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EFFICACY OF SCREEN-BASED VIRTUAL SIMULATION IN NURSING EDUCATION: COMPARATIVE ANALYSIS

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HO-SUP KIM

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Ho-Sup Kim

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The thesis examination committee certifies that the thesis
and the oral examination is approved

Supervisors:

Dr. Karen Cook
Athabasca University

Dr. Barbara Wilson-Keates
Red Deer Polytechnic

External Examiner:
Dr. Treva Job
Georgian College

February 28, 2024

1 University Drive, Athabasca, AB, T9S 3A3 Canada
Toll-free (CAN/U.S.) 1.800.788.9041 ex. 6821
fgs@athabascau.ca | fgs.athabascau.ca | athabascau.ca

Abstract

Nursing education is increasingly incorporating virtual simulation-based experiences (SBE), to provide learners with realistic clinical scenarios. While existing literature supports the effectiveness of virtual simulations, there is a need for more evidence to establish their overall effectiveness compared to traditional manikin-based SBE. To address this knowledge gap, a pilot study was conducted, guided by Kolb's Experiential Learning Theory and the NLN Jeffries Simulation Theory. The study compared the pedagogical effectiveness of virtual SBE with manikin-based SBE in terms of learner satisfaction, self-confidence, knowledge acquisition, skills development, and the transfer of learning to clinical practice. Participants (N = 30) were randomly assigned to engage in either a screen-based serious game or a manikin-based SBE, both with the same learning objectives and clinical indicators. Findings indicate that virtual serious games had less pedagogical effectiveness than manikin-based simulations in terms of learner confidence, knowledge acquisition, and critical thinking categories of learning. However, except for critical thinking aspects of learning of which manikin-based simulations were reported to be more effective, there was no statistically significant difference between the two modalities.

Keywords: virtual simulation, screen-based, effectiveness, efficacy, evaluation

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AR	Augmented Reality
BCIT	British Columbia Institute of Technology
CLECs 2.0	Clinical Learning Environment Comparison Survey 2.0
CRSS	Clinical Reasoning Skills Scale
COVID-19	Coronavirus Disease 2019
IBM SPSS	IBM Statistical Product and Service Solutions
NLN	National League of Nursing
PXI	Player Experience Inventory
SBE	Simulation-Based Experience
SET-M	Simulation Effectiveness Tool - Modified
SUS	System Usability Scale
VR	Virtual Reality

Chapter 1. Introduction

Nursing educational institutions are making greater use of virtual simulation activities. The use of virtual simulation-based experiences in nursing education increased in popularity during the recent COVID-19 pandemic (Fung et al., 2021). Faced with increased demand for nursing education due to chronic shortages of nurses in the workforce along with ever-dwindling clinical placements, there has been continued interest in the development of educational content that can be widely distributed while retaining high levels of fidelity and educational value. These factors along with continued technological advances have created an ideal environment for the continued proliferation of virtually simulated clinical content (Kamenšek, 2022). However, the pedagogical effectiveness of virtual simulation in nursing education is still under debate (Cant et al., 2022). Although virtual simulation is an experiential modality that enjoys wide acceptance and enthusiasm from both learners and educators (Leighton et al., 2021), further research is required to measure the effectiveness of virtual simulation as a pedagogical method, how it compares with pre-existing simulation modalities and whether it is worth incorporating into nursing education in the future past the COVID-19 pandemic.

Definition of Terms

Virtual simulations employ enhanced computer technology to present convincing clinical scenarios, integrating realistic settings with interactive learning for consolidation. Although all virtual simulations share this commonality, the term virtual simulation can be seen as an umbrella term for a variety of different types of simulations, reflecting the rapid pace of innovations within digital media. *Virtual reality* simulation involves

computer technology to craft a fully interactable three-dimensional world, offering simulated objects with a spatial presence. Like virtual reality simulations, *augmented reality simulations* overlay synthetic stimuli onto real-world objects to create simulated environments that blend both physical and digital presence (Lioce et al., 2020).

Computer-based simulations replicate real-life processes, with inputs and outputs confined to a computer, typically associated with a monitor and keyboard. *Screen-based simulations*, which can be seen as a type of computer-based virtual simulations, provide greater digital fidelity and intractability by presenting on to computer screens graphical images, animation, and text to engage learners through an immersive video game-like educational experience (Lioce et al., 2020). Serious games, played on computers, follow specific parameters and rules and much like their recreational counterparts, incorporate aspects of player autonomy and entertainment for educational purposes.

Simulations are often categorised by their levels of *environmental fidelity* which attempt to communicate how well simulated environments of a simulation session replicate real-world clinical situations. Often fidelity includes the use of manikins, rooms, equipment, and props but the term can also be used to communicate the level of realism of virtual simulations.

Screen-based Simulation-Based Experience

Simulation is a collaborative educational approach where a representation of a real event environment is created for learners to engage in learning and practice (Sanko, 2017). Since the earliest days of nursing education, simulations have been utilised as a pedagogical method and today, numerous educational institutions offer simulation content in dedicated practice laboratories. Simulations are offered in varying level of

fidelity (i.e. low, med, high), defined as the degree to which simulations accurately reflect physical, psychological, and environmental elements (Lioce et al., 2020).

Virtual simulations include distinct methods for delivering simulation content digitally. *Computer-Based simulations* are replications of real-life processes with inputs and outputs exclusively confined to a computer (i.e. presented on a monitor and navigated through keyboard and mouse) and are popular methods of virtual simulation delivery (Lioce et al., 2020). Computer-based simulations are also sometimes referred to as *screen-based simulations* defined as simulations presented onto a computer screen using graphical images and text and interactable by use of traditional computer interfaces (i.e. keyboard, mouse). Some screen-based simulations incorporate advanced graphics, sophisticated user interfaces and parameters, and rules to deliver simulated educational content similar to a computer game and are called *serious games* (Lioce et al., 2020).

The term virtual simulation also refers to virtual reality or augmented reality simulations. *Virtual reality simulations* utilise computer technology and virtual reality apparatus (i.e. virtual reality headsets) to create a fully interactable three-dimensional environment where objects have a sense of spatial presence that learners interact with to practice nursing and consolidate knowledge (Lioce et al., 2020). *Augmented reality simulation* is a type of virtual reality simulation where synthetic stimuli are superimposed onto real-world objects rather than fully generated like virtual reality simulations. Although many of these terms are often used interchangeably, it is important to distinguish screen-based virtual simulations from virtual reality simulations as these sub-categories of virtual simulations are sufficiently different in delivery methods and logistical consequences. While determining the effectiveness of all aspects of virtual

simulations is valuable, this research proposal will focus specifically on screen-based virtual simulations.

Manikin-based Simulation-Based Experience

Manikin-based simulation utilises lifelike models to replicate human physiology and create realistic clinical environments (Hayden et al., 2014). Degrees of replication can vary between the type of manikin, props, and artefacts utilised to replicate clinical realism but all manikin-based simulations provide in-person clinical replications via the use of physical props and technologies. Manikin-based simulations have been used for healthcare and nursing education in a variety of contexts ongoing developments are being made to enhance simulation fidelity, defined as the degree to which simulated environments, including manikins, simulation settings, and props replicate real environments and situations (Lioce et al., 2020).

Numerous research studies have explored the pedagogical outcomes of manikin-based simulations. Sullivan et al. (2019) argued that manikin-based simulation activities can provide a concentrated and focused training to learners in shorter time compared to traditional clinical experiences. Azizi et al. (2022) revealed the educational value of manikin-based simulations and concluded that simulation is an effective teaching methodology, helpful in improving both clinical performance and self-efficacy of learners. These studies systematically investigated the impact of manikin-based simulations on essential aspects of nursing, such as the development of psychomotor skills, knowledge acquisition, and learner confidence (Hayden et al., 2014; Lioce et al., 2020). Ongoing developments in simulation-based pedagogy continue to improve the overall effectiveness of preparing healthcare professionals for future clinical scenarios.

Simulation Effectiveness

Many nursing educational institutions across Canada have already introduced virtual simulations into their existing curriculum. On average, 51% for clinical courses and 34% for theory courses have used or are currently using virtual simulations as valid replacements of educational activities and/or traditional clinical hours (Canadian Association of Schools of Nursing, 2021). It is common practice for nursing educational institutes to replace traditional clinical hours with simulation-based experiences as research suggests that up to 50% of traditional clinical hours may be replaced with simulation activities (Hayden et al., 2014). While the data originates from a U.S. study, it is possible to draw similar conclusions for Canada, considering the careful evaluation of relevant factors. However, research studies have not conclusively determined whether virtual simulation experiences are similarly effective as in-person manikin-based experiences. Therefore, further discussion and research on whether screen-based virtual simulations are similarly effective in nursing education as in-person manikin-based simulations are necessary.

Statement of Problem

The objective of this research proposal is to determine the educational effectiveness of screen-based virtual simulations compared to in-person manikin-based simulations. If it can be shown that virtual simulations and in-person simulations have at least comparable levels of educational value, this may help justify the inclusion of virtual simulation-based experiences in nursing education curricula in the future.

Purpose

The purpose of the study is to determine the gap in knowledge regarding simulation efficacy in meeting learning outcomes for nursing students. Simulation-based education varies in its delivery methods and the technology used to carry out educational sessions, with virtual simulations, especially computer-based serious games, being a recent addition. Although studies on virtual simulation and its efficacy exist, there is not yet a critical mass of direct research conducted to measure the effectiveness of virtual simulation serious games and how they compare with the learning efficacy of traditional manikin-based simulation. Therefore, a direct comparison study is required to determine whether virtual simulations have educational value at least equivalent to other simulation modalities. This will enable decisions at an institutional and educational level to assess what kind of simulation-based experiences provide the greatest amount of learning support for students as well as inform whether virtual serious games meet curricular learning outcomes.

This research project was conceived with the objective of contributing to the greater body of knowledge by highlighting the similarities and differences, strengths, and challenges of the variety of simulation-based experiences available to students today. It aims to gauge whether certain activities have more educational merit than others so that decisions can be made at both the faculty and institutional levels to support specific activities both financially and pedagogically.

Research Question

This research aims to determine the pedagogical efficacy of simulation modalities. Specifically, the primary research question asks whether virtual simulations

(represented by screen-based serious games) are as effective in meeting the learning outcomes of nursing students as traditional manikin-based simulation-based activities.

A literature review was then conducted to ascertain whether there is sufficient evidence in the literature to indicate the effectiveness of screen-based virtual simulations in nursing education compared to equivalent in-person manikin-based simulations.

Chapter 2. Review of the Literature

Introduction

A review of academic literature was conducted on the topic of virtual simulation, evaluation, and efficacy. Academic articles made available by Cumulative Index to Nursing and Allied Health Literature (CINAHL) Plus and Medical Literature Analysis, and Retrieval System Online (MEDLINE) were included to best align the systematic literature review with the current body of knowledge relevant to nursing education and healthcare research and were searched using Athabasca University's Library and Scholarly Resources Database. Subjects of *virtual simulation*, *evaluation methods* (or *evaluation process* or *evaluation*), and *nursing* were searched. Subjects and terms relating to *virtual reality* (or *VR*), or *augmented reality (AR)* were excluded from the search terms to focus the literature review on computer-based simulations which aligns closer with the objectives of the research study. Only peer-reviewed academic journals that were published between 2018 and 2022 were included. This timeframe was chosen to reflect the reality of virtual simulations being a recent inclusion into nursing education and proliferating predominantly during the COVID-19 pandemic. The range was also chosen to align the literature review with the currency of academic content regarding virtual simulation education and virtual simulation technology. No geographical limitations were imposed but only articles in English were included in the literature review.

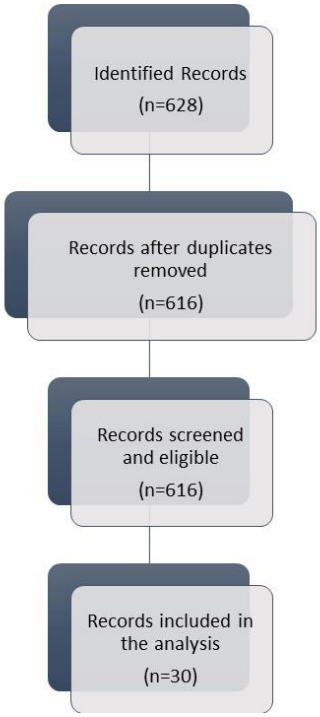
Literature Review Process

A total of 628 articles resulted from the search criteria. All editorials, opinion pieces, and conference transcripts were excluded to prevent the inclusion of rhetorical, non-

systematic, or non-experimental content in the review of literature. Articles that did not explicitly focus on virtual simulation and those that examined VR or AR simulations were manually excluded to align with the primary objectives of the research project. A further database search was then added to the literature review. Athabasca University Library and Scholarly Resources Database was again utilised and the subjects of *virtual simulation* with *evaluation* (or *assessment* or *measurement* or *analysis*) and nursing were included in the search. Subjects and terms relating to *virtual reality*, *VR*, or *augmented reality* were excluded from the search and only peer-reviewed academic journals published between 2018 and 2022 were included. The search resulted in 192 articles and a manual scan of the resulting articles was conducted to exclude any articles which were rhetorical or non-experimental.

Figure 1

Identification of Studies via databases and registers



Note: Number of studies included in review after introduction of all inclusion and exclusion criteria.

A manual review of 34 articles which satisfied all inclusion and exclusion criteria reviewed individually for suitability for the review of literature. After a closer study of the articles, one article was manually excluded as the contents of the study did not relate to virtual simulation technology. Another article was manually excluded as the paper experimented on the efficacy of virtual reality simulations only, and further two articles were removed as the study focused on simulation scenario design, rather than virtual simulation efficacy. Thirty articles satisfied all inclusion and exclusion criteria after the initial survey and were analysed as part of the literature review. Fifteen articles about virtual simulation efficacy conducted their research via meta-analysis or literature

reviews and 14 articles included an experimental design to evaluate the efficacy of virtual simulations.

A wide variety of experimental designs were utilised regarding virtual simulation efficacy. Among the literature, one conducted a meta-analysis, four conducted systematic literature reviews and two provided an analysis of descriptive statistics. The literature review included four studies of a qualitative design, nine quantitative analyses, and one mixed-method study. Of the nine quantitative studies, four studies employed a one-way pre-test/post-test method, and two studies utilised a post-test-only design. Only three studies conducted a randomized control test directly comparing the efficacy of virtual simulation with other simulation modalities or control groups.

Literature Review Synthesis

The majority of the literature concluded that virtual simulation was an innovative and effective simulation method for nursing education (Farsi et al., 2021; Fenzi et al., 2022; Fung et al., 2021; Havola et al., 2021; Joung & Kang, 2022; Keys et al., 2022; Kuszajewski et al., 2021; Mestre et al., 2022; Padilha et al., 2018; Pal et al., 2022; Plackett et al., 2022; Tjoflåt et al., 2018; Tolarba, 2021; Watari et al., 2020). Tolarba et al. (2018) concluded in their literature review on studies regarding the role and effectiveness of virtual simulations that virtual simulations displayed significant effectiveness in improving knowledge, skills, and affective domains of learning among learners. The above-mentioned studies examined the role of virtual simulation in nursing education and showed strong evidence of a positive impact on students' overall learning.

However, Cant et al. (2022), suggested that the effectiveness of virtual simulation required further analysis and closer scrutiny. The study concluded that while virtual

simulations remained an innovative and feasible option for nursing education, the actual effectiveness of virtual simulations (i.e. educational serious games) in improving student learning outcomes required further critical appraisal. While virtual simulations were increasingly utilised in medical education (including nursing education) with high levels of acceptance and engagement among students and nursing educators, the data on their pedagogical impact was less than conclusive, requiring further data to justify the simulation modality in experiential learning (Cant et al., 2021).

Measure of Efficacy

The variation in findings regarding the efficacy of virtual simulation in existing literature could stem from differing definitions and measurements of efficacy across studies on virtual simulation effectiveness. While the literature proposed a wide range of measures of efficacy and desired learning outcomes, studies had varied greatly in terms of what aspects of virtual simulation and learning were observed, and the definition of efficacy. For example, the topics and keywords varied among acquisition of theory, acquisition of skills, application of skills, affective skills, communication skills, critical thinking skills, teaching and learning skills, and clinical reasoning skills (Erlinger et al., 2019; Fenzi et al., 2022; Kuszajewski et al., 2021; Padilha et al., 2018; Plackett et al., 2022; Zhang et al., 2022).

Some studies evaluated the efficacy of virtual simulations by attributing simulation success to the successful performance of specific learning objectives within the simulation (Fung et al., 2021; Mestre et al., 2022). Other studies measured simulation efficacy based on learner satisfaction, feelings of self-efficacy, and user experience (Brown et al., 2021; Joung & Kang, 2022; Kuszajewski et al., 2021; Padilha et al., 2019).

The sheer range of definitions of success regarding virtual simulation may have contributed to a lack of a strong consensus in the body of knowledge regarding virtual simulations. Despite the lack of clear consensus in the literature, concepts of effectiveness in the literature had revolved around theory/skills acquisition, affective/communication skills, critical thinking/reasoning skills, as well as overall learner satisfaction.

Evaluation Method

Currently, there is no consensus on simulation evaluation methods or evaluation tools utilised. A review of experimental methods showed a wide array of evaluation methods, tests, and tools utilised to measure simulation efficacy. By far the most prevalent were Likert-scale questionnaires developed by researchers specifically to measure a specific experiment and given to participants to review and self-describe their experiences (Keys et al., 2021; Mestre et al., 2022; Pal et al., 2022; Tjoflåt et al., 2018; Watari et al., 2020; Zhang et al., 2022). One questionnaire elaborated on the validity and reliability of their evaluation method via attributing to an existing evaluation model (Technology Acceptance Model), whereas other studies did not include an extensive analysis on the validity and reliability of their evaluation tool (Padilha et al., 2018). This observation echoes the findings of a meta-analysis on virtual simulation efficacy that over half of the articles analysing the efficacy of virtual simulations did not include a reliability model or measured validity or reliability of their experimental methods or tools utilised (Plackett et al., 2022).

Some studies chose to utilise externally validated evaluation tools. The tools or methods however, varied widely as the evaluation subject matters and researchers did not

favour one specific evaluation method. Evaluation tools utilised included ones designed to measure student satisfaction such as the Simulation Effectiveness Tool Modified (SET-M) (Leighton et al., 2018; Brown et al., 2021; Kuszajewski et al., 2021). Other evaluation methods which attempted to measure student performance were also utilised such as; the Clinical Learning Environment Comparison Survey (CLECS 2.0) (Leighton et al., 2021; Brown et al., 2021; Fung et al., 2021), Clinical Reasoning Skills Scale (CRSS) (Havola et al., 2021), and the Self-learning Methodology in a Simulated Environment (MAES) (Fenzi et al., 2022; Rama et al., 2022). One final evaluation tool that attempts to evaluate the simulation experience, includes the Player Experience Inventory (PXI) (Verkuyl et al., 2022). Finally, rather than including a specific measurement tool, certain studies compared student performance directly via direct examination of learning objectives or measured the timeliness of the participants' ability to notice critical clinical assessment points to evaluate the efficacy of virtual simulations (Erlinger et al., 2019; Keys et al., 2021; Zhang et al., 2022). As there does not yet appear to be a favoured approach to how simulation efficacy is determined, researchers opted for a wide variety of evaluation methods and tools for their research.

Comparative Analysis

Only three studies included in this literature review conducted a randomized control trial to directly compare the efficacy of virtual simulations in comparison to other established simulation modalities. Padilha et al. (2018) carried out a randomized control study comparing 42 prelicensure nursing students using the *Learning Satisfaction with Simulation Tool*, a 10-point Likert-scale measurement tool. One-half of the students were randomly assigned to complete a computer-based simulation activity while the control

group was provided with an equivalent in-person simulation. The study found that the experimental group made more significant improvement in knowledge after intervention than the control group ($p < .001$; $d = 1.13$) and a higher level of learning satisfaction ($p < .001$; $d = 1.33$). There was no statistically significant difference in self-efficacy perceptions.

Brown et al. (2021) compared the effectiveness of virtual simulations to both manikin-based (traditional) simulation activities and online conferencing (face-to-face) simulation activities using three evaluation methods [SET-M, CLECS 2.0, and System Usability Scale (SUS)]. Almost 200 prelicensure nursing students from across 11 educational institutions participated in the study. The SUS scale indicated that virtual simulations were overall effective. Results from the CLECS 2.0 tool found statistically significant differences between in-person, virtual, and clinical experiences ($p = .002$). Between in-person and virtual simulations, a pairwise comparison indicated statistically significant differences in the communication ($p = <.001$), holism ($p = .021$), and thinking ($p = .003$) domains of education and no statistical difference in the simulation process ($p = .465$). Comparison of median (IQR) indicated that screen-based virtual simulations showed increased effectiveness in all CLECS 2.0 tool subcategories.

Farsi et al. (2020) conducted a three-pronged randomized control trial of a pre-test/post-test design involving 56 first semester nursing students enrolled in an eight-semester nursing program. Participants were assigned to either a manikin-based simulation, a virtual simulation game or, assigned not to receive simulation training. A questionnaire testing participant of knowledge regarding the educational objectives of the simulations (cardiopulmonary resuscitation) showed that while both manikin-based and

computer-based simulations showed statistically significant improvement in post-test scores ($p < .001$ for both), the differences in results between the two methods were not statistically significant (27:17 ± 2:81 vs. 25:72 ± 3:98, Mann–Whitney U test, $p = 0.988$, ns) (Farsi et al., 2020). The results of the comparison analysis suggest that virtual simulation is an effective replacement for traditional manikin-based simulations. However, the scantness of evidence along with the disparity between the methods and evaluation methods utilised invite further investigation on the matter of the efficacy of virtual simulations compared to traditional simulation modalities.

Significance

There is scholastic and practical significance in reviewing the current literature on virtual simulation efficacy. Through a review of literature, it is apparent that virtual simulation is generally well-regarded with nursing educators and nursing students. Studies that observe the perceived efficacy of simulations and participant experiences generally favour virtual simulations highly, find them a useful method in preparing for clinical experience and enjoy high levels of recommendation (Brown et al., 2021; Kuszajewski et al., 2021; Tjoflåt et al., 2018). Research data suggest that virtual simulation (serious games) reduces the psychological burden and assists in linking theory to practice (Joung & Kang, 2022). There is also data suggesting that the incorporation of virtual simulation activities with traditional manikin-based simulations improves the overall efficacy of the educational experience (Keys et al., 2021).

There does not appear to be a significant difference in simulation efficacy between screen-based virtual simulations and traditional manikin-based simulations. The experimental results of the three randomized control trial studies mentioned above

suggest that virtual simulation could be an effective replacement for traditional simulations (Brown et al., 2021; Farsi et al., 2020; Padilha et al., 2018). However, the body of evidence is scant requiring further inquiry and experimentation. Efficacy studies also have varying definitions and thresholds on simulation effectiveness, requiring further analysis and scrutiny. Future prospective studies on virtual simulation effectiveness may benefit from focusing on specific learning domains as determinants of simulation efficacy and relying on established and externally validated measurement tools or processes to measure effectiveness. These measures may help future studies contribute meaningfully to the emerging body of literature regarding virtual simulation efficacy.

Summary

The literature review conducted on virtual simulation efficacy in nursing education reveals a positive perception of virtual simulations among educators and students. The majority of studies advocate for the effectiveness of virtual simulations in enhancing knowledge, skills, and overall learning experiences. However, there is a lack of consensus on the definition and measurement of efficacy, with various studies employing diverse evaluation methods and tools.

Comparative analysis, including three randomized control trials, suggests that virtual simulations are on par with or potentially even superior to traditional manikin-based simulations. The significance of this research lies in the potential of virtual simulations to serve as effective replacements for traditional methods. Despite this, the limited evidence and varying definitions of simulation efficacy underscore the need for further investigation and standardization in evaluating virtual simulation effectiveness.

Chapter 3. Theoretical Framework

Introduction

A post-positivist view of research informed this research project and was incorporated into the design, implementation, and interpretation of the project. Additionally, it was guided by the conceptual frameworks outlined by Kolb's Experiential Learning Theory and the National League for Nursing (NLN)/Jeffries Simulation Theory. These theoretical perspectives shaped the understanding of learning pedagogy and simulation-based education. The research aimed to gauge and compare the pedagogical effectiveness of simulated clinical experiences across modalities, specifically virtual and in-person manikin-based simulations.

Statement of the Problem

There is not yet a consensus on the effectiveness of virtual simulations and virtual serious games compared to traditional manikin-based in-person simulations. Therefore, a direct comparison study was required to gauge the learning efficacies of both modalities. For this purpose, this research project created two simulation activities with equivalent content, differing only in the modality in which the educational experiences were presented. By comparing survey data provided by participants, using externally validated tools of learning efficacy, an assessment was made to see if one modality fared better than the other. Both manikin-based simulations and virtual simulations facilitate students' learning; however, it has not been determined whether one modality is more effective than the other in the various subcategories of teaching and learning, particularly about nursing knowledge.

Purpose of the Research

This research contributed to this growing body of literature by completing a pilot study that attempted to directly measure the pedagogical effectiveness of differing simulation modalities. The aim is to confirm or confirm the possibility that there is no statistically significant difference in simulation efficacy between modalities and to contribute to further research efforts by outlining the subcategories of learning efficacies, guided by current literature.

Conceptual Framework

A review of the literature on conceptual frameworks and/or guiding principles to define and outline the relevant parameters of simulation, simulation effectiveness, and simulation research was conducted. Kolb's Experiential Learning Theory and the National League for Nursing (NLN)/Jeffries Simulation Theory were identified as appropriate conceptual frameworks to guide research design and analysis.

Post-Positivism

The pilot study aimed to determine the effectiveness of screen-based virtual simulations compared to manikin-based simulations and was guided by the post-positivist approach to ontology and epistemology. The research operated under the assumption that while the existence of objective truths is present, they may not always be fully accessible for complete understanding. While objective truths may not always be directly accessible, knowledge can be derived through the falsification of hypotheses with well-defined concepts and variables, controlled conditions, precise instrumentation, and empirical testing, ultimately establishing probable truths (Bunniss & Kelly, 2010). Post-positivism guided this study and acknowledged the presence of objective truths that

may not be entirely accessible but could be derived through rigorous research methodologies and empirical testing.

In the context of comparing one simulation modality to another, the objective truth may not be directly knowable. However, through research informed by specific instrumentation techniques, controlled learning environments, and empirical data analysis, it was possible to draw a probable conclusion on how screen-based virtual simulations compared against in-person manikin-based simulations.

Kolb's Experiential Learning Theory

Kolb's Experiential Learning Theory conceptualizes educational and simulation experiences as opportunities for learners to reflect on what they have performed and notice various strengths and areas for improvement (Poore et al., 2014). Kolb's theory is based on the central concept that past experiences are foundational to the acquisition of new knowledge and this provides educators opportunities to promote critical thinking and learning (Kuszajewski et al., 2021). Kolb's theory asserts that learning is a process of creating knowledge that is dialectic, holistic, and integrative as well as a continuous cycle of learning and re-learning (Poore et al., 2014). Kolb's theory also states that learning is a direct result of interactions between learners and the environment, providing a conceptual justification for pedagogical simulation activities in education and nursing practice.

Kolb's Experiential Learning Theory consists of four phases in a cycle of learning (Poore et al., 2014). Concrete experiences, such as simulation activities provide opportunities for learners to participate in educational experiences. After concrete experiences, learners are encouraged to engage in reflective observation by critically

appraising their recent learning experience. Participants in simulation activities are often provided with guided reflection through simulation debriefing sessions. Learners reflect and identify the significance of the learning experience and consider what may have been done differently in the abstract conceptualization phase of learning. Reflections on performance then lead to active experimentation, where learners identify what was learned and how it would direct future practice.

During the research, the simulation activities provided to participants were designed to closely align with Kolb's Experiential Learning Theory, comprising the four phases in the cycle of learning. Participants engaged in concrete experiences through simulation activities. Subsequently, opportunities for reflective observation and abstract conceptualization were facilitated during debriefing sessions, which were conducted by subject matter experts with experience in simulation debriefing. The simulation activities were designed to be comprehensive, encompassing robust pre-briefing sessions, the main simulation activities themselves, and post-simulation debriefing sessions. Furthermore, data related to active experimentation were collected by administering specialized instruments designed to assess learner satisfaction and knowledge acquisition. These instruments helped gauge the effectiveness of the learning experiences within the simulation activities.

National League for Nursing and Jeffries Simulation Theory

The NLN Jeffries Simulation Theory focuses on the background and context of simulation design and simulation experience, as well as the experiences of facilitators and participants and simulation outcomes as essential qualities of simulation activities (Brown et al., 2021). According to Jeffries, Rodgers, and Adamson (2015), The Jeffries

Simulation Theory considers context, background, design, simulation experience, facilitator and educational strategies, participants, and outcomes as essential factors in simulation design and measure of efficacy. Simulations first consider contextual factors such as circumstances and setting as well as background considerations, such as how the simulation relates to the greater learning experience as essential qualities for simulation design. Simulation design must include specific learning objectives that guide learning activities and simulation fidelity, and interface options must also be considered (Brown et al., 2021; Rodgers & Adamson, 2015). Simulation experience is characterized by an environment that is experiential, interactive, collaborative, and learner-centered and takes into consideration the dynamic interaction between the facilitator and the participant and how they impact the simulation learning experience.

NLN Jeffries Simulation Theory informed the definition of simulation effectiveness or efficacy of the research. According to the Jeffries Simulation Theory, simulation effectiveness is measured by how a simulation experience improves learner reaction (satisfaction, self-confidence), learning (changes in knowledge, skills, attitudes), and behavior (learning transfers to clinical experience) (Jeffries et al., 2015). Guided by this definition of simulation effectiveness, instruments that measure learner satisfaction, self-confidence, changes in knowledge and knowledge application to clinical practice were chosen to gauge simulation effectiveness.

Summary

The research was informed by Kolb's Experiential Learning Theory which suggests that simulations provided to participants consider concrete, reflective, abstract, and active experiment aspects in simulation design. The study design was also informed

by the NLN/Jeffries Simulation Theory, which concludes that data collection and analysis methods attempt to gauge students' learning via learner reaction (satisfaction, self-confidence), learning (changes in knowledge, skills, attitudes), and behavior (learning transfers to clinical experience).

Chapter 4. Methodology

Introduction

A pilot study established the operational requirements for a randomized controlled trial comparing the effectiveness of screen-based virtual simulation with traditional manikin-based simulation. Guided by a post-positivist approach to epistemology and ontology, relevant conceptual frameworks and research design which include sampling, instrumentation, data collection, and data analysis methods were scrutinized and implemented for both academic rigor and logistical feasibility.

Pilot Study

A pilot study of a quantitative experimental design measured the pedagogical efficacy between simulation modalities (in-person manikin-based and virtual serious game). The pilot study was conducted to answer whether virtual simulations were as effective in learning education as manikin-based simulation activities. The pilot study was conducted to prepare for a possible full-scale experimentation in the future. The pilot study estimated the essential parameters required to design and implement a study and conduct experiments on a smaller scale to establish the feasibility and academic value of a full-scale research project (Eldridge et al., 2016). By completing a pilot study within the framework of a randomized controlled trial design, researchers can assess the scale and magnitude necessary to feasibly challenge and reject a null hypothesis.

Pilot studies explore implementation trial methods, and strategies, and identify potential barriers and/or enablers to gauge the acceptability, feasibility, and appropriateness of research implementation (Pearson et al., 2020). A pilot study also helps identify any organizational and/or contextual factors that might influence future

implementation trial methods, such as sample size calculation, participant recruitment and retention, and data collection and analysis methods required for future research implementation (Eldridge et al., 2016). In this research, a pilot study measured the logistical health of a proposed research study by considering whether each element of the study was logistically sound and could realistically be conducted.

Research Design

The research design assumed that equivalency is the most key factor in guaranteeing the accuracy of results. Therefore, measures were taken to ensure that the simulation experiences all participants took part in, whether it be a manikin-based simulation or a virtual simulation, were as similar to one another as possible. This similarity extended not just to learning outcomes and scenario content but also to how it was pre-briefed, delivered, and debriefed. Whenever possible, all participants were given the same information, delivered in the same method, within the same time frame allotted for each section.

Simulations rely heavily on facilitation and debriefing. Debriefing is considered an essential part of simulation according to best practice guidelines and should be conducted by experienced debriefers (Goldsworthy et al., 2022). Therefore, the individual pedagogical aptitudes of the facilitator or debriefer participating in the experiment can significantly impact the learner satisfaction and pedagogical efficacy of simulations. In the pilot study, the principal investigator conducted all pre-briefings, simulation facilitations, and debriefings to eliminate concerns regarding inter-rater reliability.

A basic assessment virtual simulation scenario was chosen as the subject of the experimental study to ensure that participants focus on the learning outcomes provided by the modality they participated in, rather than the content itself. If the learning objectives or simulation content were too advanced or specialized, it could potentially alienate certain students, introducing unforeseen biases in the data. As all participants would have completed a basic assessment segment in their nursing education, it was chosen as the baseline for this study (Appendix A).

Once the basic assessment tool simulation was chosen, an equivalent in-person manikin simulation was developed to mirror all learning objectives, scenario content, demographics, moulage, and expected outcomes. All documentation for both the in-person and the virtual simulations were identical, and both the virtual and in-person manikin simulations drew upon the same documentation to guide the simulation. The script prompts for the in-person manikin simulation were taken from the virtual simulation version to establish equivalency. In the end, both simulations were identical in learning, content, and scope from each other.

On the day of the experimental study, a cohort of participants (maximum 8 students per session) participated in one of the two simulations prepared. To ensure an element of randomness and reduce potential bias, the student bodies were randomized via Excel functionality. This approach added a layer of impartiality in the selection of participants, enhancing the representativeness of the sample and the generalizability of the research findings. All students in the session were provided with an identical pre-briefing using the same process and script. They were allowed to ask questions regarding the simulations. After the pre-briefing, the student cohorts were divided to participate in

a randomly assigned simulation modality. For example, if eight students participated in a session, four students were directed to a separate room to participate in the virtual simulation, while the other four students were directed to a simulation lab to participate in the manikin version of the simulation.

Participants who were assigned to the virtual serious game experience were taken to a separate room where computers of identical build were set up on a table near one another, with the virtual simulation game preloaded. They were directed to participate in the virtual simulation using one of the supplied computers and run through the virtual serious game. While the nature of the virtual serious game required that each student play the game separately, it was instructed that each student work together to share ideas and support each other in advancing the game. Therefore, although the games were played individually, the sessions themselves were conducted in a group. This established equivalency to manikin-based simulation where students would be supporting each other during patient interactions and clinical decision-making. A support person was available to assist students in navigating the virtual serious game. This support person, however, did not participate in the simulation itself, did not have any roles in the simulation, and did not offer any suggestions to the students during the simulation activity.

The manikin-based simulation group was taken to a lab and assigned to a medium-fidelity manikin. The medium-fidelity manikin was programmed to mimic the clinical presentation of the patient in equivalence to how the patient would have been portrayed in the virtual game, including vital signs, appearance, and other clinical factors. The participants were directed to advance the simulation as a group and provide care for the simulated patient following the learning objectives of the scenario. The investigator

and support person were not present in the simulation lab but observed and communicated in a separate audio-visual space. This strategy established equivalency with the kinds of support that the virtual simulation group would be expected to have access to. In the end, both groups completed the simulation as a group without any further external support. After the simulation time elapsed, both groups were instructed to stop the simulation and reconvene for a group debriefing session. Debriefing for the simulation occurred as a group, with both the virtual simulation and manikin simulation groups debriefing the scenario together. The debriefing was facilitated by the primary investigator only for all groups to establish equivalency.

All participation in the research project was synchronous; all participants came physically to the research space and experienced a simulation randomly assigned to each member. All feedback was also collected in person, but responses were provided digitally through the use of the Survey Monkey platform and the handheld device. No participants had asynchronous or online participation in the research project.

Participants

An undergraduate-level prelicensure nursing students the third, fourth, and fifth semesters who had completed basic assessment nursing education and clinical rotations (or its equivalent) were invited to participate in a voluntary, extracurricular simulation activity. The inclusion criteria were designed to ensure that participants had the requisite clinical experience and knowledge necessary to navigate the simulation activity effectively. Conversely, the exclusion criteria aimed to limit participant bias, particularly bias stemming from the evaluation of simulation activities that were part of the participants' current educational curriculum. No exclusion criteria based on age, gender,

or ethnicity were considered. After ethical approval, initial contact was made by email and recruitment notices. The principal investigator sent out invitation emails to all prelicensure BSN nursing students meeting inclusion criteria, and recruitment notices were placed in high-traffic simulation spaces (i.e., open simulation practice lab spaces).

Several methods were employed to gather participants for this research study. Posters highlighting the research opportunity were placed on campus in areas where BSN pre-licensure nursing students were likely to gather and be exposed to the poster's content. Finally, the primary investigator provided in-service sessions stationed near open practice stations to explain and recruit interested students. All interested members of the student body were provided with a consent form to read and sign (Appendix B).

All participants participated in the research process in person, including the collection of consent, pre-briefing, experimental activity, and debriefing. There was no video conferencing associated with the research process. An in-person delivery method was selected for logistical reasons, but also to ensure that all participants had access to the principal investigator for questions and concerns during the consent form signing. This method was chosen to establish equivalence between the two simulation activities and to ensure that all participants assigned to the virtual simulation activity had access to adequate and equivalent technologies. Additionally, they had direct contact with other participants in their cohort to discuss and support each other in advancing the simulation, similar to the opportunities provided to the in-person manikin simulation group.

Reimbursement was considered and approved by both the Athabasca University Ethics Board and BCIT Research Ethics Board. A coffee gift card valued at $5 was

provided to each participant, and light refreshments were provided to each participant during their participation in the experiment.

Sampling

Sampling in this study follows a convenience cluster sampling method, with a focus on the recruitment of participants from the Bachelor of Science (BSN) nursing student population. The recruitment process involved disseminating calls for participation through various means, including posters placed around campus, email introductions via student cohort contact lists, and in-person information sessions held in psychomotor practice spaces. This approach allowed for the inclusion of students who were readily accessible and interested in taking part in the research. Interested participants were provided with a research consent form, which they were required to review and sign before participating in the research study.

There is no universally accepted threshold for the minimum sample size required to conduct a pilot study of a quantitative design (Lewis et al., 2021). However, it is recommended that a sample size of 26 to 34 participants would be sufficient for determining statistical significance, a sample size of 18 to 25 to determine moderate statistical significance, and a sample size of 0 to 17 to strictly inform experimental design without determining statistical significance (Lewis et al., 2021). Guided by the literature, a sample size target of 18 participants was determined. A power analysis was not conducted for the pilot study.

Ethical considerations

Ethical considerations adhered to research ethics and revolved around informed consent and voluntary participation. Participants were provided with comprehensive

information regarding the research experiment's main objectives, methodologies, potential advantages, and associated risks. All participants were informed of their voluntary engagement in the research and were provided with the ability to withdraw from the study without enduring adverse consequences. Participant confidentiality was maintained by having all data provided in secure storage only accessible by the principal investigator. The ethical foundation of the research was delineated by its compliance with the evaluation of the Athabasca University Research Ethics Board and the British Columbia Institute of Technology Research Ethics Board. These ethical considerations collectively reinforced the research's commitment to safeguarding the rights and welfare of the participants during the research experiment and to maintaining the highest ethical standards in its conduct and dissemination of research findings.

Additional ethical considerations revolved around privacy. To maintain the privacy and confidentiality of all participants, only the principal investigator had access to the collected data for data entry, data analysis, and dissemination. When the research project was complete, all electronic data and physical documents were sealed via password protection, and all physical copies of consent forms were locked in a secure container. These will not be shared by other members and will be kept securely by the principal investigator for at least five years by the Research Ethics Boards.

Reliability and Validity

To ensure reliability and validity, several measures were taken to prevent issues related to interrater reliability. Only the principal investigator was involved in the prebriefing and debriefing process and the in-person simulation was facilitated by the principal investigator. All participants conducted their participation in the experimental

design with the assistance of the principal investigator, who provided the participants with pre-briefing information, facilitated the simulation, and provided debriefing support. Having only the principal investigator involved in the experimental process ensured that there were no disparities in the quality of the simulation experience that all participants were provided with.

Validity was assured by employing externally validated learning effectiveness survey tools highlighted in the related literature. No questions, other than basic demographic questions, were created by the principal investigator. Two surveys were used for this research: the Simulation Effectiveness Modified (SET-M) and the Clinical Learning Environment Comparison Survey 2.0 (CLECS 2.0). They were used to compare pre-licensed nursing students' perceptions of learning in a variety of learning environments.

Instruments

Measures of instrumentation in feasibility and pilot studies are similar to instrumentation proposals of fully realized experimental studies (Pearson et al., 2020). A review of literature assisted in identifying several instruments or instrumentation methods that collectively measure learner reaction, learning, and behavior. The Simulation Effectiveness Tool -Modified (SET-M), which measures learner reaction and learning was provided to participants to complete after the simulation activity (Leighton et al., 2018). A scenario-specific questionnaire, designed to measure learner's understanding regarding simulation learning objectives was also provided to ascertain participant learning and behavior. Finally, participants' perceptions of the effectiveness of screen-based virtual simulations and manikin-based simulations were measured via the

utilization of the Clinical Learning Environment Comparison Survey Version 2.0 (CLECS 2.0) (Leighton et al., 2021).

Simulation Effectiveness Tool – Modified

The Simulation Effectiveness Tool – Modified (SET-M) was developed to measure self-disclosed learner satisfaction in the context of simulation-based education (Leighton et al., 2018). The SET-M includes 19 3-point Likert scale questions divided into four subcategories of pre-briefing, learning, confidence, and debriefing. The SET-M is an internally validated instrument for simulation effectiveness. Reliability and validity testing for SET-M was conducted at two universities in a total of 13 sites with 1288 undergraduate nursing students in the medical-surgical semester [prebriefing $\alpha = .83$, learning $\alpha = .86$, confidence a = .91, debriefing a = .91 (Leighton et al., 2018)]. The SET-M assessed participants' measures of self-satisfaction, self-confidence, and changes in knowledge.

All participants were requested to complete a SET-M survey concerning the simulation experience in which they participated. The SET-M prompted participants to provide feedback on 19 items, indicating whether they strongly agree, somewhat agree, or do not agree with each statement. Each SET-M question falls into one of four subscales prebriefing, learning, confidence, and debriefing, the four key aspects of simulation-based learning. For data analysis purposes, descriptive statistics for each SET-M category have been gathered. Additionally, the mean value of each SET-M item was collected by assigning numerical values to survey responses (do not agree = 1; somewhat agree = 2; strongly agree = 3), producing a mean and standard deviation for each item (range 1.00 to 3.00).

Clinical Learning Environment Comparison Survey

CLECS 2.0 was developed to evaluate the learner's perception of simulation experiences compared to traditional in-person clinical experiences (Leighton et al., 2021). The CLECS 2.0 is a 29-item, four-point Likert scale with sub-categories of communication, nursing process, holism, critical thinking, self-efficacy, and teaching-learning measured between traditional clinical experiences, in-person simulation experiences and virtual (screen-based) simulations (Leighton et al., 2021). The CLECS 2.0 will be provided to participants to directly measure students' outlook on the efficacy of traditional clinical experiences, manikin-based simulations, and virtual simulations. Results of CLECS 2.0 were analyzed to determine whether statistical significance existed between groups. The CLECS 2.0 instrument series demonstrated adequate to excellent internal consistency and reliability (a = 0.73 - 0.97) (Leighton, 2015a; Leighton, 2015b).

Data Collection and Analysis

Data collection for the experiment relied on participants completing a series of questions after their simulation experience. Each participant was provided with an iPad containing surveys hosted by SurveyMonkey with an account that had undergone a privacy impact assessment at the home institute. Subsequently, each participant completed two questionnaires: the Simulation Effectiveness Tool - Modified (SET-M) and the Clinical Learning Environment Comparison Survey version 2.0 (CLECS 2.0). Data was extracted from SurveyMonkey in Excel format and then processed using IBM's SPSS (Statistical Package for the Social Sciences) version 29.0.0.0 (241) software.

Participants completed the SET-M, the simulation scenario-specific questionnaire, and CLECS 2.0 after they had finished either the screen-based or manikin-

based simulation. To ensure consistency between responses, participants completed all survey questions in person before concluding their participation in the experimental process. Identification codes were assigned to participants to ensure confidentiality and anonymity during data analysis and dissemination were maintained by assigning identification codes to all participants.

Descriptive statistics and comparative analysis were conducted using IBM SPSS® software version 29.0.0.0 (241). Descriptive statistics involved outlining the results of participants on each item of both SET-M and CLECS 2.0 as well as a comparison of mean and standard deviation among groups. The comparative analysis involved comparing participant responses on their opinions regarding traditional clinical simulations between the manikin-based and virtual serious game groups. This was done to ensure no pre-existing bias existed to potentially affect participants' other responses. Afterward, CLECS 2.0 responses of participants between the manikin-based and virtual serious game groups were compared. Participants were directed to provide feedback based on the simulation experience that the participants engaged in during the experimental study. This was done to identify any notable trends as well as statistically significant differences between the feedback provided by participants based on their experiences with manikin-based versus virtual simulations.

Statistical significance was analyzed via simple regression analysis. For SET-M results, participant responses were first quantized according to each responses' numerical equivalent and results were analyzed according to their corresponding learning sub-categories. These values were then compared visually and tested for statistically significant differences ($p = < .005$). The CLECS 2.0 results were similarly grouped into

the subcategories of learning as outlined by the instrument (communication, nursing process, holism, critical thinking, self-efficacy and, teaching and learning) and analyzed for statistically significant differences between the responses from the manikin-based simulation group and the virtual serious game group.

Summary

The conducted pilot study established the operational requirements for a randomized controlled trial that compared the effectiveness of screen-based virtual serious games with traditional manikin-based simulation. Informed by the post-positivist approach to research, the experimental design focused on ensuring equivalency in simulation experiences for participants.

The experiment directed randomly assigned participants to engage in a basic assessment virtual serious game scenario or an equivalent in-person manikin-based simulation, both designed to mirror learning objectives and content. Participants, undergraduate nursing students from the British Columbia Institute of Technology were recruited through various methods. Ethical considerations emphasized informed consent and voluntary participation, ensuring participant confidentiality.

Instruments included the Simulation Effectiveness Tool - Modified and the Clinical Learning Environment Comparison Survey 2.0. Descriptive and comparative analyses were conducted using IBM SPSS ® software. The synchronous nature of participant involvement and the acknowledgment of potential limitations were integral aspects of the research methodology.

Chapter 5. Results

Introduction

The research experiment was designed and conducted to assess the pedagogical effectiveness of different simulation modalities. The central research question explored whether virtual simulation, exemplified by screen-based serious games, were as valuable at fulfilling the learning requirements of nursing education compared to traditional manikin-based simulation activities.

All participants who consented to the experiment completed the research experiment as agreed and no participants requested to be removed from the participant list or have their data removed after the conclusion of the experiment. The pilot study initially included 30 participants, BSN prelicensure nursing students of the third, fourth, and fifth semesters (from a total of nine terms), randomly assigned to two groups, resulting in 15 participants per simulation modality. The following semesters were chosen to be included in the study as students at this level have at least experienced one semester of direct traditional clinical experience but have not yet taken part in acute care experience or have been introduced to advanced clinical reasoning, pathophysiology, and pharmacology.

Students of these semesters also have undergone relatively few clinical experiences compared to students of later semesters. As part of the curriculum, third-semester students would have previously participated in seven manikin-based and two virtual serious game simulations, fourth-semester students would have previously experienced eight manikin-based and two virtual serious games, and fifth-semester students would have seen eight manikin-based simulations and four virtual serious

games. A total of four sessions were provided to participants over two days with each session further divided into a manikin-based simulation group and a virtual serious game session). Each simulation activity consisted of three to four participants. Debriefing occurred synchronously with both modality groups participating in the same session. Responses of two participants were found to be incomplete during data analysis and thus were discarded, leading to 28 participants' results included in data analysis.

Simulation Effectiveness Tool SET-M Results

The Simulation Effectiveness Tool Modified (SET-M) assessed the effectiveness of simulation-based training in education. The SET-M prompted participants to provide feedback on 19 items, indicating whether they strongly agree, somewhat agree, or do not agree with each statement. Each SET-M question falls into one of four subscales prebriefing, learning, confidence, and debriefing, the four key aspects of simulation-based learning. For data analysis purposes, descriptive statistics for each SET-M category have been gathered. Additionally, the mean value of each SET-M item was collected by assigning numerical values to survey responses (do not agree = 1; somewhat agree = 2; strongly agree = 3), producing a mean and standard deviation for each item (range 1.00 to 3.00). Table 1 presents the SET-M results, indicating whether participants strongly agreed, somewhat agreed, or did not agree with each statement. Table 2 details the SET-M results for participants in the virtual serious game group compared to the manikin simulation group. Overall, the comparison suggests that while virtual simulations are associated with higher satisfaction rates regarding prebriefing, manikin-based simulations have higher participant regard for learning satisfaction and efficacy in the other categories of simulation learning.

Table 1

Manikin-based SBE SET-M Descriptive Statistics (n = 14)

Item	Do not Agree	Somewhat Agree	Strongly Agree	M(SD)
	% (n)	% (n)	% (n)	
Pre-briefing increased my confidence.	8.3 (1)	16.7 (2)	75.0 (9)	2.67(.651)
Pre-briefing was beneficial to my learning	8.3 (1)	25.0 (3)	66.7 (8)	2.58(.669)
I am better prepared to respond to changes in my patient's condition.	0 (0)	30.8 (4)	69.2 (9)	2.69(.480)
I developed a better understanding of the pathophysiology.	23.1 (3)	46.2 (6)	30.8 (4)	2.08(.760)
I am more confident of my nursing assessment skills.	7.7 (1)	7.7 (1)	84.6 (11)	2.77(.599)
I felt empowered to make clinical decisions.	0 (0)	23.1 (3)	76.9 (10)	2.77(.439)
I developed a better understanding of medications. (Leave blank if no medications in scenario)	7.7 (1)	46.2 (6)	46.2 (6)	2.38(.650)
I had the opportunity to practice my clinical decision-making skills.	0 (0)	7.7 (1)	92.3 (12)	2.92(.277)
I am more confident in my ability to prioritize care and interventions	0 (0)	15.4 (2)	84.6 (11)	2.85(.376)

I am more confident in communicating with my patient.	7.7 (1)	15.4 (2)	76.9 (10)	2.69(.630)
I am more confident in my ability to teach patients about their illness and interventions.	7.7 (1)	7.7 (1)	76.9 (10)	2.75(.622)
I am more confident in my ability to report information to health care team.	15.4 (2)	38.5 (5)	46.2 (6)	2.31(.751)
I am more confident in providing interventions that foster patient safety.	0 (1)	7.7 (1)	92.3 (12)	2.92(.277)
I am more confident in using evidence--based practice to provide nursing care.	0 (0)	23.1(3)	76.9 (10)	2.77(.439)
Debriefing contributed to my learning.	0 (0)	23.1 (3)	76.9 (10)	2.77(.439)
Debriefing allowed me to verbalize my feelings before focusing on the scenario.	7.7 (1)	15.4 (2)	76.9 (10)	2.69(.630)
Debriefing was valuable in helping me improve my clinical judgement.	7.7 (1)	15.4 (2)	76.9 (10)	2.69(.630)
Debriefing provided opportunities to self-reflect on my performance during simulation	0 (0)	15.4 (2)	84.6 (11)	2.85(.376)
Debriefing was a constructive evaluation of the simulation	7.7 (1)	15.4 (2)	76.9 (10)	2.69(.630)

Table 2

Screen-based Virtual Game SET-M Descriptive Statistics (n = 14)

Item	Do not Agree	Somewhat Agree	Strongly Agree	M(SD)
	% (n)	% (n)	% (n)	
Pre-briefing increased my confidence.	0 (0)	23.1 (3)	76.9 (11)	2.77(.439)
Pre-briefing was beneficial to my learning	0 (0)	30.8 (4)	69.2 (10)	2.69(.480)
I am better prepared to respond to changes in my patient's condition.	15.4 (2)	53.8 (7)	30.8 (5)	2.15(.689)
I developed a better understanding of the pathophysiology.	30.8 (4)	53.8 (7)	15.4 (3)	1.85(.689)
I am more confident of my nursing assessment skills.	30.8 (4)	23.1 (4)	46.2 (6)	2.15(.899)
I felt empowered to make clinical decisions.	33.3 (4)	33.3 (5)	33.3 (4)	2.00(.853)
I developed a better understanding of medications. (Leave blank if no medications in scenario)	41.7 (5)	41.7 (6)	16.7 (2)	1.75(.754)
I had the opportunity to practice my clinical decision-making skills.	23.1 (3)	0 (0)	76.9 (11)	2.54(.877)
I am more confident in my ability to prioritize care and interventions	30.8 (4)	38.5 (5)	30.8 (5)	2.00(.816)

I am more confident in communicating with my patient.	23.1 (4)	38.5 (5)	38.5 (5)	2.15(.801)
I am more confident in my ability to teach patients about their illness and interventions.	38.5 (6)	30.8 (4)	30.8 (4)	1.92(.862)
I am more confident in my ability to report information to health care team.	46.2 (7)	15.4 (2)	38.5 (5)	1.92(.954)
I am more confident in providing interventions that foster patient safety.	7.7 (1)	46.2 (6)	46.2 (6)	2.38(.650)
I am more confident in using evidence--based practice to provide nursing care.	23.1 (3)	23.1 (3)	53.8 (8)	2.31(.855)
Debriefing contributed to my learning.	7.7 (1)	30.8 (4)	61.5 (9)	2.54(.660)
Debriefing allowed me to verbalize my feelings before focusing on the scenario.	7.7 (1)	23.1 (3)	69.2 (10)	2.62(.650)
Debriefing was valuable in helping me improve my clinical judgement.	7.7 (1)	46.2 (6)	46.2 (7)	2.38(.650)
Debriefing provided opportunities to self-reflect on my performance during simulation	7.7 (1)	23.1 (3)	69.2 (10)	2.62(.650)
Debriefing was a constructive evaluation of the simulation	7.7 (1)	23.1 (3)	69.2 (10)	2.62(.650)

Statistical analysis was conducted between groups, comparing the assigned numerical totals of each SET-M category through an independent sample t-test to assess statistical significance. Table 3 presents both the descriptive statistics for the simulation experience of participants surveyed via the use of the SET-M with a total sample size (n)

of 28. The table includes the item score range, mean, median, and standard deviation of both manikin-based and virtual serious game simulations. Table three also displays the regression analysis data testing for statistical significance ($p = .005$). Comparing the mean and median of quantized SET-M responses indicates that virtual serious games provided more a slightly more effective prebriefing (manikin-based $m = 4.85$, virtual serious game $m = 5.50$), and the manikin-based simulations resulted in greater learner satisfaction among participants (learning manikin-based $m = 15.62$, virtual serious game $m = 12.36$; confidence manikin-based $m = 16.08$, virtual serious game $m = 12.57$; debriefing manikin-based $m = 13.69$, virtual serious game $m = 12.93$). Categories of confidence showed the greatest disparity with learning showing significant difference in scores (manikin-based $m = 16.68$, $mdn = 17$, virtual serious game $m = 12.57$, $mdn = 13$) as well as learning (manikin-based $m = 15.62$, $mdn = 16$, virtual serious game $m = 12.36$, $mdn = 13$). Comparative regression analysis however did not indicate statistically significant difference in the scores between the results of manikin-based and virtual serious game simulations.

Table 3

Participant SET-M Clinical Experience Descriptive and Comparative Statistics (n = 28)

Factor	Item	Range	Mean (SD)		Median		F	Sig.	T
			Manikin	Virtual	Manikin	Virtual			
Prebriefing	2	2-6	4.85(1.908)	5.50(.855)	6	6	4.732	.039	-1.164
Learning	6	6-18	15.62(2.434)	12.36(3.734)	16	13	4.162	.052	2.663
Confidence	6	6-18	16.08(2.565)	12.57(3.524)	17	13	2.376	.136	2.935
Debriefing	5	5-15	13.69(2.250)	12.93(2.702)	15	13	.001	.976	.795
Total	19	19-57	50.23(6.942)	43.36(8.643)	51	43.50	1.670	.208	2.267

CLECs 2.0 Results

The CLECS 2.0 includes 29-factor items judged to be essential learning needs in the prelicensure nursing practice environment. The CLECS tallies a participant's perceived effectiveness of learning in traditional clinical experiences along with different simulation modalities by prompting them to score each learning need based on the 4-point Likert scale. The 29 learning needs are divided into six subscales of effective learning (communication, nursing process, holism, critical thinking, self-efficacy, teaching, and learning) (Leighton et al., 2021).

Each participant was prompted to complete CLECS 2.0 regarding their perceptions of the learning effectiveness of traditional clinical experience and to compare this with their opinions regarding the simulation modality in which they had recently participated. The data was quantified for descriptive statistics and to assess statistical significance. Table 4 compares participant scores regarding traditional clinical experience, divided by simulation modality that each member participated in, to detect

disparity between groups regarding their regard for traditional clinical experiences. Results show that there was no statistical significance in participants' regard for traditional clinical experience between the manikin-based simulation and virtual simulation groups.

Table 4

CLECS 2.0 Traditional Clinical Learning Environment (n = 28)

		N	M	SD	f	Sig.	t	df
Overall	Manikin	14	97.00	8.963	.085	.772	-.324	25
	Virtual	14	98.14	9.339				
Communication	Manikin	14	13.69	1.377	.000	.986	-.572	25
	Virtual	14	14	1.414				
Nursing Process	Manikin	14	21.77	2.315	.004	.949	.225	25
	Virtual	14	21.57	2.243				
Holism	Manikin	14	19.69	1.702	.005	.942	-.033	25
	Virtual	14	19.71	1.729				
Critical Thinking	Manikin	14	6.92	.954	.139	.712	-.783	25
	Virtual	14	7.21	.975				
Self-Efficacy	Manikin	14	13.15	1.772	.109	.744	-1.564	25
	Virtual	14	14.14	1.512				
Teach & Learn	Manikin	14	18.08	2.019	.020	.899	.007	25
	Virtual	14	18.07	2.018				

Table 5 compares the CLECS 2.0 results between the manikin-based simulation experience and the virtual serious game group divided by educational subscales. Overall, the manikin-based simulation scored higher, as well as in all subscales of learning (overall M = 93.77; communication M = 12.62; nursing process M = 21.77; holism M =1 7.62; critical thinking M = 7.08; self-efficacy M = 14.08; teaching and learning M = 17.23) compared to the virtual serious game group (overall M = 84.07; communication

M = 11.79; nursing process M =1 8.86; holism M = 17.50; critical thinking M = 6.21; self-efficacy M = 12.29; teaching and learning M = 14.29).

Table 5

CLECS 2.0 Simulation Modality Comparison Among Manikin-based and Virtual Serious Game (n = 28)

		N	M	SD	f	Sig.	t	df
Overall	Manikin	14	93.77	8.064	2.295	.142	3.323	25
	Virtual	14	84.07	7.098				
Communication	Manikin	14	12.62	1.805	2.631	.117	1.374	25
	Virtual	14	11.79	1.311				
Nursing Process	Manikin	14	21.77	2.127	2.179	.152	4.280	25
	Virtual	14	18.86	1.351				
Holism	Manikin	14	17.62	3.595	.216	.646	.098	25
	Virtual	14	17.50	2.473				
Critical Thinking	Manikin	14	7.08	.954	10.017	.004	2.865	25
	Virtual	14	6.21	.579				
Self-Efficacy	Manikin	14	14.08	1.441	.526	.475	3.171	25
	Virtual	14	12.29	1.490				
Teach & Learn	Manikin	14	17.23	17.23	.007	.935	2.682	25
	Virtual	14	14.29	14.29				

Regression analysis via an independent sample t-test comparing the CLECS 2.0 score between groups ($p = < 0.005$) showed no statistical significance between the CLECS 2.0 score between the simulation modality groups overall ($p = .142$, $F = 2.295$, t

= 3.323). Table 5 outlines the statistical significance of the CLECS 2.0 score between the manikin-based and virtual simulation group (overall p = .142; communication p = .117; nursing process p = .152; holism p = .646; critical thinking p = 0.004; self-efficacy p = 4.75; teaching and learning p = .935). The analysis concludes that there is a statistically significant disparity between manikin-based and virtual serious game simulations on the critical thinking educational aspects. The results also reveal that there is no statistically relevant difference between manikin-based simulations and virtual simulations on (all other educational sub-categories), even though virtual simulation serious games consistently scored lower than the manikin-based simulation group.

Summary

This research experiment aimed to assess the pedagogical effectiveness of different simulation modalities in nursing education, specifically comparing virtual simulations, represented by screen-based serious games, with traditional manikin-based simulation activities. The study involved 30 participants engaged in either manikin-based simulation or virtual serious games, utilizing the Simulation Effectiveness Tool Modified (SET-M) and the Clinical Learning Environment Comparison Survey (CLECS 2.0). The results indicated that while virtual simulations were associated with higher satisfaction rates in prebriefing, manikin-based simulations garnered greater participant regard for learning satisfaction and efficacy in other simulation learning categories. Statistical analyses revealed no significant differences between the groups in terms of self-disclosed learning efficacy and educational satisfaction. Additionally, the CLECS 2.0 results showed that overall, manikin-based simulations outperformed virtual serious games in various learning categories, with critical thinking being the only statistically significant

difference between the two modalities with the manikin-based simulation showing greater efficacy.

Chapter 6. Discussion

Introduction

The existing literature indicates that manikin-based simulations and virtual-based simulations yield similar learning outcomes for nursing students. However, as previously discussed, there is a scarcity of direct comparison studies measuring the efficacy of these different modalities in student learning outcomes. The results of this experimental study led to the conclusion that, overall, virtual-based simulation experiences are less effective in meeting learning outcomes than traditional manikin-based simulation experiences. Several factors may contribute to this outcome, whether they are logistical or substantial.

Padilha et al. (2018) conducted a randomized control study comparing 42 pre-licensure nursing students using the Learning Satisfaction with Simulation Tool, a 10-point Likert scale measuring tool. The study concluded that the experimental group, the virtual simulation group, showed a more significant improvement in knowledge and learning satisfaction than the traditional simulation group, with knowledge ($p < 0.001$, $f = 1.13$) and learning satisfaction ($p < 0.01$, $f = 1.33$). Farsi et al. (2020), who conducted a three-prong randomized control trial with a pre-test post-test design involving 56 pre-licensure first-semester nursing students for a cardiopulmonary resuscitation simulation, revealed that the differences in modalities were not statistically significant (27.17 ± 2.81 vs. 25.72 ± 3.98, Mann–Whitney U test, $p = 0.988$, ns).

The results obtained in this research process largely confirm that virtual simulations scored lower overall than manikin-based simulations in both the SET-M and CLECS 2.0. There was, by and large, no statistical difference between the two modalities; however, there were statistically significant differences in the critical

thinking aspects between traditional manikin-based experiences and virtual simulation serious games with participants scoring the manikin-based simulation experiences higher than the virtual serious game simulation.

The data itself cannot definitively confirm or rule out the possible cause of the disparity between manikin-based simulation and virtual simulation concerning critical thinking. Speculation might suggest that a psychosomatically equivalent environment to traditional clinical experiences, offering a learning environment closer to what students are accustomed to, helps students apply their learning more efficiently. The differences might also be related to the challenges of the virtual simulation platform itself, suggesting that additional difficulties with this new method of simulated learning experience may impact students' learning perceptions.

One possible explanation for the disparity in scores between simulation modalities is that virtual simulations represent a novel technology, and students may encounter access or user interface issues that impede their full appreciation of the simulation education content. In contrast, manikin-based simulations replicate the clinical experience in both content and tactile or psychomotor experiences. Virtual simulations emulate the clinical setting through graphics and user interfaces. While some learners may have no issues navigating their simulation experience through this platform, other students might not be as comfortable translating their clinical understanding through a computer screen and a series of virtual executables. Therefore, it may be that students found virtual simulations less appealing as an educational platform due to additional challenges in navigating the platform itself.

The concept of cognitive load and cognitive burden may help explain the data regarding virtual screen-based simulations having statistically significant lower scores related to critical thinking and learning. Cognitive load theory posits that instructional material can be designed in a way that minimizes the mental efforts required to process relevant information to unload mental burden (extraneous cognitive load) and optimizing learning by helping direct the cognitive burden towards content which maximizes learning (Paas et al., 2003). The goal of an optimized learning activity according to the concept of cognitive load, therefore, is to maximize mental effort towards intrinsic cognitive load, defined as mental effort inherent to the complexity of the materials that are being learned, and reduce as much as possible, efforts irrelevant to the learning objectives but required by the design of the educational material (Paas et al., 2003). Therefore, a possible explanation for the disparity between the critical thinking elements of learning and cognitive learning in general may be due to the increased external cognitive load that a virtual serious game requires of participants and learners. It may be that virtual serious games require additional knowledge and confluence in virtual processes and user interfaces in addition to the learning objectives relevant to the educational activity. This may explain the disparity between the results of the two simulation modalities.

High-fidelity simulations can enhance critical thinking opportunities, but they have a risk of increasing cognitive load for learners (Louw, 2021). Louw (2021) recommends that cognitive learning theory be considered to enhance critical thinking and problem-solving skills for learners during simulation experiences. While further

investigation is necessary, considering the concept of cognitive load may help with future studies in establishing experimental equivalence and recommendations for the future.

Virtual simulation experiences, especially virtual serious games, face the challenge of lacking a strong consensus on how each program is designed. Numerous developers, programmers, and educational content creators are involved in creating virtual simulations and screen-based serious games in diverse ways. Consequently, it becomes difficult to determine whether one serious game developed and presented in a particular manner can be readily compared to other simulations available for nursing education. For instance, some developers possess greater resources and experience in crafting virtual experiences than others, and certain developers excel in expertise related to virtual serious games, such as programming, graphical fidelity, and user interface design.

In addition, as virtual simulations are delivered in a manner more aligned with video games, knowledge of game theory, story progression, and scenario development may contribute to enhancing the learning experience beyond the simulation content itself. While all simulations, including manikin-based simulations, benefit from these areas of expertise, it may be particularly pivotal, if not essential, for virtual simulations to incorporate this knowledge and expertise when developing virtual serious games. There exist externally validated instruments that may provide a valuable and practical means of assessing and improving the usability of the various virtual serious game products coming out onto the market.

Various methods have been devised to measure the effectiveness of a virtual program or game, as well as the effectiveness of the platform itself. Validated

measurements such as the System Usability Scale (SUS) (Brooke, 1996) and the Player Experience Inventory (PXI) are widely used and mentioned in the literature (Vanden Abeele et al., 2020). Therefore, it would be crucial to consider in future versions of direct comparison studies between in-person manikin-based and virtual simulation modalities that simulations undergo evaluation using the SUS and the PXI. This can help determine or ensure that the end-user experience and participants' evaluation of learning efficacy are not influenced solely by the platform itself, but also by the modality in which the educational content is delivered.

Another possible explanation for the disparity between the two modalities is that virtual simulations cannot be seen as equivalent to manikin-based simulations in the way they are delivered. The assumption for this experimental design revolves around the fact that both manikin-based simulations and virtual simulation-based education follow the same format in delivery, including having the same preparatory material, simulation content, pre-briefing script, debriefing format, and the same amount of time allotted for each segment of the simulation experience. This was a deliberate choice to make the two platforms as similar to each other as possible. However, beyond the scope of this experimental study, we must consider that perhaps virtual simulations benefit from being presented to students differently, highlighting the inherent strengths of the virtual platform over manikin-based simulation. For example, one of the benefits of a virtual simulation experience is that it is much easier for it to be delivered asynchronously with multiple attempts, while the resourcing and logistics required for an in-person manikin-based simulation involve specific timing, human resources, and limited attempts. Virtual

simulations can be accessed and practiced by a learner on multiple occasions at the ease and convenience of the individual learner.

Virtual simulations have unique advantages such as the ability to provide an immersive experience that is accessible, safe, and importantly, an experience that is self-pacing and allows for repetition in simulation engagement (Luctkar-Flude et al., 2021). These advantages were largely omitted in the design of the pilot study to focus on the equivalency of experience between simulation modalities, but there may be elements that must be considered in future comparison studies measuring the pedagogical efficacies of different simulation modalities. Virtual simulations also benefit from learners pacing the simulation to their liking, pausing, and returning to simulations in between other learning-related activities, such as research review or additional support. It may be that virtual simulations may have a greater impact if delivered in a manner that is radically different from manikin-based simulations.

The exceptional advantages of virtual simulation activities also open possibilities for unfolding case study simulations incorporating both manikin-based simulations and virtual simulations into a comprehensive learning experience. Park, Hur, and Chung (2022) explored the impact of virtual simulation and high-fidelity simulation on nursing students in a quasi-experimental crossover design study comparing learning efficacy in problem-solving, clinical reasoning, reflective thinking, and self-confidence. Comparing the responses of two groups with one group engaging in a virtual simulation activity first then a high-fidelity simulation afterward and the other group engaging in a high-fidelity simulation first, then a virtual simulation found that the group that engaged with a virtual simulation before the high-fidelity manikin-based simulation scored significantly higher

scores in reflective thinking ($z = 3.52$, $p = .728$). The researchers also concluded that after the first simulation session, the second simulation session also showed significant improvement in clinical reasoning ($z = 2.16$, $p = .031$) and problem-solving ($z = 2.76$, $p = .006$). The results open up possibilities for future research regarding the effectiveness of multi-modal and/or hybrid simulation activities which can highlight the unique benefits of different simulation modalities.

After the pilot study, it was determined that while virtual simulations overall are less effective in learning efficacy, according to the validated survey method utilized, there was no statistical significance between the results of the two modality studies, except for critical thinking skills and critical thinking development. While these results may be genuine and can be extrapolated and used as inference, in general, there may be several alternative explanations that account for the results.

One explanation may be the limited sample size and participation numbers for this pilot study. It may be that if there were more participants from greater sampling sources, the disparity between the two results may align or diverge. It may be the case that if more participants were able to take part in the study, the disparity between the two scores may widen, revealing that there is statistical significance between the learning efficacy of simulation-based experiences divided by modality. However, the reverse could be true as well, and if there were greater numbers of participants, there would be a propensity for the results to reflect normal distribution statistically more closely, showing that there is an overall negligible difference between the results of manikin-based simulations and virtual simulations.

As this was a pilot study, we relied on literature to justify our sample size; however, in future iterations of the study, it will be important, if not essential, to ensure that a power analysis is performed, and the appropriate number of participants take part in the study to further guarantee if the disparity in results between modalities is statistically significant.

Limitations

A pilot study provides valuable insights but involves several limitations that should be considered. First, as mentioned above, the sample size, while adequate for a pilot study, is relatively small. In future studies, a power analysis should be conducted to ensure that the results truly represent the population. Similarly, the current research study drew participants from only a single institution. Future studies should consider sourcing participants from multiple nursing educational institutions.

Data collected from the pilot study utilizes externally validated instruments but currently relies solely on self-reported measures by the participants of learning efficacy and learner satisfaction. Therefore, there is a possibility that response bias of participants exists within the data presented. Future studies may benefit from both self-disclosed learning efficacy along with summative evaluation of learning efficacy via the utilization of instruments and methods which gauge pedagogical efficacy through external observation.

Although inclusion and exclusion criteria of this pilot study were created to minimize prior participant bias regarding simulation modalities, there were still some disparities between how many prior simulations each participant experienced. Future

studies should consider the potential for prior participant bias regarding certain simulation modalities.

Recommendations for Future Research

As this experiment is a pilot study, it is limited in scope; however, there are numerous ways to build upon the central premise and the initial experimental design of this pilot study for future research opportunities. Several recommendations for future research stemming from this experimental process are considered. First, to increase the scope and power of this research process by including more participation from more BSN pre-licensure nursing students. Second, to ensure the quality and accuracy of the simulation content by pre-testing the simulation using established academic resources and validated evaluation methods; and third, to further the evaluation and measurement of learning efficacy by introducing summative evaluation and external assessment of learning outcomes in ways other than participants' own perceptions of learning efficacy and satisfaction.

The pilot study initially included 30 participants who were divided into two groups, resulting in 15 participants per modality. However, as two results were incomplete at the end of the experiment, they were discarded, and a total of 28 participants were included in the final results of the experiment. One method and recommendation for further research is to conduct a true quantitative randomized study by performing a statistical power analysis and recruiting enough members to ensure the accuracy of results, allowing for confident inferences to the general population. Furthermore, it is recommended that the scope of the study be expanded to include BSN

pre-licensure nursing students from other undergraduate institutions to ensure the validity and possibly generalizability of the experimental results.

There may also be opportunities to target simulation content and activities to participants based on the content they are currently studying. The pilot study relied on a basic assessment simulation to ensure that all participants had at least some familiarity with the clinical concepts offered in the simulation, so as not to skew the data based on the participant's level of understanding of the educational content. However, in the future, it may be possible to target certain cohorts and offer simulation content that is directly relevant to the subjects that the participants are currently learning about.

The second recommendation is to establish a formalized method of validating the virtual simulation of serious games based on pre-established methods designed to validate the level of game design, user interface, and user experience. It is possible that factors related to the virtual simulation, which are unrelated to the simulation modality or content, may have affected the result of this pilot study. Therefore, ensuring that these measures are taken before future studies will account for this limitation and ensure that results are more accurate and valid in future studies.

As mentioned previously, it is recommended that the System Usability Score (SUS) and Player Experience Inventory (PXI) be used to validate the usability and functionality of a virtual simulation serious game platform before use in the experiment. This has the added benefit of ensuring that future studies can be replicated by other researchers using virtual simulation serious games that are created by different distributors and educational bodies. If a certain threshold of SUS and PXI scores can be used to validate the virtual simulation experience, other virtual serious games can be used

for the study if they also meet and satisfy the SUS threshold. This will account for the possible limitation of the diversity in virtual simulation delivery methods affecting the experimental outcomes.

There is a possibility that individual participant's willingness and capacities involving the use of technology affected the resulting data. Certain participants may be more technologically fluent than other participants who may have existing aversions regarding the use of emerging technologies. The Unified Theory of Acceptance and Use of Technology (UTAUT) is a theoretical model developed to understand and describe factors that influence an individual's decision to accept and use emerging technologies (Venkatesh et al., 2003). Future studies may consider incorporating the UTAUT into its research theoretical framework and approach research with an increased critical perspective.

Finally, it is recommended that future studies related to comparing simulation modalities in terms of educational effectiveness employ methods to account for external summative evaluations or direct testing, which measures the meeting of learning objectives for students. Past studies have utilized knowledge examinations to attempt to measure the satisfaction of learning outcomes for participants. If such measures are to be utilized, it is recommended that these evaluative examinations be statistically validated before use. If future studies would use summative evaluations to include an external measurement of learning effectiveness and satisfaction, it is recommended that the evaluations take place using a validated method, and interrater reliability be accounted for among researchers.

One such summative evaluation method observed in the literature related to simulation effectiveness is the Creighton's Competency Evaluation Instrument (CCE-I) (Manz et al., 2022). Such validated evaluation tools to standardize summative observations of simulation effectiveness would strengthen the results of future experimental studies and include the aspect of external observation in addition to participants' observations of learning efficacy when analyzing data. Aligning all researchers to follow a singular summative evaluation format, could also assist in strengthening interrater reliability when assessing simulation effectiveness.

The pilot study explored the effectiveness of virtual-based simulations compared to traditional manikin-based simulations in nursing education. Findings suggested that overall, virtual simulations were less effective in meeting learning outcomes, with potential factors including user interface issues, differences in content delivery, and challenges specific to virtual simulation platforms. The study recommended expanding sample sizes, targeting simulation content based on participants' current studies, and validating virtual simulation serious games for future research. Additionally, it emphasized the importance of employing validated methods, such as the System Usability Scale and Player Experience Inventory, to assess the usability and functionality of virtual simulation platforms and incorporating external summative evaluations to enhance the robustness of comparative studies.

Conclusion

Nursing education has witnessed a growing integration of virtual simulation-based experiences, particularly screen-based serious games, aiming to provide learners with realistic clinical scenarios. The pilot study conducted to address the existing knowledge gap compared the pedagogical effectiveness of virtual simulations with traditional manikin-based simulations in terms of learner satisfaction, self-confidence, knowledge acquisition, skills development, and the transfer of learning to clinical practice. Guided by Kolb's Experiential Learning Theory and the NLN Jeffries Simulation Theory, the study involved 30 participants randomly assigned to engage in either a screen-based serious game or a manikin-based simulation, both designed with identical learning objectives and clinical indicators. While findings indicated that virtual serious games exhibited less pedagogical effectiveness than manikin-based simulations, except for critical thinking aspects of learning, there was no statistically significant difference between the two modalities in terms of overall learning outcomes.

The pilot study not only examined the merits of virtual-based simulations with traditional manikin-based simulations in nursing education but also highlighted the nuanced differences in learning outcomes and critical thinking aspects between the two modalities. The findings underscore the importance of refining virtual simulation experiences, considering factors such as user interface challenges and content delivery, and expanding the scope of future research to enhance the understanding of their pedagogical effectiveness in nursing education.

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Appendix A: Basic Assessment Care Lab Simulation Document

BCIT

Simulation Package: Basic Assessment Care Lab Simulation	
BCIT School of Health Sciences BSN	
Written by: Virtual Pulse	**Reviewed by:** Experiential Learning Team

Table of Contents

BCIT

Instructor Briefing	
Term 6 6030 Post-Trauma Care Lab Simulation	
Author & Date: BSN simulation	Reviewed by: Experiential Learning Team, Term 6 Faculty

SCENARIO GOAL & SYNOPSIS

The goal of the simulation is to provide all learners with the opportunity to assess and make decisions about the care of a client.

Scenario Synopsis

Location: BCIT Hospital
Client Name: Mark Jones

Age: January 7th 19xx
Admitted for: Pneumonia, COPD exacerbation.

Scenario: Mark Jones presented to the Emergency Department 2 days ago after being brought in by his son for a worsening cough and mild shortness of breath overnight. He is a 79-year-old man who developed a productive cough of green phlegm 9 days ago. Mark was initially seen by his family doctor and started on Prednisone 40 mg PO daily and Azithromycin 250 mg PO for 5 days. However, Mark's cough continued to worsen, and he developed shortness of breath which prompted Mark's family to take him to the Emergency department. He was assessed in the Emergency department and transferred to the ward 2 days ago for treatment of COPD exacerbation and pneumonia. He has improved significantly with Oxygen therapy, IV antibiotics and fluids. As the student nurse assigned to this patient today, you are asked to complete a comprehensive health history and basic assessment to review Mark's readiness for discharge. You will be expected to record relevant findings and report these to your primary RN.
Additional patient details will be available to you once you have started the virtual simulation scenario.

Mark presented to the Emergency Department 2 days ago after being brought in by his son for a worsening cough and mild shortness of breath.

LEARNING OBJECTIVES

Learning Objectives

At the conclusion of the simulation experience, the learner will be able to:

1. Perform a systematic basic head to toe health assessment.
2. Notice and gather relevant patient health data to inform decision making.
3. Identify and appropriately report pertinent health data.
4. Demonstrate therapeutic communication skills when initiating a health assessment interview to build relational practice.
5. Demonstrate basic skills in reporting pertinent health assessment findings to the primary RN using SBAR (Situation, Background, Assessment and Recommendation).

BCIT

- **Can** listen to lung sounds, heart sounds, bowel sounds, get RR, HR, BP. Velcro on equipment for Temp, O2 sat. Lanyards on manikins have color, warmth, movement, sensation.

Safety: Hand sanitizer at the front, sinks and gloves at back corners, wall units non-functional
Workspace: (medication cart, supply room nursing work stations, microphone on the wall)

- Provide instructions for what to do with supplies (what to throw out, what to keep)

Documents and resources: (Chart and Kardex, Drug Guide, Documentation, formulary etc.) on iPad
Monitors: Explain usage of monitors including how to get the blood pressure.

VERBALIZE REPORT (Review the report in briefing)
Shift report:

Time 0700

You are a student nurse beginning your shift with the assigned primary RN. It is 0730 and you have completed the morning report. The primary RN is starting all morning medication administration and has asked you to do a basic head to toe assessment of Mark.

Mark Jones is a 79-year-old man who was admitted two days ago to a general medical floor with pneumonia. He was admitted via the emergency department, having presented with a week long history of increasing productive cough and mild shortness of breath.

Mark's condition has progressively improved following oxygen therapy, IV antibiotics and fluids. It is anticipated that he may be fit for discharge in the next day or two.

Please perform a systematic basic health assessment in order to establish this patient's current health status.

Infection considerations: MRSA positive

QUESTIONS: Any questions?

PEARLS DEBRIEFING GUIDE	
For additional information about PEARLS: https://debrief2learn.org/pearls-debriefing-tool/	
Setting the Scene: Start with something to get participants into the debrief (i.e., "Lots of good learning here. Let's all take a deep breath and then we can start to debrief and discuss this scenario").	
Reaction Phase	
Prompting Query	**Teaching & Learning Objective**
What was it like to work through that scenario? Any initial reactions?	Explore feelings
Given the scenario description, how did you anticipate the client would present?	
What emotions did you feel during the scenario? Did you feel prepared with the knowledge necessary to work through this scenario?	

BCIT

Descriptive Phase	
Prompting Query	**Teaching & Learning Objective**
Describe the events that transpired? Were there any surprises?	Clarify facts, link client assessments
What did you include in your initial safety check?	
What did you identify as your priority problems based on the information in the pre-brief? Did these problems change during the scenario? (Impaired gas-exchange, impaired perfusion etc.)	
What do you think is going on with the patient? What were some potential differential diagnoses based on your assessment findings?	
What did you assess regarding the chest tube? Any significant findings?	
How did you demonstrate relational practice skills and de-escalation skills when communicating with Aaron?	
What other information would have been important to know?	
Analysis Phase	
Prompting Query	**Teaching & Learning Objective**
How did you identify what the client needed help with?	Explore a variety of performance domains
When did you know your client needed more support?	
What were your priority problems? What were some of your justifications?	
What information was important to tell your instructor/other HCPs?	
What interventions or recommendations did you request?	
Would you ask something differently next time?	
Discuss how the concepts apply to this situation.	
Application/Summary Phase	
Prompting Query	**Teaching & Learning Objective**
What did you learn from this experience?	Consolidate learning from simulation experience & identify takeaways
What will you take back to your clinical practice area?	
Describe how this simulation experience has expanded your nursing knowledge.	

BCIT

Simulation Pre-Briefing Script

WELCOME: We believe that everyone participating in activities at BCIT is intelligent, capable, cares about doing their best and wants to improve©[1]

PLAN FOR THE DAY: 10-minutes pre-briefing 30 minutes simulation (manikin-based or virtual simulation), 30 minutes debrief, 10-30 minutes completion of survey.

SIMULATION OBJECTIVES & EVALUATION

At the conclusion of the simulation experience, the learner will be able to:

- Perform a systematic basic head to toe health assessment.
- Notice and gather relevant patient health data to inform decision making.
- Identify and appropriately report pertinent health data.
- Demonstrate therapeutic communication skills when initiating a health assessment interview to build relational practice.
- Demonstrate basic skills in reporting pertinent health assessment findings to the primary RN using SBAR (Situation, Background, Assessment and Recommendation). Act as you would as a student nurse in the clinical setting in providing care for the client
- This simulation evaluates students for preparation, professionalism, punctuality, and participation. There are no grades given for performance.
- You will work on a team like nurses would work together in the clinical setting. Together decide who takes the primary role and who supports in the secondary role.
- You can acknowledge privacy but keep curtains open, so actions remain visible to instructors.
- Assume the client does not have COVID 19 despite any related symptoms.

PSYCHOLOGICAL SAFETY & FICTION CONTRACT

- If you feel overwhelmed, please request a timeout or pause, and ask for guidance. Announce your request for pause clearly to your instructor or facilitator. You may be asked to work things out with your group, or we may give more direction.
- Do your best to suspend your disbelief and enter the scenario as the fiction contract outlines, clarify if you have a question about the equipment or environment

ENVIRONMENT, EQUIPMENT, and TECHNOLOGY

Ask all students to bring out their data collection sheet, and any other equipment/supplies they need as if they are in the clinical setting. NO PENS.

Bring the students into the simulation lab. Give students a few minutes to look in the chart, review their roles, ask any questions. Tell the students when the scenario starts and ends.

- No pens

Manikins: Nurse Anne

- 10 pulse points – pedal (only DP), femoral, radial, brachial, and carotid – bilateral
- **Cannot** do 2 step BP check – speaker for the BP is on the upper forearm

[1] Copyright 2004-2020 Center for Medical Simulation, Boston, Massachusetts, USA. www.harvardmedsim.org info@havardmedsim.org. All Rights Reserved – Used with permission.

Appendix B: Information Letter and Participation Consent Form

BCIT - NW4 (Health Sciences Centre)
BSN Nursing, School of Health Sciences
British Columbia Institute of Technology
3700 Willingdon Avenue
Burnaby, BC V5G 3H2

Athabasca University
FACULTY OF HEALTH DISCIPLINES

RESEARCH CONSENT FORM

TITLE:	Determining the Efficacy of Virtual Simulation in a Bachelor of Nursing Program
PRINCIPAL INVESTIGATOR:	**Ho-Sup (Robert) Kim** robert_kim@bcit.ca 604-833-3157 Experiential Learning Coordinator BCIT BSN School of Health Sciences
CO-SUPERVISORS:	**Dr. Barbara Wilson-Keates** bwilsonkeates@athabascau.ca Academic Coordinator Faculty of Health Disciplines Athabasca University **Dr. Karen Cook** kcook@athabascau.ca Associate Professor Faculty of Health Disciplines Athabasca University

INVITATION

You are invited to take part in a research project entitled 'Determining the Efficacy of Virtual Simulation'. This form is part of the process of informed consent. The information presented should give you the basic idea of what this research is about and what your participation will involve, should you choose to participate. It also describes your right to withdraw from the project. In order to decide whether you wish to participate in this research project, you should understand enough about its risks, benefits and what it requires of you to be able to make an informed decision. This is the informed consent process. Take time to read this carefully as it is important that you understand the information given to you. Please contact the principal investigator, *Ho-Sup (Robert) Kim* if you have any questions about the project or would like more information before you consent to participate.

WHAT IS THE PURPOSE OF THE STUDY?

The purpose of this research project is to understand students' perceptions and thoughts regarding the effectiveness of virtual simulation when compared to high-fidelity manikin simulation. As well, we would like to understand the effectiveness of different simulation-based learning experiences are and how they may differ in consolidating nursing knowledge.

WHY ARE YOU BEING INVITED?

You are being invited to participate in this project because you are an undergraduate nursing student currently enrolled in BCIT Bachelor of Science Nursing Program. We are asking for year one or year two pre-licensure nursing students who have successfully completed a basic assessment nursing education and one clinical rotation (or its equivalent) to participate in this research project.

No exclusion criteria based on age, gender or ethnicity is considered. It has been determined that demographic data was not a relevant factor in attempting to study the principal research question. Students in their third or final year of nursing education is excluded due to a possibility of perceived biases on simulation modalities from previous simulation experiences they may have gathered as part of the nursing curriculum.

DO YOU HAVE TO TAKE PART?

Involvement in this study is completely voluntary. During the simulation, you may simply leave the simulation lab if you wish to withdraw from the study. During completion of the questionnaire, you may refuse to answer any questions or to share any information that you are not comfortable with. You will not be asked to provide any personally identified information or data in the questionnaire. There are no anticipated risks to participants. It is not possible to know all the risks that may happen in a study, but we have taken all reasonable safeguards to minimize any known risks to participants. Benefits may include personal consolidation of nursing knowledge and a development of knowledge to better organize simulation experiences in the future. At the end of the questionnaire, you will be given the choice to provide your email address. If you decide to provide your email address, you will receive a Tim Horton's gift card.

It is entirely up to you whether you take part in this research. If you choose not to take part, or if you decide to withdraw from the research once it has started, there will be no negative consequences for you now, or in the future. Your decision to participate, or to later withdraw may be done without explanation and without any consequences to your course grade or progress through the graduate program. Your decision not to participate will not affect you, your grades, or your progress through the undergraduate nursing program.

You may withdraw from the questionnaire at any time by simply closing out of your browser. Once you submit your completed survey, however, data cannot be withdrawn as the stored survey data is anonymous. Withdrawal will not affect your

academic progression or grade in your current clinical course. Please print a copy of this consent form for your records.

CAN YOU BE ASKED TO LEAVE THE STUDY?
If you are not complying with the requirements of the study or for any other reason, the researchers may withdraw you from the study.

WHAT WILL YOU NEED TO DO IF YOU TAKE PART?
In this study, you are being invited to participate in either an in-lab or virtual simulation and to complete a questionnaire about your experiences with simulations. You will be randomly selected to participate in either a virtual simulation or a high-fidelity manikin simulation. Both simulation types will occur in an in-lab environment. All participants will receive a pre-briefing preparation material to prepare for the simulation and participate in a debriefing session. Preparation documents will be sent to you via your BCIT email at least 1 week before your scheduled simulation time.

After completion of the simulation-based experience, you will be invited to complete an online, 50-item questionnaire about your perspectives, attitudes, and satisfaction about your simulation experience. You will also be asked to compare your experience with the other type of simulation as well as five demographic questions. Participation in the study will take approximately 60 - 90 minutes of your time in total.

HOW WILL MY INFORMATION BE USED?
The research study results will be reported via a graduate thesis project through Athabasca University. Participants can receive a summary of the results upon request.

WHAT ARE THE POSSIBLE DISADVANTAGES AND RISKS OF TAKING PART?
There are no identified disadvantages to taking part in this study. The study is of minimal risk and the risk of participation will not be greater than those encountered by the participants in everyday life.

WHAT ARE THE BENEFITS OF TAKING PART?
Participants may gain valuable exposure to the research process and gain nursing knowledge through participating in the clinical simulation.

WILL MY TAKING PART IN THIS STUDY BE KEPT CONFIDENTIAL?
All hard copy data will be kept in a locked cabinet at the principal investigator's home office. All electronic data will be encrypted and kept in a password protected computer at the principal investigator's locked business office. Email addresses provided will not be associated with your survey responses. Confidential shredding will destroy all information and records and electronic records will be deleted when all project requirements have been met approximately by February 2029.

All secure data will be stored on British Columbia Institute of Technology servers, located within Canada (cIRcuit: BCIT's Institutional Repository). This data will be accessed and accessed only by the principal investigator. cIRcuit: BCIT's Institutional Repository).

No data that includes your name or email address will be released outside of the researcher's office or published by the researchers. Only the principal investigator (Ho-Sup (Robert) Kim) will have access to the data. We may publish the results in an academic journal and present it at an academic conference. You will not be personally identified in the results. We may use the data we get from this study in future research, but if we do, it will be approved by a Research Ethics Board. You may ask to receive a copy of the report of the research findings by asking the researcher.

This study has been reviewed by the Athabasca University Research Ethics Board and British Columbia Institute of Technology Research Ethics Board. Should you have any comments or concerns regarding your treatment as a participant in this study please contact the REB below. .

WHO IS ORGANIZING AND FUNDING THIS RESEARCH?
This study is note sponsored. This research is organized and funded by the principal investigator.

WILL YOU BE PAID FOR BEING IN THIS STUDY?
$5 coffee gift card will be provided to each participant. There will be no costs to you for participating in this study. You will not be charged for any research procedures.

CONTACT FOR FURTHER INFORMATION.
If you have any questions or desire further information with respect to this study, you should contact Robert Ho-Sup Kim at robert_kim@bcit.ca.

If you would like a summary of the study when available, please contact Robert Ho-Sup Kim at robert_kim@bcit.ca.

If you have any concerns about your treatment or rights as a research participant, you may contact the chair of the BCIT Research Ethics Board at 604432-8554 or research_ethics@bcit.ca

Thank you for reading this.

WHY ARE YOU SIGNING THIS CONSENT FORM?
By signing this consent form, you agree that:

- You have read the information about the research project.
- You have been able to ask questions about this project.

- You are satisfied with the answers to any questions you may have had.
- You understand what the research project is about and what you will be asked to do.
- You understand that you are free to withdraw your participation in the research project without having to give a reason and that doing so will not affect you now or in the future.
- You understand that if you choose to end your participation **during** data collection, any data collected will be destroyed and not included as part of the research study.
- You understand that once you submit your completed survey, data cannot be withdrawn as the stored survey data is anonymized.

SIGNATURE(S)

Your signature confirms:

- You have read what this research project is about and understood the risks and benefits. You have had time to think about participating in the project and had the opportunity to ask questions and have those questions answered to your satisfaction.
- You understand that participating in the project is entirely voluntary and that you may end your participation at any time without any penalty or negative consequences.
- You have been given a copy of this Informed Consent form for your records; and
- You agree to participate in this research project.

I_____, consent to participate in *Determining the Efficacy of Virtual Simulation in a Bachelor of Nursing Program* conducted by Robert (Ho-Sup) Kim. I have understood the nature of this project and wish to participate. My signature below indicates my consent.

_____
E-mail address of Participant

_____ _____
Signature of Participant Date

I have explained this project to the best of my ability. I invited questions and responded to any that were asked. I believe that the participant fully understands what is involved in participating in the research project and any potential risks and that they have freely chosen to participate.

_____ _____
Signature of Principal Investigator Date

Appendix C: Certification of Ethical Approval

Athabasca University
RESEARCH CENTRE

Appendix C: Certification of Ethical Approval

CERTIFICATION OF ETHICAL APPROVAL

The Athabasca University Research Ethics Board (REB) has reviewed and approved the research project noted below. The REB is constituted and operates in accordance with the current version of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2) and Athabasca University Policy and Procedures.

Ethics File No.: 25199

Principal Investigator:
Mr. Ho-Sup Kim, Graduate Student
Faculty of Health Disciplines\Master of Nursing

Supervisor/Project Team:
Dr. Barbara Wilson-Keates (Co-Supervisor)
Dr. Karen Cook (Co-Supervisor)

Project Title:
Determining the Efficacy of Virtual Simulation
Effective Date: April 3, 2023 **Expiry Date**: April 2, 2024

Restrictions:

Any modification/amendment to the approved research must be submitted to the AUREB for approval prior to proceeding.

Any adverse event or incidental findings must be reported to the AUREB as soon as possible, for review.

Ethical approval is valid *for a period of one year*. An annual request for renewal must be submitted and approved by the above expiry date if a project is ongoing beyond one year.

An Ethics Final Report must be submitted when the research is complete *(i.e. all participant contact and data collection is concluded, no follow-up with participants is anticipated and findings have been made available/provided to participants (if applicable))* or the research is terminated.

Approved by: **Date: April 03, 2023**

Paul Jerry, Chair
Faculty of Health Disciplines, Departmental Ethics Review Committee

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Athabasca University Research Ethics Board
University Research Services Office
1 University Drive, Athabasca AB Canada T9S 3A3
E-mail rebsec@athabascau.ca
Telephone: 780.213.2033