigning codes, merging codes, eliminating codes, and creating categories of codes, the researcher extrapolated six themes (Table 13). The five attributes of an interruption, "(1) a human experience; (2) an intrusion of a secondary, unplanned, and unexpected task; (3) discontinuity; (4) externally or internally initiated; and (5) situated within a context" (Brixey et al., 2007, p. E30), informed coding.

Table 13

Study Themes

Theme	Categories
Theme 1: What are interruptions	• Description • Types • External: Person • External: Device • Internal
Theme 2: What are the effects of interruptions	• Emotions • Outcomes
Theme 3: How to manage interruptions	• Prioritization • Delegation • Blocking • Resuming patient care strategies • Patient Communication Strategies • Self-management strategies
Theme 4: How participants learn about interruptions	• Clinical setting • Non-clinical setting • Experience
Theme 5: The difference in computer-based simulation and real life	• Computer-based simulated clinical setting • Real life
Theme 6: How is computer-based simulation with interruptions beneficial	• Assist learning • Future nursing practice

Furthermore, the 4-level taxonomy for managing interruptions, (a) engaging a higher priority secondary task immediately by suspending a primary task; (b) multitasking resulting in both tasks being done simultaneously by splitting attention; (c) mediation involving prospective memory, deflection, or delegation of a task; and (d) blocking the secondary task due to the higher priority of the primary task (Colligan & Bass, 2012), also informed coding. The first theme (what are interruptions) and the second theme (what are the effects of interruptions) emerged from Focus Group Questions 1, 2, and 3. The third theme (how to manage interruptions) emerged from Question 4. The fourth theme (how nursing students learn about interruptions) emerged from Questions 5, 6, and 7. The fifth theme (the difference in computer-based simulation and real life) emerged from Focus Group Question 8. The sixth theme (how computer-based simulation with interruptions assist learning and future nursing practice) emerged from Focus Group Questions 9 and 10.

Table 14

Theme 1: What are Interruptions

		# Participants	# Utterances
Descriptions	Something else that needs attention	1	1
	Get side tracked off of what I am doing	1	1
	Interruptions are a part of my job	1	1
	Surprising	1	1
Type: External: People	Patient physiologic needs	19	22
	Healthcare team member entering the room	8	8
	Patient environmental needs	7	7
	Family member asking questions	7	7
	Family visits	5	6
	Patient asking questions/talking	5	5
	Patient procedure/test	4	5
	Healthcare team member communicating with the nurse	4	4
	Higher acuity patient	3	4
	Code blue/Rapid response	3	3
	Administering medication	2	2
	Multiple things happening at the same time	2	2
	Patient getting out of bed	1	2
	New healthcare provider order	1	1
Type: External: Device	Phone calls	14	28
	Technology (smart watches, ear pieces)	11	13
	Background noise	7	7
	Alarms	5	10
	Call light	3	3
	Technology issues (not working)	1	1
Types; Internal	Thinking about other things	2	2

Table 14 depicts the first theme, what are interruptions, including both descriptions and types of interruptions provided by the participants. The types of interruptions are grouped according to the following categories (a) externally initiated by people, (b) externally initiated by a device, and (c) internally initiated (Brixey et al., 2007). The participants described interruptions as something else needing attention, something causing a nurse to get side tracked, surprising, and as a part of the job. The participants described numerous types of externally initiated interruptions by people, such as patient needs, healthcare team member interactions, and patient procedures. Furthermore, participants shared several specific patient physiologic needs that cause interruptions like vomiting, chest pain, bathroom assistance, feeling cold, drink of water, pain, and mobility assistance.

The participants also described externally initiated interruptions by technology devices, such as a work phone, earpieces, and a smart watch. Elaine described observing a nurse in the ICU using earpieces that "like talk to them." Elaine further expressed concern about using the earpieces, stating:

> I feel like having an ear bud in with noise coming through anytime I'm talking to someone or a patient, I don't really know how I would initially cope with that or you know, try to process what is coming in my ear and what I'm saying to people, it would throw me off.

Anne also described technology devices as an interruption stating "a lot of nurses wear apple watches, so when they get a notification, it shows up on their phone and they look at it. I think that is a big distraction." The description of technology as an interruption by the participants indicates the use of technology that is meant to improve the accessibility and availability of the nurse may also increase the number of interruptions that the nurse must manage.

Table 15 demonstrates the second theme, the effects of interruptions, including the reported emotions and outcomes relating to interruptions. The participants in the study described two different types of effects of interruptions including the feelings associated with interruptions and the effect on the outcome of the procedure or activity being interrupted. Many of the participants expressed feeling frustrated and annoyed when they experienced an interruption. Betty described the feelings experienced with an interruption by stating “I could get a little bit flustered and feel like I'm losing control of things because there's just so much going on at the time.” Another study participant, Angie, described the feeling associated with interruptions as being annoyed by stating “when I got an interruption I'd be annoyed because I'd have to get off what I was doing and try and use my knowledge and brain to figure out a whole different problem.” Table 15 explores the second theme’s analytic outcomes. The participants in the study also described the effect of background noise as an interruption. Sue expressed the feeling associated with background noise as annoyance by stating “you’re like annoyed by those sounds and you just want them to go off and go away.”

Table 15

Theme 2 What are the Effects of Interruptions

		# Participants	# Utterances
Emotions	Frustration	8	15
	Annoyance	8	9
	Stress	2	2
	Agitation	1	2
	Anger	1	2
	Loss of control	1	1
	Overwhelming	1	1
	Need to hurry or rush	1	1

(table continues)

		# Participants	# Utterances
Outcomes	Medication error	10	16
	Takes more time	9	14
	Patient harm or death	9	10
	Forgetfulness	9	10
	Distraction	8	10
	Stops progress of activity or skill	5	8
	Confusion	2	2
	Delay in care	1	1
	Unaware of error	1	1
	Alarm fatigue	1	1
	Delegation error	1	1

The participants also described the effect on the outcome of the procedure or activity being interrupted. Some of the possible interruption outcomes described were medication errors, procedures taking more time to complete, a delay in patient care, and patient harm or death. The participants also described experiencing forgetfulness, distraction, confusion, and being unaware of errors in response to interruptions. The description by Amelia conveyed the potential negative outcome of being interrupted, as well as the potentially worse outcome of making an error and lacking awareness of the error by stating:

> Maybe you would not even realize that you made the mistake, so you would not catch it at first and then their [patient] condition deteriorates to like a pretty bad state, because you may not have realized that you made the mistake at the time, and you may not find out until you know, like till something really bad is already happening.

Table 16 illustrates the third theme, how to manage interruptions, described by the participants in this study according to the 4-level taxonomy for managing interruptions including prioritization, multitasking, mediation (prospective memory, deflection, or delegation), and blocking (Colligan & Bass, 2012). The participants described three of the four strategies including prioritization, delegation, and blocking. The remaining interruption management strategies were grouped into self-management, resuming care tactics, and patient communication techniques.

Table 16

Theme 3 How to Manage Interruptions: Strategies

		# Participants	# Utterances
Prioritization	Prioritization	12	26
Delegation	Delegation	12	18
	Scope of practice	9	12
	Determine who is available	4	4
	Teamwork	1	1
Blocking	Block out the noise	3	3
	Ask a person to wait	2	2
	Decline a phone call	1	2
	Put the person on the phone on hold	1	2
	Ignore the interruptions	1	1
	Silencing an alarm	1	1
	Do not have a smart watch	1	1
Resuming Patient Care	Start procedure over	15	26
	Repeat checks	7	11
	Remember what you were doing before the interruption	3	3
	Write down what you need to do (note taking)	2	5
	Go back to what I was doing before the interruption at that point and move forward	1	2
	Return to what you were doing before the interruption	1	1
	Follow the procedure	1	1
	Make a schedule for the day	1	1
	Learning to remember the other patient needs	1	1
	Distance yourself from distractions	1	1
	Avoid interruptions	1	1
Patient Commun-ication	Communication	8	9
	Tell the patient that you will be back after the interruption	3	3
	Follow through on agreements with patients to return to their room after the interruption	1	1

(table continues)

		# Participants	# Utterances
Self-Management	Re-focus	5	10
	Grounding self	2	2
	Take a breath	1	4
	Focus on what I am doing	1	2
	Think about it	1	1
	Mindfulness	1	1
	Controlling emotions	1	1
	Gather my thoughts	1	1

The participants discussed delegation as a predominate interruption management strategy, including applying knowledge about the scope of practice of the healthcare team and delegating tasks according to what the team member's training and license dictates. Blocking was discussed by the participants as a strategy for interruption management; however, this strategy was discussed less than prioritization and delegation. Some of the blocking strategies listed by the participants were asking someone to wait, declining a phone call, ignoring an interruption, or silencing an alarm. Amanda explained her thoughts about blocking by stating:

> I do not ever want to have like a hardened heart or attitude towards these patients when to them their needs are really real in that moment, and my job is to just prioritize and care for them the same with genuine care.

The perceptions of not being compassionate or responsive to a need because of blocking an interruption may reduce the use of blocking as a strategy. Less discussion by the participants about blocking as a strategy may be related to the participant's reluctance to block interruptions. Colligan and Bass (2012) suggested that "empowering interruptees to block or mediate interruptions may improve their ability to filter distracting low priority secondary task.

Numerous participants listed starting a procedure over or repeating checks in response to an interruption with the procedure taking more time to complete or another patient experiencing a delay in care. A few participants expressed the need to remember what you were doing before the interruption, use note taking to stay on track, and resume a task at the same point the interruption occurred. Several participants conveyed the importance of communicating with patients as an interruption management strategy by letting them know that you (the nurse) care about their needs and will be back. Amelia described this strategy by stating "I feel like communication is a really important one, if you're having to leave a patient to tend to another one, communicating that you will be back and that their needs are still important to you."

Table 17 illustrates the fourth theme, how nursing students learn about interruptions. The participants discussed learning about interruptions in the clinical setting, non-clinical setting, and through experience. The participants described learning about interruption management in the clinical setting by observing nurses handle interruptions. Jenny highlighted the importance of nursing students engaging in opportunities to observe a nurse handle an interruption by stating "when we observe somebody else dealing with an interruption, I feel like we need to embrace that as a learning opportunity and answer, how did they handle it?"

Table 17

Theme 4 How Nursing Students Learn About Interruptions

		# Participants	# Utterances
Clinical setting	Clinical setting	9	15
	Observing nurses manage interruptions	5	6
Non-clinical setting	Everyday life: Homework and studying interruptions	4	4
	Everyday life: Timed quiz interruptions	1	1
	Everyday life: Text alerts	1	1
	Everyday life: TV commercials	1	1
Experience	Practice	3	5
	Previous job experience	3	3
	Learn from mistakes	1	1

The participants further described how they learn about interruption management through exposure to interruptions in everyday life like TV commercials, homework interruptions, timed quiz interruptions, and text alerts. Barbara described learning about interruptions through exposure to commercials by stating “the commercials that come on during your show, that is where I learned about my first interruptions.” Another strategy identified by the study participants for learning to manage interruptions was experience. Dana’s comments supported practice as a tactic for gaining experience and learning to manage interruptions. Dana explained how practicing interruption management helps you to know what to do when an interruption occurs by stating “now it is like I'm familiar with this interruption I know exactly what to do now, because I've gone through this interruption and I know who to delegate it to, so I think, the more you practice it then the easier it gets.”

The participants in this study listed several settings and types of opportunities to learn about interruptions; however, the conversations were devoid of any references to classroom, lab, or high-fidelity simulation-based education as methods for learning about interruption management. The participants in this study never mentioned or discussed learning about interruption management in nursing theory classes, from a nursing textbook, lab setting, or high-fidelity simulation.

Table 18 depicts the fifth theme, the difference in computer-based simulation and real-life. The participants described the difference between computer-based simulation and real life in terms of the possibility of real patient harm, pausing a situation, and time. Jane described the computer-based simulation as “a safe space to learn those lessons about how to deal with interruptions.” Barbara further described the safe space of computer-based simulation by stating “it allows you to make mistakes and not actually physically hurt someone.” Leigh also described simulation as a safe space stating “that in simulation you're not going to kill anybody.” In contrast, April described potential real-life effects stating “in real life, you could actually kill them [patient], or you could really hurt their health”

Table 18

Theme 5 The Difference in Computer-Based Simulation and Real-Life

		# Participants	# Utterances
Computer-based simulated clinical setting	No patient harm or serious consequences	7	8
	Complexity of interruptions	2	4
	No family members at the bedside	1	2
	Can pause the simulation	1	2
	Time	1	1
	Safe space to learn about interruptions	1	1
	Sound and alarms can be muted	1	1
Real life	Could be patient harm in real life	1	1
	Interruptions in the clinical settings are unknown	1	1
	Clinical is more stressful	1	1
	Real life has real people	1	1
	In real life you have to deal with it now	1	1
	People get angry in the real world	1	1
	Being okay with asking for help from your team	1	1

The participants described real life as different from computer-based simulation. Kelly described real life as pressing, something that cannot be paused, and as requiring timely attention. Kelly stated:

> When I realized I have like multiple pressing things that needed to get done, these are real people they are not computer people. I cannot just hit pause on my computer and walk away. I have to deal with this now, it needs to be taken care of in a timely manner.

Furthermore, the participant descriptions of real-life interruptions conveyed that interruptions are not planned. May described interruptions in real life as “surprising.” Table 19 illustrates the sixth theme, how is computer-based simulation with interruptions beneficial. The participants described computer-based simulation with interruptions as beneficial to their learning. The participants reported learning about delegation and scope of practice. Amy described the computer-based simulation as supporting the development of delegation skills by conveying that computer-based simulation with interruptions "helps us figure out what we can delegate." The participants described the computer-based simulation with interruptions as having a positive impact on their knowledge about scope of practice. Pam stated "it really helped with learning the scope of practice of the different people in the hospital setting."

Table 19

Theme 6 How is Computer-Based Simulation with Interruptions Beneficial

		# Participants	# Utterances
Assist learning	I should take my time	2	3
	Double check after an interruption	1	2
	Complete all the procedure steps	1	1
	Re-start the procedure after an interruption	1	1
	How to get back on task after an interruption	2	2
	Time management	1	1
	Try to finish one thing at a time	1	1
Future nursing practice	Learning to delegate	5	5
	Learning scope of practice	4	5
	Learning to prioritize	3	3
	Practicing with interruptions	2	2
	Realizing that there are going to be interruptions	2	2
	Self-awareness of being vulnerable to making a mistake	1	1
	Learning to focus with background noise	1	1

The participants described the computer-based simulation with interruptions as a platform to learn about interruptions including a vulnerability to making mistakes and realizing that interruptions are going to happen. Sally conveyed thoughts about discovering a vulnerability to making mistakes by stating:

> I am vulnerable to making mistakes and I need to be careful, because in the real world I will be dealing with real people and we will not have the luxury of always being able to make a mistake and not have serious consequences.

Other participants conveyed an understanding that interruptions are going to happen. Andrea explained “being a nurse, interruptions are going to be a part of your job, regardless so it's just something that you're going to have to do, whether you like it or not.” Another participant explained how the computer-based simulation with interruptions promoted an understanding of the occurrences of interruptions. Pat stated, “I think it helps me recognize that interruptions are going to happen and helps me to deal with that interruption and then to refocus on what I was doing prior to the interruption.”

CHAPTER 5

DISCUSSION AND CONCLUSION

The purpose of this study was to (a) explore the current state of nursing education in relation to the nursing student's experiences with interruptions and interruption management and (b) evaluate the impact of computer-based simulation on senior second semester undergraduate baccalaureate nursing students' knowledge and satisfaction. The study results demonstrated that the participants were satisfied with the computer-based simulation. The themes that emerged from this study describe the current state of the nursing student's experience with interruptions and interruption management. The following section includes the limitations of findings, recommendations, and future research topics.

5.1 Limitations of Findings

The convenience sampling method, small sample size, and a location that may or may not be representative limits the generalizability of the study results. The focus groups explored second semester senior nursing students' education and experience with interruptions and interruption management. The study did not explore first, second, or third semester nursing students' education and experience with interruptions and interruption management. Furthermore, the study did not explore the perspectives of the professional nursing education program faculty or school administrators on inclusion of interruptions and interruption management in the curriculum of professional nursing educational programs.

5.2 Recommendations for Improvement

The first recommendation is to use computer-based simulation with interruptions to facilitate the education of nursing students and professional nurses about interruptions and interruption management. The computer-based simulation education needs to include all three simulation phases. The debriefing needs to encompass interruption and interruption management discussion including (a) interruption identification of external person, external device, and internal (Brixey et al., 2007); (b) effects of interruptions on emotional responses and patient outcomes; (c) the strategies prioritization, multitasking, mediation (prospective memory, deflection, or delegation), and blocking (Colligan & Bass, 2012); (d) resuming patient care strategies; (e) patient communication strategies; and (f) self-management strategies.

The second recommendation is for nurse educators to integrate interruption and interruption management education throughout professional nursing education. Interruptions are a part of the clinical environment; therefore, the entry level professional nurse must be prepared to manage interruptions. Nurse educators must deliberately integrate interruption and interruption management education into the curriculum of all professional nurse educational programs including didactic, clinical, lab, and simulation settings. Interruption and interruption management concepts must be incorporated into textbooks, case studies, critical thinking exercises, and clinical judgement activities. Furthermore, interruption and interruption management concepts need to be a part of program objectives, course objectives, examinations, clinical evaluation tools, simulation evaluation tools, outcome measurements, and the program evaluation.

The third recommendation is to add interruption and interruption management concept to The Essentials: Core Competencies for Professional Nursing Education (AACN, 2021). The void of interruption management content in the nursing curriculum was evident in this study. The addition of interruption and interruption management concepts to the essentials would drive the education of all professional nursing students on interruption management.

The fourth recommendation is to incorporate the concepts of interruption and interruption management into high-fidelity clinical simulation scenarios. Scenarios with specific learning objectives focusing on interruptions and interruption management would provide an opportunity for students to practice interruption management and gain experience implementing interruption management strategies in a safe environment without the possibility of patient harm. Increasing opportunities and settings where nursing students can gain experience with interruptions and interruption management may increase the skills and ability of the entry level nurse to manage interruptions and thus reduce errors and patient harm in the clinical setting.

The fifth recommendation is to develop and implement tools that support and facilitate the management of interruptions to address prioritization, multitasking, delegation, blocking (Colligan & Bass, 2012), resuming patient care strategies, patient communication strategies, and self-management strategies. Example tools include (a) algorithms for prioritization, multitasking, delegation, and blocking; (b) worksheets for tracking and resuming patient care after an interruption; (c) patient communication guides for use during interruptions; and (d) strategies for self-management of emotions and responses. Furthermore, the healthcare team may benefit from the development and implementation of a healthcare team member communication guide for use during interruptions and interruption management. The recommendation to develop and implement worksheets for tracking and resuming patient care after an interruption is consistent with the recommendation by Li et al. (2011) to "provide environmental cues to aid recovery from interruptions" (p. 10). Li et al. (2011) further supported the recommendation by stating that "recovery from interruption is enhanced if there are cues in the environment that provide reminders about a previous task and its state" (p. 10).

5.3 Future Research

Future research should focus on the development of tools to manage interruptions, including algorithms, worksheets, and guides. Some examples of potential tools that may assist in the management of interruptions are (a) notetaking as a tactic for resuming a procedure or task after an interruption; (b) worksheets to assist with remembering and tracking tasks that need resuming after an interruption; (c) algorithms for prioritizing, multitasking, delegating, and blocking; and (d) patient communication guides for managing interruptions. The healthcare team also needs guidance on communication about interruptions and interruption management. The development of a healthcare team interruption and interruption management communication guide that includes a list of key words relating to interruptions and interruption management, identifies interruption management strategies in process, and identifies expected team responses, may improve the awareness, communication, and management of interruption by the entire healthcare team. Furthermore, research focusing on the impact of high-fidelity simulation with objectives on interruption management needs to be conducted to identify best practices for teaching interruptions and interruption management in simulation and inform nurse educators about the readiness of nursing students to manage interruptions in the clinical setting.

Computer-based simulation with interruptions needs to be analyzed in the context of other fields. Other professional fields must also manage interruptions as a part of their daily work. Occupations outside of the healthcare industry may benefit from computer-based simulation with interruptions, such as teachers, childcare workers, social workers, firefighters, veterinarians, police officers, detectives, chefs, and head cooks.

5.4 Conclusion

The purpose of this study was to (a) evaluate the impact of computer-based simulation on senior second semester undergraduate baccalaureate nursing students' knowledge and satisfaction and (b) explore the current state of nursing education in relation to the nursing student's experiences with interruptions and interruption management The participants in this study reported satisfaction with the computer-based simulation and described how the computer-based simulations with interruptions assisted their (a) learning about interruptions and interruption management and (b) future nursing practice.

The results of this study demonstrate that the professional nursing education of the study participants was devoid of interruption and interruption management education in the classroom, lab, and high-fidelity simulation. The themes that emerged from this study describe the current state of the second semester nursing student's experience with interruptions and interruption management and inform the need for interruption and interruption management education in professional nursing educational programs. The recommendations of this study to include interruption and interruption management education in professional nursing programs are consistent with recommendations by Colligan and Bass (2012), Hayes et al. (2015), and Li et al. (2011) to provide training on interruption handling. In addition, the themes that emerged in this study inform future research relating to the best practices for computer-based simulation, high-fidelity simulation, and professional nursing education programs to teach about interruptions and interruption management.

Nurse education programs are evolving with changes in technology to meet the complex clinical environment and workforce needs. Computer-based simulation is an innovative, cost-effective learning tool that provides a realistic environment for students to practice decision-making and delegation skills without the possibility of patient harm (Coyne et al., 2021; Foronda & Bauman, 2014; Foronda et al., 2017; Simpson, 2002). Computer-based simulation can be done anywhere anytime without faculty presence, thus requiring less resources than clinical experiences or high-fidelity simulation (Foronda et al., 2018; Foronda & Bauman, 2014;

Josephsen & Butt, 2014). The repeated practice feature of the computer-based simulation provides an opportunity for learners to build experience that may drive future action in clinical situations (Foronda & Bauman, 2014). The realistic learning environment and repeated practice of simulation scenarios promotes the development of critical-thinking skills, knowledge, and confidence to prepare nurses to enter the workforce practice ready (Coyne et al., 2021; Foronda & Bauman, 2014).

APPENDIX A

CONSENT FORM

Principal Investigator: Lisa Otto, MSN, RN, CMSRN, CHSE, CNE
Study Sponsor: J. Michael Spector

You are invited to participate in a research study about computer-based simulation and your experience with interruptions and interruption management.

If you agree to be part of the research study, you will complete the prebrief and technology orientation, computer-based simulation assignments, and discussion board debriefing sessions assigned in your regular course work. You will also be asked to complete a written 10 question medication calculation knowledge pretest and posttest, eighteen question satisfaction survey, group discussion debriefing session, and focus group discussion. The focus group will be a group discussion led by the principal investigator, Lisa Otto. The focus group will last approximately 30 minutes. The topic discussed during the focus group will be about your experience with interruptions. The focus group will be audio/video recorded in order to accurately capture what is said. Study participants can request that the recording be paused at any time.

If you agree to participate in the research study, it should take you no longer than two hours to complete.

Benefits of the research include no direct benefits to the participant but we hope to learn about the effect of computer-based simulation on knowledge gain and satisfaction including debrief and reflection, clinical reasoning, and clinical learning in undergraduate baccalaureate nursing students. In addition, we hope to gain insight about nursing students' experience with interruptions.

Potential risks and discomforts include no anticipation of risk in this study other than those in day-to-day life. You may find some of the questions about interruptions to be sensitive but it is not expected that this would be different from the kinds of things you discuss with family or friends. Participants may feel some pressure to reveal feelings or experiences to the group. If participants share their experiences with peers, they may feel vulnerable during or after the group.

Compensation to participate in the study is not provided.

Participating in this study is completely voluntary, and there is no penalty or loss of benefits for refusal to participate. Even if you decide to participate now, you may change your mind and stop at any time, and there is no penalty or loss of benefits. You may choose not to answer any pretest or post question, survey question, or continue with the focus group for any reason.

The confidentiality of your research records will be protected by the principal investigator storing the data on an external hard drive with access protection by a password. The research data will be coded so that all data is anonymous and cannot be linked back to the participant. The satisfaction survey will be anonymous and completed online. The audio recordings of the focus group discussion will be kept on a password protected external hard drive. After the focus group recording is transcribed and typed it will be destroyed. The typed transcription will be kept on the password-protected external hard drive and any printed copies will be kept in a locked file cabinet in a locked office. Only the research team will be able to read the typed version of the recording.

The results of the study may be published and/or presented in professional journals and or conferences.
Information collected in this project may be shared with other researchers or used for future research studies. However, we will not share any information that could identify you.

If you have questions about this research study, please contact Lisa Otto, email [redacted] or phone (xxx)xxx-xxxx.

The University Institutional Review Board operates independently from the investigator named above, and can be reached for questions, concerns, complaints, injuries, and more information about subjects' rights. Institutional Review board can be reached at [redacted] or (xxx)xxx-xxxx.

By signing this document, you are agreeing to be in this study. Make sure you understand what the study is about before you sign. I/We will give you a copy of this document for your records and I/we will keep a copy with the study records. If you have any questions about the study after you sign this document, you can contact the study team using the information in provided above.

I understand what the study is about and my questions so far have been answered. I agree to take part in this study.

Print Legal Name: ____

Signature: ____

Date of Signature (mm/dd/yy): ____

APPENDIX B

DEMOGRAPHIC SURVEY

Demographical Information

Participant Name: ________________________________

Contact Email: ________________________________

Instructions: Please complete the demographic information below. Circle the most correct answer.

Gender:	Male	Female	Prefer not to say	
Age	18-20 years	20-30 years	31-40 years	
	41-50 years	51-60 years	>60 years	
Ethnicity:	White or Caucasian		Black or African American	
	Hispanic or Latino		Asian	
	American Indian or Alaskan Native			
	Native Hawaiian or other Pacific islander			
	Other (specify)____________			
Theory Course Section	.010	.020		
Clinical Course Section	570	580	590	
	610	620	630	640
	650	660	670	680
	690			
	710	720	730	740
	750	760		

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