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UNIVERSITY OF NORTHERN COLORADO

Greeley, Colorado

The Graduate School

COMPARISON OF TEACHING STRATEGIES ON TEACHING
DRUG DOSAGE CALCULATION SKILLS IN
FUNDAMENTAL NURSING STUDENTS

A Dissertation Defense Submitted in Partial Fulfillment
of the Requirements for the Degree of
Doctor of Philosophy

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College of Natural and Health Sciences
School of Nursing
PhD Nursing Education

May, 2010

This Dissertation by: Jaclynn S. Huse

Entitled: *Comparison of Teaching Strategies on Teaching Drug Dosage Calculation Skills in Fundamental Nursing Students*

has been approved as meeting the requirement for the Degree of Doctor of Philosophy in
College of Health Sciences in School of Nursing, Program of Nursing Education

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ABSTRACT

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Dosage calculation errors in clinical settings are ongoing issues, in spite of nursing programs implementing multiple teaching strategies to improve calculation skills in nursing students. In addition, validating dosage calculation skills with a traditional paper/pencil dosage calculation instrument does not necessarily reflect how a student will perform in a real clinical setting.

This dissertation study was guided by a quasi-experimental, quantitative design. Polya's Four Phases of Problem-Solving framework and the Nursing Education Simulation Framework were utilized to design a traditional case study in the classroom and a low-fidelity scenario in a simulation lab. A pre-test/post-test was utilized to analyze changes that occurred in fundamental, associate degree nursing students as a result of the interventions. The purpose of this dissertation study was to (a) compare medication administration dosage calculation scores and scores of self-perceived judgment in medication dosage calculations in students who attended either a traditional classroom experience or a low-fidelity simulation experience and (b) determine if there was any difference between satisfaction and self-confidence in learning when comparing the classroom and simulation teaching modalities.

This study revealed that both teaching strategies improved students' abilities to accurately calculate dosages and increased perception that calculated dosages were logical. A distinguishing factor revealed in this study was that students in the simulation group were significantly more confident that the necessary skills to perform this task in the clinical environment were being developed and that appropriate resources were used. Patient safety is a major concern in the clinical environment and self-confidence has been linked to the ability to perform accurately. The simulation group was significantly more satisfied with the helpfulness and effectiveness of the teaching module, the variety of learning materials and activities provided that motivated learning, and how the instructor taught the simulation to make it suitable for individual learning needs.

Key words: simulation, dosage calculation skills, self-perceived judgment, satisfaction, self-confidence

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CHAPTER I

INTRODUCTION

Eleven years have passed since the Institute of Medicine (1999) issued an alarming report, *To Err is Human: Building a Safer Health System* that emphasized the role of medication errors in the 44,000 to 98,000 medical errors that occur annually. Because of this report, the last decade has seen an influx of patient safety initiatives to reduce medication errors such as the use of electronic prescriptions, unit dose packaging, bar codes, improved packaging and labeling, and increased use of electronic smart pumps for intravenous infusions. In spite of these initiatives, medication errors still occur (Eisenberg, 2009; Sanborn, et al., 2009; Tamblyn, et al., 2008).

Nurses have a responsibility to abide by organizational policies to ensure that these initiatives are implemented so that both patient safety and quality control are improved. However, these initiatives alone will not prevent every single medication error. The rationale for continued medication errors stems from the fact that nurses can bypass safety protocols (Eisenberg, 2009) and nurses still have to calculate correct dosages, choose the correct equipment to administer the drug, and follow the five rights of drug administration (Wright, 2009). A breach in any of these factors can be instrumental in causing a catastrophic error. In fact, the increased initiatives to improve patient safety may be contributing to errors such as drug calculation mistakes because nurses do not have to calculate dosages as frequently which could lead to a decreased fluency in this

skill (Durham & Alden, 2008; Hutton, 1998a). Dosage calculations have not been eliminated entirely and its infrequent use should stimulate a renewed interest in making sure nurses remain competent when this task is required.

Dosage calculation skills in nursing students and the responsibilities of nursing education are complex issues. The purpose of this chapter is to discuss the background of medication errors from a multidisciplinary perspective and how nurses are involved in these errors. This discussion is followed by a description of the role and responsibilities of nursing education. This discussion includes issues related to a lack of nationalized standards for validating math competency and ineffective educational approaches that have resulted in a theory-to-practice gap when practicing nursing in a realistic environment. Inspired by the background issues related to nursing education and the continued problems with dosage calculations, the potential benefits to education in a constructivist simulated environment will be introduced in the context of dosage calculation skills.

Background

Multidisciplinary Perspective on Medication Errors

In November of 2007, a near catastrophic event occurred when the newborn twins of actor Dennis Quaid received a dosage of Heparin that was 1000 times stronger than prescribed (Healthcare Risk Management, 2008a, 2008b). This high profile event amplified the media's attention on a growing concern for patient safety and its role in quality control when system safeguards fail. In 1999, the Institute of Medicine issued an alarming report, *To Err is Human: Building a Safer Health System* emphasizing the significant issues on medical errors (Institute of Medicine, 1999). According to the IOM,

medical errors account for up to 98,000 deaths per year exceeding deaths from breast cancer, AIDs, and motor vehicle accidents combined (Kohn, Corrigan, & Donaldson, 2000).

Medication errors are one of the most common types of medical errors. The National Coordinating Council for Medication Error Reporting and Prevention (2009), a combination of 26 national organizations including the American Nurses Association (ANA) and the National Council of State Boards of Nursing (NCSBN), defined a “medication error” as follows:

"A medication error is any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer. Such events may be related to professional practice, health care products, procedures, and systems, including prescribing; order communication; product labeling, packaging, and nomenclature; compounding; dispensing; distribution; administration; education; monitoring; and use."
(NCCMERP, 2009, online).

Medication errors are implicated in 2% of hospital admissions and are responsible for approximately 7000 deaths per year (Kohn, et al., 2000). These preventable adverse events occur 1.5 million times per year in the United States and result in an annual cost of \$3.5 billion dollars which does not include the inestimable human cost of the physical or psychological impact on the patient and their significant others (Institute of Medicine of the National Academies, 2007) or the cost of the loss of trust in the health care system (Institute of Medicine, 1999). When an inadvertent catastrophe does occur to a patient, the impact on the person responsible for the error can also be extremely devastating including a loss of self-confidence, powerlessness, shame, and suicidal ideations (Schelbred & Nord, 2007).

It is difficult to pinpoint a single source of responsibility when most documented medication errors are a result of a host of cascading factors that result in a systems failure rather than strictly isolated individual incompetence (Armitage & Knapman, 2003; Cohen & Shastay, 2008; Fry & Dacey, 2007; Gregory, Guse, Dick, & Russell, 2007; Harding & Petrick, 2008; Institute for Safe Medication Practices, 2005; Institute of Medicine, 1999; Kohn, et al., 2000; Milligan, 2007; Page & McKinney, 2007). Systems failure is a consequence of poor packaging and labeling, inaccuracies in prescription, erroneous dispensing and distribution of the medications, and imprecise preparation and administration of the drug (Kohn, et al., 2000).

Rationale for Medication Errors in Nursing

Although the responsibility of these errors do not lie solely within nursing, nurses are involved in the administration phase of medication delivery to patients, which accounts for 26-40% of all medication errors (Manno, 2006). Some of the contributing factors identified for nursing medication errors include attitude, overconfidence, lack of appropriate supervision, failure to correct a problematic situation (Wiegmann & Shappell, 2003), failure to follow hospital policies, poor communication, fatigue (Armitage & Knapman, 2003), distractions, interruptions (O'Shea, 1999), longer shifts and staffing levels (Milligan, 2007). It is important to consider that some of the contributing factors to medication errors have a direct relationship with the roles of nursing education including a lack of appropriate education, verification of skills (Gregory, et al., 2007; Kohn, et al., 2000) and inability to accurately calculate dosages (Polifroni, McNulty, & Allchin, 2003).

The recent release of *Preventing Medication Errors: Committee on Identifying and Preventing Medication Errors* continues to highlight a growing concern that medication errors still occur at high rates in spite of previously alarming national reports issued by the Institute of Medicine (Institute of Medicine of the National Academies, 2007). The culmination of these multidisciplinary reports is largely responsible for a renewed interest in improving safety and quality control within all parties involved in the health care system. The discipline of nursing is no exception. According to the NCSBN, patient safety is of utmost importance (2007). The board's concern for safety and competence in newly licensed registered nurses is reflected in the increased amounts of NCLEX-RN questions in relation to patient safety issues such as medication error prevention, correct dosage calculations, proper administration, and evaluation of expected effects and outcomes. Although NCLEX-RN success is a top priority for nursing schools it is of even greater importance that graduates are competent and confident and deliver safe nursing practices in a real clinical setting.

Nursing organizations such as the NCSBN, ANA, American Association of Colleges of Nursing (AACN), American Organization of Nurse Executives (AONE), and the National League for Nursing (NLN) and the accrediting agency, The National League for Nursing Accrediting Commission (NLNAC) have demonstrated an interest in improving patient safety (American Association of Colleges of Nursing, 2006, 2008; National League for Nursing Accrediting Commission, 2008). Now is the time for nurse educators to reflect on lessons learned and engage in an evaluation of student error from an educational systems perspective (Gregory, et al., 2007).

Role of Nursing Education

Lack of Appropriate Education

Nurse educators have historically concentrated on instilling the five rights of medication safety (right patient, medication, dose, route, and time) and teaching dosage calculation skills to nursing students within their first semester of nursing school in a fundamentals course (Timby, 2009; L. White, 2005) and never reassess these skills again during the remainder of the program (Polifroni, et al., 2003). This type of educational practice reduces the process of medication administration to a mechanistic procedure (United Kingdom Central Council, 2000) meanwhile giving nursing students a false assurance that adverse events will not occur if they just follow the five rights (Cohen & Shastay, 2008). Medication errors have been documented when the five rights are not followed (Harding & Petrick, 2008; Polifroni, et al., 2003). In addition, this type of teaching methodology fails to include the exercise of clinical judgment skills that are so vital to the process of medication administration (Harding & Petrick, 2008; United Kingdom Central Council, 2000).

Current Educational Approaches

Calculation skills are extremely important and nurse educators have tried various approaches to teaching students how to calculate dosages accurately. Dimensional analysis is one formula method that educators have used successfully to help students overcome math frustrations such as difficulty with conversions and confusing fractions (Greenfield, Whelan, & Cohn, 2006; Rice & Bell, 2005). Innovative teaching strategies such online math sessions (Maag, 2004; Weeks, Lyne, & Torrance, 2000; Wright, 2004), traditional lecture, drug calculation workbooks, practical sessions in the skills laboratory,

and private study with recommended literature (Wright, 2004, 2005, 2007a, 2008) have been implemented with only a moderate amount of success since no single method has been able to produce acceptable success rates in all of the participants.

Validation of Calculation Skills

Calculation skills have been identified as an important aspect of nursing education and educators must find ways to validate that students are able to safely and accurately calculate correct medication dosages. This presents quite a challenge stemming from several inconsistencies noted within educational systems (Polifroni, et al., 2003). First, higher educational institutions demonstrated that there are inconsistencies within university standards or policies for mathematical requirements upon entry into the nursing program or throughout the program. A second inconsistency exists with what constitutes the minimal score that a student should achieve to demonstrate competency in calculation skills. This inconsistency illuminates a major issue on why *any* errors would be acceptable and recommendations have been made that dosage calculation policies should mandate 100% accuracy on validation tests (Papastrat & Wallace, 2003; Pierce, Steinle, Stacey, & Widjaja, 2008; Polifroni, et al., 2003). A third inconsistency is present on when and how often a student should validate dosage calculation competency. And finally, educational institutions are inconsistent on how to manage students who do not meet the standards of performance on dosage calculation tests (Polifroni, et al., 2003).

Math skills are typically validated through computerized or paper and pencil math tests typically designed by the faculty members (Pierce, et al., 2008; Polifroni, et al., 2003) even though current literature argues the validity of this approach because these types of instruments test a student's ability to successfully take a test and have no

bearings on the student's quality of performance in the real world (Andrew, Salamonson, & Halcomb, 2009; Armitage & Knapman, 2003; Hutton, 1998b; Ludwig-Beymer, Czurylo, Gattuso, Hennessy, & Ryan, 1990; Segatore, Edge, & Miller, 1993; Wilson, 2003; Wright, 2007b, 2009). In reality, a focus on written math tests alone can result in an artificial situation that encourages nursing students to learn the skill of how to pass the test successfully to prove competence while failing to address real issues of calculating and administering drugs in clinical practice (Wright, 2009).

Future Educational Approaches

In light of current research pointing to systems failure as a major contributing factor to medication errors, nurse educators need to reexamine the educational process from a systems standpoint (Harding & Petrick, 2008). An evaluation of this magnitude at all levels of nursing education can lead to changes in the educational process that would “make it harder for people to do something wrong and easier for them to do it right” (Institute of Medicine, 1999, p. 2). A shift toward patient safety and quality control will transpire in the educational system through evaluating and implementing changes to “courses, curricula, programs, models of clinical instruction, and teaching-learning approaches” (Gregory, et al., 2007, p. 80).

The literature is replete with recommendations that curricula should include the training of undergraduate students in safe medication administration and calculation in a constructivist environment. This type of environment allows the student to learn and perform authentic tasks in a realistic setting where ‘real’ patient charts, syringes, ampoules, and IV pumps are available and the student has to pull all of the information available to insert into the formula to calculate the correct dose (Blais & Bath, 1992;

Glaister, 2005; S. Johnson & Johnson, 2002; Kelly & Colby, 2003; Rice & Bell, 2005; Weeks, et al., 2000; Wright, 2007b, 2009).

A constructivist learning environment is considered an active-learning, student-centered approach to teaching. In this environment, knowledge is constructed as the learner tries to make sense of their experiences (Driscoll, 2005). According to Driscoll, increased reasoning and critical thinking skills, retention and understanding, cognitive flexibility, self-regulation, and mindful reflection are instructional goals that can be reached through the constructivist instructional method. Five conditions must be met for learning to occur in a constructivist environment: (a) learning must be embedded in complex, realistic, and relevant environments, (b) the need to create a learning community where learners can collaborate as they interact and negotiate with their peers, (c) the provision of multiple, diverse perspectives and multiple modes of learning, (d) the encouragement of student ownership and responsibilities in the learning experience, and (e) the encouragement of student reflection on the learning process (Driscoll).

A constructivist learning environment for teaching dosage calculation skills encourages a development of “number sense” because students have the opportunity to calculate dosages in a realistic environment and then actually see and experience the results of their calculations which results in improved critical thinking and judgment skills into whether or not the calculated dosage makes sense (Kelly & Colby, 2003). Not only does it provide a better atmosphere for the development of critical thinking and judgment but it can decrease anxiety about math skills, improve confidence (Glaister, 2007) and meet the diverse learning styles and needs of an increasingly diverse nursing student population (Wright, 2004). Conducting research to evaluate competency in

dosage calculations in nursing students in an authentic clinical or simulated environment have not been documented in the nursing literature.

Simulation

“Simulation is an attempt to replicate some or nearly all of the essential aspects of a clinical situation so that the situation may be more readily understood and managed when it occurs for real in clinical practice” (Morton, 1995, p. 76). The realism of simulation is determined by the level of fidelity. Low-fidelity simulations include the use of case studies, role-play, or partial task trainers that help students develop psychomotor skills integral to patient care (Hovancsek, 2007). According to Hovancsek, medium fidelity includes more technologically sophisticated computer-based simulations in a two dimensional environment to learn to problem-solve or perform a skill. Finally, high-fidelity simulation involves a sophisticated, realistic manikin that allows a higher level of interactivity and realism for the student. High-fidelity patient simulators such as Laerdal’s SimMan© or the Medical Education Technologies, Inc. METIman manikin are extremely sophisticated computerized manikins that exhibit life-like characteristics such as pulses, breath sounds, heart sounds, speech, and chest, eye, and tongue movement (Laerdal, 2009; Medical Education Technology Inc., 2009).

Designing, implementing, and evaluating more effective and innovative ways to influence increased patient safety is imperative in nursing education. Simulation allows nurse educators to “a) teach facts, principles, and concepts, b) assess the students progress or competency with a certain skill or nursing intervention, c) integrate the use of technology in the learning experience, and d) develop problem-solving and diagnostic reasoning skills in a safe, non-threatening environment before caring for a real patient”

(Jeffries, 2006, p. 162). The advantage of simulation is that students have the opportunity to learn in a constructivist environment that encourages student collaboration and improved critical thinking skills while not putting an actual patient in harms way (Durham & Alden, 2008; Jeffries & Rogers, 2007b; Medley & Horne, 2005). It also offers a potential way to use faculty more efficiently to teach clinical skills, to increase flexibility in learning with an increasingly diverse student body, to stimulate active learning processes that require higher order thinking required for critical thinking and decision making, to foster consistency in education in a state-of-the-art environment, and to serve as a means to validate competency in student skills (Jeffries, 2006).

The Importance of Satisfaction and Self-Confidence

The role of satisfaction and learning is an important component to consider in educational design. Satisfaction in a learning experience can enhance clinical performance (Chickering & Gamson, 1987) and it can motivate students to want to learn more and practice more often because simulation helps students identify personal gaps in knowledge and experience (Durham & Alden, 2008). Fountain and Alfred (2009) highlight the positive impact that simulation and collaboration can have on learning and satisfaction in a group of diverse social and isolated learners.

Self-confidence is defined as, “confidence in oneself and in one's powers and abilities” (Merriam-Webster Online, 2009c). Development of self-confidence is critical in the nurse's ability to make clinical decisions and understand the overall clinical picture (A. White, 2003). Simulation can boost self-confidence levels and skills competency in students while decreasing the anxiety students experience in actual clinical settings (Durham & Alden, 2008; Hovancsek, 2007).

The Significance of Critical Thinking and Clinical Judgment

Critical thinking is defined as, “a dynamic, purposeful, analytic process that results in reasoned decisions and judgments” (Assessment Technologies Institute, 2003 as cited in Brown & Chronister, 2009, p. e47). Simulation affords the opportunity for faculty to implement case scenarios that students can implement the nursing process to develop critical thinking skills while posing no risk of harm to a real patient (Jeffries, Clochesy, & Hovancsek, 2009). In this environment, students have the opportunity to critically analyze their own decision-making processes and identify gaps in learning (Hovancsek, 2007). Critical thinking is required to make informed decisions and judgments on patient care. Clinical judgment refers to, “the ways in which nurses come to understand the problems, issues, or concerns of clients and patients, to attend to salient information, and to respond in concerned and involved ways” (Benner, Tanner, & Chesla, 2009, p. 200).

Increased critical thinking and clinical judgment skills are highly desirable attributes in nursing education. In consideration of dosage calculation skills, teachers have the responsibility to not allow students to have the impression that mathematical problems have no connection to each other or a connection with anything at all (Polya, 1973). Students must connect the importance of the solution to a realistic clinical situation. Without practical experience in a clinical environment, it is difficult to develop this sense of reason to make a judgment call on whether the calculation is logical or not. The majority of beginning level nursing students will not have the experience necessary to determine the appropriateness of the calculation, therefore, it is important to place

them in a realistic environment so that experience with actual medications and equipment can support development of this judgment skill under close supervision (Wright, 2009).

Polya's Four Phases of Problem-Solving Framework

One way to increase critical thinking and clinical judgment skills in dosage calculations is through the use of Polya's Four Phases of Problem-Solving Framework. This framework includes four stages of problem-solving including understanding the problem, making a plan, carrying out the plan, and then looking back (Polya, 1973). Within the first phase, students need to articulate the principal parts of the problem, identify key data points required to find the solution, and ascertain the conditions of the problem (Polya, 1973). According to Polya, the second phase of problem-solving requires a student to devise a plan. This means that the student will have to identify which calculations are going to have to be performed to be able to arrive at a solution. At the third stage, students must implement the plan to arrive at a solution. Polya (1973) encourages teachers to allow students to develop and implement their own plan on how to solve the problem because students may not follow through on the plan accurately if it is not devised on his own. Nursing education on dosage calculations tends to end at this phase (Wright, 2009).

Looking back is the final phase in Polya's problem-solving framework and is considered the most important in the development of clinical judgment. When a student reaches this final stage, an appropriate question to ask would be, "Does the solution seem logical and reasonable?" (Wright, 2009). Students are encouraged to double-check the mathematical process for accuracy and not just assume that the calculated solution is correct. Polya (1973) suggests that logic and reason can be further developed through the

use of estimating what the solution should be prior to calculating the numbers.

Generating, analyzing, and comparing alternative solutions, posing new problems, and making generalizations are suggested as additional strategies (Cai & Brook, 2006). In a constructivist learning environment, students can share alternative approaches with each other and work through the problems together to help create a better understanding of the big picture of drug calculations (Taylor & McDonald, 2007).

Problem Statement

The vast majority of nursing schools validate mathematical competencies in nursing students although an inconsistency exists in how validation occurs and what is the acceptable level of competency. Multiple teaching strategies such as instructional booklets, multi-media and computer-assisted instruction, and emphasis on single methods to improve calculations such as dimensional analysis or focus on decimal points have been implemented with only a moderate amount of success since no single method has been able to produce acceptable success rates in all of the participants. Based on the rationale behind these results, researchers have advocated for teaching and testing student's dosage calculation skills in a more realistic environment yet none have published studies indicating a follow-through on this recommendation. Until research is conducted to see if utilizing a constructivist environment for teaching, learning, and validating dosage calculation skills is effective then the conceptual and mathematical difficulties that students continue to experience will likely remain unchanged.

Purpose Statement

The purpose of this dissertation study was to determine if there was a difference in mean dosage calculation test scores and self-perceived judgment in dosage calculations in first semester Associate of Science (AS) nursing students who participated in a low-fidelity simulation scenario in the clinical lab versus students who participated in a traditional case study in a classroom setting. In addition, the mean scores from the NLN Satisfaction and Self-Confidence in Learning Scale were analyzed to see if there was a difference in levels of satisfaction and self-confidence between the two teaching modalities.

Research Questions and Hypotheses

Q1: In fundamental nursing students, what effects does a traditional case study in a classroom versus a low-fidelity simulation in a simulation laboratory have on mean dosage calculation test scores?

H₀1: There will be no differences in mean dosage calculation test scores between fundamental nursing students who participate in a traditional case study in the classroom versus a low-fidelity simulation in the simulation lab.

Q2: In fundamental nursing students, what effects does a traditional case study in a classroom versus a low-fidelity simulation in a simulation laboratory have on self-perceived judgment in dosage calculation scores?

H₀2: There will be no differences in mean self-perceived judgment scores between fundamental nursing students who participate in a traditional case study in the classroom versus a low-fidelity simulation in the simulation lab.

Q3: In fundamental nursing students, does learning in a traditional case study in a classroom versus low-fidelity simulation in a simulation laboratory make a difference in self-confidence in learning?

H₀3: There will be no difference in the level of self-confidence between fundamental nursing students in a traditional case study in the classroom versus a low-fidelity simulation in the simulation lab.

Q4: In fundamental nursing students, does learning in a traditional case study in a classroom versus low-fidelity simulation in a simulation laboratory make a difference in satisfaction with learning?

H₀4: There will be no difference in the level of satisfaction with learning between fundamental nursing students in a traditional case study in the classroom versus a low-fidelity simulation in the simulation lab.

Research Definitions

Table 1

General Terminology

Active Learning	“Students must do more than just listen: They must read, write, discuss, or be engaged in solving problems. Most important, to be actively involved, students must engage in such higher-order thinking tasks as analysis, synthesis, and evaluation” (Bonwell & Eison, 1991, p. online).
Simulation	“To replicate some or nearly all of the essential aspects of a clinical situation so that the situation may be more readily understood and managed when it occurs for real in clinical practice” (Morton, 1995, p. 76).
Fidelity	“The extent to which simulation mimics reality” (Jeffries & Rogers, 2007b, p. 28).
Low-Fidelity Simulation	The incorporation of static manikins that do not interact, speak, or have life-like features such as a pulse or breath sounds (Long, 2005) which includes the use of case studies, role-play, or partial task trainers that help students develop psychomotor skills integral to patient care (Hovancsek, 2007).
Moderate-Fidelity Simulation	The incorporation of a manikin that has limited life-like features such as a palpable pulse, breath sounds, and speech but has no movement capabilities (Long, 2005).
High-Fidelity Simulation	The incorporation of a sophisticated, computerized manikin that mimics life-like features such as speech, a pulse, breath sounds and movement such as the chest rising and falling or pupil constriction (Long, 2005).
Role-Modeling	“A person whose behavior in a particular role is imitated by others” (Merriam-Webster Online, 2009a).
Guided Reflection/Debriefing	A reflective thinking section that “provides learners with an opportunity to assess their actions, decisions, communications, and ability to deal with the unexpected in the simulation” (Jeffries & Rogers, 2007b, p. 29).

Table 2

Conceptual and Operational Definitions

Fundamentals Nursing Student	Conceptual Definition: An associate level nursing student enrolled in the NRS 106 Fundamentals I nursing course. These individuals are in their first semester of a two year associate degree nursing program and have all met the entry to program requirements of having a GPA at 2.80 or higher. In addition, students must have a math ACT score of 22 or higher or successfully take a college level math course. Operational Definition: Characteristics of this group will be obtained through the demographics tool including gender, age, class standing, ethnicity, educational experience, healthcare experience, GPA and ACT/SAT math scores.
Dosage Calculation Skills	Conceptual Definition: The ability to conceptually and mathematically calculate the prescribed dosage of a medication (Blais & Bath, 1992). Operational Definition: Dosage calculation skills will be determined by the mean scores on the Pre- and Post-Dosage Calculations Tests. A 100% score is the benchmark set for competence in dosage calculation skills. See the description given below.
Competence	Conceptual Definition: “The ability to perform a task with desirable outcomes under the varied circumstances of the real world” (Benner’s definition as cited in Cowan, Norman, & Coopamah, 2005, p. 359). Operational Definition: Competence will be determined by the mean scores obtained on the Pre- and Post-Dosage Calculation Tests. A 100% score is the benchmark set for competence in dosage calculation skills. See the description given below.
Problem-Solving	“Thinking that brings together information focused on solving a problem” (The Free Dictionary, 2009, p. online). Operational Definition: Problem-solving skills will be determined by the mean scores obtained on the Pre- and Post-Dosage Calculation Tests. See the description given below.
Pre- and Post- Dosage Calculation Test (Pre-DCT & Post- DCT)	Conceptually Defined: Two 30-item self-administered, researcher-designed instruments that test the accuracy of the dosage calculation skills. This tool demonstrates a students’ ability to understand the problem, devise a plan to solve the problem and then carry out the plan to solve the problem. Operationally defined, the Pre-DCT and the Post-DCT will be used to evaluate cognitive knowledge and content mastery pre- and post-educational experience.

Table 2, (continued)

Critical Thinking	Conceptual Definition: “A dynamic, purposeful, analytic process that results in reasoned decisions and judgments” (Assessment Technologies Institute, 2003 as cited in Brown & Chronister, 2009, p. e47). Operational Definition: Mean scores on the Pre- and Post-Dosage Calculation Tests and the means scores of the Self-Perceived Judgment in Dosage Calculations Scale will indicate levels of critical thinking.
Clinical Judgment in Dosage Calculations	Conceptual Definition: The ability to accurately answer the question, “Does my solution to the problem make sense for my patient?” (Kelly & Colby, 2003). Operational Definition: Mean scores on the Self-Perceived Judgment in Dosage Calculation Scale will be compared with responses on the Pre- and Post-Dosage Calculation Tests. See the description below.
Self-Perceived Judgment in Dosage Calculations Scale (SPJDCS)	Conceptual Definition: A 15-item self-administered, researcher-designed instrument to test a students’ ability to examine the solution obtained to see if it is logical and reasonable. Operational Definition: This tool is designed to evaluate self-perceived judgment utilizing a 5-point Likert Scale ranging from highly logical (5 points) to highly illogical (1 point). Combined with the Pre- and Post-DCT tools, these instruments measure all of the learned constructs of dosage calculations deemed necessary and essential to practicing safe medication administration in a clinical environment.
Satisfaction	Conceptual Definition: Fulfillment of a need or want, or a state of being contented and gratified (Merriam-Webster Online, 2009b). Operational Definition: The first portion of the National League for Nursing Student Satisfaction and Self-Confidence With Learning Scale is a 5-item instrument measuring satisfaction in learning using a 5-point Likert scale with responses ranging from strongly agrees (5 points) to strongly disagree (1 point). Items measure the level of satisfaction with the teaching methods, variety of learning materials and activities and how much these motivated a student to learn, and the enjoyment and satisfaction with the instructors approach to teaching.
Self- Confidence	Conceptual Definition: “Confidence in oneself and in one's powers and abilities” (Merriam-Webster Online, 2009c). Operational Definition: The second portion of the National League for Nursing Student Satisfaction and Self-Confidence With Learning Scale is an 8-item tool measuring self-confidence in learning utilizing the same 5-point Likert scale. Items measure confidence in mastery of the content, the scope of the content, skill and knowledge development, resources

Table 2, (continued)

	utilized for the simulation, self-responsibility in learning, seeking help when necessary, how to use simulation for maximizing the learning experience, and the instructors responsibility for teaching.
The National League for Nurses - Student Satisfaction and Self-Confidence with Learning Scale	Conceptually defined, the SSCLS is a 13-item self-administered instrument designed by the NLN to assess student's feelings on the simulation experience. The first portion is a 5-item tool measuring satisfaction in learning using a 5-point Likert scale with responses ranging from strongly agrees (5 points) to strongly disagree (1 point). The second portion is an 8-item tool measuring self-confidence in learning utilizing the same 5-point Likert scale. Operationally defined, the SSCLS is designed to assess student's perceptions on the level of satisfaction experienced during simulation and how this teaching strategy influences the level of self-confidence a student has after participating in simulation.

Summary

The purpose of this chapter was to provide a background of medication errors from a multidisciplinary and nursing discipline perspective. Nursing education plays a major role in the type of education that nurses receive and verifying competence in dosage calculation skills before clinical practice is allowed. This chapter offered insight into strategies that have been implemented and met with only a moderate amount of success. The strategy of implementing Polya's Four Stages of Problem-Solving Framework into nursing education offers an improved approach to teaching dosage calculations to an increasingly diverse student body. Implementing this framework in a low-fidelity simulation improves conceptual and mathematical understanding of dosage calculations in novice nursing students in a realistic environment. Chapter Two discusses an in-depth philosophical perspective of constructivism and the two frameworks utilized for this study – Polya's Four Stages of Problem-Solving and the Nurse Education

Simulation Framework. In addition, Chapter Two discusses research-based evidence on the two frameworks and on dosage calculation skills and nursing education.

CHAPTER II

REVIEW OF LITERATURE

Introduction

Eleven years has passed since the Institute of Medicine issued an alarming report, *To Err is Human: Building a Safer Health System* emphasizing the significant issues on medical errors (Institute of Medicine, 1999). Medical errors exceed the number of deaths related to breast cancer, AIDS, and motor vehicle accidents combined (Kohn, et al., 2000). Medication errors, one of the most common types of medical errors, are responsible for 7000 deaths per year (Kohn, et al., 2000) with national costs of treating the errors escalating to 3.5 billion dollars per year (Institute of Medicine of the National Academies, 2007).

Although a systems failure is responsible for many of the medication errors, nurses have a large role in medication administration which accounts for 26-40% of all medication errors (Manno, 2006). The most common contributing factors for nursing medication errors commonly include poor communication, failure to follow hospital policies (Armitage & Knapman, 2003), and distractions and interruptions (O'Shea, 1999). Calculation ability is also a problem and is related to a lack of appropriate education, verification of skills (Gregory, et al., 2007; Kohn, et al., 2000) and inability to accurately calculate dosages (Polifroni, et al., 2003).

The recent release of *Preventing Medication Errors: Committee on Identifying and Preventing Medication Errors* continues to highlight a growing concern that medication errors still occur at high rates in spite of previously alarming national reports issued by the Institute of Medicine (Institute of Medicine of the National Academies, 2007). The culmination of these multidisciplinary reports is largely responsible for a renewed interest in improving safety and quality control within all parties involved in the health care system.

The purpose of this chapter is to review literature that explains the nature of medication and calculation errors in nursing as they have occurred historically and how they have occurred over the decade since the IOM (1999) released the *To Err is Human: Building a Safer Health System* report. In support of this dissertation study, theoretical literature on the constructivist theory and its implications for nursing education are presented. In addition, the Nurse Education Simulation Conceptual Framework that guided this study is discussed, and Polya's Four Stages of Problem-Solving framework that was integrated into the teaching modalities is introduced and discussed. Current evidence-based literature is presented on both conceptual frameworks.

Five themes emerged as the review of medication error literature was reviewed. These themes include (a) policies and procedures in nursing schools and acute care facilities, (b) rationale for medication errors, (c) rationale for dosage calculation errors, (d) validating math skills, and (e) educational approaches. This review is followed by a summary of how this dissertation study can impact nursing science.

Delimitations of the Review

The search was refined to include classic literature related to dosage calculation errors in nursing and nursing education and it includes only the most relevant, current research related to constructivism, Nurse Education Simulation Framework (NESF), Polya's Four Stages of Problem-Solving and literature on dosage calculation skills and errors. This search yielded 42 articles of empirical research including both quantitative and qualitative methodologies. Sample sizes ranged from 26 to 403 subjects, and it included a range of associate to baccalaureate level nursing students as well as graduate and experienced registered nurses. The review was limited to English-language nursing articles although it was international in scope.

Keywords, Databases, and Resources

Electronic databases (CINAHL, EBSCOhost, ERIC, OVID, Academic Search Elite) and the World Wide web were examined for prospective sources of literature using keyword searches. Broad search terms and a combination of terms included: calculation skills, clinical judgment, critical thinking, drug administration errors, drug calculation skills, dosage calculations, drug errors, math skills, medication administration, medication errors, medication safety, nursing, self-confidence and student nurses. Keywords for educational approaches include clinical experience, computerized learning, constructivism, simulation, Polya's Four Stages of Problem-Solving framework, dimensional analysis, nurse education, nursing, and Nurse Education Simulation Framework. Other resources included the participating university's library and the University of Northern Colorado Michener Library.

Review of Theoretical Literature

Constructivism

The theory of constructivism draws from the cognitive and the developmental perspective of Piaget, the sociological viewpoint of interactional and cultural emphases of Bruner and Vygotsky, and the contextual nature and environment of situated learning (Driscoll, 2005). Piaget's genetic epistemology on the four stages of mental growth from birth to adulthood are influenced by how the individual constructs reality (Kastenbaum, 1993). Bruner emphasized the constructive reality of cognitive development in a social and cultural context (Slee, 2002). Vygotsky emphasized the importance of language, social interaction, and guidance that helps advance each person's thinking and learning (Bastable, 2008; Rideout, 2001). Combined, constructivism assumes that learners construct their own knowledge based upon experiences and interactions with others in an active, sociocultural environment (Driscoll, 2005).

This dissertation was based on the emphasis that the constructivist theory has on the learner seeking to be able to reason, critically think, and reflect (Rideout, 2001). Individuals learn best in environments in which they must take ownership of their learning experience. Information presented in multiple modes such as visual, auditory, and tactile formats promote an optimal learning environment because it enables different aspects of the concept to be understood (Driscoll, 2005, Rideout, 2001). Constructivists embrace non-traditional teaching styles that include technology and simulation guided by collaboration and scaffolding (Driscoll, 2005). Constructivism applied to nursing education affords the opportunity to integrate problem-based learning that encourages students to collaborate to solve issues as teachers adopt a facilitator role (Rideout, 2001).

Based on the premise that our perceptions, sensations, and knowledge do not exist outside of our minds (Hendry, Frommer, & Walker, 1999), applying constructivist principles to instruction in dosage calculation skills requires the educator to construct conceptual models of a real environment with real patient charts, equipment, and drug labels so that the students will be able to (a) identify and extract the key data within the charts and labels (b) be able to place the key data in the correct location of a math formula, and (c) correctly compute the dosage from the mathematical equation (Weeks, et al., 2000). These authors support the constructivist approach because it has the potential to narrow the theory-to-practice gap by creating an environment that helps students take abstract concepts and apply them in a practical context that holds more value and meaning.

Nurse Education Simulation Framework

Simulation is defined as an attempt “to replicate some or nearly all of the essential aspects of a clinical situation so that the situation may be more readily understood and managed when it occurs for real in clinical practice” (Morton, 1995, p. 76). Nurse educators are obligated to ensure that nursing students are competent and safe prior to entry into practice (American Nurses Association, 2001). Simulation serves as an instructional strategy that allows novice nursing students to encounter a wide range of experiences and gain competency without putting an actual patient at risk (Hovancsek, 2007).

This dissertation was guided by the NESF (see figure 1 and Appendix A for simulation detail) that was designed by a group of national nurse researchers organized by the National League for Nurses (NLN) after reviewing theoretical and empirical

research from a multidisciplinary perspective (Jeffries, 2005, 2006; Jeffries & Rizzolo, 2006; Jeffries & Rogers, 2007b). Utilizing a conceptual framework when designing simulation scenarios promotes better understanding of the processes of developing, implementing, and evaluating simulation (Jeffries, 2006). In addition, Jeffries (2006) concludes that a research-based conceptual framework can also advance nursing knowledge through a consistent, empirically supported model that guides nurse educators through the process of simulation design, implementation, and evaluation.

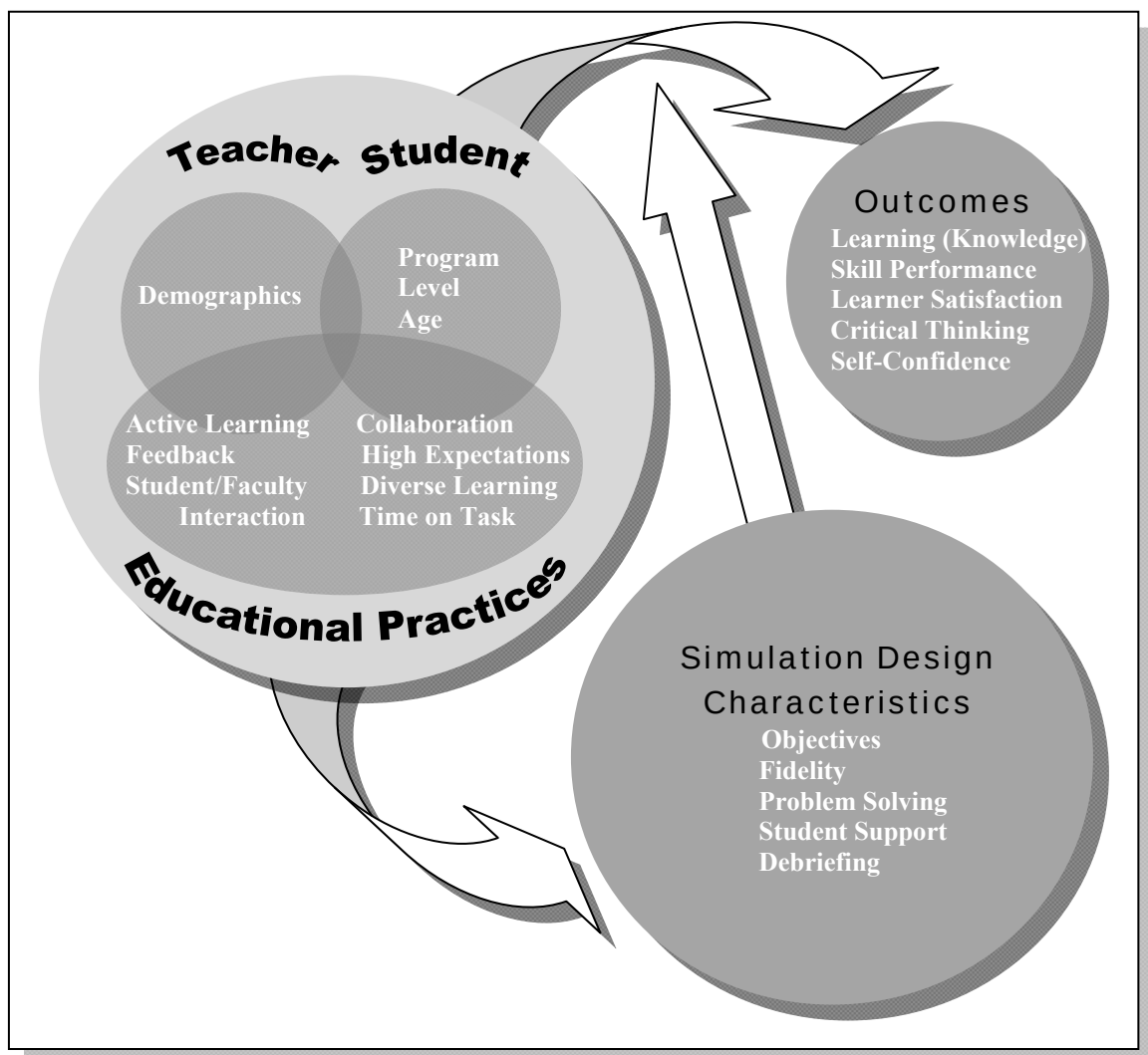


Figure 1. The Nursing Education Simulation Framework (Jeffries & Rogers, 2007b).

The NESF incorporates best practices through better interaction and communication between the teacher and the students, collaboration of diverse student peers, innovative teaching strategies and learning techniques, and students' increased responsibility for learning and drive for achieving higher academic standards (Thompson & Bonnel, 2008). There are four major components of the teacher, student, educational practices, and simulation design characteristics that all play a major role in the fifth component which is outcomes (see Figure 1) (Jeffries & Rogers, 2007b).

The Teacher

Consistent with the constructivism theory, the teacher component goes against traditional teaching styles and the classroom environment becomes more student-centered. Teachers become coaches in helping students figure out their own way of arriving at correct answers but most importantly helping students make sense of their answers (Jeffries & Rogers, 2007b; Kelly & Colby, 2003). These researchers place the emphasis on the experience of learning rather than the final product which requires increased student motivation and self-direction.

Simulation can help meet the needs that faculty face on a regular basis. Needs such as a lack of clinical sites (Durham & Alden, 2008; Jeffries, et al., 2009) and consistency in learning opportunities can be met through simulation (Durham & Alden, 2008). Factors such as patient acuity, diagnosis, time of day, and the clinical and teaching expertise of clinical instructors and staff nurses affects the consistency and the clinical experience of students (Durham & Alden, 2008). In addition, simulation affords faculty members the opportunity to validate nursing student's skills prior to beginning rotations on an actual clinical site (Jeffries, et al., 2009).

Getting teachers enthusiastic about using simulation as a teaching modality can be difficult because it involves highly technical equipment and a different frame of mind when teaching. Traditional teachers rely on classroom methods such as lectures and PowerPoint's and now they must get out of their comfort zone and relinquish some of the control to the students (Durham & Alden, 2008). It is imperative that teachers remember that this is a new learning experience for the students and that they will also be taken out of their comfort zone. Johnson, Zerwic, and Theis (1999) conducted a simulation experience just for faculty to go through so that they could understand what it was like to be in the student role. These authors found that the faculty members felt the same anxiety and apprehension that students felt when placed in a new environment. This strategy offers faculty a new perspective when designing simulation experiences and implementing strategies that will increase student comfort. Faculty development workshops and peer mentoring foster the implementation of simulation into the curriculum (Durham & Alden, 2008).

The Students

Simulation can meet the educational needs of students by increasing flexibility and accessibility to patient care, exposure to realistic environments that may not be available in a clinical setting, and increase confidence in psychomotor skills and critical thinking (Jeffries, 2006; Jeffries, et al., 2009). Students can take on either an observational or active role in simulation experiences. These experiences can be specifically designed to evaluate successful completion of learning outcomes (Jeffries & Rogers, 2007b). The constructivist approach allows students have the opportunity to discover their own methods of understanding abstract information and it involves the

metacognitive process of evaluating answers to make sure that they make sense (Kelly & Colby, 2003).

Best Educational Practices

According to Jeffries & Rogers (2007b), educational practices revolve around an active learning environment which allows the educator to be able to assess the student's abilities to problem solve and make decisions. The learning environment caters to diverse learning styles such as visual, kinesthetic, auditory, and tactile through collaboration with peers. Educational practices that have high levels of expectations tend to exhibit high levels of success. It allows students to set personal goals and evaluate methods of reaching the goals (Childs, Sepples, & Chambers, 2007; Jeffries & Rogers, 2007b).

Simulation Design Characteristics

Constructing a simulation experience based upon best practices takes a lot of time and effort. Jeffries (2006) recommended a four-stage process based upon a construction metaphor.

Stage One. According to Jeffries (2006), during the first stage, "developing the blueprint", simulation designers should conduct a thorough review of literature so that the simulation is based upon research-based evidence. Once the review is completed, the simulation design should utilize a theoretical simulation framework. It is during this stage that the nurse educator develops specific goals and objectives for the simulation experience and makes sure that the objectives match the implementation phase of the simulation (Jeffries, et al., 2009), determines the fidelity required to maximize learning during simulation, integrates problem-solving components into the design, establishes

where learner support will be required, and develops a structured guided reflection to be used during debriefing (Jeffries, 2006).

Determining the level of fidelity should be based upon the level of the nursing student (Jeffries, et al., 2009; Leigh & Hurst, 2008). Fidelity is described as low, medium, and high and is related to levels of realism. Low-fidelity simulation includes the use of partial task trainers, role-playing, and case studies (Hovancsek, 2007). Medium fidelity includes computer-based simulation and a reliance on a two-dimensional focused experience. Hovancsek describes high-fidelity simulation as full-scale, extremely realistic and sophisticated and a higher level of interactivity and realism. Parallel to Benner's novice to expert theory, literature suggests that beginning nursing students are not ready for high-fidelity, complex simulations and the use of low-fidelity, non-complex scenarios would be more appropriate (Waldner & Olson, 2007). Communication skills, psychomotor performance, and basic assessment techniques can be developed in novice nursing students from utilizing basic, non-complex scenarios (Jeffries, et al., 2009). As students become more advanced the complexity of the scenarios can increase. Students in this level will benefit from complex scenarios in a realistic setting through collaboration with the instructor and peers. As students become more advanced they are able to demonstrate increased problem-solving and decision making skills, communication, and collaboration (Jeffries, et al., 2009).

Stage Two. The second stage is "procuring the bill of materials". This stage includes gathering all materials that will be necessary to run the simulation including props, equipment, and materials (Jeffries, 2006). Furthermore, Jeffries recommends that for problem-solving scenarios, the educator should gather all of the necessary equipment

that would be required when students make decisions that go down different paths than what is anticipated. If the nurse educator chooses to not use a pre-designed simulation scenario, choosing rather to modify a pre-existing scenario or develop one entirely from scratch, it will take a great amount of time and effort to get the scenario into the simulation software. Mastering the software requires a steep learning curve and workload constraints exacerbate frustrations and anxieties that educators may feel when trying to produce the simulation design ideas into the software (Leigh & Hurst, 2008). Once the simulation experience is ready for student learning, the computer must be set up and a computer technician needs to be available to run the simulator (Jeffries, 2006). In addition, it is imperative to schedule an adequate amount of time and make room reservations for students to participate in the simulation and debriefing, procure enough staff to assist with the experience, and arrange for videotaping if desired (Jeffries, 2006).

Stage Three. Once all of the equipment has been gathered and everything has been scheduled the next step is to “assemble the structure” (Jeffries, 2006). In this third stage, there are four major components to focus on when assembling the structure. The first component, the teacher’s role, the teacher acts as a facilitator and provides cues in a learner-centered environment (Jeffries, 2006; Jeffries, et al., 2009). Most teachers are experienced in traditional teaching modalities such as lectures and PowerPoint, so teaching in a simulation environment can invoke fear and anxiety over working in a new environment and gaining confidence and competency with advanced, complex technology (Leigh & Hurst, 2008). It is imperative that teachers are comfortable and prepared when teaching simulation (Jeffries, 2006). Faculty development in-services may

be warranted to help faculty members establish experience and comfort (Jeffries, et al., 2009).

The second component in assembling the structure is to define the student role. Students need specific instructions when playing the role of a nurse, family member, or observer (Jeffries, 2006; Jeffries, et al., 2009). In addition, Jeffries suggests that it is ideal to limit simulation class size to six students at one time to maximize the learning experience (Jeffries, 2006; Jeffries, et al., 2009). Two roles that are commonly used in students are response-based and process-based (Cioffi, 2001). According to Cioffi, students in the response-based role have an observational role such as documentation or it could be from a distant classroom viewing a live video feed. Students in the process-based role actively participate as the nurse, family member, or any other designated active role (Cioffi, 2001; Jeffries, 2006). Learners should be observed and evaluated to ensure that the learning objectives have been met (Jeffries, 2006).

The third component of assembling the structure is embedding good educational practices. Several principles of best practice have been identified that are important in simulation design and implementation (Childs, et al., 2007; Jeffries, 2006). The first principle is engaging students in active learning while providing cues, reinforcement, feedback, and support in the learning process. The second principle is promoting collaboration in problem-solving with peers and mimicking what actually happens in the real world working environment. The third principle is accommodating diverse styles of learning to a rapidly changing diverse student body. The fourth principle is empowering students to set high goals and high expectations to become confident nurses (Childs, et al., 2007; Jeffries, 2006) by making certain that students have an adequate amount of

time to learn from practice and feedback during the simulation and have enough time to reflect during the debriefing process (Jeffries, 2006; Jeffries, et al., 2009).

Debriefing is an important component of simulation because this is where the student will assemble all of the concrete and abstract puzzle pieces into a recognizable picture through reflecting on what was learned (Jeffries, et al., 2009). Debriefing is a distinct part of simulation and it is helpful for faculty to help students recognize when simulation has ended and debriefing has begun (Leigh & Hurst, 2008). Faculty should coach students to reflect as they try to process what was experienced rather than making debriefing an additional learning experience with more material (Jeffries, et al., 2009). Debriefing should also begin with the positive aspects of simulation rather than beginning with what went wrong (Jeffries, 2006; Leigh & Hurst, 2008). Listening to students is an important way that faculty can recognize what the students have learned and if a theory-to-practice gap exists (Durham & Alden, 2008; Leigh & Hurst, 2008).

Stage Four. “Finishing the project”, the fourth stage, is where refining and revising are completed after evaluating the effectiveness of the simulation experience. Process evaluations measure the educational practices embedded in a simulation (Jeffries, 2006). Evaluation of learning outcomes can be achieved through valid instruments, procedural skill performance, confidence, satisfaction, and critical thinking (Jeffries, 2006). All of these stages are all important but it is of upmost importance that research findings are disseminated so that other nurse educators can learn from the experience as simulation continues to gain popularity in nursing education (Jeffries, 2006).

Jeffries & Rogers (2007b) found that for simulation experiences to be successful, students need clear guidelines and objectives. The appropriate level of fidelity must be

chosen for the experience and then design and implementation is done according to the knowledge and skill level of the learner. Having a clear picture of what the simulation experience should be, the teacher should make goals challenging yet attainable. It is important to provide student support during the simulation but not interfere with his or her independent problem-solving. Of equal importance is allowing time for debriefing and for the student to pause for reflective thinking (Jeffries & Rogers, 2007b).

Outcomes

Learning or knowledge acquisition, skill performance, learner satisfaction, critical thinking, and self-confidence were identified as outcomes that could be affected by simulation in nursing education (Jeffries & Rizzolo, 2006). These outcomes will be “influenced by the degree to which the best practices in education are incorporated in the design and implementation of the simulations” (Jeffries, 2006, p. 165). In addition, simulation will only be as good as the preparation of the teacher, teacher to student interactions, expectations, and roles during these simulation experiences (Durham & Alden, 2008; Jeffries, 2006). Outcomes should be established prior to the simulation and evaluation of completion of outcomes is of utmost importance. Outcome objectives should include what was learned, accuracy of skills performance, the students’ perception of the learning experience, and measuring levels of confidence (Jeffries & Rogers, 2007b).

Learning (Knowledge Acquisition). Simulation allows theory to be integrated into clinical practice but it also allows the delivery of theory to occur simultaneously with clinical practice (Durham & Alden, 2008; Prescott & Garside, 2009). The simulator and scenarios help students visualize physiological responses that are difficult concepts to

grasp when given in a lecture format (Durham & Alden, 2008). One research study revealed that students appreciated the reality of the simulation experiences and it made abstract theoretical ideas more concrete. The majority of students felt like they had a better understanding of the concepts and they showed increased confidence in their abilities to practice safely (Prescott & Garside).

Thompson and Bonnel (2008) demonstrated that simulation can be used to identify theory-to-practice gaps. Thompson and Bonnel developed a simulation experience designed to assess student's knowledge of a pharmacological agent while taking a pharmacology course. Although students performed very well on the classroom unit exam over this content they stumbled in the simulation experience. Every single simulation group administered an overdose of Demerol (meperidine) ordered by the physician when the patient complained of severe pain. It demonstrated that students can understand a concept in the classroom and clearly demonstrate that knowledge on a multiple-choice exam but not be able to apply the concept outside of the classroom and put it into context in a practical clinical environment. Simulation offers an environment for courses that are typically didactic to expand and allow educators to evaluate where the theory-to-practice gaps exist (Thompson & Bonnel).

Skill Performance. Simulation offers the opportunity to improve psychomotor and communication skills in a realistic environment where immediate feedback can be given. It also offers students the chance to repetitively practice these skills until a level of comfort and proficiency has been achieved (Durham & Alden, 2008). Skills such as measuring vital signs, assessing heart and breath sounds, performing nursing interventions and following physician's orders, administering medications, and

evaluating patient responses are imperative to patient safety and simulation offers a risk-free environment for students to become proficient in these skills (Durham & Alden).

A quantitative study by Alinier, Hunt, Gordon, & Harwood (2006) revealed that a multi-strategy approach to teaching that included lecture, clinical, and simulation improved outcomes in nursing students on a psychomotor skills performance evaluation over students who had not experienced simulation. Although the simulated students outperformed their peers, both groups had nearly equal levels of confidence and stress through the skills evaluation. Another study revealed that male nursing students benefitted from learning skills such as NG tube and Foley catheter insertion on a high-fidelity simulator (Grady, et al., 2008).

Communication skills, or a lack thereof, are the root of many untoward events in healthcare (Wolf, Hicks, & Serembus, 2006). Novice nursing students are often apprehensive about communicating with strangers in a healthcare environment. Simulated scenarios utilizing the SBAR (Situation, Background, Assessment, and Recommendation) model, can improve self-confidence in their ability to be able to communicate effectively with healthcare providers when actual clinical experiences are limited in opportunities for this type of communication (Wolf, et al., 2006). Simulated scenarios can also encourage effective verbal and documented communication and improve collaboration between multi-disciplinary team members, instructors, peers, and the interaction and education of patient and family members (Durham & Alden, 2008).

Learner Satisfaction. Simulation enhances learner satisfaction and it can motivate students to want to learn more and practice more often because simulation helps students identify personal gaps in knowledge and experience (Durham & Alden, 2008). Fountain

and Alfred (2009) conducted a quantitative study that revealed a moderate, positive correlation between social and isolated learners and levels of learner satisfaction in simulation. Social learners appreciated the active roles in simulation while isolated learners gained more from the observational role. This study indicates how learning can be enhanced when students with diverse learning needs are in a collaborative environment and are comfortable in their roles.

Learner satisfaction was enhanced in baccalaureate nursing students when simulation was combined with a lecture-format teaching strategy (Sinclair & Ferguson, 2009) although findings of this quantitative study are weakened by lack of consistent student participation in data collection. Hoadley (2009) revealed similar findings when high-fidelity simulation was used to teach an ACLS course to multidisciplinary team members rather than low-fidelity simulation although the differences in fidelity did not translate to a significant increase in knowledge gained.

Critical Thinking. Critical thinking is defined as, “a dynamic, purposeful, analytic process that results in reasoned decisions and judgments” (Assessment Technologies Institute, 2003 as cited in Brown & Chronister, 2009, p. e47). Nurse educators are challenged to help students develop critical thinking skills as students try to understand theoretical concepts taught in didactic courses and safely practice nursing utilizing the nursing process (Durham & Alden, 2008). Simulation affords the opportunity for faculty to implement case scenarios that students can implement the nursing process to develop critical thinking skills while posing no risk of harm to a real patient (Jeffries, et al., 2009). In this environment, students have the opportunity to

critically analyze their own decision-making processes and identify gaps in learning (Hovancsek, 2007).

Critical thinking is required to make informed decisions and judgments on patient care. Clinical judgment refers to, “the ways in which nurses come to understand the problems, issues, or concerns of clients and patients, to attend to salient information, and to respond in concerned and involved ways” (Benner, et al., 2009, p. 200). According to these authors, clinical judgment can be both deliberate, conscious decision-making and become more intuitive as a nurse gains expertise. Increased critical thinking and clinical judgment skills are highly desirable yet difficult to measure in nursing education. To date, very little has been published outside of student perceptions of critical thinking or judgment skills (Brown & Chronister, 2009).

Brown and Chronister (2009) conducted a study to analyze critical thinking skills in nursing students learning how to interpret and treat ECG rhythms by evaluating results of a multiple-choice exam designed by Elsevier with questions written at the application level or higher. Students demonstrated that there were no significant differences in those who received lecture-format teaching only versus students who received a combination of lecture and simulation when evaluating the impact on student assessment, critical thinking, or therapeutic nursing interventions. Students who received the lecture-format only prior to taking the EKG critical thinking test were allowed to attend two simulation events. These students showed a higher level of self-confidence than the experimental students (Brown & Chronister, 2009). Major limitations include an unequal amount of time spent in teaching between the control and experimental groups and that the entire time spent on each simulation and debriefing session for the experimental group lasted

only 30 minutes. This short time frame per simulation hardly allows an adequate amount of time for students to fully experience the simulation and reflect on what was learned.

Other researchers recognize the difficulty in measuring concepts like critical thinking and clinical judgment skills (Dillard, et al., 2009; Lasater, 2005a, 2005b, 2007a, 2007b; Lasater & Nielsen, 2009; Lasater & Tanner, 2005). After an extensive qualitative-quantitative-qualitative designed research study exploring student's responses in simulated scenarios to concepts in Tanner's Clinical Judgment Model (2006), the Lasater Critical Judgment Rubric (LCJR) was developed in an attempt to quantify judgment skills in students (Lasater, 2007a). Utilizing the rubric helped to identify gaps in understanding in the students. It also served as a valuable communication tool to help faculty provide important feedback to the students and it helped students identify performance expectations and create goals to improve judgment skills. Over the course of the study, students could readily see growth and development in clinical judgment. Dillard, Sideras, Ryan, Hodson-Carlton, Lasater, and Siktberg (2009) concurred with this finding in their study but warned against allowing students to narrowly focus on rule-based, concrete answers by helping students see the bigger connection between what happens in simulation versus a real clinical experience. Finally, Lasater and Nielsen (2009) explored the use of reflective journaling in addition to the LCJR rubric and found the combination improved the evaluation process for students, provided a clearer image of clinical judgment progress, and increased self-confidence.

Self-Confidence. Self-confidence is defined as, "confidence in oneself and in one's powers and abilities" (Merriam-Webster Online, 2009c). Development of self-confidence is critical in the nurse's ability to make clinical decisions and understand the

overall clinical picture (A. White, 2003). Simulation can boost self-confidence levels and skills competency in students while decreasing the anxiety students experience in actual clinical settings (Durham & Alden, 2008; Hovancsek, 2007).

Brown and Chronister (2009) measured self-confidence in nursing students experiencing lecture-format versus simulation teaching modalities for ECG interpretation and interventions. Results indicated that students who participated in two lengthier simulation experiences at the end of the course gained more self-confidence than students who experienced simulation weekly throughout the course in shorter bursts (Brown & Chronister). Rationale for this phenomenon could be because students have had time to process the information toward the end of the course and the simulation served as a capstone to everything that had been learned throughout the semester. Another rationale is that increased time spent in simulation at one time allows students more time to practice and refine skills as well as reflect on what was learned.

Brannan, White, and Bezanson (2008) conducted a simulation study on acute myocardial infarctions utilizing the traditional lecture format versus high-fidelity simulation. Students in the simulation group demonstrated higher cognitive scores but failed to show a significant difference in self-confidence levels although both groups showed increased overall self-confidence in learning. Another study revealed similar results when evaluating the effectiveness of adding simulation to didactics and clinical practice in improving psychomotor skills (Alinier, et al., 2006). Students who received simulation in addition to lectures and clinical experience performed better psychomotor skills than students who had not participated in simulation although there were no differences in the level of self-confidence.

Implementation of Simulation

Simulation is gaining in nationwide popularity as nursing educational institutions face clinical and faculty shortages. Simulation requires an investment of thousands of dollars (Durham & Alden, 2008; Hovancsek, 2007) but this investment does not guarantee that simulation will be successfully implemented into the nursing curriculum (Leigh & Hurst, 2008). Some of the barriers identified that prevent successful implementation are excessive costs (Durham & Alden, 2008; Hanberg, 2008; Hovancsek, 2007), commitment of time and energy in an already heavy workload (Durham & Alden, 2008; Hovancsek, 2007), lack of space for all of the equipment (Hovancsek, 2007), computer literacy and learning to use advanced technology, (Hanberg, 2008; Hovancsek, 2007), lack of realism in scenarios or patient responses, and student anxiety over using a new teaching strategy (Durham & Alden, 2008).

Leigh and Hurst (2008) recommended that nursing schools identify a faculty champion who is enthusiastic about simulation and can inspire other faculty to get on board. The faculty champion can motivate through encouraging, persuading, and assisting with the development and implementation of simulation into the classroom. Another suggestion is that once the simulators have been purchased, its use could be maximized by developing a simulation schedule. Not only does this guarantee that certain courses will have an opportunity to use simulation but it encourages the course instructor to use simulation and not let the expensive technology go unused. The final suggestion was to choose the right level of fidelity and remain flexible with simulated scenarios (Leigh & Hurst, 2008).

Evidence-based research on the Nurse Education Simulation Framework

A national, multi-site, multi-method research study was conducted by Jeffries and Rizzolo (2006) and sponsored by the NLN to (a) develop a simulation model that faculty can use to implement simulation, (b) develop a cadre of nursing faculty that can use simulation in innovative ways to enhance student learning, (c) contribute to the body of nursing knowledge related to the use of simulation in nursing education, and (d) demonstrate the benefits of collaboration. The students were assigned to one of three groups that included a case study simulation, static simulation, and high-fidelity simulation. This study revealed the importance of collaboration and that the most important simulation design feature was feedback and debriefing. High-fidelity simulation led to increased satisfaction in learning whereas case-study simulation was less effective at promoting self-confidence. High expectations received the highest ranking of the best educational practices from students as compared to active learning, collaboration, and diverse ways of learning. No differences in self-perception of performance were noted between the experimental and control groups.

A quantitative research study guided by the NESF was conducted by Smith and Roehrs (2009) to evaluate the influential factors in levels of self-confidence and satisfaction in BSN nursing students exposed to simulation. These researchers found that design factors including objectives, support, problem-solving, guided reflection, and level of fidelity significantly influenced the level of satisfaction and self-confidence experienced by the students. Focusing on all of these design factors highlights the significant amount of time required to design and implement simulation. Faculty

workloads may need adjustment to ensure that enough effort can be exerted toward implementing excellence in simulated education (Smith & Roehrs).

Kardong-Edgren, Starkweather, and Ward (2008) conducted a prospective, descriptive, repeated measures design research study utilizing the NESF to explore educational practices, simulation design, and student satisfaction and self-confidence in undergraduate nursing students when three simulation scenarios were implemented in a clinical foundations nursing course. Results revealed that educational best practices (active learning, collaboration, diverse ways of learning, and high expectations) were employed in each scenario. In addition, students highly rated simulation design factors (objectives and information, support, problem-solving, feedback, and fidelity). Finally, students experienced high levels of satisfaction with learning and increased self-confidence in learning (Kardong-Edgren, et al.).

Faculty were solicited for their perceptions on implementing simulation (Kardong-Edgren, et al., 2008). Nursing faculty indicated positive aspects of simulation such as the creative, interactive learning environment and the freedom to expand the simulation to create a rich learning experience. The repetition of learning the information in the classroom and then incorporating it into simulation was also perceived as beneficial. Faculty also admitted that it took an enormous amount of time, effort, and coordination. An important finding that supports the issues with conducting simulations was that implementing simulation without another assistant was counterproductive because their attention was split between the students, running the computer, being the voice of the manikin, and taking notes on student performance (Kardong-Edgren, et al.).

Polya's Four Phases of Problem-Solving

The teaching strategy for this study was based upon on Polya's four phases of problem-solving framework. Polya, a mathematical professor at Stanford University, introduced a problem-solving framework intended to guide students through the mathematical process and overcome difficulties with solving math equations. The framework includes four stages of problem-solving including understanding the problem, making a plan, carrying out the plan, and then looking back (Polya, 1973). According to Feeg (2006), these four phases parallel the nursing process of assessment, planning, implementation/intervention and evaluation and can ease the understanding and application of the model in novice nursing students (see Figure 2). For novice nursing students, it is useful to work through each of the four stages until the stages are more familiar (Wright, 2009). As students develop problem-solving skills, they will realize that going through the four stages is a cyclical process and that it is applauded when they back up and rethink things through when solutions do not make sense (Polya, 1973).

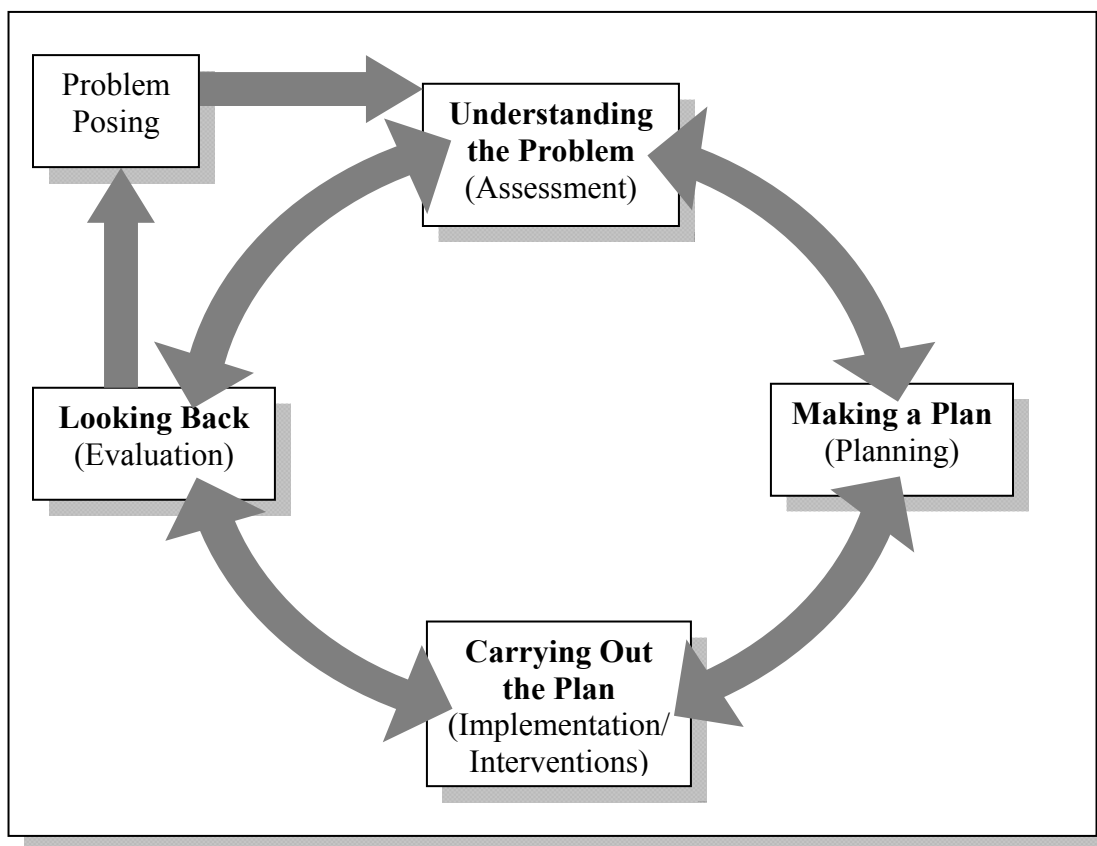


Figure 2. Conceptual Framework - Polya's Four Phases of Problem-Solving Model Paralleling the Nursing Process (Adapted from Polya, 1973 and reprinted with permission from Princeton University Press).

Phase One

According to Polya, the first phase, understanding the problem, is the most important (1973). Not only should the student aim for understanding the problem but the student should also show that he or she desires to find the solution. Within this phase, students need to articulate the principal parts of the problem, to identify key data points required to find the solution, and ascertain the conditions of the problem (Polya, 1973).

When applied to drug calculations in nursing, Wright (2009) advised that students not only identify the problem but consider what the solution means (e.g. drip rates, volumes, or units per hour) because the most common type of calculation error is

conceptually based and is the result of an inability to understand what the problem is really trying to ask (Armitage & Knapman, 2003; Jukes & Gilchrist, 2006; Wright, 2009). Wright (2009) considers the clinical environment the best place to help students develop an understanding of mathematical problem-solving because the realistic atmosphere can help students ‘see’ the problem first hand. This experience helps students develop a mental schema for particular problem types. This methodology is further enhanced in a constructivist learning environment because students can help each other identify problems and interpret data. The more exposure to realistic situations in a constructivist learning environment, the easier it will become to problem-solve (Kelly & Colby, 2003; Papastrat & Wallace, 2003).

Phase Two

The second phase of problem-solving requires a student to devise a plan. This means that the student will have to identify which calculations are going to have to be performed to be able to arrive at a solution (Polya, 1973). Pólya suggests that a student will experience the best success if the teacher can help them discover a “bright idea”. In order to provoke this bright idea, it is imperative for teachers to help students realize the importance of considering related problems that the students have experienced in the past by asking, “Do you know a related problem?” (Pólya, 1973, p. 9). Sometimes students have not had exposure to this type of problem before so another starting point may be to ask the student to restate the problem in a different way.

Beginning nursing students have not been exposed to drug calculations before but if the students can reflect on previous experience in math or chemistry courses, they will start to realize that the basic principles of those courses can be applied to drug

calculations. Wright (2009) encourages the nursing student to not only ask how will the problem be solved but to consider that there may be multiple steps involved and to figure out where to begin. Some authors have encouraged a specific mathematical formula such as dimensional analysis to solve drug calculations (Greenfield, et al., 2006; Rice & Bell, 2005) but the Polya problem-solving framework encourages students to seek out which method provides the most meaning rather than forcing the student to learn only one way to solve a problem (Polya, 1973). Considering the application of this framework within a constructivist learning environment, teachers can coach students to learn from each other that there are multiple ways of solving problems and students can be the instigators of bright ideas (Taylor & McDonald, 2007).

Phase Three

At this stage, students must implement the plan to arrive at a solution. Polya (1973) encourages teachers to allow students to develop and implement their own plan because there is danger that the student will not follow through on the plan accurately if it is not devised on his own. Students should check every step of the implementation phase to ensure accuracy and be able to prove it is correct. If any step is not completely thought out or implemented correctly it will negatively influence the next step and an incorrect solution will be obtained (Polya, 1973).

Next to conceptual errors, actual calculation errors are the most common types of errors noted in nursing students (Blais & Bath, 1992; Jukes & Gilchrist, 2006). In the world of nursing and dosage calculations, it is imperative to verify that each step is correct and that the accurate solution has been obtained every single time because

inaccurate dosages that are given can have catastrophic effects on the patient (Papastrat & Wallace, 2003; Pierce, et al., 2008; Polifroni, et al., 2003).

Phase Four

Looking back is the final phase in Polya's problem-solving framework. Even though students have checked each step of the way through the calculation by the time phase three is completed, there is still room for error (Polya, 1973). In fact, many students believe that once they have a solution that they have accomplished their mission and they can move on to something else (Cai & Brook, 2006). Therefore, Polya (1973) reinforces the importance of double checking to verify the accuracy of the solution. In addition, teachers have the responsibility to not allow students to have the impression that mathematical problems have no connection to each other or a connection with anything at all (Polya, 1973).

There has been discontent in the nursing literature regarding validating student's math skills via a paper and pencil test alone because these types of instruments test a student's ability to successfully take a test and have no bearings on the student's quality of performance in the real world (Andrew, et al., 2009; Armitage & Knapman, 2003; Hutton, 1998b; Ludwig-Beymer, et al., 1990; Segatore, et al., 1993; Wilson, 2003; Wright, 2007b, 2009). In other words, it is difficult to demonstrate with paper and pencil tests that students have connected the importance of the solution to a realistic clinical situation. So when a student reaches this final stage, an appropriate question to ask would be, "Does the solution seem logical and reasonable?" (Wright, 2009). When a student calculates that a patient needs 24 tablets of Aspirin 325 mg at one time, an IM injection of 70 mL, or an intravenous rate of 2800 mL/hr, the student should be asking themselves

if these results are logical and reasonable in an actual clinical setting and if the response is “no” then they should go back and start the process over at the beginning and not be satisfied that they did the equation to the best of their ability.

Without practical experience in a clinical environment, it is difficult to develop this sense of logic or reason to make a judgment call. The majority of beginning level nursing students will not have the experience necessary to determine the appropriateness of the calculation, therefore, it is important to place them in a realistic environment so that experience with actual medications and equipment can support development of this judgment skill under close supervision (Wright, 2009). Practicing dosage calculations is a great way to begin the learning process but without clinical experience, the solutions are devoid of meaning (Wright, 2009, 2009 in press). Polya (1973) suggests that logic and reason can be further developed through the use of estimating what the solution should be prior to calculating the numbers. Generating, analyzing, and comparing alternative solutions, posing new problems, and making generalizations are suggested as additional strategies (Cai & Brook, 2006). In a constructivist learning environment, students can share alternative approaches with each other and work through the problems together to help create a better understanding of the big picture of drug calculations (Taylor & McDonald, 2007).

Evidence-Based Research on Polya's Four Phases of Problem-Solving

To date, the use of Polya's Four Phases of Problem-Solving framework in nursing has only been a suggestion and no evidence exists on its relevance to the discipline (Wright, 2009), therefore, the search for current evidence-based research on its validity

was expanded to the use of Polya's framework at the university level. Two studies within the last ten years met these criteria and are discussed below.

Taylor and McDonald (2007) introduced Polya's Four Phases of Problem-Solving framework into a first year university mathematics course. The framework was combined with a writing heuristic and was implemented in group activities in the classroom. Throughout the course, three major assignments were used as an assessment tool to determine communication skills and problem-solving skills. Although students were initially apprehensive about the constructivist teaching strategy, a great majority expressed that the environment contributed to improving communication skills and that the problem-solving strategies introduced through Polya's framework were instrumental in increasing problem-solving skills even though there was not a dramatic increase in scores on math assignments (Taylor & McDonald).

Polya's Four Phases of Problem-Solving framework was integrated into an undergraduate chemistry course (Bilgin, 2006). The experimental group, split into pairs, utilized the framework to answer chemistry math questions together while the control group utilized the framework on an individual basis only. Bilgin revealed that when students were allowed to work in pairs, one member solves the problem and the other acting as a problem checker; they were able to significantly outscore their peers who worked on problems individually. However, a major limitation is that the paired groups were never measured on an individual basis so it is an unequal comparison against individual test takers. Also, the findings make it difficult to know if the framework was responsible for the improved scores or whether it was the pairing. For all intents and purposes, the paired groups could have scored significantly higher without the Polya

framework specifically because two individuals collaborated on the efforts to solve the problem.

Summarization of Theoretical Models

Polya's Four Phases of Problem-Solving Framework and the Nurse Education Simulation Framework emphasize that reflection (through looking back or debriefing) is absolutely crucial in the learning process. Reflection encourages students to establish an important connection between the mathematical problems and a realistic nursing practice environment where they will be responsible for calculating medication dosages and administering medications to real patients. Secondly, reflection emphasizes the importance of reviewing the process and evaluating what went right and what areas could be improved. In addition, reflection encourages the development of an understanding of the consequences that can occur when errors are made in the preparation and administration phases of medication administration. Finally, the reflective process allows nurse educators the opportunity to evaluate if a theory-to-practice gap exists.

Review of Empirical Literature

Policies and Procedures in Nursing Schools and Acute Care Facilities

Many schools of nursing employ rigorous guidelines for acceptance into a nursing program including a certain level of math proficiency before students can even be considered for admission. Flynn and Moore (1990) demonstrated that students' GPA and attitudes about math could predict scores on dosage calculation tests. Hutton (1998a) conducted a similar study and found that the only predictable variable that influenced math scores was achieving a grade higher than a C average in a math course. However, Hutton countered that using criteria such as a student's GPA may exclude some students

that could actually be outstanding clinicians from being accepted into a nursing program. Hutton's study found that students with a C grade or lower in mathematics who were initially unable to pass a dosage calculation test were able to successfully pass the test after participating in remediation with a tutor, peer mentors, and working through a mathematics booklet. However, altering admission criteria based on Hutton's finding would be ill-advised until further studies support the findings with a higher benchmark pass rate because the criteria for passing on the Hutton study was set at only 50%. If this study had set the benchmark at 80% or higher, as is common in most schools of nursing and acute care facilities, then no group of students (higher than a C grade, C average, lower than a C grade) would have achieved a passing average.

Polifroni, McNulty, and Allchin (2003) conducted a large, national study to discover how nursing schools and acute care institutions validated mathematical competency skills for medication administration for nursing students and new graduates. 318 schools of nursing offering baccalaureate, associate, and diploma programs and 23 acute-care institutions participated in the study. The majority of nursing programs had mathematical requirements as a prerequisite for entering the program. All of the acute care facilities and nearly all of the nursing programs required validating math skills prior to medication administration. The majority of these validation tests were faculty designed. An inconsistency existed in what was deemed an acceptable pass rate on these exams varying significantly from 70-100%. Only a third of the nursing programs required additional validation testing during every clinical course in which medications were administered. No correlational comparisons were conducted on the validation tools utilized between the nursing schools and the acute care facilities. After reviewing the

results of this study, the authors strongly encourage nursing programs and acute care facilities to instill a 100% pass rate for drug calculation exams into the institutional policies and procedures to promote safe practice as any single medication error would be considered unacceptable in clinical practice.

Rationale for Medication Errors

Calliari (1995) investigated the relationship between a failed dosage calculation test given to registered nurses in nursing orientation and actual medication errors in an acute care facility. The sample consisted of registered nurses with baccalaureate, associate, and diploma degrees. Incident reports from the acute care facility were obtained and reviewed for medication errors. Nurse's names from the incident reports were compared to nurses who failed the initial dosage calculation test. Only the incident reports of nurses who failed the test were investigated further. A breakdown of actual errors reported was primarily related to omitting medications (44.2%) and transcription errors (18.8%) followed by dosage and calculation errors (7.2%). A significant inverse relationship was demonstrated in the level of education and the amount of medication errors. Furthermore, the results indicate that nurses who passed the dosage calculation exam were less likely to commit actual drug errors.

Wolf, Hicks, & Serembus (2006) investigated the rationale for medication errors that occurred during the administration phase by over 1,300 nursing students by doing a secondary analysis on MEDMARX, a database operated by the United States Pharmacopeia through the Patient Safety Program. The authors revealed that the most common error was omission of a medication followed closely by the wrong dosage and the wrong route. Over half of the medication errors were related to performance deficit

followed by not abiding by procedures or protocol, knowledge deficit, and lack of communication. Dosage calculations were a smaller percentage of the errors but other errors that could influence inaccurate dosages are related to illegible physician orders, decimal point in the wrong place, and missing leading zeros. A majority of the medication errors by nursing students were committed while working with inexperienced staff or trying to administer medications while being distracted. Although many of the errors committed resulted in no patient harm, nearly a fourth of the patients required extra monitoring and/or other interventions (Wolf, et al.).

Rationale for Calculation Errors

Blais and Bath (1992), Segatore, Edge, and Miller (1993), and Jukes and Gilchrist (2006) investigated the rationale for calculation errors in nursing students. All three studies revealed that the majority of the errors were conceptual in nature indicating that students had difficulty setting the problem up correctly. Blais and Bath found that calculation errors included difficulty with multiplication, division, and decimal points. However, Jukes and Gilchrist found that students had more difficulty with ratio and proportion and unit conversions rather than multiplication and division. A major concern was that students were unable to detect errors that seemed unreasonable or irrational (i.e. 20 tablets of one drug) (Blais & Bath; Jukes & Gilchrist). An additional concern was that students showed a lack of concern about the consequences of these computational errors leaving the authors to conclude that paper and pencil tests do not reflect reality because it left students unable to appreciate the potential vastness of their errors (Segatore, et al.). Both studies concluded that problem-solving strategies should be employed in schools of nursing to help students conceptualize the problems.

Bindler and Bayne's (1991) quantitative study on calculation abilities of registered nurses revealed that specific types of medications were more difficult to calculate than others. Specifically, intravenous dosages and fluid rates were the most difficult to complete accurately and nurses erred more frequently on problems that required more than one calculation or when conversions of milligrams to grains were required. Nurses who had increased self-confidence scored higher on the calculation test although the vast majority of all of the nurses were unable to achieve the 90% benchmark set for competency in calculations indicating that self-confidence does not necessarily translate into calculation proficiency.

Drug calculations with or without the use of a calculator have been widely debated because dosage calculation errors have been tied to a lack of ability to do mathematical functions such as multiplication and division (Blais & Bath, 1992; Hutton, 1998b). Bliss-Holtz (1994) studied the rationale for dosage calculation errors through administering a dosage calculation test with and without a calculator to experienced and graduate registered nurses. Nurses struggling with mathematical concepts demonstrated that the use of calculators helped overcome problems with arithmetic operations such as multiplying and dividing. However, this study demonstrated that if the error was conceptually related then a calculation error would still occur because the wrong formula was used to solve the problem. Distinguishing types of errors assists educational institutions and hospitals in developing the appropriate type of remediation. If nurses are able to overcome arithmetic problems through using a calculator, this is a more cost-effective measure than remediating each nurse until calculations can be performed on paper. One unexpected finding was that experienced registered nurses scored lower than

graduate nurses whether a calculator was used or not (Bliss-Holtz, 1994). This deficiency points to a growing concern that safety measures such as unit dosing takes away the need to calculate dosages on a regular basis. These results indicate that the experienced nurses had lost the ability to consistently calculate accurate dosage calculations.

A lack of cognitive ability is not the only rationale for dosage calculation errors. Glaister (2007) researched the learning outcomes of nursing students who had computer and math anxiety when compared to three different teaching modalities. The three teaching strategies included integrative, computer-based instruction and then a combination of these two teaching strategies. Students who reported a negative attitude and higher anxiety toward mathematics did not perform as well on the dosage calculation tests. When compared to the three different teaching strategies, it was discovered that participants who indicated higher levels of anxiety scored significantly better on the math skills test when they had participated in the integrative or the combined integrative and computer-based instruction than using computerized instruction alone.

Walsh (2008) and Wright (2006) conducted similar studies to examine the relationship between performance on a math skills test and a nursing students' level of mathematical anxiety, beliefs about mathematics, and self-efficacy in mathematics. Although most students were not overly anxious, those who were anxious had decreased self-confidence in performing complex mathematical concepts. The findings in the Walsh and Wright studies did not support the findings of the Glaister (2007) study as there were no significant relationships between anxiety, self-efficacy, self-confidence and actual math scores. However, Wright did find a significant positive relationship between those who enjoyed mathematics and dosage calculation scores.

Validating Math Skills

Calliari (1995) investigated the relationship between a failed dosage calculation test and found that nurses who passed the dosage calculation test were less likely to commit actual drug errors although arguments have since been made regarding the validity of testing mathematical skills with a written test (Hutton, 1998a; Wright, 2007b). Research abounds on the difficulties that nursing students experience with passing traditional math or dosage calculation tests with paper and pencil or on the computer (Calliari, 1995; Glaister, 2007; Greenfield, et al., 2006; Hutton, 1998a; Maag, 2004; Rice & Bell, 2005; Wilson, 2003; Wright, 2004, 2005, 2006, 2007a, 2008).

Researchers propose that students learn safe medication administration and calculation in a constructivist environment that allows the student to learn and perform authentic tasks in a realistic setting with actual charts, equipment, and drug labels to help formulate the problems (Blais & Bath, 1992; Glaister, 2005; S. Johnson & Johnson, 2002; Kelly & Colby, 2003; Rice & Bell, 2005; Weeks, et al., 2000; Wright, 2007b, 2009). This type of approach addresses calculation and conceptual skills at the same time, however, to date; there are no research studies published on the efficacy of testing nursing students utilizing this approach (Wilson, 2003; Wright, 2007a).

A practical approach to assessing calculation errors was undertaken by Wilson (2003) who investigated the dosage calculation results of an experimental group of registered nurses who took a practical dosage calculation test in a simulated environment and then took a traditional dosage calculation test with pencil and paper. The results were compared with the control group who took the tests in the opposite order. Nurses who took the practical exam first scored significantly higher on calculation skills when

compared to the control group suggesting that exposure to a realistic environment helped improve the conceptualization of what needed to be calculated. However, this finding invokes inquiry into why experienced registered nurses in all types of acute care environments would need to have a simulation experience to help them conceptualize the calculation problems because their daily work should supply an ample amount of experience figuring out dosages in a realistic environment.

Educational Approaches

Multiple research studies have been conducted to investigate the effectiveness of different teaching strategies on a student's ability to pass dosage calculation tests. Hutton (1998b) investigated the effectiveness of a remediation program on students who were unable to successfully pass a pre-dosage calculation test. Remediated students received a self-instructed mathematical booklet covering the basic concepts of math. At the end of the semester, a post-dosage calculation test revealed that although overall scores increased the average percentages were still poor indicating that the booklet was not enough to remediate students to an acceptable proficiency level.

Maag (2004) introduced an interactive multimedia learning tool as an instructional strategy to help students develop math skills. Although the results indicated that students received equal scores as compared to students who received traditional instruction, the students who participated in the multimedia instruction reported higher levels of satisfaction with learning. Glaister (2005) conducted a similar study that implemented three teaching strategies including computer-based instruction, integrative learning, and then a combination of both teaching strategies to determine if there were any effects on learning the skill of accurate dosage calculations. Results supported

Maag's findings in that there were no significant differences between the three teaching strategies on knowledge acquisition and transfer measures although the computerized learning strategy was significantly more effective at helping students develop procedural knowledge.

Wright conducted a series of quasi-experimental studies to investigate strategies to improve math skills in student nurses (Wright, 2004, 2007a). All of the participants in these studies had the freedom to choose any or all of the learning strategy options of utilizing online math sessions, attending a 2-hour lecture explaining math formulas, completing practice math questions out of a workbook, participating in practice sessions in the skills laboratory, and privately studying with recommended texts after completing a pre-dosage calculation test.

Student perceptions indicated that the workbook strategy was the most useful. However, participants in the 2004 study did not take a post-dosage calculation test to quantify the usefulness of this strategy. Participants in the 2007 study did take a post-math test seven months after the initial test. The post-test demonstrated that math scores improved although students were still unable to achieve the 100% benchmark set for this test. Allowing students to independently choose the strategies they want to use and the amount of time they want to expend in those strategies encourages academic freedom and caters to diverse learning styles, however, this methodology was not effective in meeting the 100% standard pass rate. Unfortunately, because there was student independence in choosing learning strategies there is no way to differentiate which strategies were the most useful since the majority of student's utilized more than one strategy.

Wright (2008) repeated this research with control and experimental groups. The control group received traditional lecture only and the experimental group received education through online tutorials and practice in the skills laboratory. An intravenous additive math test was administered one year after the initial education on math skills typically received in the second year of nursing school. The results indicated a phenomena where 15% more of the control group passed the post-test at 100% over the experimental group, yet the experimental participants that failed the test did so with less errors than the control group. A recurring theme in the Wright studies are that several teaching strategies are clumped together; therefore, it is a leap to say that any particular strategy was more effective than the other when there is no differentiation within the group.

The use of dimensional analysis as an learning strategy to improve accuracy in dosage calculations has been supported in the literature (Greenfield, et al., 2006; Rice & Bell, 2005). Rice & Bell conducted a pilot study to find out if dimensional analysis improved dosage calculation abilities in baccalaureate senior nursing students enrolled in a final clinical course (Rice & Bell, 2005). All students completed a required preclinical drug dosage calculation quiz in which calculators were permitted. All students were then invited to volunteer to participate in an instructional session on dimensional analysis. Volunteer participants completed the session and then all of the participants took a math test one week later in which calculators were not permitted. Participants in the study showed a significant increase in accuracy from pre- to post-test which is consistent with the findings in the Greenfield, Whelen, and Cohn study. The majority of the errors made by the participants on the preclinical test were either conceptual or computational errors.

The post-test revealed that conceptual errors were greatly reduced but the computational errors escalated. Although this study demonstrates that dimensional analysis was effective in reducing conceptual errors, the inconsistent use of a calculator on the exams highlighted that medication errors can still occur even when the right formula is used.

Pierce, Steinle, Stacey, and Widjaja (2008) studied the effects of a time-efficient diagnostic Decimal Comparison Test (DCT) and if a one hour intervention would result in improved understanding of decimals for nursing students who were identified as having mathematical weakness in decimal points. Three months after the intervention, all students participated in an equivalent (DCT). Results indicated that students who participated in the intervention scored significantly higher than non-intervention students.

Literature Influences on Study Design

There is no denying the importance of calculation skills and the role these skills have in safe medication administration. Educators have an obligation to validate that students are proficient and competent in these skills prior to practicing in a clinical environment. However, evaluating a student's competency in dosage calculations with traditional testing methods has left researchers seeking an alternative way to validate these skills. Suggestions for validation have included the notion of testing students in a more realistic environment.

Kelly & Colby (2003) advocate for utilizing a constructivist learning environment to teach medication calculations. The argument lies in that a traditionalist approach allows students to learn and follow the steps correctly but fails to foster an understanding of the process or the underlying concept behind the solution. This in turn can lead to a false sense of security in calculation skills that leaves students baffled when errors occur

in subsequent tests or clinical experiences. A constructivist approach would encourage applying acquired math skills to a realistic learning environment and promote tying abstract mathematical concepts to concrete, realistic examples.

The instructor is a coach that encourages students to collaborate with each other and solve problems in a variety of ways that will work with an increasingly diverse student body. Utilizing Polya's four phases of problem-solving framework in a simulation experience encouraged a deeper metacognitive process of evaluating solutions and the development of "number sense" that encourages students to question whether or not the solution is logical. This dissertation compared the effectiveness of two simulated teaching modalities that integrated Polya's framework into a low-fidelity case study in a classroom environment and a low-fidelity scenario in the simulation laboratory.

Potential Contributions to Nursing Science

Nursing Education

The vast majority of nursing schools validate mathematical competencies in nursing students although an inconsistency exists in how validation occurs and what is the acceptable level of competency. Multiple teaching strategies such as instructional booklets, multi-media and computer-assisted instruction, and emphasis on single methods to improve calculations such as dimensional analysis or focus on decimal points have been researched and deemed effective. However, none of these strategies have demonstrated improvement in conceptual and calculation skills at the same time and none have produced satisfactory passing scores in all of the participants.

Literature dispels the validity of traditional formats of dosage calculation testing and calls for a more realistic way to validate competency. This study contributed to the

body of nursing education knowledge through the provision of research-based evidence on the effectiveness of simulation on the conceptual and computational skills required to solve dosage calculations accurately. In addition, it tested the validity of a dosage calculation tool that resembles what occurs in a realistic environment.

Hospitals and Acute Care Facilities

Literature has demonstrated that graduate and experienced nurses continue to struggle with accurate dosage calculations. Most hospitals and acute care agencies have adopted a validation test to verify calculation skills in nurses. This study encourages future research on the effectiveness of remediating nurses in a simulated environment who were unable to initially pass the dosage calculation test. Collaborating with colleagues would reinforce calculation skills and encourage new ways to solve problems accurately. With safety systems such as barcodes and unit dosing, nurses have less opportunities to calculate dosages and therefore maintain competency. It is imperative that ongoing validation occurs throughout the course of employment and not just during the orientation phase to the facility. In addition, hospitals and acute care facilities could also benefit from a more realistic tool that resembles what happens in clinical practice.

CHAPTER III

METHODOLOGY

Introduction

The purpose of this dissertation study was to (a) compare medication administration dosage calculation scores and scores of self-perceived judgment in medication dosage calculations in fundamental nursing students who experience either a traditional classroom experience or a low-fidelity simulation lab experience and (b) determine if there was any difference between satisfaction and self-confidence in learning when comparing the two previously identified teaching modalities.

This chapter discusses the research design for implementing Polya's Four Phases of Problem-Solving framework into two teaching modalities – a traditional case study in the classroom and a low-fidelity scenario in a simulation lab. Details outlined in this chapter include a discussion of the research design, a comparison of the parallels between the two teaching modalities, a description of the setting, population, sample strategy, ethical considerations, descriptions of the instruments, the procedure for data collection and analysis, the results of the pilot study, and threats to internal and external validity.

Research Design

Design Type

This study was guided by a quasi-experimental, quantitative design. A pre-test/post-test was utilized as a measurement system to analyze changes that occurred as a result of the interventions for the experimental and comparison group. This study determined if the independent variables – integration of a traditional case study into a classroom environment or integration of a low-fidelity simulation scenario in a simulation laboratory, had an effect on the dependent variables – medication dosage calculation skills, self-perceived judgment, satisfaction, and self-confidence.

According to Houser (2008), an experimental design is the gold standard for quantitative research contributions to evidence-based practice; however, alternative designs may be more desirable in situations where it would be unethical to withhold a potentially beneficial treatment from the control group. A quasi-experimental design for this study allowed an experimental and a comparison group to receive teaching-learning on how to accurately calculate medication administration dosages. The teaching modalities were compared by evaluating the differences in dosage calculation test scores and self-perceived judgment scores.

Quasi-experimental designs are similar to experimental designs except that existing groups are utilized to test interventions (Houser, 2008). Three characteristics of experimental designs that must exist to infer causality are (a) “the cause must precede the effect in time, (b) the influence of the cause on the effect must be demonstrated, and (c) rival explanations for the outcome must be ruled out” (Houser, 2008, p. 402). Because of

a lack of randomization, inferring causality in this quasi-experimental study was threatened by a potential alternative explanation for the outcome (Houser, 2008).

Strengths and Weaknesses

According to Houser (2008), there are several strengths of quasi-experimental designs. First, this design offers a more feasible and ethical way to conduct a study in an applied setting. Secondly, the effect of extraneous variables can be reduced by introducing a level of control in the study. Finally, larger samples may be obtained due to accessibility of groups of subjects. A major weakness includes a non-random selection of a group of subjects that may not be equivalent in characteristics. This weakness leads to an inability to draw firm conclusions on causality because rival explanations for the outcomes could exist and these explanations could weaken confidence in the results (Houser).

This study attempted to determine if the independent variable, the teaching modality (a traditional case study in the classroom versus a low-fidelity scenario in the simulation lab) could explain the variability of the dependent variables (medication administration dosage calculation test scores, self-perceived judgment in dosage calculations, and satisfaction and self-confidence in learning). The experimental group attended the low-fidelity simulation scenarios in the simulation lab and the comparison group attended the traditional case study in the classroom. Statistical analysis of the two groups was done to determine the equality of the two groups on the dependent variables.

The population of interest for this study was fundamental level nursing students beginning to learn the process of medication administration dosage calculations in the first semester of a nursing curriculum. Some students begin nursing programs with

previous experience in healthcare including certification as a licensed practical nurse (LPN), certified nursing assistant (CNA), or as an emergency medical technician (EMT). In addition, some students are earning their second college degree. Furthermore, other demographic factors such as age, gender, ethnicity, class ranking, and previous experience with simulation may influence a students' ability to calculate medication dosages. All of these extraneous variables were controlled through statistical analysis by pre- and post-testing the experimental and the comparison group on the dependent variables during the theoretical portion of student curriculum prior to any clinical practicum which would include medication administration. The extraneous variable of experience as an LPN was minimized in this study because LPN's enter the nursing program in the second semester and are not required to take the fundamentals nursing courses where this sample was drawn. The extraneous variable of experience with simulation was also minimized by the fact that all students are only exposed to a prescribed curriculum with identified, predicted experiences with simulation at the participant's level of programming. Additional threats to validity are discussed at the end of this chapter.

Comparison of Teaching Modality Designs

Polya's Four Phases of Problem-Solving framework was used as a guideline to develop the low-fidelity simulated scenario experience in the simulation lab (experimental group) and the traditional case study experience in the classroom (comparison group). All of the participants in the comparison group participated in a two hour classroom experience. The experimental group of students was divided into small groups of six students. Each small experimental group attended a two hour simulation

experience. Both the experimental and the comparison groups were unfamiliar with Polya's framework, so the first part of each of the experiences was an introduction to the framework. The instructors for the experimental and comparison groups demonstrated how to use the framework to solve a medication administration dosage calculation problem. The comparison group instructor used Polya's framework to solve a typical dosage calculation problem on the blackboard. The experimental group instructor used a typical physician's order and the necessary equipment (i.e. drug vial, syringes) to solve the problem by following the guidelines of Polya's framework.

After the demonstration, the comparison group received a simple case study on a patient requiring six medications. The worksheet contained the list of the six medications including information on how the medication was supplied. Students used this information to independently solve these six problems utilizing Polya's framework. In contrast, the experimental group participated in a simplistic case scenario that included a medical chart that had orders for the exact same six medications as the comparison group. Based upon the physician's orders, the experimental group independently solved the problems utilizing Polya's framework and the necessary equipment required to administer the drug to figure out the solutions. Each student in the experimental group was given one of the six drugs to actually prepare and administer during the scenario. Calculators were allowed and provided in the experimental and comparison groups.

For the final hour of the experience, the comparison group was divided into small groups of six students each. The small groups for the experimental and comparison groups went through the Polya process together, explaining and collaborating how to arrive at the correct solutions for these six questions. Guided reflection occurred during

the last 30 minutes of both teaching modalities to allow the instructors to narrow the theory-to-practice gap by helping connect the important components of the learning experience so that students could transfer this knowledge to a clinical setting. One way to ensure that all students had similar reflective experiences was to have questions written down on prompt cards for the instructor to use. Utilizing Gibbs' reflective cycle of questions promoted reflection-in-action and provided a consistent line of questioning (Jeffries & Rogers, 2007).

In summary, the content and testing techniques were the same for the experimental and the comparison groups except for the differences in teaching modalities. This quasi-experimental, quantitative design demonstrated if a hands-free classroom experience or a hands-on simulation experience had any impact on a fundamental nursing students (a) ability to calculate medication administration dosages correctly, (b) level of satisfaction in learning, and (c) degree of self-confidence, and (d) self-perceived judgment in dosage calculations.

Setting

This study took place at an accredited, religious-affiliated university located in southeast TN that offers degrees at the master's, baccalaureate, and associate level. The lead investigator is a full-time faculty member at this university but does not teach at the fundamental nursing level. Approval for this study was obtained through the IRB committees at the University of Northern Colorado and the university participating in the study (see Appendix B).

Population

In quasi-experimental studies, the target population is heavily dependent upon accessibility and the way the groups of subjects are naturally divided (Houser, 2008). The identified groups for this study were fundamental, associate degree nursing students. The inclusion criterion for membership in this group included a college GPA of 2.8 or higher and acceptance into the nursing program. Students in this group must also be enrolled in the fundamentals nursing course to be eligible to be in this study. Exclusion criterion included any student under the age of 18 years old, students who were repeating the course and students who skipped the required simulation laboratory or classroom experience.

Sampling Strategy

Selection of Experimental and Comparison Groups

A convenience sample of 59 associate degree nursing students who were enrolled in a fundamentals nursing course and were just beginning to learn about medication administration dosage calculations were invited to participate in this study. Informed consent was obtained (see Appendix C). Students were equally divided into an experimental and a comparison group based upon clinical group rotations (Tuesdays or Thursdays). The clinical group rotations were assigned based upon transportation needs of the students because many of these students reside out of state or the country and do not have personal transportation. Students signed up as “car groups” of 3-4 people and the lead faculty member assigned them to a full clinical group for Tuesdays or on Thursdays. The course instructor did try to make sure that equality was maintained in

each group by making sure that each group had a blend of defining student characteristics such as language or GPA.

Based on the course schedule, the course instructor required the Tuesday lab group (experimental group) to participate in simulation on Wednesday evening or on Thursday and the Thursday lab group (comparison group) participated in the classroom experience on a Tuesday morning. The Pre/Post-test Dosage Calculation Tests were also required. However, if a student declined to participate in the research study their scores from the math tests were not included as study data and they were not required to complete the demographics tool, the self-perceived judgment in medication administration tool, or NLN satisfaction and self-confidence tool.

Ethical Considerations

Ethical risks for participants in this study were limited. Risks included (a) anxiety and feelings of inadequacy over taking a medication administration dosage calculation test without preparation, (b) anxiety in using simulation as a teaching strategy, and (c) a breach of confidentiality in identifying characteristics of the participants.

Anxiety and Inadequacy

All students in this study were asked to meet at a pre-scheduled time to take the Pre-Dosage Calculation Test and complete the Self-Perceived Judgment in Dosage Calculation Scale and demographics tool. Students were informed of the nature of the research study at this time and written consent was obtained.

Students may have felt anxious over not being informed of the intent of the class period prior to arrival and they may have felt inadequate over not being prepared to perform to the best of their abilities. The feelings of anxiety and inadequacy were

minimized by informing students at the beginning of the meeting that the test scores would not negatively impact their grades for the fundamentals nursing course in any shape or form. However, because of a school of nursing dosage calculation policy that all students must score 100% on a medication administration dosage calculation test prior to administering medications in clinical, students were informed that a score of 100% on either the Pre- or Post-Dosage Calculation Test would count for this course requirement. A score of 100% did not impact the course grade in any way; rather it was a checkmark off of a list of skills that must be accomplished prior to clinical.

Students were informed of their test scores after all of the data collection has been completed by a faculty member who kept the master list of names and research identification numbers. After data collection, if a student did not score 100% on either test they had free access to a faculty tutor, computerized tutorials, and computerized tests that are regularly used for this course so that they could meet the requirements of the school of nursing policy on dosage calculation tests.

Anxiety in Simulation Teaching Strategy

Using simulation as a teaching strategy could have invoked anxiety in students who were unfamiliar with simulation and the different pedagogical approach to learning although Hoffman, O'Donnell, and Kim (2007) have found that anxiety diminishes with repeated exposure to simulation. Up until this point, exposure to simulation for this group of nursing students had been limited to learning how to listen to heart, breath, and bowel sounds, palpating pulses, and practicing injections. The literature suggests that beginning nursing students are not ready for high-fidelity, complex simulations and the use of low-fidelity, non-complex scenarios or case studies would be more appropriate (Waldner &

Olson, 2007). This advice was taken into consideration and a non-complex case study for the classroom experience and a non-complex scenario for the simulation lab was developed for this study. Easing students into simulation with a basic scenario helped diminish the anxiety over participating in an unfamiliar learning environment.

Breach of Confidentiality

In a study where anonymity cannot be guaranteed, researchers should do everything possible to maintain confidentiality (Polit & Beck, 2008). Several steps were identified to help prevent a breach of confidentiality. These steps included (a) obtaining identifying data only when it was essential, (b) assigning a research identification number to each participant and keeping the master list in a locked file, (c) restricting access to identifying data to a small number of people on a need-to-know basis, (d) not entering identifying information into a computerized database (e) destroying identifying data as soon as possible, (f) requiring confidentiality pledges of all research assistants and (g) reporting research findings in the aggregate (Polit & Beck, 2008).

Based on these recommendations, students were assured that the master list of student names and research identification numbers would be kept in a locked, fire-proof container guarded by a neutral staff member. This staff member, the lead course instructor, and the two individuals who taught the classroom and simulation experiences signed a confidentiality pledge indicating a willingness to hold all information confidential (See Appendix D). All data were collected in sealed envelopes and delivered to the neutral staff member who coded each paper with the correct research identification number and then cut the student names from the tools and shredded them. The neutral staff member did not hand over any tools to the researcher until the identifying factors

were removed and destroyed. After the tools had been scored and the data were entered into the computerized database, the medication administration dosage calculation tests were returned to the neutral staff member so that the scores could be recorded and the students who scored 100% were notified. For the sake of test security and preventing a confidentiality leak, the Pre-/Post Dosage Calculation Tests were shredded as soon as the database had been checked for accuracy. All other tools were entered into the database and destroyed once all of the data had been entered and checked for accuracy. Finally, all data was reported as an aggregate. No individual identifying characteristics were revealed in dissemination through this dissertation and neither will they be in future contributions to nursing journals or professional presentations.

Protection of Human Rights

A dissertation proposal hearing with the dissertation committee was held in August of 2009 and approval of research methodology was received prior to data collection. In addition, permission of the University of Northern Colorado and the participating university's Institutional Review Board (IRB) was sought for an expedited review. Data collection did not occur until approval was granted (See Appendix B for IRB forms).

Power Analysis

A statistical power analysis maximizes the likelihood that the differences, relationships, and effects found in statistical results are accurate and reliable (Gall, Gall, & Borg, 2007) that is, if these differences truly exist (Batterham & Atkinson, 2005). An actual calculation of statistical power improves the accuracy of the results by estimating an adequate sample size that should be utilized in the study so that time and resources are

not wasted on a sample that is too large or too small (StatSoft, 2008). Prior to conducting research, the researcher must estimate in advance three of four components that will impact the statistical power analysis (Polit & Beck, 2008). These four factors include (a) the level of significance criterion, (b) the sample size, (c) the effect size, and (d) the power ($1-\beta$). According to Polit and Beck, if three of the components are estimated then the power analysis can solve for the fourth.

Level of significance. The first component that impacts a power analysis is the level of significance, or alpha (α). This value can directly influence the susceptibility of a researcher drawing erroneous conclusions about the hypothesis and committing a Type I error by rejecting a null hypothesis when it is unwarranted (Gall, et al., 2007; Houser, 2008). The risk for a type I error can be controlled by setting a level of significance at a minimum of $\alpha = 0.05$ (Batterham & Atkinson, 2005; Gall, et al., 2007; Houser, 2008; Polit & Beck, 2008).

Sample size. The second component that influences a power analysis is the amount of subjects in the sample. A positive relationship exists between the sample size and power; indicating that the more subjects that participate, the more powerful the statistical findings (Polit & Beck, 2008). This quasi-experimental, quantitative study invited two intact groups of fundamental nursing students to participate ($n = 59$).

Effect size. The third component, the effect size, is an estimate of the magnitude of the relationship between an independent and dependent variable in a population (Polit & Beck, 2008). According to Polit and Beck, the effect size is not commonly known and it must be estimated using available evidence such as results from pilot studies or it can be based on previous findings from earlier studies on similar findings if these data were

reported. Currently, there is no research published on simulation and its effects on a nursing student's ability to calculate medication administration dosages correctly. In addition, no research has been published on utilizing a more realistic tool for evaluating proficiency in dosage calculations. However, after investigating research articles on implementing new instructional strategies, the effect size noted were moderate to large.

Power (1- β). The final component that influences a power analysis is the actual level of power set for the study. "Formally, power is equal to 1 minus the Type II error rate (beta or β)" (Batterham & Atkinson, 2005, p. 153). A type-II error occurs when the researcher erroneously accepts the null hypothesis (Glass & Hopkins, 1996) or in other words, the researcher fails to find a difference or relationship between two or more variables when one actually exists (Batterham & Atkinson, 2005). The conventional standard for 1- β is 0.80 which leaves a 20% risk for committing a Type II error (Polit & Beck, 2008).

Based upon recommendations given for the level of significance, effect size, and power, this study established the level of significance for this study to be $\alpha = 0.05$. In addition, the effect size was set at a 5% difference in scores equating to a difference of 1.5 points on the Pre-/Post-Dosage Calculation Test scores. The power of the study was established at 0.80. Utilizing Minitab 15 software to conduct a power analysis for this study using a two sample *t*-test with the testing mean 1 = mean 2 (versus not =) and the calculated power for mean 1 = mean 2 + the difference, the estimated sample size required for this study is nine subjects in each group (See Figure 3). For this study, if all of the students had agreed to participate and there were 30 participants in each group the power increased to 0.9999 (See Figure 4).

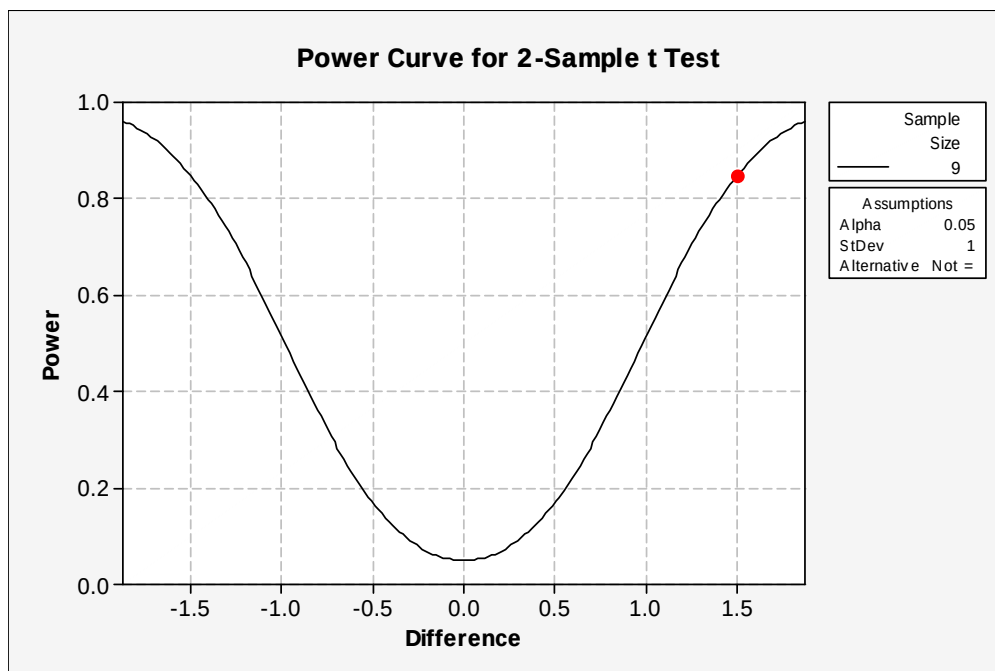


Figure 3. Power Curve for 2-Sample t -test – Minimum Sample (Minitab, 2009).

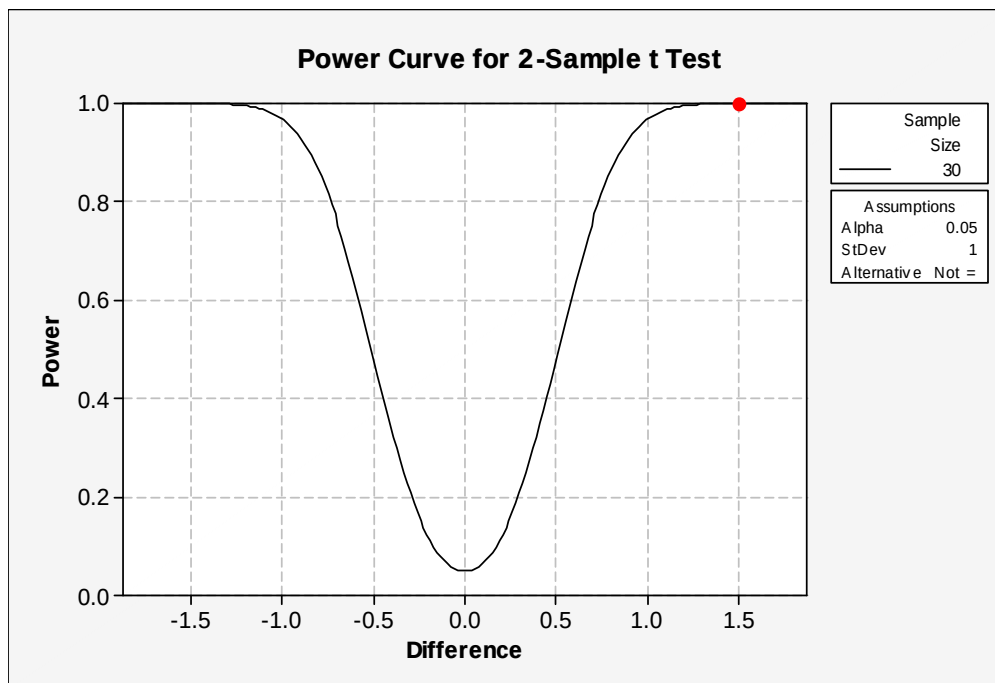


Figure 4. Power Curve for 2-Sample t -test – Maximum Sample (Minitab, 2009).

Data Collection

Procedure

Polya's Four Phases of Problem-Solving framework was utilized to design a teaching module for fundamental nursing students to improve medication administration dosage calculation skills in a low-fidelity simulation experience in the classroom and the simulation laboratory (see Figure 5). All of the students met in the classroom and signed informed consent forms. Five declined to participate in the study and seven were ineligible. These students completed the dosage calculation tools only and they attended their experiment. The rest of the students ($n = 47$) completed a demographic tool and a Pre-Dosage Calculation Test followed by the Self-Perceived Judgment in Dosage Calculation Scale. Calculators were allowed and were provided. Students were then divided into groups based upon the day of clinical rotation.

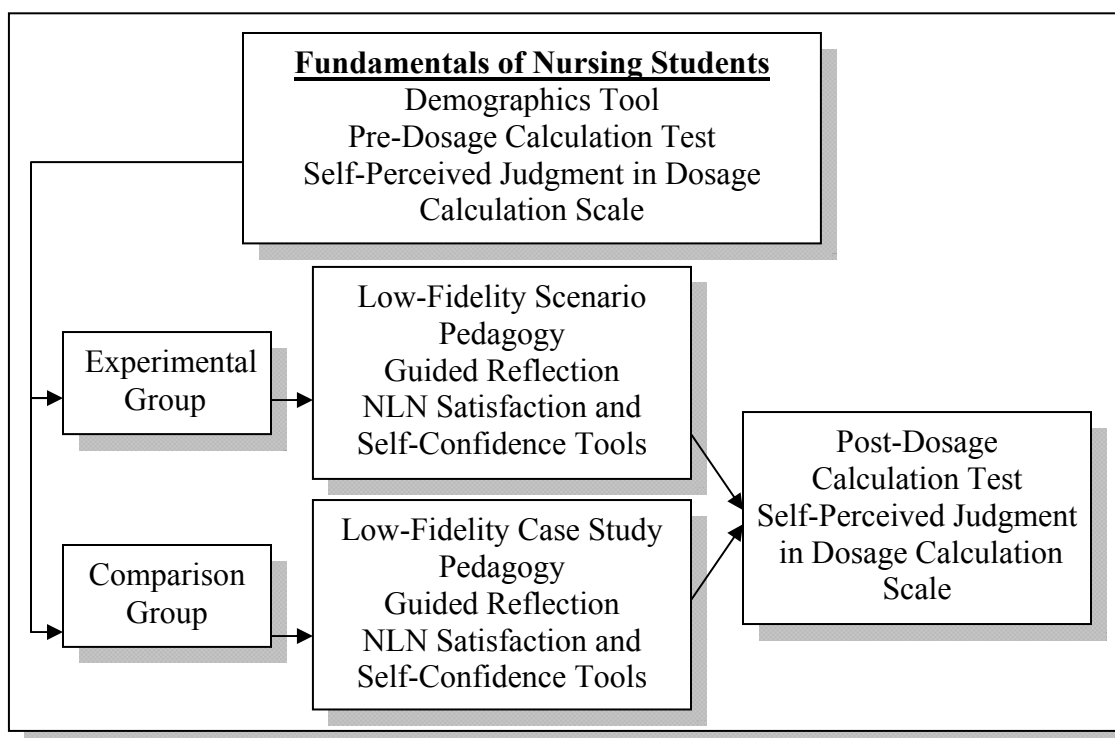


Figure 5. Data Collection Procedure

Experimental group. Students in the Thursday clinical group ($n = 22$) became the experimental group. This group of students was divided into smaller groups of approximately six students. Each small group attended a two hour simulation experience scheduled within the same week as the comparison group. Each small simulation group received a PowerPoint overview introducing Polya's Four Phases of Problem-Solving framework. Then the experimental group instructor used a typical physician's order and the necessary equipment (i.e. drug vial, syringes) and used this information to solve a dosage calculation problem by following the guidelines of Polya's framework. The experimental group then participated in a simplistic case scenario based upon the NESF guidelines. The simulation included a medical chart with six medications that were ordered to be given now. Based upon the physician's orders, the experimental group independently solved the problems utilizing Polya's framework and utilizing the necessary equipment required to administer the drug to figure out the solutions. Calculators were allowed. Each student in the experimental group was given one of the six drugs to actually prepare and administer during the scenario.

For the final hour, the simulation group went through the Polya process together, explaining and collaborating on how they arrived at the correct solutions for these six questions. Guided reflection occurred during the last 30 minutes of the simulation experience allowing the instructors to help the students connect the important concepts of the learning experience together. Gibbs' reflective cycle of questions promoted reflection-in-action and provided a consistent line of questioning for the study (Jeffries & Rogers, 2007). Students that consented to the study then completed the NLN Student Satisfaction and Self-Confidence in Learning Scale ($n = 22$).

Comparison group. Students in the Tuesday clinical group ($n = 25$) were required to attend a traditional classroom experience utilizing a low-fidelity case study. The first hour of this experience entailed a PowerPoint overview introducing Polya's Four Phases of Problem-Solving framework. The teacher demonstrated how to use the framework to solve a dosage calculation question. After the demonstration, the comparison group received a simple case study on a patient requiring six medications. The individual worksheets contained the list of the six medications and it included information on how the medication was supplied. Students used this information to independently solve these six problems utilizing Polya's framework.

During the second hour, students spread out in the classroom and divided into smaller groups of six students. These small groups used Polya's framework to go back through the six questions and they collaborated together on how to solve the problems. Guided reflection occurred during the last 30 minutes of the experiment allowing the instructor to connect the important components of the learning experience and bridge any theory-to-practice gaps that existed. Gibbs' reflective cycle of questions was utilized as previously described. Students who agreed to participate in the study completed the NLN Student Satisfaction and Self-Confidence in Learning Scale. The Post-Dosage Calculation Test and Self-Perceived Judgment in Dosage Calculations were completed at a later time when both the experimental and comparison group tested concurrently.

The experimental and comparison groups ($n = 47$) rejoined in a large classroom and took the Post-Dosage Calculation Test and the Self-Perceived Judgment in Dosage Calculations Scale at the same time within one week of completing the classroom or simulation experiences. The rationale for completing the post-test within one week was

that students must meet the school of nursing's policy for medication administration dosage calculations at 100% before administering medications in clinical. If they did not achieve this score during this research study then they needed an adequate amount of time to complete the computerized tutorials, seek help from a tutor, and take the computerized exams prior to clinical. It would have been unethical for a research study to interfere with a student's ability to fulfill course requirements and therefore, prohibit them from attending clinical. There were a total of 47 out of the 59 participants who volunteered and were eligible to participate, completed all of the forms, and attended their learning experience.

Instrumentation

The four instruments used for this study were:

1. Demographic Survey: A self-administered researcher-designed form to collect data on gender, age, class standing, ethnicity, previous experience in healthcare, education, and simulation, GPA, ACT/SAT math scores, and whether or not they had completed the college math requirement if ACT scores are < 22 . Conceptually defined, the demographic tool enabled the researcher to determine levels of potential variances such as academic standing or experience in health care or education. Operationally defined, the demographic tool was designed to collect demographic data on research participants. (See Appendix E).

2. Pre-Dosage Calculation Test (Pre-DCT) and Post-Dosage Calculation Test (Post-DCT): Conceptually defined, the Pre-/Post-DCT was a 31-item self-administered, researcher-designed instrument that reflected the original medication administration dosage calculation instrument utilized in the school of nursing for many years. The

original tool was modified to test the accuracy of medication administration dosage calculation skills and the transfer of these calculated dosages into a realistic format for medication administration in fundamental level nursing students. The medications that were calculated were in pill form, liquid suspension, intramuscular injection (IM), nasogastric tube (NGT), and intravenous pushes and infusions (IV). The items required the participants to understand the problem through interpretation of the physician's orders and the drug labels, devise a plan to solve the problem, and carry out the plan utilizing appropriate conversions when necessary and demonstrate a transfer of the calculated dosages into a realistic setting by filling in the correct dose on the appropriate equipment (i.e. tablets, medication cup, Kangaroo pump tube feeding bag, syringes, and electronic IV pumps). The items were divided into two categories – 16 items on calculating medication administration dosages and 15 items on demonstrating the transfer of the calculated dosages to the actual equipment. (See Figure 6 for the test blue print).

Operationally defined, the Pre-/Post-DCT was used to evaluate cognitive knowledge and content mastery pre- and post-educational experience. The Pre-/Post-DCT forms of the instrument portrayed the actual medication and its constitution. Students had to use this information to gather the pertinent data to calculate the dosages correctly. The questions were scored dichotomously, *yes*, the response is correct (1) and *no*, the response is incorrect (0). The questions were the exact same for both forms but the requested dosage and the patient's weight were different on the second form. Reliability and validity of the instrument are discussed in the next section (See Appendix F).

Table 3

Pre-/Post-Dosage Calculation Test Blueprint

	Interpretation of Physician's orders	Read Drug Label to Find Information	Requires conversion (i.e. mcg to gm or kg to lb)	Medication Administration Dosage Calculations	Transfer of Calculated Dosages	Total Number of Questions
Pill Form	3	3	2	3	3	3
Liquid Suspension	2	2	2	2	2	2
NG tube	1			1	1	1
SQ Injections	1	1	1	1	1	1
IM Injections	2	2		2	2	2
IV push	1	1		1	1	1
IV piggyback preparation	1	1	1	1	1	1
IV infusion electronic pump	3	1	1	3	3	3
IV infusion gravity	1		1	2		1
TOTAL	15	11	8	16	15	31

3. Self-Perceived Judgment in Dosage Calculation Scale (SPJDCS): Conceptually defined, the SPJDCS was a 15-item self-administered, researcher-designed instrument to assess a students' ability to examine the solution obtained to see if it was logical and reasonable. Operationally defined, The SPJDCS was designed to evaluate self-perceived judgment utilizing a 5-point Likert Scale ranging from *highly logical* (5 points) to *highly illogical* (1 point) - (See Appendix G). Reliability and validity of the instrument are discussed in the next section. Combined with the Pre- and Post-DCT tools, these instruments measured all of the learned constructs of dosage calculations deemed necessary and essential to practicing safe medication administration in a clinical environment.

4. National League for Nurses (NLN) Satisfaction and Self-Confidence in Learning Scale (SSCLS): Conceptually defined, the SSCLS is a 13-item self-administered instrument designed by the NLN to assess student's feelings on the simulation experience. Operationally defined, the SSCLS is designed to assess student's perceptions on the level of satisfaction experienced during simulation and how this teaching strategy influenced the level of self-confidence a student has after participating in simulation. (See Appendix H).

The first portion is a 5-item tool measuring satisfaction in learning using a 5-point Likert scale with responses ranging from *strongly agrees* (5 points) to *strongly disagree* (1 point). Items measure the level of satisfaction with the teaching methods, variety of learning materials and activities and how much these motivated a student to learn, and the enjoyment and satisfaction with the instructors approach to teaching. Cronbach's alpha established reliability at 0.94 (Jeffries, 2007).

The second portion is an 8-item tool measuring self-confidence in learning utilizing the same 5-point Likert scale. Items measure confidence in mastery of the content, the scope of the content, skill and knowledge development, resources utilized for the simulation, self-responsibility in learning, seeking help when necessary, how to use simulation for maximizing the learning experience, and the instructors responsibility for teaching. Cronbach's alpha established reliability at 0.87 (Jeffries, 2007). In this study, students rated their self-confidence in dosage calculations based upon their experience with a low-fidelity case study simulation in the traditional classroom or a low-fidelity scenario simulation in the simulation lab. Content validity for satisfaction and self-confidence items was established through nine content experts. Permission to utilize these tools was granted from the NLN (See Appendix I).

Internal Reliability of Researcher-Designed Instruments

Internal reliability refers to "the extent to which an instrument is consistent within itself as measured with the alpha coefficient statistic" (Houser, 2008, p. 252). A point-biserial correlation is conducted when one variable is truly dichotomous and the other variable is continuous (Gall, et al., 2007). In this study, the Pre-/Post-DCT instruments contained 31 items that were dichotomous (yes or no) variables. A point-biserial correlation coefficient (PBCC) was conducted for each item utilizing the Statistical Package for the Social Sciences (SPSS) Version 17.0 and the Kuder-Richardson 20 (K-R 20) formula analyzed individual items for rational equivalence. The PBCC and the K-R 20 were measured in a pilot study prior to conducting this research and are discussed within the findings of the pilot study later in this chapter.

The SPJDCS instrument contained 15 items measured on a 5 point Likert scale. Cronbach's alpha is the appropriate statistical test to run when there are multiple variables that are not scored dichotomously (Gall, et al., 2007) and should have an overall value of 0.7 or greater (Houser, 2008). According to Houser, Cronbach's alpha has two benefits: (a) it allows the researcher to verify that the way responses vary on one question follows the same pattern as the rest of the questions on the instrument and that it reflects actual changes in content and not changes in the way the questions are interpreted and (b) it allows the researcher to determine the amount of measurement error in the instrument. Cronbach's alpha for the SPJDCS was calculated using SPSS software and is discussed within the pilot study results.

Validity of Researcher-Designed Instruments

Validity is defined as "the ability of an instrument to consistently measure what it is supposed to measure" (Houser, 2008, p. 254). Although the pilot test determined the reliability of the instruments this fact alone does not ensure validity. Therefore, validity is required to draw any conclusions about the usefulness of the instrument (Houser). Several measures were used for this study to determine validity including (a) face validity, (b) content validity, and (c) Criterion-related validity – concurrent validity.

Face Validity

Face validity is considered an essential element of validity testing (Houser, 2008). Subject-matter experts review the instrument and determine that it appears to measure the concepts that it is supposed to measure (Gall, et al., 2007; Houser, 2008). A major assumption is that the subject-matter experts are competent to accurately conclude that it is a valid instrument. Subject-matter experts for this study included the course teacher for

fundamentals of nursing, the dean of nursing, and two faculty members that tutor associate level nursing students on dosage calculation skills. These experts reviewed the Pre-/Post-DCT instruments and the SPJDCS instrument and determined that these tools appeared to measure medication administration dosage calculation skills and self-perceived judgment in dosage calculation skills.

Content Validity

Content validity is “a subjective judgment about whether a measurement makes sense by assessing that items of the instrument are, in fact, the attributes being measured (face validity) or by verifying items with a panel of experts” (Houser, 2008, p. 256). Houser continues by suggesting that a test blueprint is a useful tool to help the researcher and the content-experts determine if all of the basic content is represented. For this study, a blueprint was developed and previously described in this chapter. The blueprint was distributed to the content experts for their review and all of the experts agreed that the attributes measured on these tools were dosage calculation skills, transfer of the calculated dosages to the proper equipment, and self-perceived judgment.

Criterion-Related Validity – Concurrent Validity

Criterion-related validity is defined as “a correlation of the research instrument to some external manifestation of the characteristic” (Houser, 2008, p. 257). Concurrent validity is a type of criterion-related validity that is “present when an instrument reflects actual performance” (Houser, p. 257). To measure concurrent validity, two instruments are administered at approximately the same time so that the scores can be examined to see if a positive correlation exists between the variables. For this study, the original fundamentals exam for medication administration dosage calculations was utilized to

design the new instrument. Both forms asked for identical dosage calculations. Both forms were given to the students in the pilot study to determine if a positive correlation exists between the paired variables. The results are discussed in the next section.

Pilot Study

Prior to conducting research for this study, the researcher developed instruments that were pilot tested on 59 second semester nursing students on the first day of the fall semester 2009. All students were given the original fundamental dosage calculation test and then half of the students ($n = 29$) randomly received the Pre-DCT and the other half ($n = 30$) randomly received the Post-DCT. Students were allowed to use calculators for these instruments. In addition, each student received the SPJDCS instrument that accompanied the Pre-/Post-DCT instruments. Students were informed that the scores on these tools would not impact their grade in any way but if they scored 100% on both the traditional and the researcher developed tool then it would count towards meeting the requirement of making a 100% on a dosage calculation test prior to going to clinical for their fall nursing classes. SPSS 17.0 was utilized to analyze the data for the pilot study.

Description of Sample

The participants were students who had completed the fundamentals course in the spring of 2009 and had returned to campus to begin their second semester of nursing education in an associate degree of nursing program. The entire group contained 74.6% females ($n = 44$) and 25.4% males ($n = 15$). The ages ranged from 18 years old to 35 years of age and older and the mean age was 21.25 years (SD 3.209). The GPA ranged from a 2.28 to a 3.98 with an average GPA of 3.36 (SD .36112). The mean ACT math score for the group was 21.53 (SD 3.601) with an overall range of 14 to 28. Students who

had an ACT math score of < 22 were required to take a math course prior to graduating with an associate degree. Of the 59 participants, 22 (37.3%) of the students had an ACT math score below 22 and 77.3% ($n = 17$) of those students had already completed this requirement. Comparisons of the mean age, GPA, and ACT variables were made between the Pre- and the Post-DCT groups to check for equivalency. Independent t -tests revealed no significant differences between the Pre-DCT and the Post-DCT groups (see Table 4 for a complete overview).

Table 4

Interval Variable Characteristics

Characteristics	Pre-DCT Group	Post-DCT Group	Total Group
Age (Years)			
Mean	21.28	21.23	21.25
SD	3.150	3.319	3.209
Range	18 to > 35 years	19 to > 35 years	18 to > 35 years
	$t(57) = -.050, p = .960$		
GPA			
Mean	3.395	3.377	3.386
SD	.312	.404	.361
Range	2.94 to 3.96	2.28 to 3.98	2.28 to 3.98
	$t(50) = -.180, p = .858$		
Math ACT Scores			
Mean	21.130	21.857	21.529
SD	3.334	3.837	3.602
Range	15 to 27	14 to 28	14 to 28
	$t(49) = .713, p = .479$		

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*No significant differences between the two groups were found at $p < 0.05$.

The class consisted of 55.9% ($n = 33$) junior level nursing students, 25.4% sophomores ($n = 15$), and 18.6% seniors ($n = 11$). The participants were primarily Caucasians (61.0%, $n = 36$), followed by Asian/Pacific Islanders (15.3%, $n = 9$), Hispanics (13.6%, $n = 8$), African-Americans (3.4%, $n = 2$), American Indian/Alaskan Natives (3.4%, $n = 2$), and “other” (3.4%, $n = 2$). Eighteen students (30.5%) had healthcare experience with the majority of that experience working as a certified nursing assistant (72.2%, $n = 13$) for less than one year (66.7%, $n = 12$). Four participants were earning a second degree (6.8%) after having earned a non-medical degree (see Table 5 for a complete overview of the nominal demographic data). A chi-square test of independence revealed that there were no significant relationships between the Pre- and Post-DCT groups in comparison with gender, class standing, ethnicity, healthcare experience, type of healthcare experience, length of healthcare experience, second degree seekers, and completion of the math requirement (see Table 6 for a complete overview of the chi-square results).

Table 5

Nominal Variable Characteristics

Characteristics	Pre-DCT Group n (%)	Post-DCT Group n (%)	Total Group n (%)
Gender			
Male	5 (17.2)	10 (33.3)	15 (25.4)
Female	24 (82.8)	20 (66.7)	44 (74.6)
Class Standing			
Sophomore	6 (20.7)	9 (30.0)	15 (25.4)
Junior	18 (62.1)	15 (50.0)	33 (55.9)
Senior	5 (17.2)	6 (20.0)	11 (18.6)
Ethnicity			
African-American	1 (3.4)	1 (3.3)	2 (3.4)
American-Indian/Alaskan	2 (6.9)	N/A	2 (3.4)
Asian/Pacific Islander	5 (17.2)	4 (13.3)	9 (15.3)
Caucasian (Non-Hispanic)	18 (62.1)	18 (60.0)	36 (61.0)
Hispanic	2 (6.9)	6 (20.0)	8 (13.6)
Other	1 (3.4)	N/A	2 (3.4)
Healthcare Experience			
Experienced	10 (34.5)	8 (26.7)	18 (30.5)
Not Experienced	19 (65.5)	22 (73.3)	41 (69.5)
Type of Healthcare Experience			
CNA	6 (60.0)	5 (55.6)	11 (57.9)
LPN	N/A	1 (11.1)	1 (5.3)
EMT	1 (10.0)	N/A	1 (5.3)
Other	3 (30.0)	2 (22.2)	6 (31.8)
Length of Healthcare Experience			
Less than 1 year	6 (66.7)	6 (75.0)	12 (66.7)
More than 1 year	3 (33.3)	2 (25.0)	5 (27.8)
Second Degree			
Seeking 2 nd Degree	2 (6.9)	2 (6.7)	4 (6.8)
Not Seeking 2 nd Degree	27 (93.1)	28 (93.9)	55 (93.2)
Required Math Course			
Completed Requirement	8 (72.7)	9 (81.8)	17 (77.3)
Did Not Complete Requirement	3 (27.3)	2 (18.2)	5 (22.7)

Table 6

Chi-Square Analysis of Nominal Demographic Data

Characteristics	Chi-Square X^2	df	Significance
Gender	2.014	1	.156
Class Standing	.947	1	.623
Ethnicity	4.095	1	.536
Healthcare Experience	.425	1	.514
Type of Healthcare Experience	2.712	1	.438
Length of Healthcare Experience	1.200	1	.549
Second Degree	.001	1	.972
Required Math Course	.259	1	.611

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*No significant relationships between the two groups were found at $p < 0.05$.

*Traditional Dosage Calculation Test**Assumptions of Normality*

Before performing parametric tests, it is essential that the researcher address the assumptions of normality. These assumptions include a) that the sample is normally distributed via histograms or scatter plots and that the sample is large enough to support these findings, b) that the independent variables are of interval or ratio measurement, and c) that homogeneity of variance exists between the two groups being compared (Gall, et al., 2007; Houser, 2008; Martin & Thompson, 2000).

Although a Q-Q plot of the mean average of the traditional test showed a close association between the actual scores as compared to the diagonal line that represents the expected scores if the sample had been normally distributed, the histogram showed a

negatively skewed curve (-.872) with no gross deviations. However, on a dosage calculation test of this nature, a negative skew is anticipated because the expected norm is that the student will achieve a 100% score on the test.

In instances where a normal curve is skewed, Field (2005) recommends converting the mean and standard deviation into a z -score. The z -score standardizes the values in an effort to derive meaning from the skewness and kurtosis values. According to Field, an absolute value of 1.96 or higher for either skewness or kurtosis is significant at $p < .05$. A z -score revealed that the level of skewness and kurtosis (2.80, .57) was too high for parametric tests, so nonparametric tests were utilized to examine the differences between the traditional tool and the Pre- and Post-DCT tool.

The purpose for administering the traditional fundamentals medication dosage calculation test during the pilot study was to compare the differences between the test scores in the traditional test versus the Pre- and Post-DCT. The questions required the same calculations but the traditional tool was written in word problem format and the new tool was written in a format that provided the physician's order and the necessary equipment required to calculate the correct dosage and administer the medication. The traditional tool was not administered during the dissertation study.

Assessment of Reliability

The traditional fundamentals medication dosage calculation test contained 15 items. This traditional form of this tool has been utilized within this nursing program for greater than seven years. The overall mean score on these items was 11.27 (SD 2.31) for all of the participants ($n = 59$).

A Kuder-Richardson Formula 20 (K-R 20) measures the consistency among the test scores and it reflects: a) the total number of items on a test, b) the proportion of the correct and incorrect responses to an individual item, and c) the variance for that set of scores (McGahee & Ball, 2009). The K-R 20 is the appropriate reliability coefficient to use when examining the consistency of dichotomous test items. The K-R 20 index ranges from 0 to 1 and the closer a test performs to 1 then the more likely a test will produce consistent scores when administered on multiple occasions to multiple groups (2009). Typically, a K-R 20 coefficient of $> .70$ is desirable (LoBiondo-Wood & Haber, 2006). The K-R 20 coefficient for this sample on the traditional dosage calculation test was estimated to be .563.

Influential Factors on Reliability

According to Oermann and Gaberson (2006), reliability of the test scores can be influenced by: a) the number of items on the test, b) the homogeneity of test content, and c) the discrimination and difficulty of individual test items. The biggest contributing factor for the low estimated K-R 20 coefficient is the number of items on the instrument. With only 15 items, a Spearman-Brown coefficient produced a reliability estimate of .482. Another possible influential factor was that although the content was homogenous, it was not necessarily organized in a logical manner. Easier calculations were interspersed with more difficult ones throughout the tool.

Percentage of Correct Items. McGahee and Ball (2009) describe how the discrimination and difficulty of individual test items can influence reliability. For the traditional test, the correct responses for individual questions ranged from 47.5% to 98.3%. For the traditional tool, no items were correctly answered by 100% of the

students, two items (13.3%) were answered 90-99% correctly, four items (26.7%) were answered 80-89% correctly, three items (20.0%) were answered 70-79% correctly, four items (26.7%) were answered 60-69% correctly, one item (6.7%) was answered 50-59% correctly, and one item (6.7%) was answered 40-49% correctly (see Table 7).

Table 7

Evaluation of Correct Responses on the Traditional Dosage Calculation Test

Percentage Range	Number of Items (%)
90-99%	2 (13.3%)
80-89%	4 (26.7%)
70-79%	3 (20.0%)
60-69%	4 (26.7%)
50-59%	1 (6.7%)
40-49%	1 (6.7%)

Point-Biserial Correlation Coefficient. A point-biserial correlation coefficient (PBCC) measures the quality of an individual test item and is an appropriate measure for items that are dichotomous (1 = correct or 0 = incorrect). Although nursing education has not established a set standard on what PBCC is the most desirable, generally, items that score between .40 and .70 are considered “good”, items between .20 and .39 are considered “fair”, and items scoring under .20 are deemed “poor” questions and generally need evaluation and revision (McGahee & Ball, 2009). However, McGahee and Ball stipulated that in certain circumstances, nurse educators want all of the students to grasp a particular concept and therefore desire that all students answer the question(s) correctly.

In this case, the PBCC would be satisfactorily below .20. This is particularly true in the instance of calculating dosages for medications. The desire is that all students will calculate all of the dosages for medications accurately every single time it is required.

A PBCC was conducted to ascertain the effectiveness of the traditional test items at measuring a student's cognitive ability to calculate dosages for medications (See Tables 8 and 9 for a complete overview). On this traditional tool, four items (26.7%) scored higher than a .40, ten items (66.7%) were in the .20 to .39 range, and one item (6.7%) scored in the .10 to .19 range. As previously mentioned, the goal for dosage calculation tests is a PBCC of 0. Students had difficulty with several of the items that required multiple conversions in the calculations for IV route medications. This finding enlightened the researcher on what type of calculations should be included in the simulation and classroom experience for the dissertation study.

Table 8

Point Biserial Coefficient Assessment of Traditional Dosage Calculation Test

PBCC	
.40 and above	4 (26.7%)
.20 to .39	10 (66.7%)
Below .19	1 (6.7%)

Table 9

Point-Biserial Correlation Coefficient Analysis of Traditional Dosage Calculation Test

Medication	r_{pb}	Significance
Zofran	.587	.000*
Haldol	.359	.005*
Lanoxin	.226	.085
Synthroid	.382	.003*
Dilantin	.366	.004*
Amikacin	.468	.000*
Symmetrel	.224	.089
Heparin	.641	.000*
Aminophylline	.290	.026*
Vincristine	.629	.000*
Insulin Drip	.391	.002*
Pulmocare	.355	.006*
Ranitidine	.168	.204
NS	.359	.005*
D5NS	.341	.008*

*Two-tailed significant correlations were found at $p < 0.05$.

*Pre- and Post-Dosage Calculation Tests**Assumptions of Normality*

For this pilot study, a comparison of the Pre-DCT and Post-DCT were needed to determine if the two tools produced similar valid results between the two groups of students. A Q-Q plot of the Pre-DCT and Post-DCT demonstrated a close association of the actual scores with the expected scores if the sample had been normally distributed. The histograms revealed a negatively skewed curve for the Pre-DCT and Post-DCT (-.452 and -.349 respectively) with no gross deviations. Again, on a dosage calculation test of this nature, a negative skew is anticipated because the expected norm is that the

student will achieve a 100% score on the test. The z -scores for skewness and kurtosis were insignificant in the Pre-DCT (1.06, .79) and the Post-DCT (.80, .57).

The scale of measurement compared for the independent variables was interval or ratio (age, GPA, ACT math scores, traditional fundamentals calculation test scores, Pre-DCT scores, and Post-DCT scores). A Levene's test was conducted on each of these variables in relation to the two groups. The distributions between both groups were homogenous and all of the variances of group traits (interval and ratio data) were statistically insignificant. This data combined with the Q-Q plots, histograms, and z -scores led to the decision to assume that the sample is only moderately skewed and that parametric tests between these two instruments were appropriate for further statistical analysis.

Assessment of Reliability

The Pre-DCT is a 31-item researcher-designed instrument that was administered to half of the participants ($n = 29$) after they completed the traditional fundamentals medication dosage calculation test. The mean score on this tool for this group was 22.62 (SD 4.92). The Post-DCT is also a 31-item researcher-designed instrument that mirrored the questions on the Pre-DCT with minor variations on the questions such as a different patient weight or a different dosage prescribed so that the students would not have the opportunity to memorize the answers from one form of the test to the other. The other half of the participants completed the Post-DCT tool ($n = 30$). Students who completed this tool achieved a mean score of 24.13 (SD = 3.66). The estimated K-R 20 reliability coefficient for this sample on the Pre-DCT was .70 and .83 for the Post-DCT which meets the minimal score acceptable on a tool.

Influential Factors on Reliability

The acceptable reliability estimates obtained on the Pre-/Post-DCT were most likely influenced by an increased number of test questions (31 items) as compared to the traditional tool (15 items). Oermann and Gaberson (2006), described that it is typical for a reliability estimate to increase as the number of test items increased. The content was homogenous and it was tightly organized from the easiest calculations to the most difficult.

Percentage of correct items. The level of discrimination and difficulty could also influence reliability. For the group who took the Pre-DCT, the correct responses for individual questions ranged from 36.7% to 100%. For the Pre-DCT, two items (6.5%) were correctly answered by 100% of the students, eight items (25.8%) were answered 90-99% correctly, eight items (25.8%) were answered 80-89% correctly, six items (19.4%) were answered 70-79% correctly, two items (6.5%) were answered 50-59% correctly, one item (3.2%) was answered 40-49% correctly, and two items (6.5%) were answered 30-39% correctly. In contrast, the Post-DCT scores ranged from 31.0% to 100%. The Post-DCT had two items (6.5%) answered correctly by 100% of the students, six items (19.4%) answered 90-99% correctly, seven items (22.6%) answered 80-89% correctly, five items (16.1%) answered 70-79% correctly, one item (3.2%) answered 60-69% correctly, two items (6.5%) answered 50-59% correctly, one item (3.2%) answered 40-49% correctly, and five items (16.1%) answered 30-39% correctly (see Table 10).

Table 10

Evaluation of Correct Responses on the Pre- and Post-Dosage Calculation Tests

Percentage Range	Number of Items (%)	
	Pre-DCT	Post-DCT
100%	2 (6.5%)	2 (6.5%)
90-99%	8 (25.8%)	6 (19.4%)
80-89%	8 (25.8%)	7 (22.6%)
70-79%	6 (19.4%)	5 (16.1%)
60-69%	-	1 (3.2%)
50-59%	2 (6.5%)	2 (6.5%)
40-49%	1 (3.2%)	1 (3.2%)
30-39%	2 (6.5%)	5 (16.1%)

Point Biserial Correlation Coefficients. PBCCs were analyzed for all of the 31 items on the Pre- and Post- DCTs (see Table 11 for a comparison of the Pre-/Post-DCT and Table 12 for a complete comparison of the Pre-/Post-DCT with the Traditional tool). For the Pre-DCT, students scored 100% on two items ($r_{pb} = 1.000$). Fifteen items (48.4%) demonstrated a significant moderate, positive correlation ($r_{pb} = .40 - .70$) at the level of $< .05$. Eleven items (35.5%) scored in the .20 to .39 range and five items (16.1%) were below .20 ($p > .05$). Because this was a new researcher-developed tool, items that did not obtain significant PBCC's were examined for clarity. Minor revisions were required for two of the questions to help eliminate uncertainty as to what the question was really asking. The K-R 20 reliability coefficient for this sample on this tool was .70 which meets the minimal score acceptable on a tool.

A PBCC analysis of the Post-DCT revealed that two items (6.5%) were answered correctly by all of the students ($r_{pb} = 1.000$) scored 1.000. Seventeen items (54.8%) had significant moderately positive correlations ($r_{pb} = .40 - .70$) at the level of $p < .05$. There were six items (19.4%) that obtained PBCC's between .20 and .39 and six items (19.4%) that obtained PBCC's $< .20$ ($p > .05$). Questions that did not obtain significant PBCC's were evaluated for clarity. Minor revisions were made to two of the questions to eliminate ambiguity. The K-R 20 reliability coefficient for this sample on this form of the tool was .83 which meets the minimal score acceptable on a tool.

Table 11

Point Biserial Coefficient Comparison Between the Pre- and Post-Dosage Calculation Tests

r_{pb}	Pre-DCT	Post-DCT
.40 and above	15 (48.4%)	19 (61.3%)
.20 to .39	11 (35.5%)	6 (19.4%)
Below .19	5 (16.1%)	6 (19.4%)

Table 12

Point-Biserial Correlation Coefficient Comparison of Traditional and Dosage Calculation Test Instruments

Medication			r_{pb}	Significance
<u>Zofran</u>	A	Pre-DCT ^a	.216	.261
		Post-DCT ^b	1.000	1.000
		Traditional ^c	.587	.000*
	B	Pre-DCT	.216	.261
		Post-DCT	1.000	1.000
		Traditional	-	-
<u>Haldol</u>	A	Pre-DCT	.534	.003*
		Post-DCT	.197	.314
		Traditional	.359	.005*
	B	Pre-DCT	.534	.003*
		Post-DCT	.197	.314
		Traditional	-	-
<u>Lanoxin</u>	A	Pre-DCT	1.000	1.000
		Post-DCT	.023	.908
		Traditional	.226	.085
	B	Pre-DCT	1.000	1.000
		Post-DCT	.023	.908
		Traditional	-	-
<u>Synthroid</u>	A	Pre-DCT	.202	.294
		Post-DCT	.537	.003*
		Traditional	.382	.003*
	B	Pre-DCT	.202	.294
		Post-DCT	.537	.003*
		Traditional	-	-
<u>Dilantin</u>	A	Pre-DCT	.326	.085
		Post-DCT	.411	.030*
		Traditional	.366	.004*
	B	Pre-DCT	.273	.152
		Post-DCT	.268	.169
		Traditional	-	-
<u>Amikacin</u>	A	Pre-DCT	.074	.705
		Post-DCT	.459	.014*
		Traditional	.468	.000*
	B	Pre-DCT	.074	.705
		Post-DCT	.459	.014*
		Traditional	-	-
<u>Symmetrel</u>	A	Pre-DCT	.094	.628
		Post-DCT	.440	.019*
		Traditional	.224	.089
	B	Pre-DCT	.181	.348
		Post-DCT	.547	.003*
		Traditional	-	-

^a $n = 29$. ^b $n = 30$. ^c $n = 59$.

*Two-tailed significant correlations were found at $p < 0.05$

Table 12, (continued)

Medication			r_{pb}	Significance
<u>Heparin</u>	A	Pre-DCT	.410	.027*
		Post-DCT	.328	.088
		Traditional	.641	.000*
	B	Pre-DCT	.308	.105
		Post-DCT	.533	.004*
		Traditional	-	-
<u>Aminophylline</u>	A	Pre-DCT	.489	.007*
		Post-DCT	.554	.002*
		Traditional	.290	.026*
	B	Pre-DCT	.246	.198
		Post-DCT	.703	.000*
		Traditional	-	-
<u>Vincristine</u>	A	Pre-DCT	.423	.022*
		Post-DCT	.677	.000*
		Traditional	.629	.000*
	B	Pre-DCT	.419	.024*
		Post-DCT	.695	.000*
		Traditional	-	-
<u>Insulin Drip</u>	A	Pre-DCT	.513	.004*
		Post-DCT	.532	.004*
		Traditional	.391	.002*
	B	Pre-DCT	.513	.004*
		Post-DCT	.639	.000*
		Traditional	-	-
<u>Pulmocare</u>	A	Pre-DCT	.271	.155
		Post-DCT	.670	.000*
		Traditional	.355	.006*
	B	Pre-DCT	.019	.923
		Post-DCT	.670	.000*
		Traditional	-	-
<u>Ranitidine</u>	A	Pre-DCT	.215	.263
		Post-DCT	.056	.776
		Traditional	.168	.204
	B	Pre-DCT	.410	.027*
		Post-DCT	.362	.058
		Traditional	-	-
	C	Pre-DCT	.458	.012*
		Post-DCT	.360	.060
		Traditional	-	-
<u>NS</u>	A	Pre-DCT	.559	.002*
		Post-DCT	.205	.296
		Traditional	.359	.005*
	B	Pre-DCT	.467	.011*
		Post-DCT	.205	.296
		Traditional	-	-

^a $n = 29$. ^b $n = 30$. ^c $n = 59$.*Two-tailed significant correlations were found at $p < 0.05$.

Table 12, (continued)

Medication			r_{pb}	Significance
<u>D5NS</u>	A	Pre-DCT	.404	.030*
		Post-DCT	.036	.857
		Traditional	.341	.008*
	B	Pre-DCT	.387	.038*
		Post-DCT	.404	.033*
		Traditional	-	-

^a $n = 29$, ^b $n = 30$, ^c $n = 59$.

*Two-tailed significant correlations were found at $p < 0.05$.

Statistical Results of the Dosage Calculation Tests

Comparison of the Pre- and Post-Dosage Calculation Tests. Students who took the Pre-DCT scored a mean of 22.41 (SD = 4.77) and the students who took the Post-DCT scored a mean of 24.33 (SD = 3.76). An independent samples t -test with equality of variances assumed ($F = 1.870$, $p = .177$) revealed that the difference between the mean Pre- and Post-DCT scores between the two groups was insignificant, $t(57) = 1.719$, $p = .091$.

Both tools were organized from the easiest dosage calculations to the most difficult. In addition, items were organized into pairs – the first item in a pair required a dosage calculation and then the second item in the pair required the student to illustrate the calculated dosage. Typically, when a student calculated an incorrect dosage then they were more likely to miss the illustration portion as well. The first several pairs of items required more simplistic calculations and therefore, participants rarely missed those items. In general, the most difficult questions for both groups required multiple conversions for calculating the dosages of intravenous medications (see Table 13 for a complete comparison of the Pre-DCT, Post-DCT, and the Traditional tool).

A one-way analysis of variance (ANOVA) was conducted to compare the mean scores for each individual question between the Pre- and the Post-DCT groups in an effort to analyze equality between the questions since the questions were the exact same except that different dosages were ordered or the patient had a different weight. This analysis revealed that there were four items that had a significant difference between the groups (see Table 14 for significant results).

The first item that had a significant difference was part B of the Dilantin question. Students were required to calculate the dosage of Dilantin tablets and then color in the amount of pills that would be necessary to administer this dosage. A one-way ANOVA revealed that students in the Post-DCT group answered this question correctly more often (mean = .933, SD = .253) than the Pre-DCT group (mean = .724, SD = .455), $F(1, 57) = 4.802, p = .033$. Although the mean differences in scores on part A of this question were insignificant, the Post-DCT group answered the first part of the question more often than the Pre-DCT group. An inquiry into the differences between the two forms showed that the only difference between the two forms was the patient's weight. The question was taken back to the content and face validity experts and it was unanimously agreed that the question should remain unchanged on the tool.

The second and third items that demonstrated significant differences were paired together and dealt with calculating an intravenous rate for an insulin drip. The rate was based on the patient's weight and the student had to convert pounds to kilograms. A one-way ANOVA revealed that students who took the Post-DCT scored significantly higher (mean = .800, SD = .406) on this question than students who took the Pre-DCT (mean = .483, SD = .508), $F(1, 57) = 4.147, p = .046$. In addition, a one-way ANOVA

showed that the Pre-DCT students who missed the first question missed the paired question of setting the IV pump at the correct rate (mean = .379, SD = .494) more often than the Post-DCT group of students (mean = .800, SD = .406), $F(1, 57) = 8.440$, $p = .005$. These findings led to an investigation of the paired questions to make sure that they required the same level of difficulty. The only difference between the two items was a difference in the patient's weight. This pair of questions was taken back to the four face validity and content validity experts and they unanimously agreed that the question was equal in degree of difficulty. These items remained unchanged for the dissertation study.

The fourth item that demonstrated a significant difference in scores was an intravenous infusion item that asked the students to calculate how many mL per hour it would take to get a 500 mL bag of D5NS infused over a three hour period (Pre-DCT) or a four hour period (Post-DCT). A one-way ANOVA revealed that students in the Post-DCT group correctly answered this item significantly more often (mean = .871, SD = .341) than did students in the Pre-DCT group (mean = .483, SD = .509), $F(1, 57) = 17.373$, $p = .000$. This item was also taken back to the face validity and content validity experts for review and they unanimously agreed that the question was similar in degree of difficulty and it did not require any revisions for the Pre-DCT group.

Table 13

Comparison of Mean Scores on the Traditional, Pre-, and Post-Dosage Calculation Tests

Medication			Traditional Tool ^a	Pre-DCT Group ^b	Post-DCT Group ^c	Total Pre- & Post-DCT Group ^d
<u>Zofran</u>	A	% Correct	86.4	100	96.7	98.3
		Mean	.864	1.00	.967	.983
		SD	.345	.000	.183	.130
	B	% Correct	-	100	96.7	98.3
		Mean	-	1.00	.967	.983
		SD	-	.000	.183	.130
<u>Haldol</u>	A	% Correct	98.3	93.1	93.3	93.2
		Mean	.983	.931	.933	.932
		SD	.130	.258	.254	.254
	B	% Correct	-	93.1	93.3	93.2
		Mean	-	.931	.933	.932
		SD	-	.258	.254	.254
<u>Lanoxin</u>	A	% Correct	88.1	93.1	100	96.6
		Mean	.881	.931	1.00	.966
		SD	.326	.258	.000	.183
	B	% Correct	-	93.1	100	96.6
		Mean	-	.931	1.00	.966
		SD	-	.258	.000	.183
<u>Synthroid</u>	A	% Correct	67.8	89.7	90.0	89.7
		Mean	.678	.897	.900	.898
		SD	.471	.310	.305	.305
	B	% Correct	-	89.7	90.0	89.7
		Mean	-	.897	.900	.898
		SD	-	.310	.305	.305
<u>Dilantin</u>	A	% Correct	78.0	75.9	90.0	83.1
		Mean	.780	.759	.900	.831
		SD	.418	.435	.305	.378
	B	% Correct	-	72.4	93.3	83.1
		Mean	-	.724	.933	.831
		SD	-	.455	.253	.378
<u>Amikacin</u>	A	% Correct	83.1	93.1	86.7	89.8
		Mean	.831	.931	.867	.898
		SD	.378	.258	.346	.305
	B	% Correct	-	93.1	86.7	89.8
		Mean	-	.931	.867	.898
		SD	-	.258	.346	.305

^an = 59, ^bn = 29, ^cn = 30, ^dn = 59.

Table 13, (continued)

Medication			Traditional Tool ^a	Pre-DCT Group ^b	Post-DCT Group ^c	Total Pre- & Post-DCT Group ^d
<u>Symmetrel</u>	A	% Correct	78.0	89.7	80.0	84.7
		Mean	.780	.897	.800	.847
		SD	.418	.310	.407	.363
	B	% Correct	-	86.2	76.7	81.4
		Mean	-	.862	.767	.813
		SD	-	.351	.430	.393
<u>Heparin</u>	A	% Correct	61.0	34.5	36.7	35.6
		Mean	.610	.345	.367	.356
		SD	.492	.484	.490	.482
	B	% Correct	-	37.9	56.7	47.5
		Mean	-	.379	.567	.475
		SD	-	.494	.504	.504
<u>Aminophylline</u>	A	% Correct	83.1	58.6	53.3	55.9
		Mean	.831	.586	.533	.559
		SD	.378	.501	.507	.501
	B	% Correct	-	62.1	70.0	66.1
		Mean	-	.621	.700	.661
		SD	-	.494	.466	.477
<u>Vincristine</u>	A	% Correct	64.4	89.7	80.0	84.7
		Mean	.644	.897	.800	.847
		SD	.483	.310	.407	.363
	B	% Correct	-	86.2	76.7	81.4
		Mean	-	.862	.767	.813
		SD	-	.351	.430	.393
<u>Insulin IV</u>	A	% Correct	47.5	48.3	80.0	64.4
		Mean	.475	.483	.800	.644
		SD	.503	.508	.406	.482
	B	% Correct	-	37.9	80.0	59.3
		Mean	-	.379	.800	.593
		SD	-	.494	.406	.495
<u>Pulmocare</u>	A	% Correct	72.9	75.9	83.3	79.7
		Mean	.729	.759	.833	.797
		SD	.448	.435	.379	.406
	B	% Correct	-	75.9	86.7	81.4
		Mean	-	.759	.867	.813
		SD	-	.434	.346	.393

^an = 59. ^bn = 29. ^cn = 30. ^dn = 59.

Table 13, (continued)

Medication			Traditional Tool ^a	Pre-DCT Group ^b	Post-DCT Group ^c	Total Pre- & Post-DCT Group ^d
<u>Ranitidine</u>	A	% Correct	62.7	58.6	70.0	64.4
		Mean	.627	.586	.700	.644
		SD	.488	.310	.466	.483
	B	% Correct	-	31.0	36.7	33.9
		Mean	-	.310	.367	.338
		SD	-	.351	.490	.477
	C	% Correct	-	34.5	40.0	37.3
		Mean	-	.345	.400	.373
		SD	-	.484	.498	.488
<u>NS</u>	A	% Correct	98.3	86.2	76.7	81.3
		Mean	.983	.862	.767	.813
		SD	.130	.351	.430	.393
	B	% Correct	-	86.2	73.3	79.7
		Mean	-	.862	.733	.797
		SD	-	.351	.450	.406
<u>D5NS</u>	A	% Correct	57.6	62.1	51.6	55.9
		Mean	.576	.621	.516	.559
		SD	.498	.494	.508	.501
	B	% Correct	-	48.3	87.1	67.8
		Mean	-	.483	.871	.471
		SD	-	.509	.341	.393
Total Score for Calculation Questions Only	Ave %		75.1	75.9	77.5	76.7
	Mean		11.271	11.379	11.633	11.508
	SD		2.311	2.178	1.956	2.054
Total Scores with Paired Questions	Ave %		-	73.0	77.8	75.5
	Mean		-	22.621	24.133	23.390
	SD		-	4.924	3.665	4.359

^a*n* = 59. ^b*n* = 29. ^c*n* = 30. ^d*n* = 59.

Table 14

One-Way Analysis of Variance Comparison Between and Within Pre-/Post-Dosage Calculation Test Groups

Medication	Sum of Squares	df	Mean Square	F	Significance
<u>Zofran</u>					
Part A					
Between	.016	1	.016	.966	.330
Within	.967	57	.017		
Total	.983	58			
Part B					
Between	.016	1	.016	.966	.330
Within	.967	57	.017		
Total	.983	58			
<u>Haldol</u>					
Part A					
Between	.000	1	.000	.001	.973
Within	3.729	57	.065		
Total	3.729	58			
Part B					
Between	.000	1	.000	.072	.791
Within	3.729	57	.065		
Total	3.729	58			
<u>Lanoxin</u>					
Part A					
Between	.070	1	.070	2.147	.148
Within	1.862	57	.033		
Total	1.932	58			
Part B					
Between	.070	1	.070	2.147	.148
Within	1.862	57	.033		
Total	1.932	58			
<u>Synthroid</u>					
Part A					
Between	.000	1	.000	.002	.966
Within	5.390	57	.095		
Total	5.390	58			
Part B					
Between	.000	1	.000	.002	.966
Within	5.390	57	.095		
Total	5.390	58			
<u>Dilantin</u>					
Part A					
Between	.295	1	.295	2.097	.153
Within	8.010	57	.141		
Total	8.305	58			
Part B					
Between	.645	1	.645	4.802	.033*
Within	7.660	57	.134		
Total	8.305	58			

*Significant differences within the two groups were found at $p < 0.05$.

Table 14, (continued)

Medication	Sum of Squares	df	Mean Square	F	Significance
<u>Amikacin</u>					
Between	.061	1	.061	.654	.422
Within	5.329	57	.093		
Total	5.390	58			
Part B					
Between	.061	1	.061	.654	.422
Within	5.329	57	.093		
Total	5.390	58			
<u>Symmetrel</u>					
Part A					
Between	.137	1	.137	1.046	.311
Within	7.490	57	.131		
Total	7.627	58			
Part B					
Between	.134	1	.134	.868	.355
Within	8.815	57	.155		
Total	8.949	58			
<u>Heparin</u>					
Part A					
Between	.119	1	.119	.504	.481
Within	13.407	57	.235		
Total	13.525	58			
Part B					
Between	.960	1	.960	3.980	.051
Within	13.752	57	.241		
Total	14.712	58			
<u>Aminophylline</u>					
Part A					
Between	.010	1	.010	.058	.811
Within	10.125	57	.178		
Total	10.136	58			
Part B					
Between	.000	1	.000	.003	.954
Within	8.305	57	.146		
Total	8.305	58			
<u>Vincristine</u>					
Part A					
Between	.041	1	.041	.162	.689
Within	14.501	57	.254		
Total	14.542	58			
Part B					
Between	.093	1	.093	.403	.528
Within	13.128	57	.230		
Total	13.220	58			

*Significant differences within the two groups were found at $p < 0.05$.

Table 14, (continued)

Medication	Sum of Squares	df	Mean Square	F	Significance
<u>Insulin</u>					
Part A					
Between	.917	1	.917	4.147	.046*
Within	12.608	57	.221		
Total	13.525	58			
Part B					
Between	1.836	1	1.836	8.440	.005*
Within	12.401	57	.218		
Total	14.237	58			
<u>Pulmocare</u>					
Part A					
Between	.082	1	.082	.495	.485
Within	9.477	57	.166		
Total	9.559	58			
Part B					
Between	.172	1	.172	1.118	.295
Within	8.777	57	.154		
Total	8.949	58			
<u>Ranitidine</u>					
Part A					
Between	.191	1	.191	.816	.370
Within	13.334	57	.234		
Total	13.525	58			
Part B					
Between	.227	1	.227	.997	.322
Within	12.993	57	.228		
Total	13.220	58			
Part C					
Between	.223	1	.223	.937	.337
Within	13.574	57	.238		
Total	13.797	58			
<u>NS Drip</u>					
Part A					
Between	.011	1	.011	.072	.790
Within	8.939	57	.157		
Total	8.949	58			
Part B					
Between	.055	1	.055	.328	.569
Within	9.505	57	.167		
Total	9.559	58			
<u>D5NS Drip</u>					
Part A					
Between	.041	1	.041	.162	.689
Within	14.501	57	.254		
Total	14.542	58			
Part B					
Between	3.009	1	3.009	17.373	.000*
Within	9.872	57	.173		
Total	12.881	58			

*Significant differences within the two groups were found at $p < 0.05$.

Comparison of traditional calculation test with the Pre-/Post-Dosage Calculation

Test. The comparison between the traditional fundamentals test and the Pre- and Post-DCT test only included the 15 items that had the same calculations that were required for all three of these tools (see Table 13 for a complete comparison). The items that measured the transfer of the calculation to the equipment were not included because this skill was not measured in the traditional fundamental tool. The mean score for the Pre-DCT on these 15 calculation items was 11.38 (SD = 2.18) and the Post-DCT was 11.63 (SD = 1.96) as compared to the traditional tool (mean = 11.27, SD 2.31).

A Spearman *rho* correlation coefficient was calculated for the relationship between a students' ability to accurately calculate dosages for medications on the traditional tool versus the Pre- and the Post-DCT (see Table 15). A strong positive correlation was found in the comparison of the traditional tool with the Pre-DCT ($r(28) = .654, p = .000$) and the Post-DCT ($r(27) = .593, p = .001$) indicating a significant relationship between the test scores. Students who received a high score on the traditional tool tended to achieve a high score on the Pre- or Post-DCT tools.

Table 15

Spearman Rho Correlation of Traditional Calculation Tool with Pre-/Post-Dosage Calculation Test

	<i>n</i>	<i>r</i>	df	Significance
Pre-DCT	30	.654	28	.000*
Post-DCT	29	.593	27	.001*

*Significant relationships were found at $p < 0.05$.

A Wilcoxon test examined the results of the traditional tool with the Pre- and Post-DCT (see Table 16). No significant differences were found when comparing the scores of the traditional test with the Pre-DCT ($Z = -1.199, p = .231$) or the traditional test with the Post-DCT ($Z = -.336, p = .737$). Students tended to obtain similar scores on both tools.

Table 16

Wilcoxon Comparison Between the Traditional Calculation Tool and the Pre-/Post-Dosage Calculation Test

	<i>n</i>	<i>Z</i>	Significance
Pre-DCT	29	-1.199	.231
Post-DCT	30	-.336	.737

*No significant relationships were found at $p < 0.05$.

Self-Perceived Judgment in Dosage Calculations Scale

Assumptions of Normality

A Q-Q plot revealed that the observed scores on the SPJDCS demonstrated a close association with the expected normal values on this instrument. A histogram revealed a positive skew (.556). In addition, z-scores for skewness and kurtosis were significant (1.70, 2.07), therefore, nonparametric tests were appropriate for further statistical analysis on the self-perceived judgment tool.

Assessment of Reliability

The SPJDCS contained 15 items that asked the students to describe their opinion on how logical their answers were to the calculation questions. Each question contained an ordinal variable using a 5-point Likert scale ranging from highly logical (5 points) to

highly illogical (1 point). Since the items were not dichotomous, Cronbach's alpha is the appropriate reliability score to measure internal consistency (Gall, et al., 2007).

Cronbach's alpha established reliability at 0.90 for this tool.

Statistical Results of the Self-Perceived Judgment in Dosage Calculation Scale

After completing the traditional and the Pre- or Post-DCT, all of the participants completed the self-perceived judgment scale. The overall mean score for self-perceived judgment was 3.52 (SD = .623). Students who completed the Pre-DCT averaged a mean of 3.67 (SD = .617) on the self-perceived judgment scales as compared to students who took the Post-DCT with a mean of 3.35 (SD = .596). A Kruskal-Wallis H test was utilized to examine the difference in self-perceived judgment in students who completed the Pre- and the Post-DCT tool. No significant difference in the self-perceived judgment scores was found ($H = 1.813, p = .178$). Students who took the Pre-DCT averaged a ranking of 29.80 and students who took the Post-DCT averaged a ranking of 24.10.

The majority of students found that eight of the dosages calculated were logical calculations in their own self- perceived judgment (Table 17 contains a complete overview of the mean scores). These judgments were given for the calculations of intramuscular injections (Haldol and Zofran), tablets (Lanoxin, Synthroid, and Dilantin), IV push (Amikacin Sulfate), a liquid suspension (Symmetrel), and an intravenous infusion (Vincristine). The majority of these calculations did not require multiple conversions and the overall mean of correct responses on these calculations were higher for these dosages (see Table 13. Students remained neutral on their self-perceived judgment on six of the items. These included subcutaneous injection (Heparin), liquid suspension (Aminophylline), tube feeding (Pulmocare), and intravenous infusions

(Ranitidine, NS, and D5NS). One item, Insulin - given in an intravenous infusion, was divided among those who felt the calculation seemed logical and those who remained neutral.

A Kruskal-Wallis H test was calculated to examine the difference in self-perceived judgment for each individual medication between the Pre- and the Post-DCT groups. Three items had significant results (see Table 18 for a complete overview). Post-DCT students ($n = 30$) felt the calculated answer for Dilantin was more logical (ranked 35.89) than compared to the Pre-DCT group ($n = 29$; ranked 22.34), $H = 10.428$, $p = .001$. In this particular instance, Post-DCT students answered the question correctly (mean = .900, SD = .305) more often than the Pre-DCT group (mean = .759, SD = .435) although a one-way ANOVA between the Pre- and Post-DCT score on this particular calculation was statistically insignificant ($F(1, 57) = 2.097$, $p = .156$). In the instances of calculating the dosage for Zofran and Amikacin, the Post-DCT group felt their calculated dosages were more logical (ranked 33.04 and 33.32 respectively) than the Pre-DCT group (ranked 24.28 and 24.83), $H = 4.573$, $p = .032$ and $H = 4.149$, $p = .042$. However, the Post-DCT group erroneously calculated the dosage (mean = .967, SD = .183; mean = .867, SD = .346) more often than the Pre-DCT group (mean = 1.000, SD = .000; mean = .931, SD = .258) although these differences in scores were statistically insignificant in one-way ANOVA tests for Zofran ($F(1, 57) = .966$, $p = .330$) and Amikacin ($F(1, 57) = .654$, $p = .422$).

Table 17

Comparison of Self-Perceived Judgment and the Pre- and Post-Dosage Calculation Test Scores

Medication	Route		Pre-DCT Group ^a		Post-DCT Group ^b		Total Pre- & Post-DCT Group ^c	
			Judgment Scores	Calculation Scores	Judgment Scores	Calculation Scores	Judgment Scores	Calculation Scores
Zofran	IM	Mean SD	3.380 1.178	1.00 .000	4.074 .781	.967 .183	3.714 1.057	.983 .130
Haldol	IM	Mean SD	3.724 .922	.931 .258	3.857 1.008	.933 .254	3.790 .959	.932 .254
Lanoxin	Tablet	Mean SD	3.759 .872	.931 .258	4.143 .756	1.00 .000	3.947 .833	.966 .183
Synthroid	Tablet	Mean SD	3.379 1.015	.897 .310	3.679 .983	.900 .305	3.526 1.001	.898 .305
Dilantin	Tablet	Mean SD	3.138 .990	.759 .435	4.000 .817	.900 .305	3.561 1.000	.831 .378
Amikacin	IV push	Mean SD	3.517 .871	.931 .258	4.036 .838	.867 .346	3.772 .887	.898 .305
Symmetrel	Liquid Suspension	Mean SD	3.621 .942	.897 .310	3.750 1.041	.800 .407	3.684 .985	.847 .363

^a*n* = 29. ^b*n* = 30. ^c*n* = 59.

Table 17, (continued)

Medication	Route		Pre-DCT Group ^a		Post-DCT Group ^b		Total Pre- & Post-DCT Group ^c	
			Judgment Scores	Calculation Scores	Judgment Scores	Calculation Scores	Judgment Scores	Calculation Scores
Heparin	Subcutaneous	Mean SD	3.414 .946	.345 .484	3.250 1.143	.367 .490	3.333 1.041	.356 .482
Aminophylline	Liquid Suspension	Mean SD	3.241 .872	.586 .501	3.464 .999	.533 .507	3.351 .935	.559 .501
Vincristine	IV Infusion	Mean SD	3.286 .937	.897 .310	3.750 .752	.800 .407	3.518 .874	.847 .363
Insulin	IV Infusion	Mean SD	2.966 1.085	.483 .508	3.143 1.008	.800 .406	3.053 1.042	.644 .482
Pulmocare	Tube Feeding	Mean SD	3.414 .907	.759 .435	3.571 1.103	.833 .379	3.491 1.002	.797 .406
Rantidine	IV Infusion	Mean SD	3.241 .872	.586 .310	3.321 .819	.700 .466	3.281 .840	.644 .483
NS	IV Infusion	Mean SD	3.214 .995	.862 .351	3.429 .960	.767 .430	3.321 .974	.813 .393
D5NS	IV Infusion – drops/gtt	Mean SD	3.333 1.000	.621 .494	3.286 1.049	.516 .508	3.309 1.016	.559 .501

^a*n* = 29. ^b*n* = 30. ^c*n* = 59.

Table 18

Kruskal-Wallis H Comparison of Pre- and Post-Dosage Calculation Test Scores and Self-Perceived Judgment

Medication		Mean Rank	H	df	Significance
<u>Zofran</u>	Pre-DCT Group ^a Post-DCT Group ^b	24.28 33.04	4.573	1	.032*
<u>Haldol</u>	Pre-DCT Group Post-DCT Group	27.72 30.32	.394	1	.530
<u>Lanoxin</u>	Pre-DCT Group Post-DCT Group	25.83 32.29	2.554	1	.110
<u>Synthroid</u>	Pre-DCT Group Post-DCT Group	27.26 30.80	.717	1	.397
<u>Dilantin</u>	Pre-DCT Group Post-DCT Group	22.34 35.89	10.428	1	.001*
<u>Amikacin</u>	Pre-DCT Group Post-DCT Group	24.83 33.32	4.149	1	.042*
<u>Symmetrel</u>	Pre-DCT Group Post-DCT Group	27.90 30.14	.284	1	.594
<u>Heparin</u>	Pre-DCT Group Post-DCT Group	30.41 27.54	.472	1	.492
<u>Aminophylline</u>	Pre-DCT Group Post-DCT Group	27.53 30.52	.515	1	.473
<u>Vincristine</u>	Pre-DCT Group Post-DCT Group	24.59 32.41	3.647	1	.057
<u>Insulin</u>	Pre-DCT Group Post-DCT Group	27.55 30.50	.487	1	.485
<u>Pulmocare</u>	Pre-DCT Group Post-DCT Group	27.91 30.13	.278	1	.598
<u>Ranitidine</u>	Pre-DCT Group Post-DCT Group	28.74 29.27	.017	1	.895
<u>NS Drip</u>	Pre-DCT Group Post-DCT Group	27.46 29.54	.254	1	.614
<u>D5NS Drip</u>	Pre-DCT Group Post-DCT Group	28.54 27.48	.067	1	.796

^an = 29. ^bn = 30.

*Significant differences were found at $p < 0.05$.

Summary of Pilot Study Findings

The researcher-designed Pre-/Post-DCT performed as well as the original traditional dosage calculation test although students in this pilot study demonstrated difficulty with dosage calculation skills on both the traditional and researcher-designed instruments. The self-perceived judgment tool demonstrated that although a student felt that a calculated dosage was logical, it did not necessarily mean that the calculated dosage was correct. This tool also showed that students were uncertain if their calculations were correct or logical on half of the calculations required. The reliability on all of the researcher-designed instruments was $> .70$ and in the acceptable range.

Data Analysis

The purpose of this dissertation study was to determine if there was a difference in mean dosage calculation test scores and self-perceived judgment in dosage calculations in first semester Associate of Science (AS) nursing students who participated in a low-fidelity simulation scenario in the clinical lab versus students who participated in a traditional case study in a classroom setting. In addition, the mean scores from the NLN Satisfaction and Self-Confidence in Learning Scale were analyzed to see if there was a difference in levels of satisfaction and self-confidence between the two teaching modalities. Statistical Package for the Social Sciences (SPSS) Version 17.0 was utilized to analyze all of the data.

The study design was quasi-experimental due to the use of a convenience sample and non-randomized groups. After obtaining written consent and the completion of the demographics tool, the Pre-DCT, and the SPJDCS, students were informed that they would be divided into two equal groups based upon clinical rotation. The experimental group (Thursday clinical group) participated in the low-fidelity simulation experience. The comparison group (Tuesday clinical group) participated in the traditional classroom experience.

Research Questions and Hypotheses Analysis

Q1: In fundamental nursing students, what effects does a traditional case study in a classroom versus a low-fidelity simulation in a simulation laboratory have on mean dosage calculation test scores?

H₀₁: There will be no differences in mean dosage calculation test scores between fundamental nursing students who participate in a traditional case study in the classroom versus a low-fidelity simulation in the simulation lab.

Before any statistical tests were conducted, it was determined that the assumptions of normality were not met. Therefore, nonparametric tests were utilized to analyze this research question. The appropriate statistical test to analyze the null hypothesis and examine the differences between the classroom versus the simulation group was the Mann-Whitney *U* test. In addition, the ANCOVA test was used to control for covariances such as age, GPA, and ACT scores and their possible influence on self-perceived judgment. The Kruskal-Wallis test was used to determine if there was a significant difference between the findings for the two groups. Finally, the Wilcoxin signed rank sum test was utilized to examine the differences within groups.

Q2: In fundamental nursing students, what effects does a traditional case study in a classroom versus a low-fidelity simulation in a simulation laboratory have on self-perceived judgment in dosage calculation scores?

H₀₂: There will be no differences in mean self-perceived judgment scores between fundamental nursing students who participate in a traditional case study in the classroom versus a low-fidelity simulation in the simulation lab.

The scores obtained on the SPJDCS are considered ordinal data because the tool utilizes a 5-point Likert scale. The appropriate statistical test to analyze the differences between the classroom versus the simulation group was the Mann-Whitney test (Polit & Beck, 2008). To control for covariances such as gender, age, ethnicity, class rank, GPA, ACT/SAT scores and experience in healthcare or second degree students, ANCOVA was

be used. The nonparametric Kruskal-Wallis H test was used to determine if there was a significant difference in the findings of self-perceived judgment between the two groups. Finally, the Wilcoxin signed rank sum test was utilized to examine the differences in self-perceived judgment within groups.

Q3: In fundamental nursing students, does learning in a traditional case study in a classroom versus low-fidelity simulation in a simulation laboratory make a difference in self-confidence in learning?

H₀₃: There will be no difference in the level of self-confidence between fundamental nursing students in a traditional case study in the classroom versus a low-fidelity simulation in the simulation lab.

Histograms revealed that the data was not distributed normally, therefore, the Mann-Whitney U test was used to examine the differences in self-confidence between the experimental and control group (Polit & Beck, 2008). Spearman's ρ was utilized to determine the strength of the relationship between these variables.

Q4: In fundamental nursing students, does learning in a traditional case study in a classroom versus low-fidelity simulation in a simulation laboratory make a difference in satisfaction with learning?

H₀₄: There will be no difference in the level of satisfaction with learning between fundamental nursing students in a traditional case study in the classroom versus a low-fidelity simulation in the simulation lab.

A Mann-Whitney U test was utilized to examine the differences in mean satisfaction scores between the experimental and control group since the data were not normally distributed. Spearman's ρ determined the strength of the relationship.

Methodological and Theoretical Limitations

Threats to Internal Validity

“Internal validity refers specifically to whether or not the researcher and reader can be confident that an experimental treatment or condition made a difference – and whether rival explanations for the differences can be systematically ruled out” (Houser, 2008, pp. 293-294). Houser describes three conditions that must be met to determine if the treatment actually caused the effect, or as is the case for this study, did the low-fidelity scenario simulation in the simulation lab or the traditional case study in the classroom have an effect on fundamental nursing students ability to do dosage calculations and self-perceived judgment in dosage calculations? The first condition is that “changes in the presumed cause must be related to changes in the presumed effect” (p. 295). In other words, if changes were made in any way to the teaching strategies then the differences would be reflected in dosage calculation scores. The second condition is that “the presumed cause must occur before the presumed effect” (p. 295). In this study, the teaching strategies will be implemented after administering a Pre-DCT to determine the students’ dosage calculation skills prior to implementing a learning strategy. Students will demonstrate the presumed effect by completing a modified Post-DCT.

The final condition is that “there are no plausible alternative explanations” (Houser, 2008). Several methods recommended by Houser were utilized in this study to minimize the chances of other plausible explanations. The first method was the use of an appropriate research design. A quasi-experimental, quantitative design allowed the researcher to determine if a teaching modality (a case study in a traditional classroom or

low-fidelity simulation scenario in the clinical laboratory) had an effect on a fundamental nursing students' ability to accurately calculate dosages.

The second method to decrease alternative explanations was to control bias. Although this study utilized a convenience sample of two groups of fundamental nursing students, bias was reduced by controlling the actions of the researcher. First, the principal investigator in this dissertation study was not present in either the classroom or the simulation experiences. Secondly, one teacher conducted the classroom experience and another teacher managed the simulation experiences to reduce the biases a single teacher could have on a preferred teaching modality. Finally, the principal researcher did not have access to the master list of student names and research identification numbers.

Appropriate statistical analysis was the final recommendation to reduce the chances of other plausible explanations. Demographic variables such as age, GPA, and ACT scores had the potential to influence the scores and were therefore considered a threat to internal validity. Therefore, ANCOVA was used to determine these extraneous variables explained the test results.

Other major factors that could threaten internal validity and reduce a researcher's ability to draw accurate conclusions included the effects of history, maturation, testing, instrumentation, treatment, and selection. In addition, statistical regression, experimental mortality, experimental treatment diffusion, compensatory rivalry by the control group, and resentful demoralization of the control group were threats to internal validity. Each one of these factors is addressed in the following paragraphs.

Historical effects. “Historical threats refer to events or circumstances that occur around the time of the introduction of the intervention, or they may occur at any time during data collection” (Houser, 2008, p. 302). Historical threats were minimized for this study because the amount of time that elapsed from the pre-test to the post-test was one week. There were no unforeseen circumstances that occurred during the data collection week that could have had a positive or negative influence on this study.

Maturation effects. “Maturation in a research study is related to changes that occur in subjects over time that do not occur as a result of the intervention or attribute being studied” (Houser, 2008, p. 302). Risks for physical or psychological maturation effects impacting the outcomes of this dissertation study were minimal. The entire study was completed in a one week time span. During this one week period, students did not have any clinical labs scheduled. This greatly reduced the opportunity for students to have experienced a psychological or physical influence that would impact the results of this study.

Testing effects. Testing can become a threat if retesting is involved because subjects can become experienced and proficient at test taking when multiple tests are involved (Houser, 2008). This was a legitimate threat for this study because students completed a Pre-/Post-DCT. Therefore, minor changes were made between the Pre-/Post-DCT forms so that calculation skills were tested and not a student’s ability to memorize answers from one test to another. The questions remained the same except that minor changes such as the requested dose or the patient’s weight were changed. This was especially beneficial because the amount of time that will have elapsed between the Pre- & Post-DCT was only one week.

Consideration was taken for students who achieved a 100% score on the first Pre-DCT tool. If the student scored 100% on the first test then why would it be necessary for them to participate in the classroom or simulation experience? The answer lies in research findings that indicate that some students may be able to obtain high scores on dosage calculation tests or even unit exams over drug content yet remain unable to connect the information given on a written test to clinical practice (Kelly & Colby, 2003; Thompson & Bonnel, 2008). The treatment in this study aimed to bridge the theory-to-practice gap for all students regardless of the level of academic giftedness. The Pre-/Post-DCT tools were designed to give students the opportunity for increased exposure to a more realistic format of how medications are ordered and then completed by the nurse in the clinical setting. As previously mentioned, the overall goal of this study was to improve patient safety. Fundamental nursing students are novice in nursing practice regardless of academic giftedness. The more exposure they have to calculating dosages and applying the calculated dosages in a realistic setting the more competent they will be as practicing nurses.

In addition to the arguments made on why students should participate regardless of the initial score was that these students remained unaware of their scores on the Pre-DCT until after all of the data collection was completed. If they had been notified immediately that they had scored 100% then they would have reasoned that they did not need to attend the required class or take the Post-DCT. The whole point of using Polya's Four Stages of Problem-Solving Framework to design the teaching module was that everyone learns to exercise judgment once a solution has been obtained by questioning the logic of the dosage they have just calculated as a means for double-checking the

solution for accuracy. Many students want to stop at Phase 3 (carry out the plan) and not follow through with Phase 4 by thinking about the whether or not the solution makes sense (Cai & Brook, 2006). In addition, students need opportunities to recognize the importance of collaboration and this gave the stronger students an opportunity to share their problem-solving strategies with their peers. The interventions in this study illustrated the importance of collaboration and teamwork to these fundamental nursing students.

Because these students were required to take a computerized calculation test and make 100% per the school of nursing policy prior to going to clinical and administering medications, enough time was provided after the data collection was completed to allow the students to get help from a tutor, online tutorials, and computerized practice tests if they needed it so that they could take the required test and pass it at 100%. It would have been unethical and improper to widen the time span to several months to see if the methodology worked at a later date and not allow students access to other methods of calculating dosages if the implemented strategies of this study did not work. Besides, if the time span had been widened then the results of this study would have been potentially skewed by extraneous variables such as clinical experience, tutors, online tutorials, and practice tests. It would have been impossible to distinguish whether the teaching modality or these other strategies were responsible for improved dosage calculation test scores.

Instrumentation effects. Instrumentation effects can occur when either the instrument has changed in some type of way or if multiple individuals administer the test. First of all, the changes in the test format as mentioned above were minimal (Houser, 2008). These changes still required the exact same calculation skills that were required in

the Pre-DCT; therefore, these minimal changes did not threaten validity. In addition, the same person administered the Pre-/Post-DCT test and all students tested at the same exact time.

Treatment effects. The Hawthorne effect, or subjects behaving or responding differently primarily because they know they are in a research study, can threaten the validity of a study (Polit & Beck, 2008). Subjects in this study were informed that they were participating in research on learning strategies for solving medication dosage calculations without informing them of expected outcomes such as improved dosage calculations scores, improved satisfaction and self-confidence, or increased self-perceived judgment. If students had known what the researcher expected to find then responses could have been purposefully elicited to favor or negate the researcher's opinions. In addition, students were informed of the teaching modality for their group when they arrived at the classroom for the scheduled class period. Students in the simulation group signed up for one of five different simulation times but they did not know what to expect until they arrived at the simulation. This minimized the risk of contamination of one group telling the other group what to expect prior to each experience. At the completion of this study, students received a thank you letter describing the research in more detail. They also receive a copy of Polya's framework for future use in dosage calculations (See Appendix J).

Selection effects. Biases can result in selection or assignment of subjects in such a way that renders the groups unequal (Houser, 2008). Unfortunately, random sampling was not an option for this study and the experimental and comparison groups were

determined by the clinical rotation day. To decrease selection effects, statistical analysis was done to determine the equality of the two groups and is discussed in Chapter Four.

Statistical regression. “Statistical regression is the tendency for research participants whose scores fall at either extreme on a measure to score nearer the mean when the variable is measured the second time” (Gall, et al., 2007, p. 385). In other words, researchers need to take into account that students who obtained very low or very high scores do not usually obtain the same score the second time they are tested and their scores tend to shift toward the mean. This type of internal threat was not something that could be controlled in this study but the threat was taken into consideration when analyzing test scores.

Experimental mortality. Experimental mortality is commonly referred to attrition or the loss of subjects during a study (Houser, 2008). This threat was minimal for this study because this study took place over a one week period. Also, the scheduling of the classroom or simulation experiences as well as the pre-/post-test work was all arranged at times that was convenient to this group of students. Students were required to take the Pre- and Post-DCTs and attend the classroom or simulation experience (whichever modality that was assigned to their clinical group). These requirements served as motivation to participate in the research study. However, several students voluntarily choose not to participate and the data collected on the Pre-/Post-DCT was considered in the statistical analysis.

Experimental treatment diffusion. If a control group perceives that the treatment for the experimental group is highly desirable then they might try to seek access to the treatment condition (Gall, et al., 2007). It was anticipated that this threat may be likely

for students who were participating in the traditional classroom experience. These students could have perceived that the simulation group had an advantage by participating in a hands-on learning experience. Therefore, to minimize this threat, the two teaching modalities were designed to be very similar with little differences between them. In addition, the simulation teacher conducted a simulation lab for those students who expressed a desire to have access to this teaching strategy after data collection was completed.

Compensatory rivalry by the control group. The John Henry effect or the results noted when participants in the control group perform better because they perceive they are in a competition with the experimental group can pose a threat to internal validity (Gall, et al., 2007). To minimize this threat, the two instructors emphasized to the students that this study was meant to evaluate teaching strategies rather than informing them that it was a study to analyze the differences between the scores of the two groups. In addition, both groups seemed to perform to the best of their abilities since a 100% test score fulfilled the school of nursing's policy on taking a medication administration dosage calculation test prior to any clinical experience in medication administration.

Resentful demoralization of the control group. Subjects in the control group can become discouraged or resentful if they perceive that the experimental group has access to a treatment that is desirable and it is being withheld from the control group (Gall, et al., 2007). This threat was minimized by the similarities of the two teaching modalities. However, the classroom participants were provided the opportunity to participate in the simulation lab experience if they so desired after data collection was completed.

Threats to External Validity

“External validity refers to how generalizable the results are and to whom and is about applicability and usefulness of the findings” (Houser, 2008, p. 294). Several threats to external validity included effects on selection, time and history, novelty, and the experimenter. Each of these threats are discussed in the following paragraphs.

Selection effect. Population validity is “the capacity to confidently generalize the results of a study from one group of subjects to another population group” (Houser, 2008, p. 306). The effects of using a convenience sample from a single geographic location did threaten the ability to generalize the findings of this study to another group of subjects. However, this does not mean that the findings are not be useful. The literature is replete with articles on dosage calculation skills and teaching strategies that have been implemented without successfully helping all nursing students achieve a pass rate of 100%. Other schools of nursing from all different backgrounds could benefit from replicating this study to see if utilizing a new, innovative teaching strategy is more effective in helping their students learn to do medication administration dosage calculations accurately and if it is more effective at evaluating the students’ ability to transfer the calculated dosages to realistic equipment necessary for medication administration.

Time and historical effects. Research results obtained during a time and place in history may not be transferrable to another group if a significant amount of time has elapsed since the previous study. Case in point, Hutton (1998b) conducted a dosage calculation research study but did not allow the use of calculators because calculators were not readily available in every acute care facility and outpatient setting at that

particular time. Hutton obtained poor results on the calculation test while other studies have shown that calculator use can have a positive impact on dosage calculation scores (Bliss-Holtz, 1994). The point could be argued that over a decade has passed since these studies were completed and that the technological explosion has greatly impacted the nursing profession. Nurses have access to technology on every level of nursing including bedside computers, palm pilots, Blackberries, and cell phones; therefore, arguing the legitimacy of using a calculator on a medication administration dosage calculation test in 2010 is senseless. The time has changed and now is the time to research how technology can influence education in a way that makes nursing students safer and more competent to practice nursing in the clinical setting than they were over ten years ago.

Novelty effect. Subjects can respond to something such as a teaching modality simply because it is novel and unique (Houser, 2008). Certainly simulation is a unique teaching strategy that the fundamental students have had little experience but the classroom experience is also novel. Currently, the fundamental class is taught by a professor that utilizes PowerPoint and lecture format only. So both groups experienced a novel teaching modality. There was a risk that students will respond to the strategy itself rather than the treatment that occurred during the strategy. The risk for this threat was minimized by students attending the experience one time rather than multiple times over the course of a semester.

Experimenter effects. Subjects in a research study may respond to the person conducting the research (Houser, 2008). The lead investigator did not actively participate in data collection at any point in this study; however, there was one teacher responsible for the simulation experiences and another teacher responsible for the classroom

experience. Both teachers expressed enthusiasm about participating and a desire to do a great job on their particular teaching modality. Two separate teachers were used for this study to minimize the chances of a single teacher showing a preference for a certain teaching style. This minimized the risk of the students responding to the teacher rather than the strategy.

Discussion of Communication of Findings

This dissertation study has taken into account that there are controllable and uncontrollable circumstances that can alter the findings of any research study. This chapter has shed light on how to conduct this study in such a way that minimizes the risks yet maximizes the opportunity to learn of a potentially beneficial way to use simulation that can change the way students conceptualize and calculate dosage calculations. The overall aim of this study was to increase the safety and performance level of nursing students in an environment that is non-threatening to the student or the patient before the student practices dosage calculations in a clinical setting. The statistical findings of this dissertation study are discussed in detail in Chapter Four of this study. Elaboration of the meaning of all of the statistical findings is discussed in Chapter Five.

CHAPTER IV

ANALYSIS

Introduction

The purpose of this dissertation study was to (a) compare medication administration dosage calculation scores and scores of self-perceived judgment in medication dosage calculations in fundamental nursing students who experienced either a traditional classroom experience or a low-fidelity simulation lab experience and (b) determine if there was any difference between satisfaction and self-confidence in learning when comparing the two previously identified teaching modalities.

Characteristics of the Sample

The population for this study included fundamental, associate degree nursing students. Eligible research participants ($n = 59$) comprised a convenience sample of southeastern, fundamental level nursing students enrolled in an associate degree program. Inclusion criteria included acceptance into the nursing program, a college GPA of 2.8 or higher prior to admission into the nursing program and enrollment in the fundamentals nursing course. Exclusion criterion included any student under the age of 18 years old ($n = 0$), students who were repeating the course ($n = 4$) and students who did not attend any portion of the required simulation laboratory, classroom experience, or post-testing ($n = 3$). In addition, five students did not agree to sign the consent form yielding a final sample size of 47 participants.

All 47 participants participated in the pre-test data collection in October, 2009. After the initial data collection the participants were divided into the experimental and comparison groups based upon the clinical laboratory assignments given by the lead teacher. The Thursday clinical group ($n = 22$) comprised the experimental group and the Tuesday clinical group ($n = 25$) became the comparison group. Both groups participated in their respective intervention and then both groups rejoined to do the post-testing which occurred within one week of pre-testing.

Descriptive Data

Descriptive data were collected during a selected class period through a self-administered demographics tool. The tool contained eight questions that the students completed and then four questions that the research assistant completed with information obtained from online academic records after receiving students' permission. See Tables 19 and 20 for a complete overview of the interval data and Tables 21 and 22 for an overview of nominal data.

Age

The 47 participants in this study had a mean age of 20.64 years ($SD = 3.313$). The ages ranged from 19 years to more than 35 years of age. The 35 years and older group ($n = 2$) was analyzed as 35 years of age. The mean age of the experimental group ($n = 22$) was 20.73 years ($SD = 3.425$) and the mean age of the comparison group ($n = 25$) was 20.56 years ($SD = 3.280$). An independent samples t -test with equality of variances assumed ($F = .053$, $p = .819$) demonstrated that the difference in the mean age between the experimental and the control group was insignificant, $t(45) = -.171$, $p = .865$.

Grade Point Average

The mean grade point average (GPA) of the 47 participants in this study was 3.40 (SD = .35846). The range of GPA's spanned from 2.69 to 4.0. The mean GPA of the experimental group ($n = 22$) was 3.56 (SD = .33624) and the mean GPA of the comparison group ($n = 25$) was 3.28 (SD = .33918). The Levene's test for equality of variances demonstrated that the experimental and comparison groups were approximately equal, $F = .055$, $p = .816$. An independent samples t -test indicated that students in the experimental group had a significantly higher mean GPA of 3.539 (SD = .336) as compared to the comparison group with a mean GPA of 3.281 (SD = .339), $t(45) = -2.607$, $p = .012$. The impact of GPA on the results of this study will be discussed within the findings of the research questions and hypotheses.

ACT Math Scores

Participants enrolled in this particular nursing program had the option of taking the ACT exam or the SAT exam prior to admission to the university. However, the school of nursing converted all SAT math scores to ACT math scores utilizing a standardized conversion chart because the ACT math score was an influential factor in the decision making process for admission into the nursing program. In addition, the ACT math score determined what courses a student must enroll in prior to graduating with an associate degree in nursing. This particular nursing program required a freshman level math course prior to graduating with an AS degree in nursing in the event that the student was unable to achieve an ACT math score of 22 or higher. For this dissertation study, all SAT scores were converted to ACT scores via the same standardized conversion chart in an effort to make an equivalent comparison of the participants.

The mean ACT math score for all of the participants ($n = 46$; one participant had no official record of a math ACT or SAT score) in this study was 21.09 ($SD = 3.717$). The ACT math scores ranged from 16 to 30. The participants in the experimental group ($n = 21$) had a mean ACT math score of 21.57 ($SD = 4.202$) as compared to the mean ACT math scores of the comparison group ($n = 25$) of 20.68 ($SD = 3.288$). An independent samples t -test, with equality of variances assumed ($F = 1.412, p = .241$), revealed that the difference in the mean ACT scores between the two groups was insignificant, $t(44) = -.807, p = .424$.

Of the 46 participants in this study with officially recorded ACT math scores, 28 of the participants (59.6%) had ACT scores under the 22 benchmark. Of these 28 students, all but four (85.7%) had already completed the math requirement. The experimental group had 40.9% of the participants with ACT math scores below 22 ($n = 9$). Of these nine students, only one student had not completed the math requirement (11.1%). Within the comparison group, 72.0% of the participants had ACT scores less than 22 ($n = 18$). Of these 18 participants, 16.7 % had not completed the math requirement ($n = 3$). A chi-square test of independence demonstrated that the relationship between the two lab groups and students who had ACT scores that were less than 22 was insignificant ($\chi^2(5) = 7.821, p = .166$). In addition, a chi-square test of independence found that the relationship between students who had or had not taken the required math course was insignificant ($\chi^2(1) = .147, p = .702$). Because there were groups with less than six within each cell a Fisher's exact test was conducted and was also found to be insignificant ($p = 1.000$).

Table 19

Interval Variable Characteristics

Characteristics		Experimental Group	Comparison Group	Total Group
Age (Years)	Mean	20.73	20.56	20.64
	SD	3.425	3.280	3.313
	Range	19 to > 35 years	19 to > 35 years	19 to > 35 years
GPA	Mean	3.4386	3.2812	3.4017
	SD	.33624	.33918	.35846
	Range	2.98 to 4.0	2.69 to 4.0	2.69 to 4.0
Math ACT Scores	Mean	21.57	20.68	21.09
	SD	4.202	3.288	3.717
	Range	16 to 30	17 to 29	16 to 30

Table 20

t-test Comparison for Interval Data

Characteristics	<i>t</i>	df	Significance
Age	-.505	45	.616
GPA	-2.607	45	.012*
Math ACT Scores	-.807	44	.424

*Significant differences between the two groups were found at $p < 0.05$.

Gender

The gender distribution for the entire sample was 70.2% female ($n = 33$) and 29.8% male ($n = 14$). The experimental group contained 68% females ($n = 17$) and 32% males ($n = 8$). The comparison group had a higher percentage of females (72.7%, $n = 16$) than males (27.3%, $n = 6$) although a chi-square test of independence indicated that the relationship between gender and the two groups was insignificant ($X^2(1) = .125$, $p = .724$).

Class Standing

Class standing was defined as freshman, sophomore, junior, and senior levels for this study. Of the 47 total participants, only one student was a freshman (2.1%), 30 students were sophomores (63.8%), 15 students were juniors (31.9%), and one student was a senior (2.1%). Because the freshman and senior level sample size was limited to only one student each, the freshman student was combined with the sophomores to comprise the underclassmen group ($n = 31$) and the senior was combined with the juniors to establish the upperclassmen group ($n = 16$).

An analysis of the two research study groups revealed that the experimental group contained 19 underclassmen (86.4%) and three upperclassmen (13.6%) whereas the comparison group included 12 underclassmen (48%) and 13 upperclassmen (52%). A chi-square test of independence revealed that the relationship between class levels and the two groups was significant ($X^2(1) = 7.670$, $p = .006$). These results were confirmed by a Fisher's exact test ($p = .007$). The majority of the experimental group participants were underclassmen students (86.4%) whereas the comparison group contained the majority of all of the upperclassmen students in this entire sample (81.3%). Further analysis on the

effects of class standing on these study results will be discussed within the findings of the research questions and hypotheses.

Ethnicity

The sample of 47 participants included two African-Americans (4.3%), two Asian/Pacific Islanders (4.3%), 32 Caucasians (68.1%), 10 Hispanics (21.3%), and one identified as “other” (2.1%). Because there were few diverse students participating in the experimental or control groups, the students were combined into Caucasians and non-Caucasians. Within the experimental group there were 16 Caucasians (72.7%) and six non-Caucasians (27.3%). The comparison group had 16 Caucasians (64%), and nine non-Caucasians (36%). A chi-square test of independence revealed no significant relationship when comparing ethnic diversity between the two research groups ($\chi^2(1) = .410$, $p = .522$). This result was confirmed by a Fisher’s exact test ($p = .550$).

Work Experience in a Healthcare Setting

Out of the 47 participants, 14.9% ($n = 7$) had work experience in a healthcare setting prior to nursing school. Of these seven students, three were Certified Nursing Assistants (42.9%), two were Emergency Medical Technicians (28.6%), one was a unit clerk (14.3%) and one was a patient transporter (14.3%). Four of these seven students had less than one year of experience in the healthcare field (57.1%) and three students had more than one year (42.9%). All seven of these individuals were in the comparison group of 25 students. The overall percentage of students experienced in the realm of healthcare within the comparison group was 28%. A chi-square test of independence indicated that the relationship between having experienced healthcare workers in the comparison group and not having any in the experimental group was significant ($\chi^2(1) = 7.238$, $p = .007$). A

chi-square test of independence was not conducted between the two research groups for type of healthcare experience and the length of healthcare experience because there was no one to compare it to in the experimental group. Further analysis on the effects of work experience on these study results will be discussed within the findings of the research questions and hypotheses.

Second Degree

An associate's degree in nursing is the first degree sought by all of the participants with the exception of one student (2.1%) who was in the comparison group. This student's first degree was non-healthcare related and a chi-square test of independence indicated that the relationship between the comparison and experimental group in association with students obtaining a second degree was insignificant ($\chi^2(1) = .899, p = .343$). These results were confirmed by an insignificant Fisher's exact test ($p = 1.000$).

Table 21

Nominal Variable Characteristics

Characteristics	Experimental Group <i>n</i> (%)	Comparison Group <i>n</i> (%)	Total Group <i>n</i> (%)
Gender			
Male	6 (27.3)	8 (32.0)	14 (29.8)
Female	16 (72.7)	17 (68.0)	33 (70.2)
Class Standing			
Underclassmen	18 (81.8)	12 (48.0)	30 (63.8)
Upperclassmen	2 (9.1)	13 (52.0)	15 (31.9)
Ethnicity			
Caucasian	16 (72.7)	16 (64.0)	32 (68.1)
Non-Caucasian	6 (27.3)	9 (36.0)	15 (31.9)
Healthcare Experience			
Experienced	N/A	7 (28.0)	7 (14.9)
Not Experienced	22 (100.0)	18 (72.0)	40 (85.1)
Type of Healthcare Experience			
CNA	N/A	2 (28.6)	2 (28.6)
Unit Secretary	N/A	2 (28.6)	2 (28.6)
EMT	N/A	2 (28.6)	2 (28.6)
Patient Transporter	N/A	1 (14.3)	1 (14.3)
Length of Healthcare Experience			
Less than 1 year	N/A	4 (57.1)	4 (57.1)
More than 1 year	N/A	3 (42.9)	3 (42.9)
Second Degree			
Seeking 2 nd Degree	N/A	1 (4.0)	1 (2.1)
Not Seeking 2 nd Degree	22 (100.0)	24 (96.0)	46 (97.9)
Required Math Course			
Completed Requirement	8 (88.9)	15 (83.3)	23 (85.2)
Did Not Complete Requirement	1 (11.1)	3 (16.7)	4 (14.8)

Table 22

Chi-Square Comparison of Nominal Demographic Data

Characteristics	χ^2	df	Significance
Gender	.125	1	.724
Class Standing	7.670	1	.006*
Ethnicity	.410	1	.522
Healthcare Experience	7.238	1	.007*
Second Degree	.899	1	.343
Required Math Course	.147	1	.702

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*Significant relationships between the two groups were found at $p < 0.05$.

Power Analysis

Prior to conducting a statistical analysis of the research findings, a researcher must determine if there are any potential factors that could erroneously influence the overall outcomes of the study. The Statistical Package for Social Science (SPSS) software, version 17.0 and Minitab 15.0 were utilized to detect if any influential factors existed.

A statistical power analysis maximizes the likelihood that the differences, relationships, and effects found in statistical results are accurate and reliable (Gall, et al., 2007) that is, if these differences truly exist (Batterham & Atkinson, 2005). “Formally, power is equal to 1 minus the Type II error rate (beta or β)” (Batterham & Atkinson, 2005, p. 153). A type-II error occurs when the researcher erroneously accepts the null hypothesis (Glass & Hopkins, 1996) or in other words, the researcher fails to find a difference or relationship between two or more variables when one actually exists

(Batterham & Atkinson, 2005). The conventional standard for $1-\beta$ is 0.80 which leaves a 20% risk for committing a Type II error (Polit & Beck, 2008).

Prior to data collection, it was determined that each research group must have at least eight participants in order to achieve a power of 80%. For this study, there were 22 participants in the experimental group and 25 participants in the comparison group which exceeded the predicted sample size required to achieve this power. To determine the actual power for this study, a power analysis using a two sample t -test with the testing mean 1 = mean 2 (versus not =) and the calculated power for mean 1 = mean 2 + the difference was conducted utilizing Minitab 15.0 software with the pre-determined components (a) a level of significance set at $\alpha = 0.05$, (b) an effect size of a 5% difference between pre- and post-test scores, and (c) a sample size of 22. The calculated power ($1-\beta$) for a sample of this size was 0.998894 which signifies that there is a less than a one percent risk of committing a Type II error (see Figure 6).

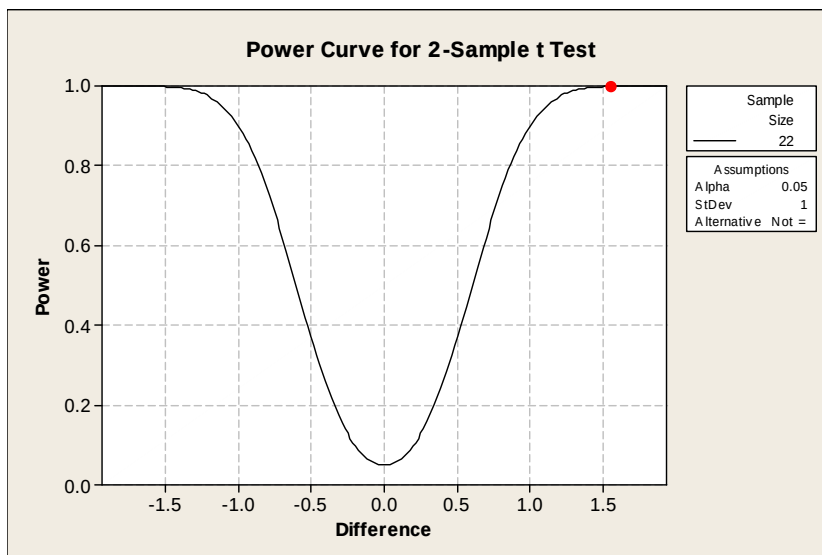


Figure 6. Power Curve for 2-Sample t -test – Actual Research Participants (Minitab, 2009).

Description of Tools

Four separate tools were utilized in the data collection process for this dissertation study: a) the Pre- and the Post- Dosage Calculation Tool (DCT), b) the Self-Perceived Judgment in Dosage Calculations Scale (SPJDCS), and c) the NLN tool for Satisfaction and Self-Confidence in Learning Scale (SSCLS). The SSCLS was the only instrument that had established validity and reliability through a national study on simulation. Cronbach's alpha established reliability at .94 for the satisfaction items and .87 for the self-confidence items (Jeffries & Rogers, 2007a). The three researcher-developed instruments utilized in this study were administered during a pilot study during the fall of 2009 in an effort to analyze and determine reliability. Cronbach's alpha established reliability for the Pre-DCT at .70, the Post-DCT at .83, and the SPJDCS at .90. The following description of each tool discusses the assumptions of normality that must be addressed prior to statistical analysis. In addition, the established reliability achieved during this dissertation study and any influential factors on reliability are discussed.

Pre- and Post-Dosage Calculation Tests

Assumptions of Normality

Before performing statistical analysis utilizing parametric tests, the researcher must address the assumptions of normality. These assumptions include a) that the sample is normally distributed via a histogram or a scatter plot and that the sample is large enough to support these findings, b) the analyzed variables are independent and are of interval or ratio measurement, and c) that homogeneity of variance exists between the two groups being compared (Gall, et al., 2007; Houser, 2008; Martin & Thompson, 2000).

The histogram of the Pre-DCT and the Post-DCT demonstrated a negatively skewed curve (-1.100 and -1.177 respectively) although on a dosage calculation test of this nature, a negative skew is anticipated because the expected norm is that the student will achieve a 100% score on the test. In instances where a normal curve is skewed, Field (2005) recommends converting the mean and standard deviation of skewness and kurtosis into z -scores. The z -score standardizes the values in an effort to derive meaning from the skewness and kurtosis values. According to Field, an absolute value of 1.96 or higher for either skewness or kurtosis is significant at $p < .05$. A calculation of z -scores revealed that the level of skewness (s) and kurtosis (k) was significant ($p < .05$) for the Pre-DCT ($s = 3.17, k = 1.94$) and the Post-DCT ($s = 3.39, k = 1.16$). Therefore, it was appropriate to utilize nonparametric tests when examining the relationships between these variables.

Assessment of Reliability

The Pre-DCT and the Post-DCT are equivalent forms of a 31-item researcher-designed instrument that were administered to all of the participants ($n = 47$) within a one week period. The items on this instrument were measured dichotomously; 1 = correct and 0 = incorrect. The combined mean score for both research groups on the Pre-DCT was 24.13 (SD = 4.192) and the mean score on the Post-DCT was 28.07 (SD = 3.100).

A Kuder-Richardson Formula 20 (K-R 20) measures the consistency among the test scores with dichotomous items and it reflects: a) the total number of items on a tool, b) the proportion of the correct and incorrect responses to an individual item, and c) the variance for that set of scores (McGahee & Ball, 2009). The K-R 20 index ranges from 0 to 1 and the closer a test performs to 1 then the more likely a test will produce consistent scores when administered on multiple occasions to multiple groups (McGahee

& Ball). Typically, a K-R 20 coefficient of $> .70$ is desirable (LoBiondo-Wood & Haber, 2006). The K-R 20 reliability coefficient for this sample on the Pre-DCT and the Post-DCT tool was estimated to be .80 and .76 respectively.

Influential Factors on Reliability

According to Oermann and Gaberson (2006), the length of the test, the homogeneity of test content, and the discrimination and difficulty of individual test items can impact the reliability of test scores. Although the K-R 20 coefficient estimate was sufficient in this instance, it is still prudent to assess the instruments for test length, homogeneity of test content, and discrimination and difficulty of the individual items.

Test Length. The first factor that influenced the K-R 20 coefficient was the length of the test. In previous semesters, students were given 15 items on their dosage calculation exams. The new tool has 31 items. When there is an increase in test items there will also be an increase in the reliability coefficient within that instrument (Oermann & Gaberson, 2006). The additional items were necessary to assess the transfer of the calculated dosage into a practical format. This type of testing had not been done within this university and there was no way to assess if students understood the meaning of the numbers they calculated with previous testing methods if they did not have to demonstrate the results. The addition of these items resulted in K-R 20 coefficients of .80 on the Pre-DCT and .76 on the Post-DCT as compared to the .56 reliability estimate on the traditional tool utilized within the pilot study.

Homogeneity of Test Content. The second factor that could have positively influenced the K-R 20 coefficient in this study is the homogeneity of test content. According to Oermann and Gaberson (2006), “content that is tightly organized and

highly interrelated tends to make homogeneous test content easier to achieve” (p. 33). On the Pre- and Post-DCT, the content was strictly about dosage calculations and transferring the calculated dosages into a practical format. This increased homogeneity because the students were not tested on any other content such as the action of the medication, side effects, or medication interactions, etc. The homogeneity of the content was improved by the tightly organized, interrelated pairs of questions that were structured from easiest to hardest.

Test Item Difficulty and Discrimination. Finally, the discrimination and difficulty of the test items could have influenced the reliability of the tool. For the Pre-DCT, the correct responses for individual questions ranged from 28.9% to 100%. Five items (16.1%) were correctly answered by 100% of the students, eight items (25.8%) were answered 90-99% correctly, five items (16.1%) were answered 80-89% correctly, two items (6.5%) were answered 70-79% correctly, three items (9.7%) were answered 60-69% correctly, five items (16.1%) were answered 50-59% correctly, one item (3.2%) was answered 40-49% correctly, and two items (6.5%) were answered 20-29% correctly. In contrast, the Post-DCT scores ranged from 71.1% to 100%. The Post-DCT had six items (19.4%) answered correctly by 100% of the students, 14 items (45.2%) answered 90-99% correctly, six items (19.4%) answered 80-89% correctly, and five items (16.1%) answered 70-79% correctly (see Table 23 for a complete overview).

Table 23

Comparison of Correct Responses to Items on the Pre- and Post-Dosage Calculation Tests

Percentage Range	# Pre-DCT Items	# Post-DCT Items
100%	5	6
90-99%	8	14
80-89%	5	6
70-79%	2	5
60-69%	3	0
50-59%	5	0
40-49%	1	0
30-39%	0	0
20-29%	2	0

When considering the percentages of items that scored higher than 90% on the Pre-DCT, there were 13 items that did not require multiple conversions to calculate the answer and they may have been too easy for the students. However, there were 20 items that scored higher than a 90% on the Post-DCT. This could indicate that these items were too easy or that the students learned how to calculate the more difficult dosage calculations in their learning experience, therefore, making these questions much easier to calculate than on the Pre-DCT. For the sake of patient safety, the goal is 100% correct calculations every single time, and the calculation skills of fundamental nursing students needs to be evaluated within a broad scope of difficulty in order for educators to assess the learning needs of a diverse group of learners. What was easy for this particular group may not necessarily be easy for the next fundamentals group.

Point-Biserial Correlation Coefficients. A point-biserial correlation coefficient (PBCC) measures the quality of an individual test item and is an appropriate measure for items that are dichotomous (1 = correct or 0 = incorrect). Although nursing education has not established a set standard on what PBCC is the most desirable, generally, items that score between .40 and .70 are considered “good”, items between .20 and .39 are considered “fair”, and items scoring under .20 are deemed “poor” questions and generally need evaluation and revision (McGahee & Ball, 2009).

PBCC's were conducted on all of the 31 items on the Pre-DCT (see Table 24 and 25). Four items were answered correctly by all students ($r_{pb} = 1.000$). One item (3.2%) was in the .70 to .99 range and had a significant moderately, positive correlation ($r_{pb} = .720, p = .000$). Twenty items (64.5%) were in the .40 to .70 range and demonstrated significant moderately, positive correlations ($p < .05$). Four items (12.9%) were in the .20 to .39 range. Three of these items had significant moderately positive correlations ($p < .05$) and one item did not have a significant correlation. Two items (6.5%) were below .20 and did not have significant correlations ($p > .05$). The items with PBCC's below .20 and those that were 1.00 were questions that answered correctly by the majority of the students. The items that were above .40 were more difficult and required multiple conversions for an accurate dosage calculation (see Table 26 for a comparison of the mean and SD for each individual test item for the Pre-/Post-DCT).

A PBCC analysis on the Post-DCT revealed that six items were answered correctly by all students ($r_{pb} = 1.000$). One item (3.2%) was in the .70 to .99 range and had a significantly moderately, positive correlation ($p = .000$). Ten items were in the .40

to .70 range and demonstrated significant moderately, positive correlations ($p < .05$).

Finally, 14 items had PBCC's in the .20 to .39 range. Eleven of these items showed significant moderately, positive correlations ($p < .05$) and three items were insignificant.

The Post-DCT revealed that students answered more questions correctly. In addition, the multiple conversion questions remained the most difficult (see Table 26).

Table 24

Point Biserial Correlation Coefficient Comparison of Pre- and Post-Dosage Calculation Test

PBCC	Pre-DCT	Post-DCT
1.000	4 (12.9%)	6 (19.4%)
.71 to .99	1 (3.2%)	1 (3.2%)
.40 to .70	20 (64.5%)	10 (32.3%)
.20 to .39	4 (12.9%)	14 (45.2%)
Below .19	2 (6.5%)	-

Table 25

Point Biserial Correlation Coefficient Comparison of the Pre- and Post-Dosage Calculation Test

Medication			PBCC	Significance
<u>Zofran</u>	A	Pre-DCT	1.000	1.000
		Post-DCT	1.000	1.000
	B	Pre-DCT	1.000	1.000
		Post-DCT	1.000	1.000
<u>Haldol</u>	A	Pre-DCT	.623	.000*
		Post-DCT	.227	.125
	B	Pre-DCT	.623	.000*
		Post-DCT	.227	.125
<u>Lanoxin</u>	A	Pre-DCT	.304	.038*
		Post-DCT	.394	.006*
	B	Pre-DCT	.362	.012*
		Post-DCT	.394	.006*
<u>Synthroid</u>	A	Pre-DCT	.477	.001*
		Post-DCT	.329	.024*
	B	Pre-DCT	.188	.206
		Post-DCT	.329	.024*
<u>Dilantin</u>	A	Pre-DCT	.677	.000*
		Post-DCT	1.000	1.000
	B	Pre-DCT	.677	.000*
		Post-DCT	1.000	1.000
<u>Amikacin</u>	A	Pre-DCT	1.000	1.000
		Post-DCT	.297	.042*
	B	Pre-DCT	1.000	1.000
		Post-DCT	.297	.042*
<u>Symmetrel</u>	A	Pre-DCT	.020	.893
		Post-DCT	.710	.000*
	B	Pre-DCT	.230	.120
		Post-DCT	.650	.000*
<u>Heparin</u>	A	Pre-DCT	.373	.010*
		Post-DCT	.393	.006*
	B	Pre-DCT	.540	.000*
		Post-DCT	.577	.000*
<u>Aminophylline</u>	A	Pre-DCT	.625	.000*
		Post-DCT	1.000	1.000
	B	Pre-DCT	.629	.000*
		Post-DCT	1.000	1.000

*Significant correlations were found at $p < 0.05$

Table 25, (continued)

Medication			PBCC	Significance
<u>Vincristine</u>	A	Pre-DCT	.491	.000*
		Post-DCT	.344	.018*
	B	Pre-DCT	.491	.000*
		Post-DCT	.430	.003*
<u>Insulin</u>	A	Pre-DCT	.417	.004*
		Post-DCT	.201	.176
	B	Pre-DCT	.453	.001*
		Post-DCT	.590	.000*
<u>Pulmocare</u>	A	Pre-DCT	.448	.002*
		Post-DCT	.370	.011*
	B	Pre-DCT	.417	.004*
		Post-DCT	.445	.002*
<u>NS</u>	A	Pre-DCT	.532	.000*
		Post-DCT	.385	.008*
	B	Pre-DCT	.532	.000*
		Post-DCT	.540	.000*
<u>Rantidine</u>	A	Pre-DCT	.720	.000*
		Post-DCT	.379	.009*
	B	Pre-DCT	.532	.000*
		Post-DCT	.464	.001*
	C	Pre-DCT	.532	.000*
		Post-DCT	.464	.001*
<u>D5NS</u>	A	Pre-DCT	.478	.001*
		Post-DCT	.451	.001*
	B	Pre-DCT	.485	.001*
		Post-DCT	.438	.002*

*Significant correlations were found at $p < 0.05$

Table 26

Comparison of Mean Scores on the Pre-and Post-Dosage Calculation Test Tool

Medication			Experimental Group ^a		Comparison Group ^b		Total Group ^c	
			Pre-DCT	Post-DCT	Pre-DCT	Post-DCT	Pre-DCT	Post-DCT
<u>Zofran</u>	A	% Correct	100	100	100	100	100	100
		Mean	1.00	1.00	1.00	1.00	1.00	1.00
		SD	.000	.000	.000	.000	.000	.000
	B	% Correct	100	100	100	100	100	100
		Mean	1.00	1.00	1.00	1.00	1.00	1.00
		SD	.000	.000	.000	.000	.000	.000
<u>Haldol</u>	A	% Correct	91.0	86.0	96.0	96.0	94.0	91.0
		Mean	.91	.86	.96	.96	.94	.91
		SD	.294	.351	.200	.200	.247	.282
	B	% Correct	91.0	86.0	96.0	96.0	94.0	91.0
		Mean	.91	.86	.96	.96	.94	.91
		SD	.294	.351	.200	.200	.247	.282
<u>Lanoxin</u>	A	% Correct	95.0	100	84.0	88.0	89.0	94.0
		Mean	.95	1.00	.84	.88	.89	.94
		SD	.213	.000	.374	.332	.312	.247
	B	% Correct	95.0	100	80.0	88.0	87.0	94.0
		Mean	.95	1.00	.80	.88	.87	.94
		SD	.213	.000	.408	.332	.337	.247
<u>Synthroid</u>	A	% Correct	100	100	96.0	92.0	98.0	96.0
		Mean	1.00	1.00	.96	.92	.98	.96
		SD	.000	.000	.200	.277	.146	.204
	B	% Correct	100	100	96.0	92.0	98.0	96.0
		Mean	1.00	1.00	.96	.92	.98	.96
		SD	.000	.000	.200	.277	.146	.204
<u>Dilantin</u>	A	% Correct	86.0	100	80.0	100	83.0	100
		Mean	.86	1.00	.80	1.00	.83	1.00
		SD	.351	.000	.408	.000	.380	.000
	B	% Correct	86.0	100	80.0	100	83.0	100
		Mean	.86	1.00	.80	1.00	.83	1.00
		SD	.351	.000	.408	.000	.380	.000
<u>Amikacin</u>	A	% Correct	100	91.0	100	100	100	96.0
		Mean	1.00	.91	1.00	1.00	1.00	.96
		SD	.000	.294	.000	.000	.000	.204
	B	% Correct	100	91.0	100	100	100	96.0
		Mean	1.00	.91	1.00	1.00	1.00	.96
		SD	.000	.294	.000	.000	.000	.204

^an = 22. ^bn = 25. ^cn = 47.

Table 26, (continued)

Medication			Experimental Group ^a		Comparison Group ^b		Total Group ^c	
			Pre-DCT	Post-DCT	Pre-DCT	Post-DCT	Pre-DCT	Post-DCT
<u>Symmetrel</u>	A	% Correct	95.0	95.0	96.0	80.0	96.0	87.0
		Mean	.95	.95	.96	.80	.96	.87
		SD	.213	.213	.200	.408	.204	.337
	B	% Correct	91.0	100	96.0	80.0	94.0	89.0
		Mean	.91	1.00	.96	.80	.94	.89
		SD	.294	.000	.200	.408	.247	.312
<u>Heparin</u>	A	% Correct	77.0	64.0	64.0	88.0	70.0	77.0
		Mean	.77	.64	.64	.88	.70	.77
		SD	.429	.492	.490	.332	.462	.428
	B	% Correct	55.0	86.0	68.0	88.0	62.0	87.0
		Mean	.55	.86	.68	.88	.620	.87
		SD	.510	.351	.476	.332	.491	.337
<u>Aminophylline</u>	A	% Correct	82.0	100	92.0	100	87.0	100
		Mean	.82	1.00	.92	1.00	.87	1.00
		SD	.395	.000	.277	.000	.337	.000
	B	% Correct	86.0	100	92.0	100	89.0	100
		Mean	.86	1.00	.92	1.00	.89	1.00
		SD	.351	.000	.277	.000	.312	.000
<u>Vincristine</u>	A	% Correct	41.0	91.0	16.0	88.0	28.0	89.0
		Mean	.41	.91	.16	.88	.28	.89
		SD	.503	.294	.374	.332	.452	.312
	B	% Correct	41.0	91.0	16.0	92.0	28.0	91.0
		Mean	.41	.91	.16	.92	.28	.91
		SD	.503	.294	.374	.277	.452	.282
<u>Insulin IV</u>	A	% Correct	41.0	82.0	64.0	96.0	53.0	89.0
		Mean	.41	.82	.64	.96	.53	.89
		SD	.503	.395	.490	.200	.504	.312
	B	% Correct	41.0	82.0	60.0	88.0	51.0	85.0
		Mean	.41	.82	.60	.88	.51	.85
		SD	.503	.395	.500	.332	.505	.360
<u>Pulmocare</u>	A	% Correct	77.0	91.0	76.0	84.0	77.0	87.0
		Mean	.77	.91	.76	.84	.77	.87
		SD	.429	.294	.436	.374	.428	.337
	B	% Correct	77.0	91.0	80.0	84.0	79.0	87.0
		Mean	.77	.91	.80	.84	.79	.87
		SD	.429	.294	.408	.374	.414	.337

^an = 22. ^bn = 25. ^cn = 47.

Table 26, (continued)

Medication			Experimental Group ^a		Comparison Group ^b		Total Group ^c	
			Pre-DCT	Post-DCT	Pre-DCT	Post-DCT	Pre-DCT	Post-DCT
<u>Ranitidine</u>	A	% Correct	73.0	86.0	64.0	72.0	68.0	79.0
		Mean	.73	.86	.64	.72	.68	.79
		SD	.456	.351	.490	.458	.471	.414
	B	% Correct	59.0	73.0	52.0	68.0	55.0	70.0
		Mean	.59	.73	.52	.68	.55	.70
		SD	.503	.456	.510	.476	.503	.462
	C	% Correct	59.0	73.0	52.0	68.0	55.0	70.0
		Mean	.59	.73	.52	.68	.55	.70
		SD	.503	.456	.510	.476	.503	.462
<u>NS</u>	A	% Correct	77.0	100	76.7	80.0	68.0	89.0
		Mean	.77	1.00	.767	.80	.68	.89
		SD	.429	.000	.430	.408	.471	.312
	B	% Correct	77.0	100	73.3	76.0	68.0	87.0
		Mean	.77	1.00	.733	.76	.68	.87
		SD	.429	.000	.450	.436	.471	.337
<u>D5NS</u>	A	% Correct	59.0	82.0	44.0	68.0	51.0	74.0
		Mean	.59	.82	.44	.68	.51	.74
		SD	.503	.395	.507	.476	.505	.441
	B	% Correct	59.0	82.0	32.0	84.0	45.0	83.0
		Mean	.59	.82	.32	.84	.45	.83
		SD	.503	.395	.476	.374	.503	.380
<u>Overall Scores</u>			77.9	91.1	73.9	88.3	75.8	89.6
			24.14	28.23	22.92	27.36	23.49	27.77
			5.401	2.759	4.957	3.915	5.149	3.415

^a*n* = 22. ^b*n* = 25. ^c*n* = 47.

Self-Perceived Judgment in Dosage Calculations Scale

Assumptions of Normality. A Q-Q plot revealed that the observed scores on the Self-Perceived Judgment in Dosage Calculations Scale (Pre- and Post-SPJDSC) demonstrated a close association to the expected normal values for this tool. However, the histogram revealed a negative skew (-1.101) for the Pre-SPJDSC and the Post-SPJDSC (-.315). In addition, z-scores for skewness and kurtosis were significant (2.91, 3.52) at a $p < .05$ level for the Pre-SPJDSC although the z-scores were in the acceptable range for skewness and kurtosis (.907, 1.07) for the Post-SPJDSC. Because the Pre-SPJDSC was more than moderately skewed, nonparametric tests were appropriate for further statistical analysis on the self-perceived judgment tool.

Assessment of Reliability. The Pre- and Post-SPJDSC contained 15 identical items that asked the students to describe their opinion on how logical their answers were to the calculation questions. Each question contained an ordinal variable using a 5-point Likert scale ranging from highly logical (5 points) to highly illogical (1 point). Since the items were not scored dichotomously, Cronbach's alpha was the appropriate reliability score to estimate internal reliability (Gall, et al., 2007). Cronbach's alpha established reliability at 0.94 for the Pre-SPJDSC and .96 for the Post-SPJDSC.

NLN Satisfaction and Self-Confidence in Learning Scale

Assumptions of Normality. The NLN Satisfaction and Self-Confidence in Learning Scale (SSCLS) is a 13-item instrument that is divided into two sections. The first section contained five items related to satisfaction in learning and then the second section of eight items measured the level of self-confidence in learning. A Q-Q plot of the mean satisfaction and self-confidence revealed that the observed scores for both of these

means were closely associated with the normal expected scores. Histograms revealed negatively skewed curves and the z-scores for skewness and kurtosis were significant ($p < .05$) for satisfaction (4.90, 4.79) and self-confidence (2.49, .86). Because these results are more than moderately skewed, nonparametric tests were utilized to analyze the results.

Assessment of reliability. The SSCLS had 13 items utilizing a 5-point Likert scale that measured a students' opinion as to whether he or she agreed with the item. The items ranged from strongly agreed (5 points) to strongly disagreed (1 point). The assessment of reliability was conducted on the two separate sections of this tool. Cronbach's alpha was established at .95 for the satisfaction section and .84 for the self-confidence section of this tool.

Results

Research Question and Hypothesis One

Q1: In fundamental nursing students, what effects does a traditional case study in a classroom versus a low-fidelity simulation in a simulation laboratory have on mean dosage calculation test scores?

H₀₁: There will be no differences in mean dosage calculation test scores between fundamental nursing students who participate in a traditional case study in the classroom versus a low-fidelity simulation in the simulation lab.

The appropriate statistical test to analyze the null hypothesis and examine the differences between the classroom versus the simulation group was the Mann-Whitney *U* test since the data were not normally distributed. In addition, the ANCOVA test was used to control for covariances such as age, GPA, and ACT scores and their possible influence on self-perceived judgment. The Kruskal-Wallis test was used to determine the

dependent variables (age, GPA, ACT math scores, gender, ethnicity, class standing, healthcare experience) had an effect on the independent variable (DCT scores). The Wilcoxon signed rank sum test was utilized to determine the difference in scores within a group from Pre-DCT to Post-DCT. Finally, Cohen d scores were calculated to measure the effect sizes. This section of results will begin by analyzing the differences between the two research groups and the mean Pre- and Post-DCT scores and it will conclude with the overall effects of the teaching modules.

Differences in Mean Dosage Calculation Scores

The overall mean score for the entire group ($n = 47$) for the Pre-DCT was 23.49 (SD = 5.149) out of 31 points. The experimental group ($n = 22$) scored a mean of 24.14 (SD = 5.401) on the Pre-DCT and the comparison group ($n = 25$) scored a mean average of 22.92 (SD = 4.957). A Mann-Whitney U test was used to examine the difference in the performance on the Pre-DCT between the experimental group and the comparison group. No significant difference was found ($U = 225.000$, $p = .283$). The experimental group students averaged a mean rank of 26.27, whereas the comparison group ranked 22.00.

The Post-DCT was taken after both groups had participated in their learning module. The overall mean score for the entire group on the Post-DCT was 27.77 (SD = 3.415) out of 31 points. The experimental group attended the low-fidelity simulation experience in the simulation lab. This group achieved an overall mean score of 28.23 (SD = 2.759) whereas the comparison group, who attended the traditional case study in the classroom achieved an overall mean score of 27.36 (SD = 3.915). A Mann-Whitney U test was utilized to examine the difference in the performance on the Post-DCT between the experimental group and the comparison group. No significant

difference was found ($U = 254.000$, $p = .650$). The experimental group students ranked an average of 24.95, whereas the comparison group ranked 23.16 (see Table 27). These findings led to a failure to reject the null hypothesis. Both research groups improved equally on the Post-DCT after attending their respective learning module.

Table 27

Mann-Whitney U Comparison of the Experimental and Comparison Groups

Characteristics	Experimental Group ^a	Comparison Group ^b	Total Group	Mann-Whitney U	Significance
Pre-DCT					
Mean	24.14	22.92	23.49		
SD	5.401	4.957	5.149		
Rank	26.27	22.00	-	225.000	.283
Post-DCT					
Mean	28.23	27.36	27.77		
SD	2.759	3.915	3.415		
Rank	24.95	23.16	-	254.000	.650

^a $n = 22$. ^b $n = 25$.

*No significant differences between the two groups were found at $p < 0.05$.

Analysis of Covariates

To determine if extraneous variables had any influence on the Pre-/Post-DCT test scores an analysis of covariance (ANCOVA) was conducted to obtain a more precise estimate of the differences between the experimental and comparison group in this study.

The ANCOVA is a statistical procedure that can test the differences in mean scores

between two groups while controlling possible influential variables; therefore, supporting the assumption that the teaching modality made a difference in the test scores (Polit & Beck, 2008). The ANCOVA was utilized in this study even though the assumptions of normality were not met because there are currently no nonparametric equivalent tests available.

A one-way between-subjects ANCOVA was calculated to examine the effects of the teaching module on the Pre-DCT mean scores when the covariances of age, GPA, and ACT math scores were taken into account. The main effect for the experimental and comparison group was insignificant ($F(1, 41) = 1.959, p = .119$), with the experimental group not achieving a significantly higher Pre-DCT mean score (mean = 24.14, SD = 5.401) than the comparison group (mean = 22.92, SD = 4.957), when covarying out the effect of age, GPA, and ACT math scores (see Table 28 for a complete overview).

After the Pre-DCT, the experimental group attended a low-fidelity simulation in the simulation laboratory and the comparison group attended a traditional case study in the classroom. Then the two groups rejoined and took the Post-DCT at the same time. A one-way between-subjects ANCOVA was utilized to examine if the increased scores could be explained by the effects of age, GPA, and ACT math scores. The main effect for experimental and comparison group was insignificant ($F(1, 41) = 1.410, p = .248$), with the experimental group not achieving a significantly higher Post-DCT score (mean = 28.23, SD = 2.759) than the comparison group (mean = 27.36, SD = 3.915), when age, GPA, and ACT math scores were covaried out of the equation.

Table 28

Analysis of Covariates Between Groups Pre- and Post-Dosage Calculation Test Scores

Characteristics	Sum of Square	df	Mean Square	<i>F</i>	Significance
Age					
Pre-DCT	43.155	1	43.155	1.728	.196
Post-DCT	2.306	1	2.306	.202	.655
GPA					
Pre-DCT	97.427	1	97.427	3.902	.055
Post-DCT	15.955	1	15.955	1.401	.243
ACT Math					
Pre-DCT	33.628	1	33.628	1.347	.253
Post-DCT	18.014	1	18.014	1.581	.216

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* No statistical significance found.

Differences Within and Between Groups

Analysis of variance (ANOVA) is a procedure that tells us “how independent variables interact with each other and what effects these interactions have on the dependent variables” (Field, 2000, p. 309). The independent variables must be at the interval or ratio level. The ANOVA test is based upon the assumption that the data are normally distributed. Since these assumptions were violated, the Kruskal-Wallis *H* test, the nonparametric ANOVA equivalent, was the appropriate test to use in this instance. In addition, the Kruskal-Wallis *H* test can compare the outcomes of two or more groups at one time and decrease the risk for Type II errors (Houser, 2008) – (see Table 29 for a complete overview of all of the demographic variables).

Age. A Kruskal-Wallis H test was conducted comparing the outcome of the Pre-DCT with the varying levels of age. Because there were age categories after the age group of 21 years old with zero, one, or two participants in it, those students who were 22 years of age and older were combined into one group in an effort to maintain anonymity. No significant differences were found ($H(3) = 3.097, p = .377$), indicating that the age groups did not differ significantly from each other. Students who were in the 22 years old and older group ($n = 6$) ranked the highest (28.50), followed by 21 year olds ($n = 7$; ranking = 26.57), 19 year olds ($n = 20$, ranking = 25.35), and then 20 year olds ($n = 14$, ranking = 18.86). The Kruskal-Wallis H test was also conducted to compare the Post-DCT with the same age categories. No significant differences were found ($H(3) = 1.873, p = .599$). In this particular instance, the ranking order began with 21 year olds (27.57), then 20 year olds (25.68), 19 year olds (23.33), and 22 year olds and older (18.17). Age did not seem to influence the results.

Grade point average. Out of the 47 participants there were 36 different GPA scores recorded. Therefore, the GPA scores were combined into five separate range groups in an attempt to maintain anonymity. A Kruskal-Wallis H test was conducted comparing the outcome of the mean Pre-DCT score with the varying ranges of GPA scores. No significant differences were found ($H(4) = 8.215, p = .084$), indicating that the different groups of GPA ranges did not differ significantly from each other on the Pre-DCT test. Students with the highest GPA range of 3.76 - 4.00 ($n = 10$) ranked 34.55, followed by those in the 3.26 to 3.50 range ($n = 12$) who ranked 22.33, then students in the 3.01 to 3.25 range ($n = 12$) who ranked 22.29, then students in the 3.51 to 3.75 range ($n = 7$) who ranked 20.07, and then those who had a $GPA \leq 3.00$ ($n = 6$) who ranked

17.75. The Kruskal-Wallis H test for the Post-DCT also demonstrated no significant differences ($H(4) = 5.599, p = .231$) although the ranges of GPA took on a different pattern of rankings. The 3.26 to 3.50 GPA group ranked 28.96, the 3.51 to 3.75 GPA group ranked 28.64, the 3.76 to 4.00 group ranked 22.70, the 3.01 to 3.25 group ranked 22.04, and then the ≤ 3.00 group ranked 14.75. Although there was a significant difference in the GPA's between the experimental and control group, GPA did not seem to influence the results of the Pre-DCT or the Post-DCT scores.

ACT math scores. The ACT math scores were scattered across such a wide range that some ACT scores contained only one participant within that group. Therefore, in order to maintain anonymity, the groups were combined into two separate groups; those who had an ACT math score < 22 ($n = 28$) and then those who had ≥ 22 ($n = 19$). The groups were divided in this manner because an ACT math score of 22 was the benchmark score that students needed to achieve at this university in order to not have to complete a required math course. A Kruskal-Wallis H test was conducted comparing the outcome of the Pre-DCT with varying levels of ACT math scores. No significant difference was found ($H(1) = 3.360, p = .067$), indicating that the two different groups of ACT math scores did not differ significantly from each other on the Pre-DCT scores. The students with ACT math scores that were ≥ 22 ranked 28.42 and the students with ACT math scores < 22 ranked 21.00. The Kruskal-Wallis H test on the Post-DCT revealed similar findings with no significant difference in the two ACT groups and the Post-DCT scores ($H(1) = 2.205, p = .138$). The ranking order remained the same with the ACT math scores of ≥ 22 ranking 27.55 and < 22 ranking 21.59. ACT math scores did not seem to influence the results of the Pre- or Post-DCT scores.

Another Kruskal-Wallis H test was conducted on only those students who had < 22 ACT math score. The groups were divided between those students who had ($n = 24$) or had not ($n = 4$) completed the required math course. These groups were compared on the Pre- and the Post-DCT. No significant differences were found with either test ($H(1) = .027, p = .869$) and ($H(1) = .533, p = .465$). Those who had not completed the math requirement ranked 15.13 on the Pre-DCT as compared to those who had completed the requirement who ranked 14.40. The Post-DCT demonstrated that those who had not completed the math requirement ranked 17.25 and those who had completed the course ranked 14.04. The required math course did not seem to influence the results of the Pre- or Post-DCT scores for students with ACT math scores < 22 .

Gender. A Kruskal-Wallis H test comparing the outcomes of the Pre-DCT and the Post-DCT with gender revealed no significant difference in the scores ($H(1) = .001, p = .972$) and ($H(1) = .469, p = .494$) respectively. The males ($n = 14$) ranked 24.11 (Pre-DCT) and 26.07 (Post-DCT) as compared to the females ($n = 33$) who ranked 23.95 (Pre-DCT) and 23.12 (Post-DCT). Gender did not seem to influence the Pre- or Post-DCT.

Class level. In this particular sample, there was one freshman and one senior student. Therefore, the freshman and sophomore group combined into the lowerclassmen group ($n = 31$) and the junior and senior group combined for the upperclassmen group ($n = 16$). A Kruskal-Wallis H test revealed no significant difference in the Pre-DCT scores ($H(1) = .056, p = .812$) between the groups. The underclassmen group ranked 24.34, and the upperclassmen group ranked 23.34. The Kruskal-Wallis H test on the Post-DCT showed similar insignificant findings ($H(1) = .452, p = .502$). This time, the upperclassmen group ranked 25.84 and the lowerclassmen ranked 23.05. Although there

was a significant difference between the class levels and the experimental and control group, class ranking did not seem to influence the results of the Pre- or Post-DCT scores.

Ethnicity. Students were combined into Caucasian ($n = 32$) and non-Caucasian ($n = 15$) groups. The Kruskal-Wallis H test revealed that there were no significant differences in the scores between these groups ($H(1) = .153, p = .696$). Caucasians ranked 24.53 while non-Caucasians ranked 22.87. The Kruskal-Wallis H test conducted on differences between the two ethnic groups and the Post-DCT scores was also insignificant ($H(1) = .467, p = .494$). Caucasians ranked 24.92 while non-Caucasians ranked 22.03. Ethnicity did not seem to influence the Pre- or Post-DCT scores.

Healthcare experience. A final Kruskal-Wallis H test was conducted comparing the outcomes of students who had healthcare experience ($n = 7$) from those who did not ($n = 40$) on the Pre- and the Post-DCT. No significant differences were found with either test ($H(1) = .177, p = .674$) and ($H(1) = .405, p = .524$) respectively. The students without healthcare experienced ranked 24.35 as compared to the experienced students who ranked 22.00 on the Pre-DCT. Similar findings were discovered on the Post-DCT with students who had no healthcare experience ranking 24.53 as compared to the students with healthcare experience who ranked 21.00. Although the two research groups were imbalanced with students and healthcare experience, having or not having healthcare experience did not seem to influence the Pre-DCT or the Post-DCT scores.

Table 29

Kruskal-Wallis H Test Differences of Groups in Demographic Variables on Pre- and Post-Dosage Calculation Test Scores

Characteristics	<i>n</i>	Mean Rank	Kruskal-Wallis (<i>H</i>)	df	Significance
<u>Age</u>					
Pre-DCT			3.097	3	.377
19	20	25.35			
20	14	18.86			
21	7	26.57			
22 and older	6	28.50			
Post-DCT			1.873	3	.599
19	20	23.33			
20	14	25.68			
21	7	27.57			
22 and older	6	18.17			
<u>GPA</u>					
Pre-DCT			8.215	4	.084
≤ 3.00	6	17.75			
3.01 to 3.25	12	22.29			
3.26 to 3.50	12	22.33			
3.51 to 3.75	7	20.07			
3.76 to 4.00	10	34.55			
Post-DCT			5.599	4	.231
≤ 3.00	6	14.75			
3.01 to 3.25	12	22.04			
3.26 to 3.50	12	28.96			
3.51 to 3.75	7	28.64			
3.76 to 4.00	10	22.70			
<u>ACT Math Scores</u>					
Pre-DCT			3.360	1	.067
16 to 21	28	21.00			
22 to 30	19	28.42			
Post-DCT			2.205	1	.138
16 to 21	28	21.59			
22 to 30	19	27.55			
<u>Math Course for ACT < 22</u>					
Pre-DCT			.027	1	.869
Completed	24	14.40			
Not Completed	4	15.13			
Post-DCT			.533	1	.465
Completed	24	14.04			
Not Completed	4	17.25			
<u>Gender</u>					
Pre-DCT			.001	1	.972
Male	14	24.11			
Female	33	23.95			
Post-DCT			.469	1	.494
Male	14	26.07			
Female	33	23.12			

* No statistical significance found.

Table 29, (continued)

Characteristics	<i>n</i>	Mean Rank	Kruskal-Wallis (<i>H</i>)	df	Significance
<u>Class Level</u>					
Pre-DCT			.056	1	.812
Lowerclassmen	31	24.34			
Upperclassmen	15	23.34			
Post-DCT			.452	1	.502
Lowerclassmen	31	23.05			
Upperclassmen	15	25.84			
<u>Ethnicity</u>					
Pre-DCT			.153	1	.696
Caucasian	32	24.53			
Non-Caucasian	15	22.87			
Post-DCT			.467	1	.494
Caucasian	32	24.92			
Non-Caucasian	15	22.03			
<u>Healthcare Experience</u>					
Pre-DCT			.177	1	.674
Experienced	7	22.00			
Not Experienced	40	24.35			
Post-DCT			.405	1	.524
Experienced	7	21.00			
Not Experienced	40	24.53			

* No statistical significance found.

Effects of the Learning Experiences

A paired sample *t*-test is the preferred statistical test to analyze significant differences of how one variable changes when it is measured on more than one occasion. However, conducting paired *t*-tests would have been a violation of assumptions since these data were not normally distributed. Therefore, the nonparametric equivalent – a Wilcoxon signed rank sum test – was the appropriate test to use because it makes no assumptions about the shape of the distribution (Cronk, 2008) – (see Table 30 for a complete overview of the Wilcoxon signed rank sum test and the comparison with the demographic variables).

In order to answer the research question, Cohen's d scores were calculated to analyze the effects that a traditional case study in a classroom versus a low-fidelity simulation in a simulation laboratory had on the mean dosage calculation test scores between the experimental and the comparison group. Cohen d scores were also calculated to examine the effect between the other demographic variables. The findings are described below and are demonstrated in Table 31.

Experimental versus comparison group. A Wilcoxon signed rank sum test examined the results of the experimental groups ($n = 22$) Pre-DCT (mean = 24.14, SD = 5.401) and Post-DCT (mean = 28.23, SD = 2.759) scores. Students scored significantly higher on the Post-DCT after attending a low-fidelity simulation experience in the simulation laboratory ($Z = -3.225$, $p = .001$). A Wilcoxon test was also conducted on the comparison group ($n = 25$) to examine the results of the Pre- (mean = 22.92, SD = 4.957) and Post-DCT (mean = 27.36, SD = 3.915) scores. Students in the comparison group also did significantly better on the Post-DCT after having attended a classroom experience as compared to the Pre-DCT ($Z = -3.901$, $p = .000$).

According to Gravetter and Wallnau (2009), Cohen's d criterion for analyzing effect size indicates that an effect of 0.20 is considered "small", 0.50 is considered a "medium", and 0.80 and higher is considered "large". The answer to the research question is that the simulation and the classroom teaching methodology had a medium effect size in dosage calculation scores for both the experimental group (.49) and the comparison group (.55). The results of attending either teaching module yielded a difference of 4.28 questions or a 13.8% increase in overall scores for the entire group

($n = 47$). The experimental group increased by an average of 4.09 (13.2%) points and the comparison group increased by an average of 4.44 (14.3%) points.

Wilcoxon signed rank sum tests were conducted on each group of demographic variables. All groups experienced a significant increase in scores from Pre- to Post-DCT with the exception of students who were > 21 years old, had GPA scores < 3.01 or > 3.75 , had not completed the math course if they had an ACT math score < 22 , and those with healthcare experience (see Table 30 for complete statistical results). Cohen d scores were calculated for each demographic group. The majority of demographic groups experienced a medium effect size with the exception of students who were > 21 years old and had GPA scores > 3.75 . These groups experienced a small effect size (see Table 31 for a complete overview of the Cohen d results).

Table 30

Wilcoxon Signed Rank Sums Test – Comparison of Demographic Variables on the Pre- and Post-Dosage Calculation Test Scores

Characteristics	<i>n</i>		Pre-DCT Scores	Post-DCT Scores	Wilcoxon <i>Z</i>	Significance
<u>Experimental Group</u>	22	Mean	24.14	28.23	-3.225	.001*
		SD	5.401	2.759		
		Range	11 to 31	22 to 31		
<u>Comparison Group</u>	25	Mean	22.92	27.36	-3.901	.000*
		SD	4.957	3.915		
		Range	7 to 29	18 to 31		
<u>Age</u>						
19 years	20	Mean	23.95	27.80	-3.008	.003*
		SD	5.155	3.105		
		Range	11 to 31	19 to 31		
20 years	14	Mean	21.57	27.71	-3.183	.001*
		SD	5.680	4.177		
		Range	7 to 29	18 to 31		
21 years	7	Mean	24.86	29.00	-2.023	.043*
		SD	3.625	1.915		
		Range	19 to 29	26 to 31		
22 years and older	6	Mean	24.83	26.33	-.813	.416
		SD	5.231	4.033		
		Range	16 to 29	21 to 30		
<u>GPA Range</u>						
< or = 3.00	6	Mean	20.17	24.67	-1.577	.115
		SD	7.757	4.885		
		Range	7 to 28	18 to 31		
3.01 to 3.25	12	Mean	23.50	27.17	-2.567	.010*
		SD	3.344	3.927		
		Range	16 to 29	19 to 31		
3.26 to 3.50	12	Mean	22.75	29.00	-2.949	.003*
		SD	5.627	2.486		
		Range	11 to 29	24 to 31		
3.51 to 3.75	7	Mean	22.57	28.57	-2.375	.018*
		SD	4.860	3.505		
		Range	16 to 29	23 to 31		
3.76 to 4.00	10	Mean	27.00	28.30	-1.198	.231
		SD	3.399	1.418		
		Range	19 to 31	26 to 31		
<u>ACT Math Scores</u>						
Less than 22	28	Mean	22.46	27.00	-4.070	.000*
		SD	5.302	3.897		
		Range	7 to 29	18 to 31		
22 or Higher	19	Mean	25.00	28.89	-2.939	.003*
		SD	4.643	2.183		
		Range	14 to 31	23 to 31		

*Significant differences within the two groups were found at $p < 0.05$.

Table 30, (continued)

Characteristics	<i>n</i>		Pre-DCT Scores	Post-DCT Scores	<i>Wilcoxon Z</i>	Significance
<u>Required Math Course for ACT < 22</u>						
Completed	24	Mean SD Range	22.29 5.528 7 to 29	26.79 4.000 18 to 31	-3.755	.000*
Not Completed	4	Mean SD Range	23.50 4.123 19 to 27	28.25 3.403 24 to 31	-1.604	.109
<u>Gender</u>						
Males	14	Mean SD Range	24.07 3.430 16 to 28	28.29 3.099 21 to 31	-3.191	.001*
Females	33	Mean SD Range	23.24 5.756 7 to 31	27.55 3.563 18 to 31	-3.899	.000*
<u>Class Level</u>						
Lowerclassmen	31	Mean SD Range	23.77 4.822 11 to 31	27.87 2.655 22 to 31	-4.038	.000*
Upperclassmen	16	Mean SD Range	22.94 5.859 7 to 29	27.56 4.647 18 to 30	-3.081	.002*
<u>Ethnicity</u>						
Caucasians	32	Mean SD Range	23.97 4.344 14 to 31	28.16 2.864 21 to 31	-4.267	.000*
Non-Caucasians	15	Mean SD Range	22.47 6.610 7 to 29	26.93 4.367 18 to 31	-2.771	.006*
<u>Healthcare Experience</u>						
Experienced	7	Mean SD Range	23.29 4.112 16 to 29	26.43 4.826 19 to 31	-1.614	.106
Not Experienced	40	Mean SD Range	23.53 5.354 7 to 31	28.00 3.130 18 to 31	-4.830	.000*

*Significant differences within the two groups were found at $p < 0.05$.

Table 31

Effect Size for Demographic Groupings Utilizing Cohen d

Characteristics	<i>n</i>	Cohen's <i>d</i>	Effect Size
Experimental Group	22	.49	Medium
Comparison Group	25	.55	Medium
<u>Age</u>			
19 years	20	.48	Medium
20 years	14	.60	Medium
21 years	7	.54	Medium
22 years and older	6	.23	Small
<u>GPA Range</u>			
< or = 3.00	6	.46	Medium
3.01 to 3.25	12	.52	Medium
3.26 to 3.50	12	.60	Medium
3.51 to 3.75	7	.63	Medium
3.76 to 4.00	10	.27	Small
<u>ACT Math Scores</u>			
Less than 22	28	.54	Medium
22 or higher	19	.48	Medium
<u>Required Math Course for ACT < 22</u>			
Completed	24	.54	Medium
Not Completed	4	.58	Medium
<u>Gender</u>			
Males	14	.60	Medium
Females	33	.48	Medium
<u>Class Level</u>			
Lowerclassmen	31	.51	Medium
Upperclassmen	15	.56	Medium
<u>Ethnicity</u>			
Caucasians	32	.53	Medium
Non-Caucasians	15	.51	Medium
<u>Healthcare Experience</u>			
Experienced	7	.54	Medium
Not Experienced	40	.43	Medium

Research Question and Hypothesis Two

Q2: In fundamental nursing students, what effects does a traditional case study in a classroom versus a low-fidelity simulation in a simulation laboratory have on self-perceived judgment in dosage calculation scores?

H₀₂: There will be no differences in mean self-perceived judgment scores between fundamental nursing students who participate in a traditional case study in the classroom versus a low-fidelity simulation in the simulation lab.

In order to answer the research question, the nonparametric Wilcoxon signed rank sums test was utilized to measure the differences in self-perceived judgment before and after participants attended an experience in a traditional classroom environment or the simulation laboratory. Cohen *d* scores were then calculated to determine the effect size.

The appropriate statistical test to analyze the hypothesis was the nonparametric Mann-Whitney *U* test to examine the differences between the experimental group and the comparison group. In addition, the ANCOVA test was used to control for covariances such as age, GPA, and ACT scores and their possible influence on self-perceived judgment. Finally, the Kruskal-Wallis test was used to determine whether or not independent samples came from the same population. This section of results will begin with the differences in self-perceived judgment scores and will conclude with the effects that the teaching modules had on self-perceived judgment.

Differences in Mean Self-Perceived Judgment Scores

The Self-Perceived Judgment in Dosage Calculations Scale (SPJDSC) was a 15-item tool that utilized a 5-point Likert scale. The Pre-SPJDSC was administered after the students had completed the Pre-DCT. Students were to look back at the dosages they

had calculated for the Pre-DCT and determine how logical (5 points for highly logical) or illogical (1 point for highly illogical) their answers were for each one of the calculations completed. The overall mean score for the entire group ($n = 47$) for the Pre- SPJDCS was 3.740 (SD = .702) indicating that they were on the higher end of neutral in their self-perceived judgment as to whether their responses were logical or not. The experimental group ($n = 22$) scored a mean average of 3.867 (SD = .552) on the Pre-SPJDCS and the comparison group ($n = 25$) scored a mean average of 3.629 (SD = .807). A Mann-Whitney U test was used to examine the difference in self-perceived judgment on the Pre-SPJDCS between the experimental and comparison groups. No significant difference was found ($U = 237.500, p = .423$). The experimental group students averaged a mean rank of 25.70 on the Pre-SPJDCS, whereas the comparison group ranked 22.50.

The Post-SPJDCS was taken after both groups participated in their respective learning modules and then rejoined to complete the Post-DCT. Again, the students were to look back at their calculations for the dosages in the Post-DCT and then rate their self-perceived judgment on how logical or illogical their calculations were in their own opinion. The overall mean score for the entire group ($n = 47$) on the Post-SPJDCS was 4.166 (SD = .597) which indicated that students now perceived their calculations to be more logical than the Pre-DCT calculations. The experimental group ($n = 22$) attended the low-fidelity simulation experience in the simulation lab and obtained an overall mean score of 4.233 (SD = .564). In comparison, the comparison group ($n = 25$) attended the traditional case study in the classroom and obtained an overall mean score of 4.107 (SD = .629). A Mann-Whitney U test was utilized to examine the difference in the performance on the Post-SPJDCS between the experimental group and the comparison

group. No significant differences in the results of the mean scores were found ($U = 243.500, p = .500$). The experimental group students ranked an average of 25.43, whereas the comparison group ranked 22.74 (see Table 32). These findings led to a failure to reject the null hypothesis.

Table 32

Mann-Whitney U Comparison of the Experimental and Comparison Groups

Characteristics	Experimental Group ^a	Comparison Group ^b	Total Group ^c	Mann-Whitney U	Significance
Pre-SPJDCS					
Mean	3.867	3.629	3.740		
SD	.552	.807	.702		
Rank	25.70	22.50	-	237.500	.423
Post-SPJDCS					
Mean	4.233	4.107	4.166		
SD	.564	.629	.597		
Rank	25.43	22.74	-	243.500	.500

^a $n = 22$. ^b $n = 25$. ^c $n = 47$

*No significant differences between the two groups were found at $p < 0.05$.

Further analysis was conducted on self-perceived judgment and each individual dosage calculation question (see Table 33 for a complete overview). The entire group ($n = 47$) perceived that six calculations (40%) seemed logical (mean > 4.0) on the pre-DCT. These items were considered easier dosage calculations because they did not require multiple conversions to calculate the correct dosage. Four items (26.7%) were

perceived as neutral to logical and students remained neutral on five items (33.3%).

These five items were considered the most difficult because they required multiple conversions for intravenous route medications. In contrast, the Post-SPJDCS revealed that students perceived that twelve (80%) calculated dosages on the Post-DCT seemed logical. The three (20%) items that were perceived as neutral to logical were calculations that required multiple conversions for intravenous route medications.

Table 33

Comparison of Mean Scores for the Pre-/Post-Dosage Calculation Test and Self-Perceived Judgment in Dosage Calculations Skills

Medication		Experimental Group ^a				Comparison Group ^b				Combined Groups ^c			
		Pre-SPJ	Pre-DCT	Post-SPJ	Post-DCT	Pre-SPJ	Pre-DCT	Post-SPJ	Post-DCT	Pre-SPJ	Pre-DCT	Post-SPJ	Post-DCT
Zofran	Mean SD	4.32 .716	1.00 .000	4.27 .985	1.00 .000	3.92 1.077	1.00 .000	4.28 .737	1.00 .000	4.11 .938	1.00 .000	4.28 .852	1.00 .000
Haldol	Mean SD	4.23 .752	.91 .294	4.45 .596	.86 .351	3.96 1.172	.96 .200	4.32 .690	.96 .200	4.09 .996	.94 .247	4.38 .644	.91 .282
Lanoxin	Mean SD	4.18 .795	.95 .213	4.50 .598	1.00 .000	3.88 1.013	.84 .374	4.28 .737	.88 .332	4.02 .921	.89 .312	4.38 .677	.94 .247
Synthroid	Mean SD	4.23 .813	1.00 .000	4.41 .590	1.00 .000	3.96 1.098	.96 .200	4.20 .764	.92 .277	4.09 .974	.98 .146	4.30 .689	.96 .204
Dilantin	Mean SD	4.09 .868	.86 .351	4.41 .666	1.00 .000	3.60 1.118	.80 .408	4.20 .707	1.00 .000	3.83 1.028	.83 .380	4.30 .689	1.00 .000
Amikacin	Mean SD	4.41 .666	1.00 .000	4.45 .596	.91 .294	3.96 1.098	1.00 .000	4.32 .690	1.00 .000	4.17 .940	1.00 .000	4.38 .644	.96 .204
Symmetrel	Mean SD	4.14 .941	.95 .213	4.23 .752	.95 .213	3.88 1.054	.96 .200	4.08 .759	.80 .408	4.00 1.000	.96 .204	4.15 .751	.87 .337

^a $n = 22$. ^b $n = 25$. ^c $n = 47$

Table 33, (continued)

Medication		Experimental Group ^a				Comparison Group ^b				Combined Groups ^c			
		Pre-SPJ	Pre-DCT	Post-SPJ	Post-DCT	Pre-SPJ	Pre-DCT	Post-SPJ	Post-DCT	Pre-SPJ	Pre-DCT	Post-SPJ	Post-DCT
Heparin	Mean SD	3.86 .710	.77 .429	4.36 .658	.64 .492	3.68 1.069	.64 .490	4.16 .746	.88 .332	3.77 .914	.70 .462	4.26 .706	.77 .428
Aminophylline	Mean SD	3.95 .722	.82 .395	4.36 .727	1.00 .000	3.76 1.052	.92 .277	4.28 .678	1.00 .000	3.85 .908	.87 .337	4.32 .695	1.00 .000
Vincristine	Mean SD	3.23 .973	.41 .503	4.18 .853	.91 .294	3.24 .926	.16 .274	4.08 .759	.88 .332	3.23 .937	.28 .452	4.13 .797	.89 .312
Insulin	Mean SD	3.45 .858	.41 .503	4.00 .756	.82 .395	3.48 .770	.64 .490	4.00 .816	.96 .200	3.47 .804	.53 .504	4.00 .780	.89 .312
Pulmocare	Mean SD	3.68 .995	.77 .429	4.23 .685	.91 .294	3.60 .957	.76 .436	3.96 .790	.84 .374	3.64 .965	.77 .428	4.09 .747	.87 .337
Rantidine	Mean SD	3.23 .813	.73 .456	3.86 .834	.86 .351	3.24 .926	.64 .490	3.96 .790	.72 .458	3.23 .865	.68 .471	3.91 .803	.79 .414
NS	Mean SD	3.64 .848	.77 .429	3.95 .899	1.00 .000	3.36 1.075	.60 .500	3.84 .898	.80 .408	3.49 .975	.68 .471	3.89 .890	.89 .312
D5NS	Mean SD	3.36 .790	.59 .503	3.82 .958	.82 .395	2.92 1.115	.44 .507	3.64 .952	.68 .476	3.13 .992	.51 .505	3.72 .949	.74 .441

^a $n = 22$. ^b $n = 25$. ^c $n = 47$

The experimental group ($n = 22$) perceived that seven (26.7%) dosage calculations were logical, five (33.3%) were neutral to logical, and three (20%) were neutral on the Pre-DCT. The level of difficulty paralleled the findings for the entire group with the easier questions seeming more logical than the more difficult calculations. Twelve items (80%) were perceived as logical and three items (20%) – IV dosage calculations – were perceived as neutral to logical for the Post-DCT. In contrast, the comparison group ($n = 25$) felt that none of the calculated dosages were logical and that 10 calculations (66.6%) were perceived as neutral to logical, four items (26.7%) were neutral, and one item (6.7%) was illogical to neutral. After the Post-DCT, the comparison group perceived that eleven dosage calculations were logical (73.3%) and four items (26.7%) on IV dosage calculations were perceived as logical to neutral. Mann Whitney U tests revealed no significant differences between the groups (see Table 34).

Table 34

Mann-Whitney U Comparison of Individual Items on the Pre-/Post-Self-Perceived Judgment in Dosage Calculation Skills

Medication	Pre-SPJDCS			Post-SPJDCS		
	Mean Rank	<i>U</i>	Sig	Mean Rank	<i>U</i>	Sig
<u>Zofran</u>						
Experimental Group ^a	26.41	222.000	.228	24.77	258.000	.693
Comparison Group ^b	21.88			23.32		
<u>Haldol</u>						
Experimental Group	24.98	253.500	.626	25.18	249.000	.537
Comparison Group	23.14			22.96		
<u>Lanoxin</u>						
Experimental Group	25.86	234.000	.353	25.91	233.000	.322
Comparison Group	22.36			22.32		
<u>Synthroid</u>						
Experimental Group	25.43	243.500	.475	25.70	237.500	.381
Comparison Group	22.74			22.50		
<u>Dilantin</u>						
Experimental Group	27.11	206.500	.124	26.02	230.500	.298
Comparison Group	21.26			22.22		
<u>Amikacin</u>						
Experimental Group	26.66	216.500	.180	25.18	249.000	.537
Comparison Group	21.66			22.96		
<u>Symmetrel</u>						
Experimental Group	25.80	235.500	.372	25.55	241.000	.429
Comparison Group	22.42			22.64		
<u>Heparin</u>						
Experimental Group	25.14	250.000	.573	25.82	235.000	.353
Comparison Group	23.00			22.40		
<u>Aminophylline</u>						
Experimental Group	25.02	252.500	.611	24.98	253.500	.615
Comparison Group	23.10			23.14		
<u>Vincristine</u>						
Experimental Group	23.84	271.500	.933	25.20	248.500	.544
Comparison Group	24.14			22.94		
<u>Insulin</u>						
Experimental Group	24.18	271.000	.927	24.20	270.500	.918
Comparison Group	23.84			23.82		
<u>Pulmocare</u>						
Experimental Group	24.52	263.500	.797	26.36	223.000	.233
Comparison Group	23.54			21.92		
<u>Ranitidine</u>						
Experimental Group	23.80	270.500	.918	23.64	267.000	.854
Comparison Group	24.18			24.32		
<u>NS Drip</u>						
Experimental Group	25.64	239.000	.416	25.16	249.500	.566
Comparison Group	22.56			22.98		
<u>D5NS Drip</u>						
Experimental Group	26.27	225.000	.255	25.32	246.000	.515
Comparison Group	22.00			22.84		

^a*n* = 22. ^b*n* = 25.

*No significant differences between the two groups were found at $p < 0.05$.

Analysis of Covariates

To determine if age, GPA, and ACT scores might have had any influence on the Pre-/Post-SPJDCS scores, an ANCOVA was conducted to obtain an estimate of the differences between the experimental and comparison group in this study. The ANCOVA test is typically used when data demonstrate a normal distribution although it was utilized in this study with skewed results because there are no nonparametric equivalent tests available.

A one-way between-subjects ANCOVA was utilized to examine the effect of the experimental group ($n = 22$) and the comparison group ($n = 25$) on the Pre-SPJDCS mean scores when the covariances of age, GPA, and ACT math scores were factored out of the equation. The main effect for each lab group was insignificant ($F(1, 41) = 1.836$, $p = .140$), with the experimental group not obtaining a significantly higher Pre-SPJDCS mean score (mean = 3.867, SD = .552) than the comparison group (mean = 3.629, SD = .807) when covarying out the effect of age, GPA, and ACT math scores (see Table 35 for a complete overview).

After the Pre-DCT and Pre-SPJDCS, the experimental group attended a low-fidelity simulation in the simulation laboratory and the comparison group attended a traditional case study in the classroom. Then the two groups rejoined and took the Post-DCT and the Post-SPJDCS at the same time. A one-way between-subjects ANCOVA was utilized to examine if the increased self-perceived judgment scores could be explained by the effects of age, GPA, and ACT math scores. The main effect for each lab group was insignificant ($F(1, 41) = .960$, $p = .440$), with the experimental group not obtaining a significantly higher Post-SPJDCS mean score (mean = 4.233, SD = .564)

than the comparison group (mean = 4.107, SD = .629), when age, GPA, and ACT math scores were covaried out of the equation.

Table 35

Analysis of Covariates Between Groups Pre- and Post-Self-Perceived Judgment in Dosage Calculation Skills

Characteristics	Sum of Square	df	Mean Square	<i>F</i>	Significance
Age					
Pre-SPJDCS	.851	1	.851	1.819	.185
Post-SPJDCS	1.064	1	1.064	2.916	.095
GPA					
Pre-SPJDCS	.141	1	.141	.302	.586
Post-SPJDCS	.126	1	.126	.347	.559
ACT Math					
Pre-SPJDCS	.831	1	.831	1.775	.190
Post-SPJDCS	.174	1	.174	.476	.494

*Significance noted at $p < 0.05$. No statistical significance found.

Differences Within and Between the Groups

The Kruskal-Wallis *H* test is the nonparametric equivalent of the ANOVA test and it can compare the outcomes of two or more groups within a single category. It was the appropriate test to use since the data were not normally distributed – (see table 36 for a complete overview of all of the demographic variables).

Age. A Kruskal-Wallis H test was conducted comparing the outcome of the Pre-SPJDCS with the varying levels of age. The age categories remain as previously described with the 22 year olds and older all grouped together to protect anonymity. No significant differences were found ($H(3) = 3.443, p = .328$), indicating that the age groups did not differ significantly from each other. Students who were 21 years old ($n = 7$) ranked the highest (30.00), followed by 20 year olds ($n = 14$, ranked 26.96), 22 year olds and older ($n = 6$, ranked 20.92), and then 19 year olds ($n = 20$, ranked 20.75). The Kruskal-Wallis H test was also conducted to compare the Post-SPJDCS with the varying categories of age. Again, no significant differences were found ($H(3) = 1.591, p = .661$). In this particular instance, the ranking order began with 22 year olds and older group (29.50), then 20 year olds (24.82), 19 year olds (23.00), and then 21 year olds (20.50). Age did not seem to influence the results of the Pre-/Post-SPJDCS scores.

Grade point average. GPA scores were combined into five separate ranges in an attempt to maintain anonymity. A Kruskal-Wallis H test was conducted comparing the outcome of the mean Pre-SPJDCS score with the varying ranges of GPA scores. No significant differences were found ($H(4) = 6.116, p = .191$), indicating that the different groups of GPA ranges did not differ significantly from each other on the Pre-SPJDCS test. Students with the highest GPA range of 3.76 to 4.00 ($n = 10$) ranked 33.20, followed by students in the 3.01 to 3.25 range ($n = 12$, ranked 23.38), students in the 3.26 to 3.50 range ($n = 12$, ranked 21.00), students in the ≤ 3.00 range ($n = 6$, ranked 20.75), and then those students in the 3.51 to 3.75 range ($n = 7$, ranked 19.86). The Kruskal-Wallis H test for the Post-SPJDCS also demonstrated no significant differences ($H(4) = 3.107, p = .540$) although the ranges of GPA took on a different pattern of rankings. The 3.75 to

4.00 GPA group ranked 29.55, the 3.26 to 3.50 GPA group ranked 25.33, the 3.01 to 3.25 group ranked 22.13, the ≤ 3.00 3.01 to 3.25 group ranked 21.67, and then the 3.51 to 3.75 group ranked 19.00. GPA did not seem to influence the results of the Pre-/Post-SPJDCS scores.

ACT math scores. ACT math scores were combined into two separate groups, those who had an ACT math score < 22 ($n = 28$) and then those who had ≥ 22 ($n = 19$) based upon these universities standards for needing a required math course. A Kruskal-Wallis H test was conducted comparing the outcome of the Pre-SPJDCS with the two levels of ACT math scores. No significant difference was found ($H(1) = .795, p = .373$), indicating that the two different groups of ACT math scores did not differ significantly from each other on the Pre-SPJDCS scores. The students with higher ACT math scores ≥ 22 ranked 26.16 and the students with ACT math scores < 22 ranked 22.54. The Kruskal-Wallis H test on the Post-SPJDCS revealed similar findings with no significant differences in the two ACT groups and the Post-SPJDCS scores ($H(1) = .043, p = .836$). The ranking order remained the same with the ACT math scores of ≥ 22 ranking 24.50 and the < 22 ACT math scores ranking 23.66. ACT math scores did not seem to influence the results of the Pre-/Post-SPJDCS scores.

Another Kruskal-Wallis H test was conducted on students who had less than a 22 ACT math score. The groups were divided between those students who had ($n = 24$) or had not ($n = 4$) completed the required math course. These groups were compared on the Pre- and the Post-SPJDCS. No significant difference was found with either the Pre- ($H(1) = .478, p = .489$) or Post-SPJDCS ($H(1) = 1.408, p = .235$). Those who had not completed the math requirement ranked 17.13 on the Pre-SPJDCS as compared to those

who had completed the requirement who ranked 14.06. The Post-SPJDCS demonstrated that those who had not completed the math requirement ranked 19.00 and those who had completed the course ranked 13.75. The required math course did not seem to influence the results of the Pre-/Post-SPJDCS scores for students with ACT math scores < 22 .

Gender. A Kruskal-Wallis H test comparing the outcomes of the Pre-/Post-SPJDCS with gender revealed no significant difference in the scores ($H(1) = .218$, $p = .641$) and ($H(1) = .341$, $p = .559$) respectively. The males ($n = 14$) ranked 25.43 and the females ($n = 33$) ranked 23.39 on the Pre-SPJDCS. The females ranked 24.76 and the males ranked 22.21 on the Post-SPJDCS. Gender did not seem to influence the results of the Pre-/Post-SPJDCS scores.

Class level. The freshman and sophomore group were combined to form the underclassman group ($n = 31$) and the junior and senior group were combined into the upperclassmen group ($n = 16$). A comparison of Pre-SPJDCS scores was made with these two different class levels utilizing a Kruskal-Wallis H test. No significant difference in the scores was noted ($H(1) = .874$, $p = .350$) between the groups. The upperclassmen group ranked 26.59, and the underclassmen group ranked 22.66. The Kruskal-Wallis H test on the Post-SPJDCS showed similar insignificant findings ($H(1) = .269$, $p = .604$). Again, the upperclassmen group ranked 25.44 and the underclassmen ranked 23.26. Class levels did not seem to influence the results of the Pre-/Post-SPJDCS scores.

Ethnicity. Ethnic groups were combined into Caucasian ($n = 32$) and non-Caucasian ($n = 15$) since there were not enough participants in the five different ethnic categories. The Kruskal-Wallis H test comparing the outcomes of students from Caucasian and non-Caucasian groups and the Pre-SPJDCS revealed that there were no

significant differences in the scores between these groups ($H(1) = .189, p = .664$). The non-Caucasian group ranked 25.27 and the Caucasian group ranked 23.41. The Kruskal-Wallis H test conducted on differences between these two ethnic groups and the Post-SPJDCS scores was also insignificant ($H(1) = 1.185, p = .276$). Non-Caucasians ranked 27.17 and Caucasians ranked 22.52. Ethnicity did not seem to influence the results of the Pre-/Post-SPJDCS scores.

Healthcare experience. A final Kruskal-Wallis H test was conducted comparing the outcomes of students who had healthcare experience ($n = 7$) from those who did not ($n = 40$) on the Pre- and the Post-SPJDCS. No significant difference was found with either test ($H(1) = 1.069, p = .301$) and ($H(1) = .632, p = .427$) respectively. The students without healthcare experienced ranked 24.86 as compared to the experienced students who ranked 19.07 on the Pre-SPJDCS. Similar findings were discovered on the Post-SPJDCS with students who had no healthcare experience who ranked 24.66 as compared to the students with healthcare experience who ranked 20.21. Healthcare experience did not seem to influence the Pre-/Post-SPJDCS results.

Table 36

Kruskal-Wallis H Test Differences of Groups on Pre- and Post-Self-Perceived Judgment in Dosage Calculation Skills

Characteristics	<i>n</i>	Mean Rank	Kruskal-Wallis (<i>H</i>)	df	Significance
<u>Age</u>					
Pre-SPJDCS			3.443	3	.328
19	20	20.75			
20	14	26.96			
21	7	30.00			
22 and older	6	20.92			
Post-SPJDCS			1.591	3	.661
19	20	23.00			
20	14	24.82			
21	7	20.50			
22 and older	6	29.50			
<u>GPA</u>					
Pre-SPJDCS			6.116	4	.191
≤ 3.00	6	20.75			
3.01 to 3.25	12	23.38			
3.26 to 3.50	12	21.00			
3.51 to 3.75	7	19.86			
3.76 to 4.00	10	33.20			
Post-SPJDCS			3.107	4	.540
≤ 3.00	6	21.67			
3.01 to 3.25	12	22.13			
3.26 to 3.50	12	25.33			
3.51 to 3.75	7	19.00			
3.76 to 4.00	10	29.55			
<u>ACT Math Scores</u>					
Pre-SPJDCS			.795	1	.373
16 to 21	28	22.54			
22 to 30	19	26.16			
Post-SPJDCS			.043	1	.836
16 to 21	28	23.66			
22 to 30	19	24.50			
<u>Math Course for ACT < 22</u>					
Pre-SPJDCS			.478	1	.489
Completed	24	14.06			
Not Completed	4	17.13			
Post-SPJDCS			1.408	1	.235
Completed	24	13.75			
Not Completed	4	19.00			
<u>Gender</u>					
Pre-SPJDCS			.218	1	.641
Male	14	25.43			
Female	33	23.39			
Post-SPJDCS			.341	1	.559
Male	14	22.21			
Female	33	24.76			

*No statistical significance noted at $p < 0.05$.

Table 36, (continued)

Characteristics	<i>n</i>	Mean Rank	Kruskal-Wallis (<i>H</i>)	df	Significance
<u>Class Level</u>					
Pre-SPJDCS			.874	1	.350
Lowerclassmen	31	22.66			
Upperclassmen	16	26.59			
Post-SPJDCS			.269	1	.604
Lowerclassmen	31	23.26			
Upperclassmen	16	25.44			
<u>Ethnicity</u>					
Pre-SPJDCS			.189	1	.664
Caucasian	32	23.41			
Non-Caucasian	15	25.27			
Post-SPJDCS			1.185	1	.276
Caucasian	32	22.52			
Non-Caucasian	15	27.17			
<u>Healthcare Experience</u>					
Pre-SPJDCS			1.069	1	.301
Experienced	7	24.86			
Not Experienced	40	19.07			
Post-SPJDCS			.632	1	.427
Experienced	7	24.66			
Not Experienced	40	20.21			

*No statistical significance noted at $p < 0.05$.

Effects of the Learning Experiences

To examine the effects of each learning module and the effects noted within each demographic variable, the nonparametric equivalent of a paired *t*-test – a Wilcoxon signed rank sum test – was utilized to examine the changes in self-perceived judgment that took place after the students had attended their learning module. Cohen *d* scores were calculated to measure the effect size (see Table 37 and 38 for a complete overview of all of the demographic variables).

Experimental versus comparison group.

A Wilcoxon signed rank sum test examined the results of the experimental group's ($n = 22$) Pre- and Post-SPJDCS scores. A significant difference was found in the results ($Z = -2.984$, $p = .003$). Students scored significantly higher on the Post-SPJDCS

(mean = 4.233, SD = .564) than they did on the Pre-SPJDSC (mean = 3.867, SD = .552) after attending a low-fidelity simulation experience in the simulation laboratory. These results indicate that students perceived that their calculated dosages were more logical after attending the simulation learning module. A Wilcoxon test was also conducted on the comparison group ($n = 25$) to examine the results of the Pre-SPJDSC (mean = 3.629, SD = .807) and Post-SPJDSC (mean = 4.107, SD = .629) scores. Students in the comparison group also scored significantly higher on the Post-SPJDSC after having attended a classroom experience as compared to the Pre-SPJDSC ($Z = -2.556$, $p = .011$), which indicated that the students perceived their calculations to be more logical after they attended the classroom learning module.

Cohen's d criterion for analyzing effect size indicates that an effect of 0.20 is considered a "small" effect, approximately 0.50 is considered a "medium" effect, and 0.80 and higher is considered a "large" effect (Gravetter & Wallnau, 2009). The simulation and the classroom teaching methodology had a medium effect size in calculation scores for the experimental group (.45) and a small to medium effect size for the comparison group (.36).

Wilcoxon signed rank sum tests were conducted on each group of demographic variables. All groups experienced a significant increase in scores from Pre- to Post-SPJDSC with the exception of students who were > 20 years old, had GPA scores > 3.50, had not completed the math course if they had an ACT math score < 22, males, upperclassmen, and those with healthcare experience (see Table 37 for complete statistical results). Cohen d scores were calculated for each of these demographic groups. Most groups experienced a medium effect size. However, males and students with ACT

math scores > 22 experienced a small to medium effect size, students with GPA's > 3.50 , upperclassmen, and Caucasians experienced a small effect size, and students who were > 21 years old experienced no effect size (see Table 38 for a complete overview of the Cohen d results).

Table 37

Wilcoxon Signed Rank Sums Test – Comparison of the Pre- and Post-Self-Perceived Judgment in Dosage Calculation Skills

Characteristics	<i>n</i>		Pre-SPJDCS Scores	Post-SPJDCS Scores	Wilcoxon <i>Z</i>	Sig.
<u>Experimental Group</u>	22	Mean	3.867	4.233	-2.984	.003*
		SD	.552	.564		
		Range	3.00 to 4.87	3.00 to 5.00		
<u>Comparison Group</u>	25	Mean	3.629	4.107	-2.556	.011*
		SD	.807	.629		
		Range	1.13 to 4.60	3.00 to 5.00		
<u>Age</u>						
19 years	20	Mean	3.633	4.087	-2.843	.004*
		SD	.500	.662		
		Range	3.00 to 4.53	3.00 to 5.00		
20 years	14	Mean	3.929	4.248	-2.201	.028*
		SD	.624	.492		
		Range	2.87 to 4.87	3.60 to 5.00		
21 years	7	Mean	3.991	4.057	-.135	.893
		SD	.799	.504		
		Range	2.47 to 4.60	3.60 to 4.87		
22 years and older	6	Mean	3.347	4.367	-1.841	.066
		SD	1.187	.753		
		Range	1.13 to 4.40	3.00 to 5.00		
<u>GPA Range</u>						
< or = 3.00	6	Mean	3.600	4.133	-2.023	.043*
		SD	.811	.467		
		Range	2.47 to 4.60	3.60 to 4.80		
3.01 to 3.25	12	Mean	3.767	4.106	-2.136	.033*
		SD	.473	.658		
		Range	2.87 to 4.53	3.0 to 5.0		
3.26 to 3.50	12	Mean	3.494	4.206	-2.666	.008*
		SD	.928	.666		
		Range	1.13 to 4.60	3.0 to 5.0		
3.51 to 3.75	7	Mean	3.581	3.895	-1.016	.310
		SD	.403	.633		
		Range	3.13 to 4.00	3.00 – 4.80		
3.76 to 4.00	10	Mean	4.200	4.400	-.972	.331
		SD	.610	.485		
		Range	3.00 to 4.87	3.67 to 5.00		
<u>ACT Math Scores</u>						
Less than 22	28	Mean	3.595	4.141	-3.199	.001*
		SD	.762	.663		
		Range	1.13 to 4.60	3.00 to 5.00		
22 or Higher	19	Mean	3.933	4.211	-2.207	.027*
		SD	.589	.521		
		Range	3.00 to 4.87	3.00 to 5.00		
<u>Required Math Course for ACT < 22</u>						
Completed	24	Mean	3.603	4.094	-2.778	.005*
		SD	.823	.664		
		Range	1.13 to 4.80	3.00 to 5.00		
Not Completed	4	Mean	3.850	4.550	-1.461	.144
		SD	.494	.526		
		Range	3.13 to 4.27	3.80 to 5.00		

*Significant differences within the two groups were found at $p < 0.05$.

Table 37, (continued)

Characteristics	<i>n</i>		Pre-SPJDCS Scores	Post-SPJDCS Scores	<i>Wilcoxon Z</i>	Sig.
<u>Gender</u>						
Males	14	Mean	3.838	4.100	-1.779	.075
		SD	.662	.643		
		Range	2.87 to 4.80	3.00 to 4.87		
Females	33	Mean	3.699	4.194	-3.375	.001*
		SD	.725	.584		
		Range	1.13 to 4.87	3.00 to 5.00		
<u>Class Level</u>						
Underclassmen	31	Mean	3.731	4.136	-3.533	.000*
		SD	.550	.604		
		Range	2.87 to 4.87	3.00 to 5.00		
Upperclassmen	15	Mean	3.768	4.225	-1.767	.077
		SD	.952	.598		
		Range	1.13 to 4.60	3.00 to 5.00		
<u>Ethnicity</u>						
Caucasians	32	Mean	3.706	4.110	-2.599	.009*
		SD	.717	.609		
		Range	1.13 to 4.80	3.00 to 5.00		
Non-Caucasians	15	Mean	3.813	4.284	-3.066	.002*
		SD	.687	.572		
		Range	2.47 to 4.87	3.00 to 5.00		
<u>Healthcare Experience</u>						
Experienced	7	Mean	3.343	4.010	-1.753	.080
		SD	1.063	.664		
		Range	1.13 to 4.40	3.00 to 5.00		
Not Experienced	40	Mean	3.810	4.193	-3.533	.000*
		SD	.612	.589		
		Range	2.47 to 4.87	3.00 to 5.00		

*Significant differences within the two groups were found at $p < 0.05$.

Table 38

Cohen d Effect Size for Demographic Variables

Characteristics	<i>n</i>	Cohen's <i>d</i>	Effect Size
Experimental Group	22	.45	Medium
Comparison Group	25	.36	Small to Medium
<u>Age</u>			
19 years	20	.45	Medium
20 years	14	.42	Medium
21 years	7	.53	Medium
22 years and older	6	.04	No Effect
<u>GPA Range</u>			
< or = 3.00	6	.58	Medium
3.01 to 3.25	12	.44	Medium
3.26 to 3.50	12	.54	Medium
3.51 to 3.75	7	.27	Small
3.76 to 4.00	10	.22	Small
<u>ACT Math Scores</u>			
Less than 22	28	.43	Medium
22 or higher	19	.36	Small to Medium
<u>Required Math Course for ACT < 22</u>			
Completed	24	.40	Medium
Not Completed	4	.52	Medium
<u>Gender</u>			
Males	14	.34	Small to Medium
Females	33	.42	Medium
<u>Class Level</u>			
Lowerclassmen	31	.45	Medium
Upperclassmen	15	.32	Small
<u>Ethnicity</u>			
Caucasians	32	.32	Small
Non-Caucasians	15	.53	Medium
<u>Healthcare Experience</u>			
Experienced	7	.47	Medium
Not Experienced	40	.40	Medium

Research Question and Hypothesis Three

Q3: In fundamental nursing students, does learning in a traditional case study in a classroom versus low-fidelity simulation in a simulation laboratory make a difference in self-confidence in learning?

H₀₃: There will be no difference in the level of self-confidence between fundamental nursing students in a traditional case study in the classroom versus a low-fidelity simulation in the simulation lab.

Differences Between the Groups

Nonparametric tests were utilized to answer this research question and hypothesis since the data did not demonstrate a normal distribution. Mann-Whitney *U* tests were used to determine the differences between the two research groups and self-confidence in learning after attending their respective learning intervention. Unfortunately, the research collector for the comparison group failed to obtain identification on this tool making it impossible for the researcher to distinguish the demographic details on the classroom group of students. A second attempt to obtain the data would have risked obtaining much different results. Therefore, the data analysis is limited to the classroom group versus the simulation group. Table 39 has a complete overview of each of these tests.

A Mann-Whitney *U* test was calculated to examine the ranking of the mean self-confidence in learning scores between the two research groups – students who attended a low-fidelity simulation ($n = 22$) in the simulation lab versus students who completed a case study in a traditional classroom experience ($n = 25$). There was no significant difference between the two groups and the overall mean score for self-confidence in learning ($U = 192.500, p = .076$). Students in the experimental group averaged a rank of

27.75 whereas the comparison group averaged a rank of 20.70. This finding led to a failure to reject the null hypothesis when examining the tool as a whole.

The eight items on the NLN tool that represented self-confidence in learning were unique so individual Mann-Whitney U tests were run for each item. The first item measured a student's confidence that they were mastering the content and the second item measured the student's confidence that the learning module covered critical content. Mann Whitney U tests revealed no significant differences between the two research groups ($U = 207.000, p = .112$) and ($U = 227.500, p = .265$) respectively. The experimental group ranked higher (27.09) for confidence in content mastery and (26.16) for covering critical content than the comparison group (21.28 and 22.10 respectively).

A Mann-Whitney U test was calculated to examine the third item which measured the difference between the two research groups and their confidence that they were developing the skills and obtaining the required knowledge necessary to perform tasks in a clinical setting. Students in the experimental group were significantly more confident ($U = 163.000, p = .005$) that they had developed these necessary skills and obtained knowledge (rank = 29.09) than students in the comparison group (rank = 19.52). A corrected item-correlation was conducted on this particular item and the results revealed that this question was considered reliable on its own at .838.

A Mann-Whitney U test was calculated to examine the fourth item which measured the difference between the two research groups and the level of confidence that the instructor used helpful resources to teach the learning module. It was determined that there was a significant difference ($U = 124.500, p = .000$) between the groups. Students in the experimental group were more confident that their instructor was using helpful

resources (rank = 30.84) than students in the comparison group (rank = 19.98). A corrected item-correlation was conducted on this particular item and the results revealed that this question was considered reliable on its own at .693.

There was no significant difference between the groups and their confidence that it was their responsibility to learn what they needed to know from their teaching module ($U = 242.500, p = .403$). Students in the experimental group averaged a rank of 24.48 for confidence in self-responsibility for learning whereas the comparison group averaged a rank of 22.70. There was no significant difference between the two research groups and their confidence in their ability to know how to get help when they do not understand a concept ($U = 262.500, p = .757$). The experimental group ranked 23.43 and the comparison group ranked 24.50. The difference between the two groups and their confidence in their ability to know how to use simulation activities to learn critical aspects of necessary skills was not significant ($U = 224.500, p = .222$). The experimental group ranked 26.30 and the comparison group ranked 21.98. Finally, there was no significant difference in a student's confidence that it was the instructor's responsibility to tell them what they were expected to learn during the simulation activity during regular class time ($U = 253.500, p = .610$). Students in the experimental group ranked 24.98 and students in the comparison group ranked an average of 23.14.

An analysis of individual items revealed that students in the experimental group were significantly more confident to perform in clinical settings with the knowledge and skills they had gained and that the instructor had used helpful resources. These individual item findings led to a rejection of the null hypothesis.

Table 39

Mann-Whitney U Comparison of Self-Confidence in Learning Between Groups

Characteristics	Experimental Group ^a	Comparison Group ^b	Mann-Whitney <i>U</i>	Significance
<u>Complete Tool</u>				
Mean	4.563	4.260	192.500	.076
SD	.336	.584		
Rank	27.75	20.70		
<u>Q1</u>				
Mean	4.500	4.160	207.000	.112
SD	.598	.746		
Rank	27.09	21.28		
<u>Q2</u>				
Mean	4.500	4.200	227.500	.265
SD	.598	.866		
Rank	26.16	22.10		
<u>Q3</u>				
Mean	4.820	4.240	163.000	.005*
SD	.395	.831		
Rank	29.09	19.52		
<u>Q4</u>				
Mean	4.770	3.840	124.500	.000*
SD	.429	1.106		
Rank	30.84	17.98		
<u>Q5</u>				
Mean	4.640	4.560	242.500	.403
SD	.727	.583		
Rank	25.48	22.70		
<u>Q6</u>				
Mean	4.500	4.600	262.500	.757
SD	.673	.500		
Rank	23.43	24.50		
<u>Q7</u>				
Mean	4.590	4.360	224.500	.222
SD	.503	.638		
Rank	26.30	21.98		
<u>Q8</u>				
Mean	4.180	4.120	253.500	.610
SD	.907	.781		
Rank	24.98	23.14		

^a*n* = 22. ^b*n* = 25.*Significant differences between the two groups were found at $p < 0.05$.

Relationships Between The Groups

To determine the strength of the relationship between the two research groups and self-confidence in learning, a Spearman *rho* correlation coefficient was calculated. A coefficient of $> .8$ indicates a strong correlation, $.6$ to $.8$ is moderately strong, $.4$ to $.6$ is moderate, $.2$ to $.4$ is weak, and $< .2$ indicates no correlation (Houser, 2008) – (Table 40 contains a complete overview).

A Spearman *rho* correlation coefficient was calculated for the relationship of the mean score of self-confidence in learning with students who were in the experimental group versus students in the comparison group. A weak, positive correlation that was not significant was found ($r(45) = .261, p = .076$). Students in both research groups were equally self-confident in their learning experience.

Spearman *rho* correlation coefficients were analyzed for each individual item. A Spearman *rho* correlation coefficient was calculated for the relationship between the two research groups and a student's confidence that they were developing the necessary skills and obtaining the required knowledge to perform tasks in a clinical setting. A moderate, positive correlation was found ($r(45) = .410, p = .004$) indicating that students in the experimental group tended to be more confident that they were developing skills and gaining knowledge that would help them in a clinical setting than students in the comparison group.

A Spearman *rho* correlation coefficient was calculated for the relationship between the two research groups and their confidence that the instructor used helpful resources to teach the simulation module. A moderate positive correlation was revealed ($r(45) = .523, p = .000$) indicating that students in the experimental group tended to feel

their instructor used helpful resources more so than students in the comparison group. No other significant relationships were found between any of the other six items on this tool.

Table 40

Spearman Rho Correlation Coefficient of Self-Confidence in Learning

Characteristics	<i>r</i>	df	Significance
Overall Mean	.261	45	.076
Q1	.234	45	.113
Q2	.164	45	.270
Q3	.410	45	.004*
Q4	.523	45	.000*
Q5	.123	45	.409
Q6	-.046	45	.761
Q7	.180	45	.226
Q8	.075	45	.616

*Significant correlations were found at $p < 0.05$.

Research Question and Hypothesis Four

Q4: In fundamental nursing students, does learning in a traditional case study in a classroom versus low-fidelity simulation in a simulation laboratory make a difference in satisfaction with learning?

H₀₄: There will be no difference in the level of satisfaction with learning between fundamental nursing students in a traditional case study in the classroom versus a low-fidelity simulation in the simulation lab.

Differences Between the Groups

In order to answer this research question and hypothesis, nonparametric tests were utilized since the data did not demonstrate a normal distribution. Mann-Whitney *U* tests were used to determine the differences between the two research groups and satisfaction with learning. Table 41 has a complete overview of each of these tests.

A Mann-Whitney *U* test was calculated examining the ranking of the mean satisfaction scores with current learning between students who had attended a low-fidelity simulation experience and those who attended a traditional classroom experience and completed a case study that paralleled what the students in simulation received. Students who attended the traditional classroom experience were significantly less satisfied with the learning experience overall (rank = 16.54) than the students who participated in the low-fidelity simulation experience (rank = 32.48; $U = 88.500$, $p = .000$). This finding led to a rejection of the null hypothesis that there would be no differences between the two groups.

The five items related to satisfaction with current learning were unique. Therefore, a Mann-Whitney *U* test was conducted with each individual item to provide enlightenment on what constituted satisfaction with current learning. The first question assessed whether the simulation experience was helpful and effective. The experimental group was significantly more satisfied (rank = 31.05) with how helpful and effective the teaching module was in their opinion as compared to the comparison group who attended

the classroom experience (rank = 17.80; $U = 120.000$, $p = .000$). The next question asked about the variety of learning materials and activities provided that would promote learning. Again, the experimental group was more satisfied (rank = 32.18) as compared to the comparison group (rank = 16.80; $U = 95.000$, $p = .000$). The third question addressed how much the student enjoyed how the instructor taught the module and the experimental group was more satisfied (rank = 32.07) than the comparison group (rank = 16.90; $U = 97.500$, $p = .000$). The fourth question determined that students in the experimental group were more satisfied with how the teaching materials motivated them to learn (rank = 30.70) than the comparison group (rank = 18.10; $U = 127.500$, $p = .000$). Finally, the last question revealed that the experimental group was more satisfied (rank = 32.14) with how the instructor taught the simulation to make it suitable for their own learning needs (rank = 16.84; $U = 96.000$, $p = .000$) than the comparison group. All of these findings led to a rejection of the null hypothesis that there would be no differences in satisfaction with current learning between students who attended a low-fidelity simulation experience versus students who completed a case study in a traditional classroom experience.

Table 41

Mann-Whitney U Comparison of Satisfaction with Current Learning Between Groups

Characteristics		Experimental Group ^a	Comparison Group ^b	Mann-Whitney <i>U</i>	Significance
<u>Complete Tool</u>					
	Mean	4.909	3.968	88.500	.000*
	SD	.172	.890		
	Rank	32.48	16.54		
<u>Q1</u>	Mean	4.910	4.120	120.000	.000*
	SD	.294	.881		
	Rank	31.05	17.80		
<u>Q2</u>	Mean	4.910	3.800	95.000	.000*
	SD	.294	1.118		
	Rank	32.18	16.80		
<u>Q3</u>	Mean	4.950	3.960	97.500	.000*
	SD	.213	1.020		
	Rank	32.07	16.90		
<u>Q4</u>	Mean	4.860	4.040	127.500	.000*
	SD	.351	.978		
	Rank	30.70	18.10		
<u>Q5</u>	Mean	4.910	3.920	96.000	.000*
	SD	.294	.997		
	Rank	32.14	16.84		

^a $n = 22$. ^b $n = 25$.

*Significant differences between the two groups were found at $p < 0.05$.

Relationships Between The Groups

To determine the strength of the relationship between the two research groups and satisfaction with current learning, a Spearman *rho* correlation coefficient test was utilized (Table 42 contains a complete overview). A Spearman *rho* correlation coefficient was calculated for the relationship of the mean score of satisfaction with current learning with

students who were in the simulation group versus those who attended the traditional classroom experience. A moderately strong positive correlation was found ($r(45) = .619$, $p = .000$), indicating a significant relationship between the research group and overall satisfaction with learning. Students in the experimental group were generally more satisfied with their current learning experience than the students in the comparison group.

A moderate positive correlation between being satisfied with the usefulness and effectiveness teaching methods used was found ($r(45) = .567$, $p = .000$) when calculating a Spearman *rho* correlation coefficient for the first item on satisfaction with current learning. Students in the experimental group tended to be more satisfied with how useful and helpful the simulation experience was to their own learning experience than students in the comparison group who attended the additional classroom experience.

A Spearman *rho* correlation coefficient revealed a moderately strong positive correlation between the two research groups and satisfaction with the variety of learning materials and activities provided that helped to promote learning ($r(45) = .637$, $p = .000$). Students in the experimental group tended to be more satisfied with the learning materials and activities than the students in the comparison group.

The positive correlation between students in the two research groups and their satisfaction and enjoyment of how the instructor taught their experience was moderately strong when a Spearman *rho* correlation coefficient was calculated ($r(45) = .645$, $p = .000$). Students who were in the experimental group tended to enjoy their instructor more than the students in the comparison group.

A moderate, positive correlation was revealed when a Spearman *rho* correlation coefficient was calculated between the two research groups and satisfaction with the

teaching materials provided to help motivate their learning ($r(45) = .530, p = .000$).

Students in the experimental group tended to be more satisfied with the teaching materials than the students in the comparison group.

Finally, a moderately strong positive correlation was found between the two research groups and satisfaction with how the instructor made the experience suitable to their learning needs ($r(45) = .636, p = .000$). Again, students in the experimental group were more satisfied with the instructors' ability to teach the learning module so that it was suitable to their learning needs than students in the comparison group.

Table 42

Spearman Rho Correlation Coefficient of Satisfaction with Current Learning

Characteristics	Spearman <i>rho</i>	df	Significance
Overall Mean	.619	45	.000*
Q1	.567	45	.000*
Q2	.637	45	.000*
Q3	.645	45	.000*
Q4	.530	45	.000*
Q5	.636	45	.000*

*Significant correlations were found at $p < 0.05$.

Additional Findings

This particular university keeps diligent, organized records every semester of how many attempts were necessary for each student within each level of the nursing program to pass the traditional dosage calculation test with 100% accuracy. Out of the 59 students in the fall 2009 fundamentals cohort, six students (10.2%) were required to take the test more than one time in order to achieve a 100% score. In comparison, the spring 2009 fundamentals cohort ($n = 64$) had 20 students (31.3%) who needed to take the test multiple times in order to achieve a 100% score. The spring 2009 cohort arrived back on campus after having more than three months off from nursing-related courses. No students were able to pass the DCT at 100% when they participated in the pilot study on the first day of the semester. In comparison, the fall 2009 cohort had one student pass the Pre-DCT with a 100% score attempt and 13 students who passed the Post-DCT with a 100% score.

An analysis of the 14 students who were able to achieve a 100% score on either the Pre- or Post-DCT revealed that seven students were in the experimental group and seven students were in the comparison group. In addition, there were nine females and five males, with ages ranging from 19-21 years of age. The majority of the students were lowerclassmen, Caucasian, and had no previous healthcare experience. The GPA scores ranged from 2.93 to 4.00 and nine of those students (64.3%) had GPA scores that were ≤ 3.50 . ACT math scores ranged from 16 to 30. Exactly half of the students had ACT math scores that were < 22 and the other half had ACT math scores ≥ 22 . Table 43 contains a complete description of the demographic variables between these students.

Table 43

Characteristics of Students Who Scored 100% on the Pre- or Post-Dosage Calculation Test

Characteristics	<i>n</i>	%	Characteristics	<i>n</i>	%
Experimental Group	7	50.0	<u>Gender</u>		
Comparison Group	7	50.0	Males	5	35.7
			Females	9	64.3
<u>Age</u>			<u>Class Level</u>		
19 years	6	42.9	Lowerclassmen	9	64.3
20 years	6	42.9	Upperclassmen	5	35.7
21 years	2	14.3	<u>Ethnicity</u>		
<u>GPA Range</u>			Caucasians	11	78.6
< or = 3.00	1	7.1	Non-Caucasians	3	21.4
3.01 to 3.25	3	21.4	<u>Healthcare Experience</u>		
3.26 to 3.50	5	35.7	Experienced	2	14.3
3.51 to 3.75	3	21.4	Not Experienced	12	85.7
3.76 to 4.00	2	14.3			
<u>ACT Math Scores</u>					
Less than 22	7	50.0			
22 or higher	7	50.0			

This dissertation study did not contain a qualitative component and the researcher was not involved in the data collection process. However, students knew who the researcher was because the study was introduced to their class by the researcher prior to data collection. Students approached the researcher on multiple occasions after the study was completed to thank the researcher for conducting the study and to request that more simulations like this one be added to the nursing program. After data collection was completed, students who did not pass the Pre- or the Post-DCT were offered the opportunity to have a question and answer session about calculations that were the most difficult. Nineteen students voluntarily came to that session. In addition, students who had attended the traditional classroom session were offered the opportunity to come to

the simulation lab to participate in the same simulation that their peers attended. Six students voluntarily went to simulation and expressed great appreciation to the simulation instructor for the opportunity.

Discovering the rationale for many of the dosage calculation errors was an unintentional finding for this dissertation study. Students utilized the blank spaces on the DCT tool to write out the formulas that they used to calculate the dosages. The majority of errors observed were from where the students had formulated the problem incorrectly; therefore, the calculations were incorrect even though they were using a calculator. These formulation errors were most evident on the items that required multiple conversions to arrive at the correct dosage and they were primarily on intravenous route medications.

A final unintentional finding was that it appeared that some students were rethinking some of their calculations. Some students had colored in more than 10 pills or they had drawn in extra syringes because the syringe in the image was not large enough for their calculated dose. Right next to these images, it was evident that the student had reworked the calculation and arrived at a more plausible answer because erase marks or cross out marks were obvious on the images.

Summary of Findings

This dissertation study revealed that there was no statistical difference when comparing the experimental and comparison group's Pre-/Post-DCT scores. Both teaching modules were effective at improving dosage calculation scores. Both the experimental and comparison group experienced a significant increase in mean scores when comparing how they performed initially on the Pre-DCT as compared to the Post-DCT although the difference in scores when comparing both research groups side-by-side

was statistically insignificant. An analysis of the demographic variables revealed a significant increase in Post-DCT scores for all groupings except for students who were > 22 years old, had GPA's ≤ 3.00 or > 3.75 , had healthcare experience, and had not completed the required math course if they had an ACT math score < 22 .

Both research groups experienced a medium effect size when comparing the Pre-DCT scores to the Post-DCT scores. When comparing the overall group, all demographic categories experienced a medium effect size with the exception of students who were > 22 years old and students with GPA's > 3.75 . These two groups experienced a small effect size.

Students completed the Pre-SPJDCS after completing the Pre-DCT. Overall, the experimental and comparison group perceived that their calculated responses were neutral to logical. After attending the simulation or classroom module, students completed the Post-DCT and the Post-SPJDCS followed. There was no difference in self-perceived judgment between the two groups although both groups perceived their Post-DCT calculations to be more logical overall than they were originally on the Pre-SPJDCS. The perception of both groups was that calculated dosages that required multiple conversions were less logical than easier dosage calculations. The experimental group experienced a medium effect size and the comparison group experienced a small to medium effect size on self-perceived judgment in dosage calculations.

Statistical analysis revealed that the majority of demographic groups experienced a significant increase in self-perceived judgment after attending a learning module on dosage calculations. The significant demographic groups included 19 and 20 year olds, GPA's that were ≤ 3.50 , both ACT math score ranges and students who completed the

required math course, females, underclassmen, both categories of ethnicity, and inexperienced healthcare providers. The rest of the demographics also experienced an increase in self-perceived judgment although the results were statistically insignificant. In addition, all demographic groupings experienced a small to medium effect size with the exception of the 22 year olds and older group that experienced essentially no effect size on self-perceived judgment.

Students who attended the low-fidelity simulation or the classroom experience demonstrated no significant difference between the overall mean scores of the NLN Satisfaction and Self-Confidence in Learning Scale (SSCLS). However, the items on the tool were not identical and a statistical analysis on the individual items revealed that students in the experimental group were significantly more confident than the comparison group that they were developing the skills and obtaining the required knowledge necessary to perform these tasks in a clinical setting. In addition, the experimental group was significantly more confident that the instructor used helpful resources to teach the learning module than the comparison group.

Six items revealed no significant differences between the experimental and comparison groups. Both groups of students were confident that they were mastering the content and that the learning module covered critical content. The two groups were confident that it was their responsibility to learn what they needed to know from their teaching module and that they had the ability to know how to get help when they did not understand a concept. Both groups were confident in their ability to know how to use simulation activities to learn critical aspects of necessary skills. Finally, the experimental and comparison group were confident that it was the instructor's responsibility to tell

them what they were expected to learn during the simulation activity during regular class time.

A significant difference between the overall mean scores of satisfaction and learning was found between the experimental and comparison group. The experimental group was more satisfied overall with the learning module. An analysis of individual items revealed that the experimental group was more satisfied with the helpfulness and effectiveness of the simulation experience. The experimental group was more satisfied with the variety of learning materials and activities provided that would promote learning. These students also enjoyed how the instructor taught the module and the simulation group more than the comparison group. The experimental group was more satisfied with how the teaching materials motivated them to learn and how the instructor taught the simulation to make it suitable for their own learning needs.

Students were able to achieve higher scores on their dosage calculation tests regardless of the learning module. In addition, students who were able to successfully pass the Pre- or Post-DCT with a 100% included both genders, 19 to 21 year olds, both class levels, the full spectrum of GPA and ACT math scores, and both ethnic groups. Students verbalized their gratitude for offering this learning experience to their class.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this chapter is to analyze and discuss the results of the dissertation study. Previous research findings and recommendations for further studies in simulation and dosage calculations in nursing education provided the background and inspiration for this current study. This chapter includes the summary of the results, a discussion of how the findings of this study contribute to evidence-based teaching and learning in the nursing profession, limitations and the generalizability of the study, recommendations for future research – specifically in teaching dosage calculation skills in nursing education, and final conclusions.

Summarization of Methodology

Eleven years have elapsed since the Institute of Medicine issued an alarming report, *To Err is Human: Building a Safer Health System* that emphasized the role of medication errors in the 44,000 to 98,000 medical errors that occur annually (1999). The recent release of *Preventing Medication Errors: Committee on Identifying and Preventing Medication Errors* continues to highlight a growing concern that medication errors continue to be problematic in spite of the startling findings of the initial report (Institute of Medicine of the National Academies, 2007). The culmination of these multidisciplinary reports is largely responsible for a renewed interest in improving safety

and quality control within all parties of the health care system that are involved in the process of medication administration.

It is important to consider that some of the contributing factors to medication errors have a direct relationship with the roles of nursing education, including a lack of effective education, inconsistency in verification of dosage calculation skills (Gregory, et al., 2007; Kohn, et al., 2000) and students' inability to accurately calculate dosages (Polifroni, et al., 2003). Ineffective educational approaches to learning dosage calculation skills have resulted in a theory-to-practice gap when students practice nursing in a realistic environment. Researchers have advocated for teaching and testing student's dosage calculation skills in a more realistic environment yet currently there are few published studies regarding learning or testing dosage calculation skills in this environment and there are no published studies when teaching these skills in a simulation laboratory.

Purpose of the Study

The purpose of this dissertation study was to determine if there was a difference in mean dosage calculation test scores and self-perceived judgment in dosage calculations in first semester Associate of Science (AS) nursing students who participated in a low-fidelity simulation scenario in the clinical lab versus students who participated in a traditional case study in a classroom setting. Outcomes were measured analyzing the difference between the Pre- and Post-Dosage Calculation Tests (DCT). Demographic characteristics were correlated with the outcomes to determine variances and statistically significant differences between groups and characteristics. In addition, the mean scores from the NLN Satisfaction and Self-Confidence in Learning Scale were analyzed to see if

there was a difference in levels of satisfaction and self-confidence between the two teaching modalities.

Design, Population, and Methodology

This study used a quasi-experimental, quantitative design utilizing a pre-test/post-test as a measurement system to analyze changes that occurred as a result of the interventions for the experimental and comparison group. This study determined if the integration of a case study into a traditional classroom setting or integration of a low-fidelity simulation scenario in a simulation laboratory (independent variables), had an effect on medication dosage calculation skills, self-perceived judgment, satisfaction and self-confidence in learning (dependent variables).

The population for this study included fundamental, AS level nursing students. The research participants comprised a convenience sample of fundamental level students enrolled in an AS nursing program located in a rural southeastern region of the United States. All of these students achieved a college GPA of 2.8 or higher prior to admission into the nursing program and had been accepted into the fall 2009 cohort of the AS degree nursing program. Eligible students in this study were current enrollees in the fundamentals nursing course ($n = 59$). Students who were repeating the course and those who skipped any portion of the required simulation laboratory, classroom experience, or post-testing were excluded from the study. In addition, five students did not agree to sign the consent form yielding a total sample size of 47 participants.

All of the 47 students participated in the pre-test data collection in October, 2009. Demographic data, Pre-DCT scores, and the Pre-SPJDCS instruments were collected and then participants were divided into the experimental and comparison groups based upon

the clinical laboratory assignments given by the lead teacher. The Thursday clinical group ($n = 22$) comprised the experimental group and the Tuesday clinical group ($n = 25$) became the comparison group.

The Nurse Education Simulation Framework was used as a guideline to develop the low-fidelity simulated scenario experience in the simulation lab (experimental group) and the traditional case study experience in the classroom (comparison group). In addition, Polya's Four Phases of Problem-Solving framework was integrated within both groups as a learning strategy for mastering dosage calculation skills.

All of the participants in the comparison group participated in a two-hour classroom experience facilitated by a single teacher during one class period. The first part of the experience was an introduction to Polya's framework. The comparison group instructor used Polya's framework to solve a typical dosage calculation problem on the blackboard. After the demonstration, the comparison group received a simple case study on a patient requiring six medications. The worksheet contained the list of the six medications including information on how the medication was supplied. Students used this information to independently solve these six problems utilizing Polya's framework. Calculators were allowed and were provided.

For the final hour of the experience, the comparison group was divided into small groups of six students. The small groups went through the Polya process together, explaining and collaborating on how to arrive at the correct solutions for these six questions. Guided reflection, utilizing Gibb's reflective cycle, occurred during the last 30 minutes of this teaching modality to allow the instructors to narrow the theory-to-practice

gap by reinforcing the important components of the learning experience so that students could transfer this knowledge into a clinical setting.

The experimental group of students was divided into small groups of six students. Each small experimental group attended a two-hour simulation experience over a two day period. Each of the simulations was facilitated by a single teacher. The experimental group instructor used a typical physician's order and the necessary equipment (i.e. drug vial, syringes) to solve a dosage calculation problem by following the guidelines of Polya's framework. Then the experimental group participated in a low-fidelity simulation utilizing a simplistic case scenario that included a medical chart with orders for the same six medications as the comparison group. Based upon the physician's orders, the experimental group independently solved the problems utilizing Polya's framework and the necessary equipment required to administer the drug to figure out the solutions. Time was also given for students to collaborate on how they arrived at their individual answers. Each student in the experimental group was given one of the six drugs to actually prepare and administer during the scenario. Each simulation group had 30 minutes designated at the end of the simulation for debriefing. The instructor utilized Gibb's reflective cycle to ascertain how the students felt about the learning experience and to reinforce the most important concepts about accurately calculating medication dosages.

All teaching sessions were completed prior to the administration of the Post-DCT, Post- SPJDCS, and the NLN Satisfaction and Self-Confidence in Learning Scale. All of the participants completed these instruments at the same time. Calculators were allowed and provided. Students were notified by the research assistant of their Pre- and Post-DCT scores within 24 hours of completion of all of the tools.

In summary, the content and testing techniques were the same for the experimental and the comparison groups except for the differences in teaching modalities. This quasi-experimental, quantitative design demonstrated whether a hands-free classroom experience or a hands-on simulation experience would have any impact on a fundamental nursing students (a) ability to calculate medication administration dosages correctly, (b) self-perceived judgment in dosage calculations, (c) level of satisfaction in learning, and (d) degree of self-confidence.

Summarization of Findings

Demographics

Descriptive data were collected during a selected class period through a self-administered demographics tool. The tool contained eight questions that the students completed and then four questions that the research assistant completed with information obtained from online academic records after receiving students' permission. All identifying data was removed prior to giving the instruments to the researcher. In order to discuss the ability to generalize these findings with other schools of nursing, each demographic variable described below is compared with the national average of nursing graduates.

The mean age for the 47 participants was 20.64 years with no significant differences noted between the experimental and comparison group. The ages ranged from 19 to 35 years of age. The Health Resources and Service Administration (HRSA) for the U.S. Department of Health and Human Services conducted a national survey of nursing graduates from associate, baccalaureate, and master's degree nursing programs. The national average age of an associate level nursing graduate was 31.8 years old (HRSA,

2007). In comparison to the national average of nursing students, this university has a younger population of nursing students by more than eleven years.

The mean GPA of the 47 participants in this study was 3.40. The range of GPA's spanned from 2.69 to 4.0. Students in the experimental group did have a significantly higher mean GPA (3.539) than the comparison group (mean = 3.281, $p = .012$). Although the difference in GPA existed between the two groups, there was no significant difference in mean Pre-/Post-DCT or Pre-/Post-SPJDCS scores between the groups.

The mean ACT math score for all of the participants in this study was 21.09. The ACT math scores ranged from 16 to 30. There were no significant differences between the two research groups. Of all of the participants in this study with officially recorded ACT math scores, 28 students had ACT scores under the 22 benchmark set by this university. Of these 28 students, all but four had already completed the math requirement. The experimental group had nine out of 22 participants with ACT math scores below 22. Of these nine students, only one student had not completed the math requirement. Within the comparison group, 18 of the 25 participants had ACT scores less than 22. Of these 18 participants, three had not completed the math requirement. There was no significant relationship between the two research groups and participants with ACT scores that were less than 22 or students who had or had not completed the required math course.

The gender distribution for the entire sample was 33 females and 14 males. There was no statistical difference in the distribution of males and females between the experimental and comparison groups. The national survey conducted by the HRSA (2007) revealed that the majority of nursing graduates are female (94.2%). In comparison, this cohort of fundamentals level nursing students was 29.8% males which is

way above the national average should all of these males complete the program. It is noteworthy that this university has an average attrition rate of approximately 5% for all of its nursing students in the AS nursing program.

Students were combined into lowerclassmen and upperclassmen groups since there was only one freshman and one senior representative. Overall, the entire sample contained 31 lowerclassmen and 16 upperclassmen participants. The majority of the experimental group participants were underclassmen students (86.4%) whereas the comparison group contained the majority of all of the upperclassmen students in this entire sample (81.3%). This difference in distribution between the two research groups was statistically significant ($p = .006$) although the underclassmen and upperclassmen performed equally on the Pre-/Post-DCT and the Pre-/Post-SPJDCS.

Students were combined into Caucasians and non-Caucasians since there were not enough participants that were African-American, Asian/Pacific Islanders, or Hispanic. Overall, the entire sample contained 32 Caucasians and 15 non-Caucasians. There was no significant difference in the distribution of ethnicity between the groups. The HRSA national survey (2007) illustrated that the majority of nursing graduates are Caucasian (81.8%). In comparison, this sample of fundamentals level nursing students was 68.1% Caucasian. This sample did contain more ethnic diversity than the national average although unfortunately, the number of participants within each ethnic group was too small to compare on an individual basis.

Out of the 47 participants, seven (14.9%) had work experience in a healthcare setting prior to nursing school. Of these seven students, three were Certified Nursing Assistants, two were Emergency Medical Technicians, one was a unit clerk, and one was

a patient transporter. Four of these seven students had less than one year of experience in the healthcare field and three students had more than one year. All seven of these individuals were in the comparison group which was statistically significant ($p = .007$) when comparing the differences between the two research groups. Although this difference existed, students who had healthcare experience performed the same as students with no healthcare experience on the Pre-/Post-DCT and the Pre-/Post-SPJDCS tools. In comparison to the national average, students in this cohort were far more inexperienced than the typical nursing graduate from an AS level program. The national average of AS nursing graduates who had experience in healthcare prior to graduating was 52.8% (HRSA, 2007). This higher percentage could be related to the fact the average nursing graduate is older and had time to gain healthcare experience prior to enrolling in a nursing program. In addition, nursing students who have completed fundamentals in nursing are eligible to work as a certified nursing assistant (CNA). Since the data for this dissertation was collected prior to students completing a fundamentals nursing course, students would have had less opportunity to work as an assistant unless they had specifically completed CNA courses prior to enrolling in the nursing program.

An associate's degree in nursing is the first degree sought by all of the participants with the exception of one student (2.1%) who was in the comparison group. There was no significant difference in the amount of students seeking a second degree in the experimental and comparison group. However, this university has an unusually low number of students seeking second degree when compared to the national average of 16.3% (HRSA, 2007). Again, this is most likely related to the fact that the majority of this cohort was not old enough to have gone to school long enough to have completed

another degree prior to starting nursing education. Overall, distinctive group dynamics were noted within this study that made it unique in comparison to the national average AS level nursing graduate. The findings for this dissertation study are given with these unique characteristics in mind.

Summarization of Research Questions and Hypotheses

Section One

Research question one. The first research question asked what effects a traditional case study in a classroom versus a low-fidelity simulation in a simulation laboratory would have on mean dosage calculation test scores. This research question was answered by utilizing a 31-item, researcher-designed instrument – the Pre- and Post-Dosage Calculation Tool which measured a student's ability to accurately calculate medication dosages and then transfer the calculation to the equipment necessary to administer the dosage.

First, the difference between the mean scores of the Pre-DCT and the Post-DCT was determined to be significant for the experimental group ($Z = -3.225, p = .001$) and the comparison group ($Z = -3.901, p = .000$). The experimental group increased their mean test scores by 4.09 points or 13.2% (Post-DCT mean = 28.23, SD = 2.759) whereas the comparison group experienced an increase of 4.44 points or 14.3% (Post-DCT mean = 27.36, SD = 3.915) from Pre- to Post-DCT. In addition, only one student was able to achieve a 100% score on the Pre-DCT as compared to 13 students on the Post-DCT. Six of these students were in the experimental group and seven were in the comparison group. Statistical analysis revealed that there was no significant difference between these two groups. Based upon Cohen's d criterion for analyzing effect size

where an effect of 0.20 is considered “small”, 0.50 is considered “medium”, and 0.80 is considered “large” (Gravetter & Wallnau, 2009), this study revealed that the traditional case study in a classroom and the low-fidelity simulation in a simulation laboratory had a medium effect size on the mean Post-DCT scores.

The different groupings of demographic data were also analyzed to compare the differences between the Pre-/Post-DCT scores and the effect size. In this study, demographic groupings that were 19 to 21 years of age, had GPA scores that were 3.01 to 3.75, or had no healthcare experience scored significantly higher on the Post-DCT and experienced a medium effect size. In addition, all levels of ACT math ranges – including students who had completed the required math course, gender, class standing, and ethnic groups scored significantly higher on the Post-DCT after attending their respective learning module and had a medium effect size.

Students who were 22 years old or older, had GPA scores that were < 3.01 or > 3.75 , and those who had not completed the required math course if their ACT math score was < 22 did not experience a significant difference in their Post-DCT scores. Students who were older and had higher GPA's experienced a small effect size whereas students who had the lower GPA and had not completed the math course experienced a medium effect size.

Hypothesis one. Hypothesis one stated that there would be no differences in mean dosage calculation test scores between fundamental nursing students who participate in a traditional case study in the classroom versus a low-fidelity simulation in the simulation lab. The differences between the two research groups and the mean scores of the Pre-DCT scores were insignificant. The experimental group went from a mean

score of 24.14 (SD = 5.401) on the Pre-DCT to a mean score of 28.23 (SD = 2.759) whereas the comparison group went from 22.92 (SD = 4.957) on the Pre-DCT to 27.36 (SD = 3.915) on the Post-DCT. Furthermore, statistics revealed that the difference in scores remained insignificant after accounting for students' age, GPA, and ACT math scores. Finally, the Kruskal-Wallis tests revealed that there were no significant differences between scores achieved on the Pre- and Post-DCT when comparing the demographic groupings of age, GPA, ACT scores, gender, class rank, ethnicity, and experience in healthcare. These findings led to a failure to reject the null hypothesis because both research groups improved equally on the Post-DCT after attending their respective learning module.

Comparison with evidence-based teaching strategies. Research has been conducted on the effectiveness of multiple teaching strategies on student's dosage calculation skills and the rationale why students continue to make dosage calculation errors. However, there are currently no research studies reporting the effectiveness of learning dosage calculation skills in constructivist, simulated environment. The findings from this dissertation study will be discussed in the context of new discoveries and how it enhances what is already known about multiple teaching strategies.

Previous research has demonstrated that learning dosage calculation skills can occur when comparing interactive teaching strategies with the more traditional methods (Glaister, 2005; Maag, 2004). Wright conducted a series of quasi-experimental studies and found that students scores did improve (2004, 2007a) although students who attended a traditional lecture did score significantly higher on the post-test than students who attended skills practice lab and did online tutorials (2008). This dissertation study

supported Maag and Glaister's findings since both the simulation and classroom group of students were able to significantly achieve higher scores on the Post-DCT. In addition, both research groups had an equal number of students who were able to score 100% on the Post-DCT.

Greenfield, Whelan, and Cohn (2006) and Rice and Bell (2005) revealed that the use of dimensional analysis as a learning strategy improved accuracy in dosage calculation skills. However, this study did not mandate the use of a certain type of problem-solving technique because Polya's problem-solving framework encourages students to seek out which method provides the most meaning to the student rather than forcing the student to learn only one way to solve a problem (Polya, 1973; Taylor & McDonald, 2007). Considering the application of this framework within a constructivist learning environment, the teacher in the classroom and the teacher in the simulation sections of this dissertation study were able to coach students to learn from each other that there were multiple ways of solving problems and arriving at accurate solutions. In addition, students became the instigators of lively discussions on the different strategies that were utilized. This study showed that a particular problem-solving strategy does not have to be required to achieve successful scores on dosage calculation tests.

Section Two

Research question two. The second research question asked if a traditional case study in a classroom versus a low-fidelity simulation in a simulation laboratory had any effect on self-perceived judgment in dosage calculation scores in fundamental nursing students. Self-perceived judgment was measured utilizing the 15-item researcher-designed instrument – Self Perceived Judgment in Dosage Calculations Scale (SPJDCS)

– that was administered after the completion of the Pre- and Post-DCT instruments.

Students analyzed calculated dosages from the Pre- and Post-DCT and then determined if those calculated dosages were highly logical to highly illogical utilizing a 5-point Likert scale.

The differences between the Pre- and Post-SPJDCS had to be determined for each group prior to measuring the effect size. Statistics revealed that the experimental and comparison group perceived that their calculated dosages were significantly more logical ($Z = -2.984, p = .003$; $Z = -2.556, p = .011$ respectively) after attending their respective learning module. Students in the experimental group went from a mean score of 3.867 (SD = .552) on the Pre-SPJDCS to a mean score of 4.233 (SD = .564) on the Post-SPJDCS and students in the comparison group went from a mean of 3.629 (SD = .807) to a mean of 4.107 (SD = .629) on the Post-SPJDCS. Based upon Cohen's d criterion for analyzing effect size, the experimental group experienced a medium effect size in self-perceived judgment in dosage calculation skills whereas the comparison group experienced a small to medium effect size.

Further statistical analysis on the different demographic groupings revealed that students who were 19 and 20 year old, had GPA scores that were ≤ 3.50 , and were in either ACT score range scored significantly higher on the Post-SPJDCS when compared to mean scores on the Pre-SPJDCS. In addition, students who were underclassmen, female, in either ethnic group, or inexperienced in healthcare also scored significantly higher on the Post-SPJDCS. All of these demographic groups experienced a medium effect size in self-perceived judgment after attending either learning module with the exception of students who had an ACT score that was ≥ 22 or were Caucasian. These

demographic groups experienced a small to medium effect size on self-perceived judgment.

Some demographic groups experienced no significant changes when comparing the Pre- to Post-SPJDCS scores. These demographic groups included students who were 21 year old and older, had GPA scores > 3.50 , had not completed a math course if their ACT math score was < 22 , males, upperclassmen, and those experienced in healthcare. The effect size was essentially nothing for students who were ≥ 22 years of age. Students who had GPA scores > 3.50 , were Caucasian, or were upperclassmen experienced a small effect size on self-perceived judgment. Males experienced a small to medium effect size and students who were 21 years old or experienced in healthcare experienced a medium effect size in self-perceived judgment.

Hypothesis two. Hypothesis two stated that there will be no differences in mean self-perceived judgment scores between fundamental nursing students who participate in a traditional case study in the classroom versus a low-fidelity simulation in the simulation lab. The experimental group scored a mean average of 3.867 (SD = .552) on the Pre-SPJDCS and the comparison group scored a mean average of 3.629 (SD = .807). There was no statistical difference between the two groups and the Pre-SPJDCS scores. For the Post-SPJDCS, the experimental group achieved an overall mean score of 4.233 (SD = .564) after attending a low-fidelity simulation experience in the simulation lab. The comparison group, who attended the traditional case study in the classroom, achieved an overall mean score of 4.107 (SD = .629). Again, there was no difference in self-perceived judgment scores when comparing the two research groups and the Post-SPJDCS scores. These findings remained insignificant after age, GPA, and ACT math

scores were covaried out. In addition, analysis of the demographic groupings of age, GPA, ACT math scores, gender, class level, ethnic groups, and experience in healthcare revealed no significant differences when comparing Pre- and Post-SPJDCS scores. All of these findings led to a failure to reject the null hypothesis.

Comparison with evidence-based teaching strategies. The findings on self-perceived judgment in this study are similar to what has been found in the literature although there are currently no published studies on self-perceived judgment and dosage calculation skills. Brown and Chronister (2009) conducted a study to analyze critical thinking skills in nursing students learning how to interpret and treat ECG rhythms. The findings of this dissertation study were comparable in that students demonstrated no significant differences in those who received lecture-format teaching only versus those who received a combination of lecture and simulation when evaluating the impact on student assessment, critical thinking, or therapeutic nursing interventions.

After an extensive qualitative-quantitative-qualitative designed research study exploring student's responses in simulated scenarios to concepts in Tanner's Clinical Judgment Model (Tanner, 2006), the Lasater Critical Judgment Rubric was developed in an attempt to quantify judgment skills in students (Lasater, 2007a). Utilizing the rubric helped to identify gaps in understanding in the students. It also served as a valuable communication tool to help faculty provide important feedback to the students and it helped students identify performance expectations and create goals to improve judgment skills. Over the course of the study, students could readily see growth and development in clinical judgment. Dillard, Sideras, Ryan, Hodson-Carlton, Lasater, and Siktberg (2009) concurred with this finding in their study but warned against allowing students to

narrowly focus on rule-based, concrete answers by helping students see the bigger connection between what happens in simulation versus a real clinical experience.

The tool utilized in this study was not a rubric but it served as an introduction to critical thinking and judgment for these fundamental nursing students because it required the student to look back and analyze each calculated response. Based upon markings on their instruments, students did analyze and recalculate many dosages that had initially been incorrect and arrive at more plausible solutions. This tool also helped faculty identify which types of dosage calculations seemed to be illogical for the students. In this dissertation study, illogical responses were associated with intravenous calculations that required multiple conversions. This knowledge can assist faculty with the development and refinement of the teaching modules in this study and can be the source of inspiration for future research studies.

Section Three

Research question and hypothesis three. The third research question asked if there would be a difference in self-confidence levels when comparing fundamental nursing students who participated in a traditional case study in a classroom versus students who participated in a low-fidelity simulation in a simulation laboratory. The hypothesis stated that there would be no difference in self-confidence levels when comparing the two research groups. Levels of self-confidence were measured utilizing the NLN Satisfaction and Self-Confidence in Learning Scale. This tool contained eight items on self-confidence utilizing a 5-point Likert scale.

No significant differences in overall mean scores were found when comparing the scores of the experimental (mean = 4.563, SD = .336) and comparison group (mean =

4.260, $SD = .584$). This finding led to a failure to reject the null hypothesis when examining the tool as a whole. However, the eight items on the NLN tool that represented self-confidence in learning were unique so individual analysis was conducted for each item. Students in the simulation group were significantly more confident than the students in the traditional classroom group that they were developing the necessary skills to perform this task in the clinical environment ($U = 163.000, p = .005$) and that their instructor was using helpful resources ($U = 124.500, p = .000$). Significant moderately, positive correlations were found when comparing the type of teaching module with self-confidence in performing these skills in a clinical environment ($p = .004$) and that the instructor was using helpful resources ($p = .000$). Students in the simulation group were more likely to be confident in these two aspects than students who attended the traditional classroom experience.

Six items revealed no significant differences in self-confidence levels between the experimental and comparison groups. Both groups of students were confident that they were mastering the content and that the learning module covered critical content. The two groups were confident that it was their responsibility to learn what they needed to know from their teaching module and that they had the ability to know how to get help when they did not understand a concept. Both groups were confident in their ability to know how to use simulation activities to learn critical aspects of necessary skills. Finally, the experimental and comparison group were confident that it was the instructor's responsibility to tell them what they were expected to learn during the simulation activity during regular class time. No significant correlations were found between any of these six items on this tool.

Comparison with evidence-based teaching strategies. Currently, there are no published studies comparing self-confidence utilizing multiple teaching strategies in students who are learning dosage calculation skills. However, there are previous research studies that have measured self-confidence while learning other areas of nursing in a simulated environment. Comparisons will be made based upon the findings of these research studies.

A national, multi-site, multi-method research study, conducted by Jeffries and Rizzolo (2006) and sponsored by the NLN, measured the level of self-confidence in students who were assigned to one of three groups that included a paper/pencil case study simulation, static simulation, or high-fidelity simulation. The pencil/paper case-study simulation method was less effective at promoting self-confidence than the other teaching strategies. Similarly, Smith and Roehrs (2009) evaluated influential factors in self-confidence in BSN nursing students exposed to simulation and found that there was a direct correlation between the level of fidelity and self-confidence. Both of these studies utilized the NLN Satisfaction and Self-Confidence in Learning Scale. The results of this dissertation study were similar to these studies although neither of these studies elaborated on what specific areas students were less confident in since there was no report of the mean scores of the individual items on the tool.

Brannan, White, and Bezanson (2008) conducted a simulation study on acute myocardial infarctions utilizing the traditional lecture format versus high-fidelity simulation. Students in the simulation group demonstrated higher cognitive scores but failed to show a significant difference in self-confidence levels although both groups showed increased overall self-confidence in learning. The findings of this dissertation

study were similar in that the experimental and comparison group demonstrated higher scores on their Post-DCT test and high levels of self-confidence in their learning experience. However, the experimental group in this dissertation study was more confident that they could perform these skills in a clinical practice setting and that the teacher had utilized learning materials that enhanced their learning experience.

Alinier, Hunt, Gordon, and Harwood (2006) revealed the effectiveness of adding simulation to didactics and clinical practice in improving psychomotor skills. Students who received simulation in addition to lectures and clinical experience performed better psychomotor skills than students who had not participated in simulation although there were no differences in the level of self-confidence. Unfortunately, this study did not quantitatively measure psychomotor skills but there was a higher level of self-confidence in the experimental students in their ability to perform these skills in a clinical setting and having the teacher use appropriate materials for learning.

There were several major differences noted between this dissertation study and previous research studies. First, several of the studies utilized different tools to measure self-confidence and the items were dissimilar. This made it difficult to make a true comparison because the NLN tool measured different aspects of self-confidence than the other instruments. Finally, the majority of studies reported self-confidence as an overall mean score so there was no way to differentiate if students were more self-confident in some aspects more than others.

Section Four

Research question and hypothesis four. The fourth research question asked if there would be a difference in levels of satisfaction in learning when comparing

fundamental nursing students who participated in a traditional case study in a classroom versus students who participated in a low-fidelity simulation in a simulation laboratory. The hypothesis stated that there would be no difference in levels of satisfaction in learning when comparing the two research groups. Levels of satisfaction in learning were measured utilizing the NLN Satisfaction and Self-Confidence in Learning Scale. This tool contained five items on satisfaction utilizing a 5-point Likert scale.

Overall mean satisfaction scores were compared between the experimental and comparison group. Students who participated in the low-fidelity simulation experience (mean = 4.909, SD = .172) were significantly more satisfied with the learning experience overall ($U = 88.5000$, $p = .000$) than students attended the traditional classroom experience (mean = 3.968, SD = .890).

Further analysis was conducted on each of the five items since they were unique. The simulation group was significantly more satisfied than the traditional classroom group with the helpfulness and effectiveness of the teaching module ($U = 120.000$, $p = .000$), the variety of learning materials and activities provided that would promote learning ($U = 95.000$, $p = .000$), how the teaching materials motivated them to learn ($U = 127.500$, $p = .000$), how much they enjoyed how the instructor taught the module ($U = 97.500$, $p = .000$), and how the instructor taught the simulation to make it suitable for their own learning needs ($U = 96.000$, $p = .000$). Significant moderately, positive correlations were found when comparing the teaching modality with each of these five items ($p = .000$). Students who attended the low-fidelity simulation experience in the simulation lab were more likely to be satisfied with their learning experience than students who attended the traditional classroom experience. All of these findings led to a

rejection of the null hypothesis that there would be no differences in satisfaction with current learning between students who attended a low-fidelity simulation experience versus students who completed a case study in a traditional classroom experience.

Comparison with evidence-based teaching strategies. Again, there is a lack of current research comparing satisfaction in learning with multiple teaching strategies in students who are learning dosage calculation skills. However, there are previous research studies that measured student satisfaction in other areas of nursing while learning in a simulated environment. Comparisons will be made based upon the findings of these research studies.

Learner satisfaction was enhanced in baccalaureate nursing students when simulation was combined with a lecture-format teaching strategy (Sinclair & Ferguson, 2009). Maag (2004) had similar findings when an interactive multimedia learning tool was introduced as an instructional strategy to help students develop math skills. The results indicated that students who received traditional instruction earned equal dosage calculation test scores as students who participated in the multimedia instruction. However, students who participated in the multimedia instruction method reported higher levels of satisfaction with learning. Similar to Maag, this dissertation study found that the more interactive simulation in a realistic environment was far more satisfying to the experimental group than the traditional classroom experience was for the comparison group.

The national, multi-site, multi-method research study conducted by Jeffries and Rizzolo (2006), Kardong-Edgren, Starkweather, and Ward (2008), Smith and Roehrs (2009), and Hoadley (2009) found that the level of fidelity was correlated with

satisfaction. Students who participated in the high-fidelity simulation had increased levels of satisfaction in learning. Also, several of these studies measured cognitive gain after attending simulation or a traditional teaching method and found that increased levels of satisfaction did not translate to increased cognitive gain. Students performed equally well on post-tests in these studies. This dissertation study utilized two low-fidelity methods – a case scenario in the simulation laboratory and a pencil/paper case study in the classroom. Both are considered low-fidelity simulation (Hovancsek, 2007) but the scenario in the simulation laboratory was more realistic since the students had access to all of the equipment that would be necessary to administer all of the medications. The hands-on experience was more satisfying than learning the same material in a classroom environment where students could not “play” with the equipment and practice administering the dosages.

Additional Findings

In this particular study, 14 students were able to achieve a 100% score on either the Pre- or Post-DCT. An analysis of these students revealed that seven students were in the experimental group and seven students were in the comparison group. In addition, there were nine females and five males, with ages ranging from 19-21 years of age. The majority of the students were lowerclassmen, Caucasian, and had no previous healthcare experience. The GPA scores ranged from 2.93 to 4.00 and nine of those students had GPA scores that were ≤ 3.50 . ACT math scores ranged from 16 to 30. Exactly half of the students had ACT math scores that were < 22 and the other half had ACT math scores ≥ 22 .

Discovering the rationale for many of the dosage calculation errors was an unintentional finding for this dissertation study. Students utilized the blank spaces on the DCT tools to write out the formulas that they used to calculate the dosages. The majority of errors observed were from where the students had formulated the problem incorrectly; therefore, the calculations were incorrect even though they were using a calculator. These formulation errors were most evident on the items that required multiple conversions to arrive at the correct dosage and they were primarily on intravenous route medications.

Another unintentional finding was that it appeared that some students were rethinking some of their calculations. Some students had colored in more than 10 pills or they had drawn in extra syringes because the syringe in the image was not large enough for their calculated dose. Right next to these images, it was evident that the student had reworked the calculation and arrived at a more plausible answer because erase marks or cross out marks were obvious on the images.

Finally, this dissertation study did not contain a qualitative component and the researcher was not involved in the data collection process. However, students recognized the researcher because the researcher introduced the study to their class prior to data collection. Students approached the researcher on multiple occasions after the study was completed to express gratitude for conducting the study and to request that more simulations like this one be added to the nursing program. After data collection was completed, nineteen students who did not pass the Pre- or the Post-DCT voluntarily came to a question and answer session about calculations that were the most difficult. In addition, six students who had attended the traditional classroom session voluntarily went to the simulation lab to participate in the same simulation that their peers attended.

Comparison with evidence-based teaching strategies. Research has been conducted on the rationale of why students continue to make dosage calculation errors. In addition, there is still much debate on policies and procedures employed by schools of nursing with the processes of admission and progression through the nursing program. The additional findings from this dissertation study will be discussed in the context of new discoveries and how it enhances what is already known about the rationale for dosage calculation errors and policies and procedures for schools of nursing.

Blais and Bath (1992), Segatore, Edge, and Miller (1993), and Jukes and Gilchrist (2006) revealed that the rationale for the majority of the dosage calculation errors were conceptual in nature and that students had more difficulty with ratio and proportion and unit conversions. Additionally, students were unable to detect errors that seemed unreasonable or irrational (i.e. 20 tablets of one drug) and that students showed a lack of concern about the consequences of these errors (Blais & Bath; Jukes & Gilchrist). The authors concluded that paper and pencil tests did not reflect reality because it left students unable to appreciate the potential vastness of their errors (Segatore, et al.).

This dissertation study introduced Polya's Problem Solving framework into the traditional classroom experience with a case study and the low-fidelity simulation in the simulation laboratory. Students utilized this model to solve dosage calculation problems. The model encouraged a thoughtful, reflective process that helped students identify potential errors before committing to an answer for that particular test question. In addition, the paper and pencil test was designed in a way that mimics reality by including the physician's order and images of the equipment that were necessary to calculate the correct dose. Students were encouraged to write down formulas and math strategies

directly onto the paper and pencil test. This allowed the researcher to see that similarly to Blais and Bath (1992), Segatore, Edge, and Miller (1993), and Jukes and Gilchrist (2006) findings, the majority of errors were conceptually related because students had written down incorrect formulas on their papers. In addition, the majority of the errors were on questions that utilized ratio and proportion. Specifically, intravenous dosages and fluid rates were the most difficult to complete accurately.

Students demonstrated that taking their dosage calculations test on a more realistic tool seemed to make them think more about the rationality of their answers. On multiple occasions there was evidence that students had colored in the incorrect amount of pills (ex. 10 pills) or they had started to draw in extra syringes because the one depicted on the test was not large enough. Right next to these images, students demonstrated where they had reworked the problem and came up with a more plausible solution. Although this was a paper and pencil testing method, it seemed to begin to address the issue of nonchalance about dosage calculation errors or the ability to detect irrational calculations that had been noted in nursing students from previous research.

As far as policies and procedures go for admission into a nursing program, many schools of nursing employ rigorous guidelines for acceptance into a nursing program. This includes a certain level of math proficiency before students can even be considered for admission. Flynn and Moore (1990) demonstrated that students GPA and attitudes about math could predict scores on dosage calculation tests. However, Hutton (1998a) countered that using criteria such as a student's GPA may exclude some students that could actually be outstanding clinicians from being accepted into a nursing program. Hutton's study found that students with a C grade or lower in mathematics who were

initially unable to pass a dosage calculation test were able to successfully pass the test after participating in remediation with a tutor, peer mentors, and working through a mathematics booklet.

This dissertation study compared ACT and GPA scores with dosage calculation scores. Although math course grades were not compared, students with ACT scores that ranged from as low as 16 to 21 were able to successfully increase their scores after participating in either educational module. However, students with GPA scores that were 3.00 or less did not significantly improve their scores although one of these students did score a 100% on the Post-DCT test. Furthermore, it is important to consider that after the data collection was completed, only six students within the entire group of 59 fundamental students had to take the course required dosage calculation test more than one time to successfully achieve the benchmark passing rate of 100%.

These dissertation findings support Hutton's findings that students with lower ACT math scores and overall GPA scores can be successfully taught how to accurately calculate dosages even when the benchmark is set at a 100% score. Utilizing ACT math scores and GPA scores as criteria for admission into a nursing program may in effect be eliminating future nurses that could be excellent clinicians. These findings warrant further analysis in how these students perform in other areas of nursing before implementing new admission criteria because calculating accurate dosages is only one small part of being an excellent clinician.

Discussion of Findings

To date, calculation skills are typically validated through computerized or paper and pencil math tests typically designed by faculty members (Pierce, et al., 2008;

Polifroni, et al., 2003) even though current literature argues against the validity of this approach because these types of instruments test a student's ability to successfully take a test and have no bearings on the student's quality of performance in the real world (Andrew, et al., 2009; Armitage & Knapman, 2003; Hutton, 1998b; Ludwig-Beymer, et al., 1990; Segatore, et al., 1993; Wilson, 2003; Wright, 2007b, 2009). In reality, a focus on written math tests alone can result in an artificial situation that encourages nursing students to learn the skill of how to pass the test successfully to prove competence while failing to address real issues of calculating and administering drugs in clinical practice (Wright, 2009).

The goal of this study was to modify the traditional learning process so that the students could learn dosage calculation skills but do so in a realistic context. It was hoped that through a constructivist, realistic environment that it would "make it harder for people to do something wrong and easier for them to do it right" (Institute of Medicine, 1999, p. 2). Additionally, it was hoped that the process would become less of mechanistic procedure and that students could begin to learn how to exercise clinical judgment skills that are so vital to the process of medication administration.

Both teaching modalities were designed by utilizing the NESF and Polya's Four Phases of Problem-Solving framework. This study was designed to determine whether a low-fidelity scenario in the simulation lab or a case study in a traditional classroom environment would have any bearings on a student's ability to accurately calculate dosages for medications, self-perceived judgment in determining how logical the calculated dosage was, and satisfaction and self-confidence in learning.

Both teaching modalities were considered low-fidelity simulation (Hovancsek, 2007) but the experimental group was able to experience a hands-on simulation, whereas the comparison group completed the case study in the classroom. The agenda, objectives, and debriefing were identical for both groups. The major difference was the realism in that students in the simulation group had the opportunity to utilize real equipment such as syringes, vials, and physician orders to learn how to calculate dosages and administer the medications, whereas the classroom group calculated the same dosages but without a manikin or real equipment.

Results demonstrated that learning occurred with either teaching modality because both research groups were equally able to successfully increase dosage calculation scores whether they participated in a hands-on or hands-off experience. These results were significant even when accounting for students' age, GPA, and ACT math scores. Both teaching modalities were equally successful in helping students achieve the 100% benchmark set by the school of nursing regardless of gender, GPA, ACT scores, ethnicity, and class level. Improved dosage calculation scores were demonstrated in students who were 19 to 21 years old, had GPA scores that were 3.01 to 3.75, or were in either ACT math score range. In addition, both of the class levels, gender, and ethnic groups experienced higher Post-DCT scores.

Students who were 22 years old or older, had GPA scores that were < 3.01 or > 3.75 , and those who had not completed the required math course if their ACT math score was < 22 did not experience a significant difference in their Post-DCT scores. These results may be explained by the fact that students who had higher GPA's scored high on the Pre-DCT and therefore, had little room to improve. In general, students who

had GPA's that were < 3.00 did improve but not at the same rate as the rest of the class. There was a wider range of scores within this group for the Pre- and the Post-DCT that contributed to the insignificant findings. Students who were 22 years old and older may not have been as influenced by either teaching modality and may have responded better to a different type of strategy. Finally students who did not complete the required math course if their ACT math score was < 22 may have done better if they had already completed the math course and understood the basic concepts of mathematics prior to participating in this study.

Results indicate that both teaching modalities were equally successful at helping students feel that their calculated dosages were more logical on the Post-DCT than they were on the Pre-DCT even when age, GPA, and ACT math scores were covaried out. In addition, students who were 19 and 20 year old, had GPA scores that were ≤ 3.50 , and were in either ACT score range, were underclassmen, female, in either ethnic group, or inexperienced in healthcare scored significantly higher on the Post-SPJDCS indicating that they felt their calculated responses on the Post-DCT were more logical than they were on the Pre-DCT.

Demographic groups that experienced no significant changes in Pre- to Post-SPJDCS scores included students who were 21 year old and older, had GPA scores > 3.50 , had not completed a math course if their ACT math score was < 22 , males, upperclassmen, and those experienced in healthcare. A plausible explanation for this is that students in these demographics may have had a stronger self-assurance of their calculation abilities prior to this research study although these demographic groups did not score significantly higher on the Pre- or Post-DCT than any of the other demographic

groups. It is important to note that perceiving that the calculated dosage was logical did not necessarily translate to correct calculations all of the time.

Students in the experimental and comparison group were equally self-confident in their learning experience when reviewing the overall mean scores from the NLN tool. However, due to the unique nature of the items on the tool, an individual analysis revealed that the experimental group was more confident that they were developing the skills and obtaining the required knowledge necessary to perform tasks in a clinical setting and that the instructor used helpful resources to teach the learning module. These findings are important for faculty to recognize that although both research groups scored equally on the Pre- and Post-DCT tests one group felt less prepared to practice these skills in a clinical setting. This finding supports Wright's (2009) conclusion that focusing on passing written tests fails to address the real issues of performing calculations and drug administration in clinical practice. Although the focus of the comparison group was not strictly on math skills, the lack of hands-on experience with appropriate equipment may have contributed to the phenomena of feeling ill-prepared to practice dosage calculation skills in a real clinical environment.

The experimental group was more satisfied with the simulation learning experience than the comparison group was with the classroom experience. Specifically, the simulation group was more satisfied with the helpfulness and effectiveness of the teaching module, the variety of learning materials and activities that were provided to promote learning, how the teaching materials motivated them to learn, how much they enjoyed how the instructor taught the module, and how the instructor taught the simulation to make it suitable for their own learning needs.

Rationale for a decreased level of satisfaction in the comparison group could have been related to the fact that the classroom instructor was a novice teacher. Both instructors were novice but the simulation instructor had a little more experience with simulation than the classroom teacher had in the classroom. However, the classroom teacher was very enthusiastic about teaching the module and spent a lot of time getting prepared for the experience. The effectiveness of her teaching abilities showed because students in the comparison group were able to make the same scores as students in the experimental group.

Another contributing factor to a decreased level of satisfaction in the comparison group was that the entire group met in one classroom and went through this two hour experience together. In conversing with the classroom teacher, even when the large group sub-divided into groups of six students, the students had questions for her and she was unable to be available to each small group at the same time (K.C. Allen, personal communication, October 20, 2009). This large group of students in the classroom led to a lack of ability on her part to be able to be effective and connect with each student to find out their individual needs so that she could help them feel motivated to learn. However, she was able to determine that there were many areas where theory-to-practice gaps existed although she was unable to modify the teaching strategy accordingly during the teaching session. Finally, she commented that debriefing in a large group led to a lack of participation from all of the students – especially the quiet ones.

The rationale for the majority of errors observed on the students' instruments was an inability to formulate the problem correctly; therefore, it did not matter if they used the calculator correctly because they would still arrive at an incorrect solution. This finding

supports Bliss-Holtz (1994) findings that medication errors will continue to abound if nurses do not know how to formulate the problem correctly. Also, it offers insight into where the gap in knowledge exists so that learning experiences can be modified to focus on how to help students learn how to formulate problems correctly.

The testing methods seemed to have persuaded students to rethink some of their calculations that seemed illogical. The rationale for this finding could be that students were required to transfer the calculated dosage to the equipment (syringe, IV pump, etc) on the Pre- and Post-DCT instruments. There is the possibility that the actual coloring in of the syringe might have made the student think that they had calculated the dosage incorrectly because the syringe in the image was inadequate for their calculation or they were coloring in an unusual amount of pills (> 10 for one dose). There is also the possibility that the Pre- and Post-SPJDCS also made them think about what they had calculated and rework the problem if they perceived that the calculated dosage was illogical. Regardless, the majority of reworked problems resulted in more plausible solutions that were correct.

Contributions to Nursing Science

Nursing Education

Previous research has recommended that education in dosage calculations and medication administration be conducted in a constructivist environment that allows the student to learn and perform authentic tasks in a realistic setting where ‘real’ patient charts, syringes, ampoules, and IV pumps are available and the student has to pull all of the information available to insert into the formula to calculate the correct dose (Blais & Bath, 1992; Glaister, 2005; S. Johnson & Johnson, 2002; Kelly & Colby, 2003; Rice &

Bell, 2005; Weeks, et al., 2000; Wright, 2007b, 2009). With all of the technological advances that simulators have accomplished within the last decade, schools of nursing have increased opportunities to utilize simulators in such a way that learning dosage calculation skills can be achieved in a realistic environment while not placing an actual patient in harm's way. In addition, hospitals can also benefit from more realistic ways to validate that their current employees have accurate dosage calculation skills.

This study can contribute research-based evidence on how to increase patient safety by demonstrating the effectiveness of two teaching strategies on the conceptual and computational skills required for solving dosage calculations accurately. Although both teaching modalities resulted in higher dosage calculation scores, one of the distinguishing factors noted in this study was that the simulation group was more confident in their ability to practice dosage calculations in a clinical setting. When it comes to patient safety, this was a key finding that nurse educators should consider because the more realistic environment made students feel like they could successfully replicate these skills in a clinical environment. Patient safety concerns are a major factor when students administer medications in a clinical environment and confidence has been linked to the ability to perform accurately (Durham & Alden, 2008; Hovancsek, 2007). A simulated experience for dosage calculations and medication administration decreases the risks that errors will occur in an actual clinical environment.

Students in the simulation group were more satisfied than the classroom group in every aspect of the learning experience. Satisfaction in a learning experience can enhance clinical performance (Chickering & Gamson, 1987) and therefore increase patient safety. It also serves to motivate students to want to learn more and practice more often because

simulation helps students identify personal gaps in knowledge and experience (Durham & Alden, 2008). Organizing the simulation so that there were no more than six students in each group maximized the opportunities for students to recognize their own weaknesses and it allowed the instructor to fill in the knowledge gaps although it does put a strain on faculty workload because of the increased demands on the time required to conduct the simulation.

Utilizing the NESF to develop the case study and simulation scenario helped incorporate best practices through better interaction and communication between the teacher and the students, collaboration of diverse student peers, innovative teaching strategies and learning techniques, and students' increased responsibility for learning and drive for achieving higher academic standards (Thompson & Bonnel, 2008). There are four major components of the teacher, student, educational practices, and simulation design characteristics that all play a major role in the fifth component which is outcomes (Jeffries & Rogers, 2007b). Detailed consideration of the teacher, student, educational practices, and simulation design characteristics resulted in positive student outcomes for this study because all students were able to improve their dosage calculation scores.

The teaching modalities were designed to include Polya's four phases of problem-solving framework. Polya introduced a problem-solving framework intended to guide students through the mathematical process and overcome difficulties with solving math equations. The framework includes four stages of problem-solving including understanding the problem, making a plan, carrying out the plan, and then looking back (Polya, 1973). According to Feeg (2006), these four phases parallel the nursing process of assessment, planning, implementation/intervention and evaluation and can ease the

understanding and application of the model in novice nursing students. The inclusion of a mathematical framework helped organize the teaching and learning experience for the students by helping create a pattern of thinking to implement every time a dosage calculation is necessary. It encouraged critical thinking and evaluation of calculated dosages which is an important process in improving patient safety. Another positive aspect of this model was that encouraged collaboration between peers and it reduced the fear of asking for help. Collaboration is one way that can help improve communication skills (Taylor & McDonald, 2007) which are vital when it comes to patient safety. The final positive aspect was that it did not recommend that teachers encourage only one style of problem-solving (Polya, 1973). This methodology allowed students to find the problem-solving method that suited their own learning needs. This study demonstrated that the freedom to choose a problem-solving method resulted in positive dosage calculation outcomes for both research groups.

Finally, literature dispels the validity of traditional formats of dosage calculation testing and calls for a more realistic way to validate competency. This study has demonstrated the validity and reliability of a dosage calculation instrument that resembles what occurs in a realistic environment. Although this study was conducted on fundamental nursing students only, there is no reason why reliable and valid tools cannot be developed for each level of nursing so that students receive a consistent method of testing throughout the nursing program.

Hospitals and Acute Care Facilities

Literature has demonstrated that graduate and experienced nurses continue to struggle with accurate dosage calculations (Wilson, 2003). Most hospitals and acute care

agencies have adopted a dosage calculation test to verify calculation skills in nurses. The positive outcomes of this research study could also stimulate future research on the effectiveness of competency testing graduate nurses, new nurse hires, or even remediating nurses who are unable to initially pass the dosage calculation test in a simulated environment. Collaborating with colleagues would reinforce calculation skills and encourage new ways to solve problems accurately. With safety systems such as barcodes and unit dosing, nurses have less opportunities to calculate dosages and therefore maintain competency. It is imperative that ongoing validation occurs throughout the course of employment and not just during the orientation phase to the facility. In addition, hospitals and acute care facilities could also benefit from a more realistic tool that resembles what happens in clinical practice.

Limitations

Conducting a quasi-experimental study presented several study limitations related to convenience sampling with a small sample size and an inequality among the experimental and comparison group. Other issues included novice nursing faculty and testing limitations. Each one of these limitations is described below.

Convenience Sample

Students in this study came from a religious-affiliated, private university located in a single, geographic location in southeast Tennessee. Because of its religious affiliation, the university attracts students from all over the United States and the world. Although these students represent different regions of the country and the world, students who attend private universities and share a religious affiliation share many similar, distinct characteristics; therefore, the ability to generalize these findings to nursing

programs located in public university settings or programs that cater to students that are from a specific region may be limited.

Non-Caucasian students were under-represented in this convenience sample. Although non-Caucasian students experienced significant increases in their dosage calculation scores and self-perceived judgment in their dosage calculations, it would be presumptuous to conclude that it would be as successful for other non-Caucasians without replicating this study on a more diverse group of students.

The nursing students in this nursing program are young in comparison to the national average. Students who were 22 years old and older were under-represented in this sample. In this study, older students did not obtain significantly higher scores on the post-dosage calculation test and they did not experience an increase in self-perceived judgment in their calculated dosage although they felt they were logical from the beginning. A replication of the study with a larger sample size of older nursing students would be necessary to determine if the results would be consistent in older students before generalizations can be made to this population.

The inability to randomly assign students to a research group is a major weakness of the study. The convenience sampling method led to several inequalities noted between the two research groups. First, the experimental group had a significantly higher mean GPA average than the comparison group. Second, the majority of the experimental group participants were underclassmen students whereas the comparison group contained the majority of all of the upperclassmen students in this entire sample. Finally, the comparison group had all of the students who had any previous healthcare experience.

Even these inequalities existed between the groups there were still no significant differences when comparing Pre-/Post-DCT and Pre-/Post-SPJDCS scores.

Finally, statistical analysis revealed that the data were not distributed normally. Non-parametric tests were utilized to analyze the data with the exception of the ANCOVA test since there were no non-parametric equivalent tests. Although parametric tests are described as robust, utilizing the ANCOVA when assumptions of normality have been violated could have led to inaccurate conclusions about whether GPA, age, or ACT math scores influenced DCT or SPJDCS scores.

Faculty Limitations

The faculty involved in this study were considered novice, although both educators expressed great enthusiasm in participating in this research study and both put a great amount of effort into preparing for the experience. The simulation faculty member did have more experience teaching simulation than the classroom teacher had teaching in a classroom environment.

The simulation teacher did the majority of creating the simulation scenario and had more input into the design and flow of the simulation than the classroom teacher. This amount of input and effort could have prepared the simulation educator more thoroughly. Once the research study began, the simulation teacher had five different groups of students attend the experience. Having the opportunity to experience the first group and fix any unanticipated hitches was advantageous for the simulation teacher because there were four more opportunities for it to go more smoothly whereas the classroom teacher had only one opportunity to teach the content. This advantage could have influenced the increased levels of satisfaction experienced by students who attended

the simulation experience. Also, the simulation faculty made sure that every piece of equipment was readily available and in working condition prior to the simulation. This could have influenced the self-confidence levels in students with their ability to replicate these skills in a clinical environment and feel confident that the instructor used the right equipment to enhance the learning process. This study would need to be replicated with a more seasoned faculty member in the classroom before generalizing the findings to other schools of nursing.

Testing Limitations

The school of nursing participating in this study has a policy on passing a dosage calculation test with a 100% score prior to participating in any clinical experience where medications are administered. The timing of this research study was scheduled at the most logical point in the nursing program where students would readily be able to grasp the concepts. However, this only left a two week period prior to hospital clinical so the study had to be completed within a one week time frame to allow students access to remediation and tutoring if necessary so that they could progress in the nursing program. It is a major limitation to administer a post-test within a short time frame because it increases the risk that students could have memorized calculations from the pre-test although the Post-DCT was altered so that the dosages calculated were not exactly the same. It also limits the ability to determine how long these nursing students will remember what they learned from the experiment. Future research would include another post-test several months later to see how much students retained.

A final limitation related to Post-DCT scores, it was impossible to control the access that students could have had to dosage calculation websites, free computer-

assisted learning tools accessible in the computer learning center, or tutoring from peers prior to taking the Post-DCT. Access to any of these resources could have influenced inflated test scores. Isolation was not an option and the influences of outside resources and the short span of time from experiment to post-testing limits the generalizability of this study.

Recommendations for Future Research

To date, this is the first study conducted on how simulation can be used to teach dosage calculation skills. The results of this study have provided inspiration for future research endeavors. The majority of students demonstrated cognitive gain in dosage calculation scores and increased self-perceived judgment in dosage calculation scores although this study needs to be replicated with a larger sample size that contains more students in each of the demographic groups. The effectiveness of using simulation to teach dosage calculation skills to older adults needs to be studied as more nursing programs consider the implementation of programs that specifically cater to older adults. In addition, as more minorities enroll in nursing programs, it is important to find teaching strategies that are effective to meet their specific learning needs so that they can be successful in the program. Although this study obtained increased scores for non-Caucasians, the study needs to be replicated to see if a larger sample would obtain similar results.

This study was conducted within a very short time span. Future research could include retesting this cohort of students at the beginning of each of their three remaining semesters to see how much knowledge has been retained. It would also be of interest to

study the next cohort of fundamental nursing students doing simulation only and then compare the findings to this study to see if the results are duplicated.

Another area of research interest would include an evaluation of whether the dosage calculation skills acquired in the simulation or classroom experience transferred to the clinical practice setting. Research could be conducted to see if the actual rates of dosage calculation errors are reduced in the clinical setting.

The NLN has developed two instruments that measure a student's opinion about the simulation experience. Future research studies could utilize the Simulation Design Scale that measures a student's opinion about the specific features of the simulation design and how important those features are to the learning experience (Jeffries, 2007). The Educational Practices in Simulation Scale measures whether the four educational practices of active learning, collaboration, diverse ways of learning, and high expectations were present in the simulation (2007). Both of these tools could obtain valuable information about the effectiveness of the simulation experience for the students.

Conclusions

The purpose of this dissertation study was to determine if there was a difference in mean dosage calculation test scores and self-perceived judgment in dosage calculations in first semester Associate of Science (AS) nursing students who participated in a low-fidelity simulation scenario in the clinical lab versus students who participated in a traditional case study in a classroom setting. In addition, the mean scores from the NLN Satisfaction and Self-Confidence in Learning Scale were analyzed to see if there was a difference in levels of satisfaction and self-confidence between two teaching modalities.

Students did experience a significant increase in dosage calculation scores although both research groups improved their scores equally. Students also experienced a significant increase in self-perceived judgment scores although once again, both groups improved equally and both felt that their calculations overall were logical on the Post-DCT. Of interest, student perceptions that a calculated dosage was logical did not always translate into increased correct responses on that particular test item. An analysis of overall mean self-confidence scores revealed no significant differences between the two research groups. However, an individual analysis of these items revealed that students in the simulation group were significantly more confident that they could perform these skills in a clinical setting and that the instructor had used appropriate resources to help them learn. Finally, students in the simulation group were more satisfied than the classroom group with every aspect of the learning experience.

This study revealed that both teaching strategies helped improve a student's ability to accurately calculate dosages and increase perception that calculated dosages were logical. The distinguishing factor in this study was that the simulation group was more confident in their ability to practice dosage calculations in a clinical setting. Nurse educators should consider the implications to patient safety that this finding may have because the more realistic environment made students feel like they could successfully replicate these skills in a clinical environment. Patient safety concerns are a major factor when students administer medications in a clinical environment and confidence has been linked to the ability to perform accurately. A simulated experience for dosage calculations and medication administration decreases the risks that errors will occur in an actual clinical environment and the experience is more satisfying in the process.

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APPENDIX A

NURSING EDUCATION SIMULATION FRAMEWORK
AND SIMULATION TEMPLATE
PHYSICIANS ORDERS
MEDICATION ADMINISTRATION RECORD
INSULIN – FLOW SHEET

Nurse Education Simulation Framework

Template for Simulation Development

Stage 1: Develop the Blueprint			
Course Name:	NRSG 107: Fundamentals II		
Client Name:	Larry Hawkins	Client Acuity:	Stable
Manikin:	Static	Content:	Medication Administration
Skills:	Dosage calculations and the process of medication administration		
Type:	Low-fidelity case study in the classroom	Time:	8:00-10:00 am
Evaluation:	Post-DCT Test Self-Perceived Judgment in Dosage Calculation Scale NLN Satisfaction and Self-Confidence Tools		
Authors:	Joelle Wolf – Simulation Coordinator and Primary Developer Jaclynn Huse – Lead Investigator		
Date Created:	4/15/2009		

Goal:	Improve accuracy and judgment skills during medication dosage calculations
Objectives:	At the end of this scenario the student will be able to: 1. Explain what the physician's orders are really asking them to do. 2. Identify key data required to solve the dosage calculation. 3. Formulate a plan to solve dosage calculation problems accurately and consistently. 4. Solve the dosage calculation problem. 5. Judge whether dosage calculation solutions are logical or illogical and apply it to the patients specific situation.
Participant Preparation:	Each student will be required to bring Davis's Drug Guide and Medical-Surgical Nursing: Critical Thinking for Collaborative care by Ignatavicius and Workman. There will be no pre-work but the references will be needed while participating in the scenario.

Stage 2: Procuring the Bill of Materials

Simulation Scenario Equipment			
EQUIPMENT IN ROOM:			
Gender	Male	Dress:	Hospital Gown
IV	Peripheral R arm	Oxygen Device:	2L/NC
IV pump	X 1	IV fluid	NS at 30 mL/hr
IV piggyback tubing	X1	IV fluid for PB	250 NS
Syringes	1 mL, 3 mL, & 10 mL Insulin syringe	IV flush	NS
Medication Cup	Graduated medication cup		

DOCUMENTATION AND ORDER FORMS

Physician's Order Sheet
 Medication Administration Record
 Insulin – Flow sheet
(See Appendix A for all of these forms)

MEDICATIONS AVAILABLE:

Rocephin	500 mg vials of powdered Rocephin	Solumedrol	125 mg vial
Heparin	5,000 unit vial	Lasix	100 mg vial
Novolog Insulin	Vial	K-G Elixir	20 mEq/15 mL (need 2 total)

GENERAL EQUIPMENT:

Patient Chart
 Name band
 Stretcher bed
 Alcohol wipes

Stage 3: Assembling the Structure

Teacher Role:	The teacher acts as a facilitator and provides cues in a learner-centered environment. Faculty members responsible for implementing the classroom and clinical lab simulation have met with lead investigator and had the majority of the input into the development of this scenario. Future meeting will be scheduled prior to implementation to problem-solve and ensure that teachers are comfortable with this format.

Student Role:	All students will have the role of the nurse in calculating the medications. Each student will play a leadership role and becomes the expert on one medication and will discuss with the small group of students how they arrived at their solution and what the references have to say about dosing and administration. Each student will also play the role of observer to the lead student and listen and actively give input during the discussion of each medication. Students in clinical lab will each prepare one of the medications they have calculated and give it to the manikin.
Embedding Best Educational Practices:	- Engage students in active learning while providing cues, reinforcement, feedback, and support in the learning process. - Students will actively participate in small group discussions - Teacher will be available for clarification and support - Promote collaboration in problem-solving with peers and mimicking what actually happens in the real world working environment. - Small group work will be encouraged - Polya's Four Phases of Problem-Solving will encourage this collaboration - Accommodate diverse styles of learning to a rapidly changing diverse student body. - Utilizing simulation and collaboration - Empower students to set high goals and high expectations to become confident nurses - This simulation gives them the opportunity to learn to be successful in dosage calculations prior to beginning clinical rotations which require medication administration.
Debriefing Priorities:	- Identify theory to practice gaps. - Investigate the emotional experience of the student. - Reinforce learning objectives.
Debriefing Questions:	Utilizing Gibb's reflective cycle: - Describe what happened with this case study today? - What were you thinking and feeling while you were doing the dosage calculations?

	3. What was good and bad about the experience? 4. What sense can you make of this situation? 5. What else could you have done? 6. If the issues you experienced arose again, what would you do?
Stage 4: Finishing the Project	
Evaluate the Learning Process	Post-DCT Test Self-Perceived Judgment in Dosage Calculation Scale NLN Satisfaction and Self-Confidence Tools
Revisions & Refinement	This scenario has been refined and revised after implementing it with a group of Fundamental II students during the spring of 2009. Very little has changed from the original but more of the focus is now on the dosage calculations and administration. The pathophysiology and the drug actions section has been limited to brief summaries because we want the focus of this scenario to be on the dosage calculations and administration. We still wanted a small portion of the scenario to reinforce the importance of knowing what you are giving and why you are giving it at all times and not divorce those thought processes during the decision making process. This helps instill the mindset of what they must do in a realistic environment while making thoughtful clinical judgments decisions.

APPENDIX B

INTERNAL REVIEW BOARD FORM – SOUTHERN ADVENTIST UNIVERSITY
APPROVAL LETTER – SOUTHERN ADVENTIST UNIVERSITY

INTERNAL REVIEW BOARD FORM – UNIVERSITY OF NORTHERN COLORADO
APPROVAL LETTER – UNIVERSITY OF NORTHERN COLORADO

Southern Adventist University

RESEARCH APPROVAL FORM

Form A

Directions: Please complete this form and submit with the following documents if used: (1) Informed Consent Form, (2) Data Collection Instrument (e.g., questionnaire) or Protocol.

Level I review: Obtain approval and signature from the course professor/student club or association sponsor. Submit Form A with signature to course professor and keep copy for self.

Level II review: Obtain approval and signature(s) from Chair/Dean. Submit copies of Form A with signatures to course professor, Chair/Dean(s), and self.

I. Identification of Project:

Principal Investigator: Jaclynn Huse, MSN, RN
 Address: 9553 Legacy Oaks Dr. Ooltewah, TN 37363
 Tel. & E-mail: (423)396-2824 jshuse@gmail.com
 Co-Investigator(s): None

Title of Project: Comparison of Teaching Strategies on Teaching Drug Dosage Calculation Skills in Fundamental Nursing Students

Department: University of Northern Colorado, School of Nursing
 Faculty Supervisor: Dr. Debra Leners PhD, RN, CPNP, CNE
 Starting Date: October, 2009 Estimated Completion Date: May 2010
 External Funding Agency and Identification Number: None

II. Purpose of Study

The purpose of this study is to compare the outcomes of dosage calculation scores in fundamental nursing students when Polya's Four Phases of Problem-Solving framework is implemented as a teaching strategy in a classroom versus a simulation lab.

Description and Source of Research Subjects:

A convenience sample of 65 fundamental, associate degree nursing students who have completed the first half of the semester and are just beginning to learn about dosage calculations will be invited to participate in this study.

If human subjects are involved, please check any of the following that apply:

None of these describe this sample of research subjects

- _____ Minors
- _____ Prison inmates
- _____ Mentally impaired
- _____ Physically disabled
- _____ Institutionalized residents
- _____ Vulnerable or at-risk groups, e.g., minority, poverty, pregnant women (or fetal tissue), substance abuse populations
- _____ Anyone unable to make informed decisions about participation

III. *Materials, Equipment, or Instruments*

- a. Informed Consent Letter – See Appendix A
- b. Demographic Tool – See Appendix B
- c. Dosage calculation skills – Pre-test – See Appendix C

All participants will complete the same pre-test during a pre-scheduled examination period. The test consists of 15-item paper and pencil dosage calculation questions followed by a 30-item Self-Perceived Judgment in Medication Administration Scale. Students will receive the test that has physician orders and actual drug labels from all of these medications so that they can use this to solve the 15 dosage calculation questions. The equipment necessary to give the medications will also be illustrated on the test. Students will not know their scores on this test until data collection is complete. Once data collection is completed, the faculty member in charge of keeping the list of names and identifying codes will notify the student of their grade. One motivating factor for students to do their best on this pre-test is that if a student scores 100% on this pre-test then it will count for the required computerized drug calculation test for this course. This 100% does not impact their grade in any way, rather, it is considered a checkmark on the list of things they have to do to fulfill course requirements. Scoring less than 100% on this pre-test will not impact their grade in any shape or form. This tool was created by the researcher based exactly on previous computerized dosage calculation tests that previous fundamental nursing students have had to take to validate their math skills for at least the past 6 years since I have worked at SAU. The content has been validated by the course instructor and three other content experts.

d. Dosage calculation skills – Post-test

After completing the treatment, all participants will complete the exact same dosage calculation test and Self-Perceived Judgment in Medication Administration Scale at a pre-scheduled time in the classroom. The same stipulations will go for making 100% as it did for the pre-test. Again, actual course grades will not be impacted. Students will be notified of their scores once data collection is completed.

e. Satisfaction and Self-Confidence in Learning Scale – See Appendix D

This tool was designed by the NLN and it is a 13-item survey utilizing a Likert scale. This tool was designed specifically for simulation. Five items measure satisfaction and eight items measure self-confidence. Validity of this tool was established through nine clinical experts. Cronbach's alpha scores were 0.94 for the satisfaction items and 0.87 for the self-confidence items. Students who participate in the simulation experience will complete this tool. This tool will be modified for students who participate in the classroom activity. This tool will be completed after the post-dosage calculation test.

V. *Methods and Procedure*

At the start of the semester, students are placed into clinical groups by the course instructor. Half of the class will have clinical every Tuesday morning throughout the semester and the other half will have clinical on Thursday mornings. These groups are arranged based primarily around transportation concerns. Many students do not have cars and therefore, the groups are split based upon who can drive and how many can they fit in their car. This makes random placement into groups impossible. The teacher does place these groups of 4-5 students into actual clinical groups and she does make sure that there is not an entire group of English Second Language (ESL) and she also tries to ensure that all of the academically stronger students are not in one group.

- a. **Pre-test** - All students will attend a scheduled test date to obtain the demographic data and complete the dosage calculation skills pre-test as described above.
- b. The **control group** (Thursday clinical group) will meet on Tuesday morning in the classroom for a two hour classroom activity presented by one of the nursing faculty that does not teach in the fundamentals level. This activity will encompass a 20 minute PowerPoint lecture based upon Polya's four phases of problem-solving framework. The instructor (the same one who will be doing the simulations) will demonstrate how to solve a dosage calculation based upon this framework for approximately 10 minutes. Students will then be given worksheets with six dosage calculations on it (the same dosage calculations that will be required of students in the simulation group). Students will fill this out individually. Calculators will be provided. Students will then divide into groups

of 3-4 students and they will go through the Polya process together and explain how they arrived at their answers. They will work together to seek other ways to solve the problems.

- c. The **experimental group** (Tuesday clinical group) will have several scheduled meeting times to meet the needs of the students. Students will be divided into groups of six students. Each group will attend a 2-hour simulation experience. Two 2-hour simulations experiences are scheduled for Wednesday evening and three 2-hour simulation experiences are scheduled for Thursday. The simulation instructor, another faculty member not associated with the fundamentals level, will introduce Polya's four phases of problem-solving framework to the students for 20 minutes. The instructor will also demonstrate how to use the framework to solve a dosage calculation problem. Students will then be given a case scenario on Larry Hawkins and they will assess and evaluate SimMan and his chart to see what medications are due. Calculations will be required and student groups can work together to figure them out. Students will also administer the medications to SimMan.
- d. **Post-test** – All students will attend a pre-scheduled test date and take the same exact pre-test as described above. Students will also complete the NLN satisfaction and self-confidence in learning tool at this time.

VI. Sensitivity: *Psychological discomfort or harm experienced by human participants because of topic under investigation, data collection, or data dissemination.*

On a scale of 0 (not sensitive) to 5 (extremely sensitive), rate the degree of sensitivity of the behavior being observed or information sought:

1 Sensitivity of behavior to be observed or information sought.

VII. Invasiveness: *Extent to which data collected is in public domain or intrusive of privacy of human participants within context of the study and the culture.*

On a scale of 0 (not sensitive) to 5 (extremely sensitive), rate the degree of invasiveness of the behavior being observed or information sought.

1 Sensitivity of behavior to be observed or information sought.

VIII. Risk: *Any potential damage or adverse consequences to researcher, participants, or environment. Includes physical, psychological, mental, social, or spiritual. May be part of protocol or may be a remote possibility.*

On scale of 0 (no risk) to 5 (extreme risk), rate the following by filling each blank.

<u>Extent of Risk</u>	<u>To Self</u>	<u>To Subjects</u>	<u>To Environment</u>
Physical harm	<u>0</u>	<u>0</u>	<u>0</u>
Psychological harm	<u>0</u>	<u>0</u>	
Mental harm	<u>0</u>	<u>0</u>	
Social harm	<u>0</u>	<u>0</u>	
Spiritual harm	<u>0</u>	<u>0</u>	

IX. Benefit-Risk Ratio (Benefits vs. Risks of this Study)

- a. **Benefits:** The teaching methodology is designed to improve students' abilities to safely and accurately calculate drug dosages with the aim that they do it correctly every single time. Nurse educators have a moral obligation to ensure that students are safe and competent to practice nursing and attend clinical. This study proposes to improve student's abilities to learn how to calculate dosages in a realistic environment that does not put an actual patient at risk. It has the potential to increase self-confidence in an important skill required for competent nursing practice.
- b. **Risks:** This study poses minimal for possible embarrassment of not being able to calculate dosages accurately. This risk is minimized by students not knowing the results to their tests immediately after completion. Students will be notified privately by the person that is responsible for the list of student names and research ID numbers. Scores, GPA, and ACT scores will be kept confidential.

X. Confidentiality/Security Measures

Collection: Students will sign a consent form that will be collected and kept in a locked, fire-proof box. The math test will have an identifying section at the top that has the student name and research ID on it which will be cut off and saved by the person keeping the master list once the ID number has been transferred onto the subsequent pages of all of the rest of the tools. The tools will then be given to the primary investigator. Collection of GPA and ACT scores will be obtained through the records department and given to the person keeping the master list. Tools will be kept in the fire-proof box as well until data collection and analysis is complete. Tools will be shredded once the data analysis is complete.

- Coding: Students will be given a research identification number on the first day of data collection.
- Storing: All data will be stored in a locked, fire-proof box.
- Analyzing: Data will be analyzed as students groups so that no results can be linked to any particular individual. It will be analyzed using SPSS 17.0 software.
- Disposing: All tools will be shredded once the data analysis is completed.
- Reporting: It is the intent of the lead investigator to disseminate the findings in a nursing education journal and in presentations at professional nursing education conferences. All disseminated data will be presented as student groups. No individual identifying factors will be disclosed.

XI. Informed Consent Process

Students will receive a copy of an informed consent letter prior to data collection and they will sign another copy of the consent letter that will be turned in and kept in a locked, fire-proof box.

Students will be required to participate in the classroom activity or the simulation experience depending on which clinical day they are assigned. Students will also be required to take the dosage-calculations tests. However, if a student chooses to not be part of the research then they will not need to complete the demographics tool, Self-Perceived Judgment in Dosage Calculation tool, or the Satisfaction and Self-Confidence in Learning tool.

There is no potential for coercion. Students are invited to voluntarily participate by completing the tools. There will be no impact on their grades for this course.

NO Potential for coercion, which is considered any pressure placed upon another to comply with demand, especially when the individual is in a superior position. Pressure may take the form of either positive or negative sanctions as perceived by the participants within the context and culture of the study.

NO Coercion or Deception involved. If so, explain.

XII. Debriefing Process

Students will receive the results to their math tests after data collection is completed. This will be done by the person who is in charge of the master list of students and research identification numbers. Students will not be interviewed for this research study.

XIII. Dissemination of Findings

√ **Potential** for presentation or publication outside of University.
If so, proposal requires Level II Review.

It is the intent of the lead investigator to disseminate the findings in a nursing education journal and in presentations at professional nursing education conferences. All disseminated data will be presented as student groups. No individual identifying factors will be disclosed.

XIV. Compensation to Participants

Students will not receive compensation for participating. Students overall course grades will not be impacted by this study. Students are required to pass a computerized dosage calculation test at 100% during the semester for this course. So as an incentive, if they do score 100% it will count towards this assignment which does not impact their grade whatsoever. It is considered more like a checkmark of fulfilling a requirement.

Southern Adventist University Signature Page
Form A

By compliance with the policies established by the Institutional Review Board of Southern Adventist University, the principal investigator(s) subscribe to the principles and standards of professional ethics in all research and related activities. The principal investigator(s) agree to the following provisions:

- *Prior to instituting any changes in this research project, a written description of the changes will be submitted to the appropriate **Level of Review** for approval.*
- *Development of any unexpected risks will be immediately reported to the **Institutional Review Board**.*
- *Copies of approval for off-campus sites of data collection will be obtained from the site and submitted in triplicate to the appropriate **Level of Review** prior to data collection.*
- *Close collaboration with and supervision by faculty will be maintained by SAU student investigator.*

Principal Investigator Signature _____

Jacquelyn Rhuse

Date 5-26-09

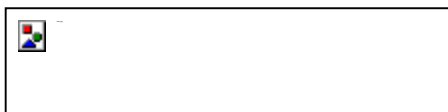
* * * * *

As the supervising faculty, I have personally discussed the proposed study with the investigator(s), and I approve the study and will provide close supervision of the project.

Supervising Faculty/Sponsor

Signature _____

(Required by all SAU student investigators)



Date 6/3/09

* * * * *

As Dean/Chair, I have read the proposed study and hereby give my approval.

Chair(s)/Dean(s) Signature _____

Barbara James

Date 5-26-09

(If **Level II** approval required)



June 15, 2009

Ms. Jaclynn Huse, MSN, RN
9553 Legacy Oaks Drive
Ooltewah, TN 37363

P.O. Box 370
Collegedale
Tennessee 37315
423.236.2000
Fax 423.236.1000
E-mail: postmaster@southern.edu

Dear Ms. Huse,

The Human Participants in Research Subcommittee has approved your research application entitled "*Comparison of Teaching Strategies on Teaching Drug Dosage Calculation Skills in Fundamental Nursing Students*" that was submitted by you to the IRB committee. The committee understands that you will compare dosage calculation test scores and self-perceived judgment in dosage calculation in two groups of fundamental nursing students. The control group will use a low-fidelity stimulated case study in a traditional classroom setting, and the experimental group will use a low-fidelity simulated scenario in the simulation lab on the campus of Southern Adventist University.

It is our understanding that your data will be collected from students on the campus of Southern Adventist University and your supervising faculty member is Dr. Debra Leners who is a faculty member of University of Northern Colorado, School of Nursing. All participation in your research must be voluntary and data kept in a secure location. The study is expected to be concluded by May 2010, and at the end of the study data collected must be destroyed in an appropriate manner.

Sincerely yours,

Linda Ann Foster, Ph.D.
Professor, Biology Department
Southern Adventist University

UNC INSTITUTIONAL REVIEW BOARD

Application Cover Page for IRB Review or Exemption

Select One: X   Expedited Review   Full Board Review   Exempt from Review
                                          Allow 2-3 weeks   Allow 1 month   Allow 1-2 weeks

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Project Title: **Comparison of teaching strategies on teaching drug dosage calculation skills in fundamental nursing students**

Lead Investigator Name: Jaclynn Huse MSN, RN

Department: School of Nursing

Telephone: (423) 396-2824

Email: jshuse@gmail.com

Research Advisor Name: Dr. Debra Leners PhD, RN, CPNP, CNE

(if applicable)

Department: School of Nursing

Telephone: (970) 351-2293

Email: Debra.Leners@unco.edu

Complete the following checklist, indicating that information required for IRB review is included with this application.

Included   Not Applicable

  X   debriefing forms.

Copies of questionnaires, surveys, interview scripts, recruitment flyers,

  X   *intended readers.*

Copies of informed consent and minor assent documents or cover letter.
Must be on letterhead and written at an appropriate level for

  X   authorities.

Letters of permission from cooperating institutions, signed by proper

CERTIFICATION OF LEAD INVESTIGATOR

I certify that this application accurately reflects the proposed research and that I and all others who will have contact with the participants or access to the data have reviewed this application and the Procedures and Guidelines of the UNC IRB and will comply with the letter and spirit of these policies. I understand that any changes in procedure which affect participants must be submitted to SPARC (using the Request for Change in Protocol Form) for written approval prior to their implementation. I further understand that any adverse events must be immediately reported in writing to SPARC.



Signature of Lead Investigator

8/27/09

Date of Signature

CERTIFICATION OF RESEARCH ADVISOR (If Lead Investigator is a Student)

I certify that I have thoroughly reviewed this application, confirm its accuracy, and accept responsibility for the conduct of this research, the maintenance of any consent documents as required by the IRB, and the continuation review of this project in approximately one year.



Signature of Research Advisor

8/27/09

Date of Signature

Date Application Received by SPARC: _____

UNC IRB: Expedited Review Requested

Project title: Comparison of teaching strategies on teaching drug dosage calculation skills in fundamental nursing students

Section I

Statement of Problem

Ten years have passed since the Institute of Medicine issued an alarming report, *To Err is Human: Building a Safer Health System* that emphasized the role of medication errors in the 44,000 to 98,000 medical errors that occur annually (1999). Because of this report, the last decade has seen an influx of patient safety initiatives to reduce medication errors such as the use of electronic prescriptions, unit dose packaging, bar codes, improved packaging and labeling, and increased use of smart intravenous pumps. In spite of these initiatives, medication errors still occur (Eisenberg, 2009; Sanborn, et al., 2009; Tamblyn, et al., 2008).

Although the responsibility of medication errors do not lie solely within nursing, nurses are involved in the administration phase which accounts for 26-40% of all medication errors (Manno, 2006). It is important to consider that some of the contributing factors to medication errors have a direct relationship with the roles of nursing education including a lack of appropriate education, verification of skills (Gregory, et al., 2007; Kohn, et al., 2000) and inability to accurately calculate dosages (Polifroni, et al., 2003).

Contributions to Nursing Science

Nursing Education

The vast majority of nursing schools validate mathematical competencies in nursing students although an inconsistency exists in how validation occurs and what is the acceptable level of competency. Multiple teaching strategies such as instructional booklets, multi-media and computer-assisted instruction, and emphasis on single methods to improve calculations such as dimensional analysis have been researched and deemed effective. However, none of these strategies have demonstrated improvement in conceptual and calculation skills at the same time while producing satisfactory passing scores in all of the participants. This study has the potential to contribute to the body of nursing education knowledge through providing research-based evidence on the effectiveness of using simulation to increase the conceptual and computational skills required to solve dosage calculations accurately while increasing satisfaction, self-confidence, and clinical judgment skills in an increasingly diverse nursing student population. Literature dispels the validity of traditional formats of dosage calculation testing and calls for a more realistic way to validate competency. This study will utilize a dosage calculation tool that resembles what occurs in a realistic clinical setting complete with physician's orders and images of vials, syringes, and other necessary equipment to calculate the dose and administer the medication. In addition, the treatment in the classroom and the simulation laboratory promotes collaboration and teamwork, two concepts that are important to future of the nursing profession.

Hospitals and Acute Care Facilities

Literature has demonstrated that graduate and experienced nurses continue to struggle with accurate dosage calculations. Most hospitals and acute care agencies have adopted a validation test to verify calculation skills in nurses. This study could encourage future research on the effectiveness of using simulation to remediate nurses who are unable to initially pass the dosage calculation test in a constructivist environment. Collaborating with colleagues would reinforce calculation skills and encourage new ways to solve problems accurately in a diverse nursing population. With safety systems such as barcodes and unit dosing, nurses have less opportunities to calculate dosages and therefore maintain competency. Because of the inconsistency in dosage calculations, it is imperative that ongoing validation occurs throughout the course of employment and not just during the orientation phase to the facility. This study

could instigate a new way to validate competency with a tool that resembles a realistic environment.

Research Questions and Hypotheses

- Q1: In fundamental nursing students, what effects does a low-fidelity simulation in a classroom versus a low-fidelity simulation in a simulation laboratory have on mean dosage calculation test scores?
- H₀1: There will be no differences in mean dosage calculation test scores between fundamental nursing students in a low-fidelity simulation in the classroom versus a low-fidelity simulation in the simulation lab.
- Q2: In fundamental nursing students, what effects does a low-fidelity simulation in a classroom versus a low-fidelity simulation in a simulation laboratory have on self-perceived judgment in dosage calculation scores?
- H₀2: There will be no differences in mean self-perceived judgment scores between fundamental nursing students in a low-fidelity simulation in the classroom versus a low-fidelity simulation in the simulation lab.
- Q3: In fundamental nursing students, does learning in a low-fidelity simulation in a classroom versus low-fidelity simulation in a simulation laboratory make a difference in self-confidence in learning?
- H₀3: There will be no difference in the level of self-confidence between fundamental nursing students in a low-fidelity simulation in the classroom versus a low-fidelity simulation in the simulation lab.
- Q4: In fundamental nursing students, does learning in a low-fidelity simulation in a classroom versus low-fidelity simulation in a simulation laboratory make a difference in satisfaction with learning?
- H₀4: There will be no difference in the level of satisfaction with learning between fundamental nursing students in a low-fidelity simulation in the classroom versus a low-fidelity simulation in the simulation lab.

Section II

Methodology

Provide the reviewers with the necessary information concerning how participants are to be recruited and treated, how confidentiality is to be protected, how the procedures are designed to safeguard participants against possible harm, and how the procedures are designed to address the research questions/hypotheses. The reviewers must be satisfied that the method is such that a clear benefit will derive from the study to offset any potential risks to participants.

1. Participants:

- a) **Are the participants adults (18 years and over)?** YES
- b) **Are the participants vulnerable (e.g., prisoners, illegal immigrants, pregnant, cognitively impaired, financially destitute)?** NO
- c) **Describe the source from which you plan to obtain your sample of participants.** A convenience sample of 65 fundamental, associate degree

nursing students from Southern Adventist University in Collegedale, TN who are enrolled in Fundamentals I and are just beginning to learn about dosage calculations will be invited to participate in this study.

- d) **How are participants to be contacted initially?** Students will be informed during a regularly scheduled class period.
- e) **How will they be made aware of their right to volunteer or not, procedures to insure confidentiality, and the general nature of activities for which they are being asked to volunteer?** Students will be informed at the beginning that this is a research study and they will receive a letter of consent that they will sign indicating their willingness to participate. As part of their course requirements, students will be required to take the pre- and post-dosage calculation skills tests and attend the classroom or simulation event, depending upon which day they go to clinical. However, participation is voluntary and if students do not want to participate then they will not be asked to complete the demographics tool, the Self-Perceived Judgment in Dosage Calculations tool, or the Satisfaction and Self-Confidence in Learning tool. Students will receive a copy of the informed consent letter and a signed copy will be obtained for our records. They have the option of dropping out of the study at any time.
- f) **Describe how confidentiality or the anonymity of the source of your data will be protected.** Anonymity and confidentiality will be maximized by having a neutral staff member keep the master list of student's names and research identification numbers in a locked, fire-proof cabinet. The lead investigator is not the lead teacher for this course and has not had these students in any courses prior to this research study. The lead investigator will only have access to the research identification number and would be unable to link data such as GPA and ACT scores back to individual students. In addition, the two teachers and any staff involved would sign a confidentiality pledge indicating their willingness to keep the information confidential. Reported data will only be done by student aggregates so that no individual person could possibly be identified by the data presented.
- g) **Informed consent: Attach a copy of the informed consent document to be signed by the participants.** See Appendix A
- h) **Describe any special arrangements to protect the safety of special populations, if applicable.** N/A
- i) **Describe any plans for debriefing your participants.** After data collection has been completed, students will receive a letter expressing the lead investigators appreciation for participating in the study. This letter outlines what the research intends to discover (See Appendix B).

In addition, students will receive a handout with Polya's Four Stages of Problem-Solving so that they can use this framework whenever they encounter dosage calculations. (See Appendix B).

2. Procedure:

- a) **Describe your sampling or participant assignment procedures.** A convenience sample of 65 fundamental nursing students who are in a Fundamentals II course and are just beginning to learn about dosage calculations will be invited to participate in this study. Informed consent will be

obtained (see Appendix A). Students will be equally divided into an experimental and a comparison group based upon clinical group rotations (Tuesdays or Thursdays). The clinical group rotations are assigned based upon transportation needs for the students because many of the students are from out of state or out of the country and they reside in the campus dormitories and do not have personal transportation. Students sign up as “car groups” of 3-4 people and the lead faculty member assigns them to a full clinical group for Tuesdays or on Thursdays. The course instructor does try to make sure that equality is maintained in each group by making sure that each group has a blend of defining student characteristics such as language or GPA.

The course instructor will require that the Thursday lab group will participate in the classroom activity on Tuesday morning and the Tuesday lab group will participate in simulation on Wednesday evening or on Thursday during the same week as the classroom group. The pre- and post-test dosage calculations test will also be required. However, if a student declines to participate in the research study their scores from the math tests will not be included as study data and they will not be required to complete the demographics tool, the self-perceived judgment in medication administration tool, or NLN satisfaction and self-confidence tool.

b) Provide a step by step protocol of everything participants will be asked to do in your study. Stipulate the nature of all data to be collected.

A two-year associate degree nursing program, with students enrolled in a Fundamentals II nursing course, will participate in a low-fidelity simulation experience in the classroom or in the simulation lab. All students will meet in a classroom and complete a demographic tool (See Appendix C) and take a self-administered pre-Dosage Calculation Test (See Appendix D) followed by a self-administered Self-Perceived Judgment in Dosage Calculation tool (See Appendix D). Calculators will be allowed and will be provided for those who request one. Students will then be divided into groups based upon the day of clinical rotation.

Comparison Group. Students in the Thursday clinical group ($n=33$) will be required to attend a classroom experience utilizing a low-fidelity case study. The first hour of this experience entails a PowerPoint lecture introducing Polya's Four Phases of Problem-Solving framework. The teacher will demonstrate how to use the framework to solve a dosage calculation question. After the demonstration, the control group will receive a simple case study on a patient requiring six medications. The individual worksheets will contain the list of the six medications including information on how the medication is supplied. Students will use this information to independently solve these six problems utilizing Polya's framework.

During the second hour, students will spread out in the classroom into groups of six students. These small groups will use Polya's framework to go back through the six questions and constructively collaborate together on how to solve the problems. Guided reflection will occur at the end of the experiment to allow the instructor to connect the important components of the learning experience to help bridge any theory-to-practice gaps that may exist. Gibbs' reflective cycle of questions will promote reflection-in-action and provide a consistent line of questioning for the study (Jeffries & Rogers, 2007). Students will complete the NLN Student Satisfaction and Self-Confidence in Learning Scale (See Appendix E). The Post-Dosage Calculation Test and Self-Perceived Judgment in Dosage

Calculations will be completed at a later date when both the experimental and control group can test at the same time.

Experimental group. Students in the Tuesday clinical group ($n = 32$) will become the experimental group. This group of students will be divided into smaller groups of approximately six students. Each small group will attend a two hour simulation experience scheduled during the same week as the control group. Each small simulation group will receive an introduction to Polya's Four Phases of Problem-Solving framework. Then the experimental group instructor will use a typical physician's order and the necessary equipment (i.e. drug vial, syringes) and use this information to solve the problem. The experimental group will participate in a simplistic case scenario based upon the NESF guidelines. The simulation will include a medical chart with six medications that have been ordered to be given now. Based upon the physician's orders, the experimental group will independently solve the problems utilizing Polya's framework and using the necessary equipment required to administer the drug to figure out the solutions. Each student in the experimental group will be given one of the six drugs to actually prepare and administer during the scenario.

For the final hour the simulation group will go through the Polya process together, explaining and collaborating how to arrive at the correct solutions for these six questions. Guided reflection will occur at the end of the simulation experience to allow the instructors to connect the important components of the learning experience together. Gibbs' reflective cycle of questions will promote reflection-in-action and provide a consistent line of questioning for the study (Jeffries & Rogers, 2007). Finally, students will complete the NLN Student Satisfaction and Self-Confidence in Learning Scale (See Appendix E) measuring their satisfaction with the learning experience and how confident they feel in their knowledge and skills.

Post-Test - Both groups will rejoin in a large classroom and take the Post-Dosage Calculation Test (See Appendix D) and the Self-Perceived Judgment in Dosage Calculations tool (See Appendix D) at the same time within one week of completing the classroom or simulation experiences. The rationale for completing the post-test within one week is that students must meet the school of nursing policy for dosage calculations at 100% before administering medications in clinical. If they do not achieve this score during this research study then they will need an adequate amount of time to complete the computerized tutorials, seek help from a tutor, and take the computerized exams prior to clinical. It would be unethical for a research study to interfere with a student's ability to fulfill course requirements and therefore, prohibit them from attending clinical.

- c) **Describe and provide clear rationale for the use of any deceptive practices. (See the deception policy in the IRB Guidelines.)** No deception used in this study.
- d) **Include copies or complete descriptions of questionnaires, interview protocols, or other measurement procedures. Investigators using their own instruments should include a full copy of the measure. Copies of widely used standardized tests are not necessary. If an interview is to be conducted and the questions are not standardized, indicate the range of topics and examples of possible questions.**

The four instruments used for this study are:

1. Demographic Survey: A self-administered researcher-designed form to collect data on gender, age, class standing, ethnicity, previous experience in healthcare and education, GPA, ACT/SAT math scores, and confirmation of college math requirement completed if ACT < 22. Conceptually defined, the demographic tool enables the researcher to determine levels of potential variances such as academic standing or experience in health care or education. Operationally defined, the demographic tool is designed to collect demographic data on research participants. (See Appendix C).
2. Pre-Dosage Calculation Test (Pre-DCT) and Post-Dosage Calculation Test (Post-DCT): Conceptually defined, the Pre-/Post-DCT is a 30-item self-administered, researcher-designed instrument that reflects the original medication administration dosage calculation instrument utilized in the SAU school of nursing for many years. The original tool has been modified to test the accuracy of medication administration dosage calculation skills and the transfer of these calculated dosages into a realistic format for medication administration in fundamental level nursing students. The medications to be calculated are in pill form, liquid suspension, nasogastric tube (NGT), intramuscular injection (IM), and intravenous pushes and infusions (IV). The items require the participants to understand the problem through interpretation of the physician's orders and the drug labels, devise a plan to solve the problem, and carry out the plan utilizing appropriate conversions when necessary and demonstrating a transfer of the calculated dosages into a realistic setting by filling in the correct dose on the appropriate equipment (i.e. tablets, medication cup, Kangaroo pump tube feeding bag, syringes, and electronic IV pumps). The items are divided into two categories – 16 items on calculating medication administration dosages and 14 items on demonstrating the transfer of the calculated dosages to the actual equipment. (See Figure 6 for the test blue print).

Operationally defined, the Pre-/Post-DCT will be used to evaluate cognitive knowledge and content mastery pre- and post-educational experience. The Pre-/Post-DCT forms of the instrument portray the actual medication and its constitution. Students will have to use this information to gather the pertinent data to calculate the dosages correctly. The questions are scored dichotomously, *yes*, the response is correct (0) and *no*, the response is incorrect (1). The questions are the exact same for both forms but the requested dosage and the patient's weight will be different on the second form. Reliability and validity of the instrument will be discussed in the next section (See Appendix D).

3. Self-Perceived Judgment in Dosage Calculation Scale (SPJDSCS): Conceptually defined, the SPJDSCS is a 15-item self-administered, researcher-designed instrument to test Polya's Fourth Phase of Problem-Solving framework by assessing a students' ability to examine the solution obtained to see if it is logical and reasonable. Operationally defined, The SPJDSCS is designed to evaluate self-perceived judgment utilizing a 5-point Likert Scale ranging from highly logical (5 points) to highly illogical (1 point). Content validity will be established by 5 content experts. Reliability will be established through a pilot study. (See Appendix D). Combined with the Pre- and Post-DCT tools, these instruments measure all of the learned constructs of dosage calculations deemed necessary and essential to practicing safe medication administration in a clinical environment.

4. National League for Nursing (NLN) Satisfaction and Self-Confidence in Learning Scale (SSCLS): Conceptually defined, the SSCLS is a 13-item self-administered instrument designed by the NLN to assess student's feelings on the simulation experience. Operationally defined, the SSCLS is designed to assess student's perceptions on the level of satisfaction experienced during simulation and how this teaching strategy influences the level of self-confidence a student has after participating in simulation. (See Appendix E).

The first portion is a 5-item tool measuring satisfaction in learning using a 5-point Likert scale with responses ranging from strongly agrees (5 points) to strongly disagree (1 point). Items measure the level of satisfaction with the teaching methods, variety of learning materials and activities and how much these motivated a student to learn, and the enjoyment and satisfaction with the instructors approach to teaching. Cronbach's alpha established reliability at 0.94 (Jeffries, 2007).

The second portion is an 8-item tool measuring self-confidence in learning utilizing the same 5-point Likert scale. Items measure confidence in mastery of the content, the scope of the content, skill and knowledge development, resources utilized for the simulation, self-responsibility in learning, seeking help when necessary, how to use simulation for maximizing the learning experience, and the instructors responsibility for teaching. Cronbach's alpha established reliability at 0.87 (Jeffries, 2007). In this study, students will rate their self-confidence in dosage calculations based upon their experience with a low-fidelity case study simulation in the classroom or a low-fidelity scenario simulation in the simulation lab. Content validity for satisfaction and self-confidence items was established through nine content experts.

3. Proposed data analysis:

- a) **Describe the form of the data to be analyzed (e.g., numbers from a Likert-type scale, journal entries, reaction time, heart rate, dichotomous 'yes' or 'no' responses, tape recorded conversations, photographs etc.).**

a. Pre/Post DCT test - The questions are scored dichotomously, yes, the response given is correct (1) and *no*, the response given is incorrect (0).

b. Self-Perceived Judgment in Dosage Calculation Scale (SPJDCS – Likert Scale

c. National League for Nursing (NLN) Satisfaction and Self-Confidence in Learning Scale (SSCLS – Likert scale

- b) **Explain the statistical design and how the corresponding analysis will address the research questions and hypotheses proposed.**

The purpose of this proposed study is to (a) compare medication administration dosage calculation scores and scores of self-perceived judgment in medication dosage calculations in fundamental nursing students who experience either a low-fidelity classroom experience or a low-fidelity simulation lab experience and (b) determine if there is any difference between satisfaction and self-confidence in learning when comparing the two previously identified teaching modalities. Statistical Package for the Social Sciences (SPSS) Version 17.0 will be utilized to analyze all of the data.

Q1: In fundamental nursing students, what effects does a low-fidelity simulation in a classroom versus a low-fidelity simulation in a simulation laboratory have on mean dosage calculation test scores?

H_0 1: There will be no differences in mean dosage calculation test scores between fundamental nursing students in a low-fidelity simulation in the classroom versus a low-fidelity simulation in the simulation lab.

Before any statistical tests are conducted, it is important to determine whether the assumptions of the planned statistical test are met. The *t*-test has an assumption of an approximately normal distribution and homoscedasticity (equality of variance.) A histogram will be visualized to determine whether the results are approximately normally distributed. If the histogram is approximately normal then the Levene's test will be used to examine the assumption equality of variance, or in other words, it tests the hypothesis that there is equality in the variances between the experimental and the comparison group (Field, 2000). Alpha will be set at 0.05 and if the Levene's test yields a *p* score greater than 0.05 then equal variances can be assumed and the appropriate *t*-test can be determined.

According to Houser (2008), the most common tests utilized to determine if differences exist between an experimental and a comparison group are tests of means and proportions. These tests are determined by identifying the level of measurement and whether the data is nominal, ordinal, interval, or ratio. The scores achieved on the Pre-/Post-DCT are categorized as continuous data and defined as a ratio measurement because the possibility for an absolute zero exists (Polit & Beck, 2008). When ratio data are compared, an independent group *t*-test is recommended to quantify the difference between the mean score of the experimental group and compares it to the mean score of the comparison group (Houser, 2008; Polit & Beck, 2008). Assuming equality of variances between the mean scores of the Pre-/Post-DCTs in the experimental and the comparison group, an independent group *t*-test will be performed to quantify the differences between the two groups. A paired sample *t*-test quantifies the difference between the mean value of the test score measured in the same group over a period of time (Houser, 2008). The paired sample *t*-test will be utilized to compare the differences of the means scores of the Pre-/Post-DCT of the experimental and the comparison group.

To determine if extraneous variables such as gender, age, ethnicity, class rank, GPA, ACT/SAT scores, experience in healthcare as an LPN, EMT, or CNA, or experience in education such as students seeking a second degree has any influence on the Pre-/Post-DCT test scores an analysis of covariance (ANCOVA) will be conducted to obtain a more precise estimate of the differences between the experimental and comparison group in this study. The ANCOVA statistical procedure can test the differences in mean scores between two groups while controlling possible influential variables therefore supporting the assumption that the teaching modality made a difference in the test scores (Polit & Beck, 2008).

Q2: In fundamental nursing students, what effect does a low-fidelity case study simulation in a classroom versus a low-fidelity scenario simulation in a simulation laboratory have on self-perceived judgment in dosage calculation scores?

H₀2: There will be no differences in mean self-perceived judgment scores between fundamental nursing students in a low-fidelity case study simulation in the classroom versus a low-fidelity scenario simulation in the simulation lab.

The scores obtained on the SPJDCS are considered ordinal data because the tool utilizes a 5-point Likert scale. The appropriate statistical test to analyze the differences between the classroom versus the simulation group is the Mann-Whitney test (Polit & Beck, 2008). However, if an approximately normal distribution exists via a histogram, then the more sensitive *t*-test will be used rather than the Mann-Whitney to determine the differences between the mean scores of the experimental and the comparison group. The Levene's test will then be used to determine which variety of *t*-test will be used once it has been determined that a normal distribution exists. In addition, to control for covariances such as gender, age, ethnicity, class rank, GPA, ACT/SAT scores and experience in healthcare or second degree students, ANCOVA will be used.

Q3: In fundamental nursing students, does learning in a low-fidelity case study simulation in a classroom versus a low-fidelity scenario simulation in a simulation laboratory make a difference in self-confidence in learning?

H₀3: There will be no difference in the level of self-confidence between fundamental nursing students in a low-fidelity case study simulation in the classroom versus a low-fidelity scenario simulation in the simulation lab.

The mean scores of the self-confidence section of the NLN Student Satisfaction and Self-Confidence with Learning Scale are considered continuous data because the tool utilizes a 5-point Likert scale. Assuming that the histogram is normally distributed, the Levene's test will determine which *t*-test is the appropriate test to compare the differences between the mean scores. If the distribution is not normal then the Mann-Whitney test will be used (Polit & Beck, 2008). To determine the strength of the relationship between these variables, Spearman's rho will be utilized.

Q4: In fundamental nursing students, does learning in a low-fidelity case study simulation in a classroom versus a low-fidelity scenario simulation in a simulation laboratory make a difference in satisfaction with learning?

H₀4: There will be no difference in the level of satisfaction with learning between fundamental nursing students in a low-fidelity case study simulation in the classroom versus a low-fidelity scenario simulation in the simulation lab.

The mean scores of the satisfaction section of the NLN Student Satisfaction and Self-Confidence with Learning Scale are considered continuous data because the tool utilizes a 5-point Likert scale. As previously described with self-confidence a histogram will determine a normal distribution and the Levene's test will determine the appropriate *t*-test. If the distribution is normal and the Levene's test is significant then a *t*-test will be conducted. If the distribution is not normal then a Mann-Whitney test will be conducted. Spearman's rho will determine the strength of the relationship.

Section III – Risks/Benefits and Costs/Compensation to Participants

Risk Statement: There are minimal risks for (a) anxiety and feelings of inadequacy over taking a dosage calculation test without preparation, (b) anxiety in using simulation as a teaching strategy, and (c) a breach of confidentiality in identifying characteristics of the participants.

Anxiety and Inadequacy

All students in this study will be asked to meet at a pre-scheduled time to take a dosage calculation test and complete the self-perceived judgment in dosage calculation tool and demographics tool. Students will be informed of the nature of the research study at this time and written consent will be obtained.

Students may have feelings of anxiety over not being informed of the intent of the test prior to arriving and they may have feelings of inadequacy over not being prepared to perform to the best of their abilities. The feelings of anxiety and inadequacy will be minimized by informing students at the beginning of the meeting that the test scores will not negatively impact their grades for the Fundamentals I course in any shape or form. However, because of a school of nursing dosage calculation policy that all students must score 100% on a dosage calculation test prior to administering medications in clinical, students will be informed that a score of 100% on either the Pre- or Post-Dosage Calculation Test will count for this course requirement. A score of 100% does not impact the course grade in any way; rather it is a checkmark off of a list of skills that must be accomplished prior to clinical.

Students will be informed of their test scores by a faculty member who will keep the master list of names and research identification numbers after all of the data collection has been completed. After data collection, if a student does not score 100% on either test they will have free access to a faculty tutor, computerized tutorials, and computerized tests that are regularly used for this course so that they can meet requirement of the school of nursing policy on dosage calculation tests.

Anxiety in Simulation Teaching Strategy

Using simulation as a teaching strategy may invoke anxiety in students who are unfamiliar with simulation and the different pedagogical approach to learning. Up until this point, exposure to simulation in the simulation lab for this group of nursing students has been limited to learning how to listen to heart, breath, and bowel sounds, palpating pulses, and practicing injections. The literature suggests that beginning nursing students are not ready for high-fidelity, complex simulations and the use of low-fidelity, non-complex scenarios would be more appropriate (Waldner & Olson, 2007). This advice has been taken into consideration and a non-complex scenario using a static manikin has been developed for this study. Easing students into simulation with a basic scenario will diminish the anxiety over participating in an unfamiliar learning strategy.

Breach of Confidentiality

In a study where anonymity cannot be guaranteed, researchers should do everything possible to maintain confidentiality (Polit & Beck, 2008). Students will be assured that the master list of student names and research identification numbers will be kept in a locked, fire-proof container guarded by a neutral staff member. This staff member plus the two individuals who will be teaching the classroom and simulation experiences will sign a confidentiality pledge indicating a willingness to hold all information confidential. All data will be collected in a sealed envelope and delivered to the neutral staff member who will code each paper with the correct research identification number and then remove student names from the tools by cutting them off and shredding them. The neutral staff member will not hand over any tools to the researcher until the identifying factors are removed. After the tools have been scored and the data has been entered into the computerized database, the dosage calculation tests will be returned to the neutral staff member so that the scores can be recorded and students who scored 100% can be notified. For the sake of test security and preventing a confidentiality leak, the dosage calculation tests will be

shredded as soon as the database has been checked for accuracy. All other tools will be entered into the database and destroyed once all of the data has been entered and checked for accuracy. Finally, all data will be reported as an aggregate. No individual identifying characteristics will be revealed in dissemination through this dissertation or future contributions to nursing journals or professional presentations.

Any costs and compensation must also be identified. An educational debriefing will occur after the data collection has been completed in the form of a letter that indicates the nature of the study and expresses appreciation for participation. Students will also be given a handout with the Polya Four Stages of Problem-Solving Framework to utilize at any point in time when they do dosage calculations in the future. In addition, if students score 100% on either the Pre- or Post-Dosage Calculation test then this will count for the required dosage calculation test that they are required to take per the school of nursing policy. It will not impact their grade in any way, rather it is a checkmark on a list of required skills.

Section IV – Grant Information

This study is not funded by a grant.

Section V – Documentation

- **Attach a copy of the informed consent document, on UNC letterhead.**
(See Appendix A)
- **Please attach a copy of any surveys or standardized interview questions, if applicable, or if an interview is not standardized, the range of topics and likely questions. It is not necessary to include copies of published tests such as IQ or personality assessments; however, if the you are using your own instrument(s), you should include a full copy of the measure.** (See Appendix C-D).
- **If the data represent records to be accessed, please describe the data, and any previous uses of these data, and exactly how the records are to be accessed. Attach written permission from the source of the data, if applicable.** GPA and ACT/SAT scores in math will be obtained by a neutral staff member that has access to the records. These data will not be accessed without the written consent of the student.
- **Present information regarding permission from site of data collection if external to UNC. This must include letters of permission signed by appropriate officials of cooperating institutions such as daycare centers, schools, hospitals, clinics and other universities. Permission letters should be on letterhead stationary.** Permission form and IRB approval has already been obtained. (See Appendix E)
- **Provide copies of any flyers or advertisements used for recruiting participants and of the debriefing form, if applicable.** N/A
- **If this is an application for Full Board Review, you must submit with it evidence of ethics training by completing the tutorial at <http://cme.nci.nih.gov/> and attaching proof of completion certificate with this application.** N/A

UNIVERSITY of
NORTHERN COLORADO
 Institutional Review Board (IRB)

September 3, 2009

TO: Ann Keller-Lally
 School of Modern Languages & Cultural Studies

FROM: Gary Heise, Co-Chair *GDK*
 UNC Institutional Review Board

RE: Expedited Review of Proposal, *Comparison of Teaching Strategies on Teaching Drug Dosage Calculation Skills in Fundamental Nursing Students*, submitted by Jaclynn Huse
 (Research Advisor: Debra Leners)

First Consultant: The above proposal is being submitted to you for an expedited review. Please review the proposal in light of the Committee's charge and direct requests for changes directly to the researcher or researcher's advisor. If you have any unresolved concerns, please contact Gary Heise, School of Sport and Exercise Science, Campus Box 39, (x1738). When you are ready to recommend approval, sign this form and return to me.

I recommend approval as is.

Ann M. Keller-Lally 10-13-09
 Signature of First Consultant Date

The above referenced prospectus has been reviewed for compliance with HHS guidelines for ethical principles in human subjects research. The decision of the Institutional Review Board is that the project is approved as proposed for a period of one year: 21 Oct 2009 to 21 Oct 2010.

Gary Heise 21 Oct 09
 Gary Heise, Co-Chair Date

Comments:

See e-mail documentation. Ann M. Keller-Lally

APPENDIX C
INFORMED CONSENT LETTER



Informed Consent for Participation in Research
University of Northern Colorado

Project Title: Comparison of teaching strategies on teaching drug dosage calculation skills in fundamental nursing students

Researcher: Jaclynn Huse, PhDc, RN, Graduate Student, Department of Nursing
Phone Number: 423-236-2987

Dear Nursing Student,

I am beginning a research project on a new teaching strategy for learning how to calculate dosages for medications. You are invited to voluntarily participate in this study that will take place over the course of the week.

Although the activities and the math tests in this research study are required by your teacher, participation in the rest of this study is completely voluntary. You will find out the directions on when and where you are supposed to be for these required events during the instructions given to you today. You may decide not to participate in this study and if you begin participation, you may still decide to stop or withdraw at any time. Your decision will be respected and will have no bearings on your grades and course work at Southern Adventist University. I am requesting that I be allowed to collect information about your overall GPA and your ACT scores in math in addition to what you fill out on the forms today. All information gathered will be kept confidential and anonymous.

Participation is voluntary. You may decide not to participate in this study and if you begin participation you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled. Having read the above and having had an opportunity to ask any questions, please sign below if you would like to participate in this research. A copy of this form will be given to you to retain for future reference. If you have any concerns about your selection or treatment as a research participant, please contact the Sponsored Programs and Academic Research Center, Kepner Hall, University of Northern Colorado Greeley, CO 80639; 970-351-1907.

Thank you so much for your participation.

Jaclynn Huse PhDc, RN

Date

Participant Signature

Date

APPENDIX D
SIGNED CONFIDENTIALITY FORMS

Confidentiality Pledge

I, Lorella Howard, understand that I am assisting with the collection of confidential research information obtained from nursing students. Information that is deemed confidential is:

1. Data obtained on the demographics including:
  - a. Age
  - b. Gender
  - c. Class Standing
  - d. Ethnicity
  - e. Experience in the healthcare environment
  - f. Educational experience
  - g. GPA
  - h. ACT scores
  - i. Required Math Course Completion (Math ACT < 22)
2. Data obtained from the math exams (other than reporting 100% scores to the lead teacher so that she can know if they met the requirements for ProCalc)
3. Data obtained on the NLN tools for self-confidence and satisfaction with learning
4. Data obtained on their self-perceived judgment in dosage calculations
5. General observations made in the classroom or simulation lab

By signing this form, I pledge to respect the confidential nature of these data and I will not discuss this information with other faculty, staff, students, or any other individuals that are not directly involved in the research project at any point in time.

Lorella Howard
(Research Collector's Name)

10-19-09
(Date)

Confidentiality Pledge

I, Kerry Allen, understand that I am assisting with the collection of confidential research information obtained from nursing students. Information that is deemed confidential is:

1. Data obtained on the demographics including:
  - a. Age
  - b. Gender
  - c. Class Standing
  - d. Ethnicity
  - e. Experience in the healthcare environment
  - f. Educational experience
  - g. GPA
  - h. ACT scores
  - i. Required Math Course Completion (Math ACT < 22)
2. Data obtained from the math exams (other than reporting 100% scores to the lead teacher so that she can know if they met the requirements for ProCalc)
3. Data obtained on the NLN tools for self-confidence and satisfaction with learning
4. Data obtained on their self-perceived judgment in dosage calculations
5. General observations made in the classroom or simulation lab

By signing this form, I pledge to respect the confidential nature of these data and I will not discuss this information with other faculty, staff, students, or any other individuals that are not directly involved in the research project at any point in time.

Kerry Allen
(Research Collector's Name)

10/19/09
(Date)

Confidentiality Pledge

I, Julie Weep, understand that I am assisting with the collection of confidential research information obtained from nursing students. Information that is deemed confidential is:

1. Data obtained on the demographics including:
  - a. Age
  - b. Gender
  - c. Class Standing
  - d. Ethnicity
  - e. Experience in the healthcare environment
  - f. Educational experience
  - g. GPA
  - h. ACT scores
  - i. Required Math Course Completion (Math ACT < 22)
2. Data obtained from the math exams (other than reporting 100% scores to the lead teacher so that she can know if they met the requirements for ProCalc)
3. Data obtained on the NLN tools for self-confidence and satisfaction with learning
4. Data obtained on their self-perceived judgment in dosage calculations
5. General observations made in the classroom or simulation lab

By signing this form, I pledge to respect the confidential nature of these data and I will not discuss this information with other faculty, staff, students, or any other individuals that are not directly involved in the research project at any point in time.

Julie Weep

(Research Collector's Name)

10-14-09

(Date)

Confidentiality Pledge

I, Ruth Saunders, understand that I am assisting with the collection of confidential research information obtained from nursing students. Information that is deemed confidential is:

1. Data obtained on the demographics including:
  - a. Age
  - b. Gender
  - c. Class Standing
  - d. Ethnicity
  - e. Experience in the healthcare environment
  - f. Educational experience
  - g. GPA
  - h. ACT scores
  - i. Required Math Course Completion (Math ACT < 22)
2. Data obtained from the math exams (other than reporting 100% scores to the lead teacher so that she can know if they met the requirements for ProCalc)
3. Data obtained on the NLN tools for self-confidence and satisfaction with learning
4. Data obtained on their self-perceived judgment in dosage calculations
5. General observations made in the classroom or simulation lab

By signing this form, I pledge to respect the confidential nature of these data and I will not discuss this information with other faculty, staff, students, or any other individuals that are not directly involved in the research project at any point in time.

Ruth Saunders
(Research Collector's Name)

10/14/09
(Date)

APPENDIX E
DEMOGRAPHIC TOOL

Demographic Tool
Student Research ID Number _____

Please place a checkmark on the appropriate responses

Gender ☐ Male ☐ Female Age ☐ 18 ☐ 27 ☐ 19 ☐ 28 ☐ 20 ☐ 29 ☐ 21 ☐ 30 ☐ 22 ☐ 31 ☐ 23 ☐ 32 ☐ 24 ☐ 33 ☐ 25 ☐ 34 ☐ 26 ☐ 35 or older Class Standing ☐ Freshman ☐ Sophomore ☐ Junior ☐ Senior Ethnicity ☐ African-American ☐ American Indian/ Alaskan Native ☐ Asian/Pacific Islander ☐ Caucasian (Non- Hispanic) ☐ Hispanic ☐ Other	Healthcare Experience ☐ No ☐ Yes (If “yes” please answer the following questions) What type of experience have you had? ☐ CNA ☐ LPN ☐ Other _____ How long have you worked in this capacity? ☐ 1 year or less ☐ Greater than 1 year Is this a 2nd degree for you? ☐ No ☐ Yes In what area was your 1st degree? _____

Please Sign Below

With your permission, the following information will be obtained from the records office

Overall GPA _____	If ACT < 22 has the student successfully completed the
Math ACT score _____	required college math course?
Math SAT score _____	☐ Yes
	☐ No



.....
Please Sign here if you agree to us obtaining the above information from your
 records. All information will be kept confidential and will be shredded ASAP.

8/27/09

(Signature here)

(Print name here)

The contents of this document will remain anonymous and confidential

APPENDIX F

PRE-DOSAGE CALCULATION TEST (PRE-DCT)
POST-DOSAGE CALCULATION TEST (POST-DCT)

Student name: _____ (This will be removed before giving to researcher)



Research ID number _____ Test Score _____

Pre-Dosage Calculation Test

Instructions: You are preparing all of the following medications. The physician's orders are shown with each question along with an image of the medication. The medications are given by pills, liquid suspension, subcutaneously, intramuscularly, intravenously, or by tube feeding. The appropriate equipment to give these types of medications is shown. You will calculate the correct dosages **and** indicate on the equipment how much you will give. Each part is worth 1 point. Directions for each of the medications are within each drug box.

Examples:



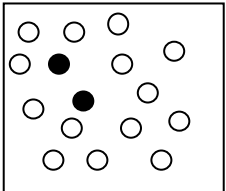
IM or IV pushes



Liquid Suspension



IV infusion



Oral tablets

A calculator will be provided for you. The score on this test will not impact your grade. However, if you score 100% it will count for the ProCalc test that is required for this course. You will be notified of your grade after all of the data for this research project has been collected.

Question 1



Image reprinted with permission from AHRQ

PHYSICIAN'S ORDERS

Zofran 4 mg IM now and then Q 6h PRN nausea

a. How many mL will you draw up in the syringe? _____

b. Please indicate on the syringe how much volume you will give by coloring the syringe in up to the correct dose.



Research ID number _____

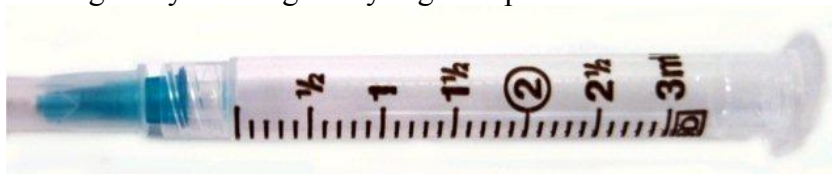
Question 2

Image reprinted with permission from Bedford Labs.

PHYSICIAN'S ORDERS

Haldol 2 mg IM now and then Q 12 hours

- a. How many mL will you draw up in the syringe? _____
- b. Please indicate on the syringe how much volume you will give by coloring the syringe in up to the correct dose.

**Question 3****PHYSICIAN'S ORDERS**

Lanoxin 0.125 mg PO now

- a. How many tablets will you give? _____
- b. Please indicate how many tablets you will give by coloring in the correct number of pills in the picture.

**Question 4****PHYSICIAN'S ORDERS**

Synthroid 0.2 mg PO now and then QD

- a. How many tablets will you give? _____
- b. Please indicate how many tablets you will give by coloring in the correct number of pills in the picture.



Research ID number _____

Question 5**PHYSICIAN'S ORDERS**

Dilantin 3 mg/kg PO (Patient Weight = 146 lbs)

- How many tablets will you give? _____
- Please indicate how many tablets you will give by coloring in the correct number of pills in the picture.

**Question 6****PHYSICIAN'S ORDERS**

Amikin 250 mg IV push now and then QD

- How many mL will you draw up in the syringe?
_____
- Please indicate on the syringe how much volume you will give by coloring in up to the correct dose.

**Question 7****PHYSICIAN'S ORDERS**

Symmetrel 100 mg NGT liquid suspension

- How many teaspoons will you give?
_____
- Please indicate on the medicine cup how much volume you will give by coloring in the medicine cup in up to the correct dose.



Research ID number _____

Question 8**PHYSICIAN'S ORDERS**

Heparin 50 units/kg SQ now and then Q12 hrs
(Pt. Weight = 231 lbs)

- How many units will you draw up? _____
- Indicate on the syringe how much volume you will draw up by coloring in the syringe to the correct spot.

**Question 9****PHYSICIAN'S ORDERS**

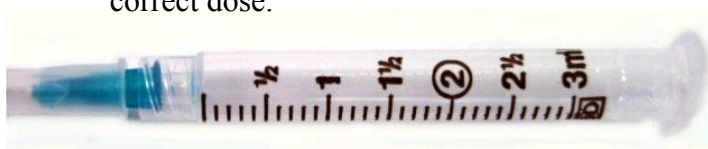
Aminophylline 6 mg/kg NGT liquid suspension
(Pt. Weight = 192.5 lbs)

- How many mL will you give?
_____
- Please indicate on the medicine cup how much volume you will give by coloring in the medicine cup in up to the correct dose.

**Question 10****PHYSICIAN'S ORDERS**

Vincristine 0.8 mg/m² in 250 NS at 100 mL hr IV
infusion (BSA = 2.06)

- How many mL will you draw up into the syringe?
_____
- Please indicate on the syringe how much volume you will give by coloring the syringe in up to the correct dose.



Research ID number _____

Question 11



PHYSICIAN'S ORDERS

Insulin drip (Novulin R 500 units/500 mL NS) at 0.1 units/kg/hr
(Pt Weight = 167 lbs)

- How many units/hr will it take to deliver the prescribed dose? _____
- Please indicate how many mL/hr you will set the IV infusion pump by writing in the calculated rate into the white screen of the pump.



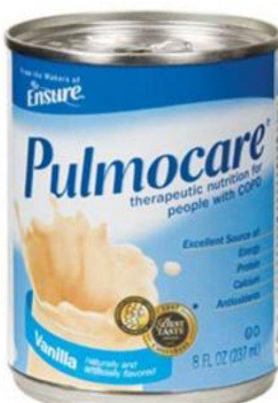
Question 12

- Indicate on the Kangaroo pump bag how much Pulmocare you will add to the bag.
- Indicate on the Kangaroo pump bag how much water you will add to the bag.

PHYSICIAN'S ORDERS

Pulmocare $\frac{3}{4}$ strength tube feeding (200 mL total) at 50 mL/hr





Example:

**Kangaroo
Pump Set**

Water
Pulmocare

Reprinted with permission from Abbott Nutrition

Research ID number _____

Question 13



PHYSICIAN'S ORDERS
 Ranitidine 300 mg in 500 mL D5W at 37.5 mg/hr now

a. How many mL/hr will it take to deliver the prescribed dose? _____

b. Please indicate how many mL/hr you will set the IV infusion pump by writing in the calculated rate into the white screen of the pump.



Question 14



PHYSICIAN'S ORDERS
 0.9% NS at 34 mL/30 minutes intravenous pump

a. How many mL/hr will it take to deliver the prescribed dose? _____

b. Please indicate how many mL/hr you will set the IV infusion pump by writing in the calculated rate into the white screen of the pump.



Question 15



PHYSICIAN'S ORDERS
 D5NS at 500 mL/3 hrs intravenously with IV set that delivers 15 gtts/mL

a. How many gtts/min will it take to deliver the prescribed dose? _____

b. How many mL/hr will infuse? _____

Student name: _____ (This will be removed before giving to researcher)



Research ID number _____ Test Score _____

Post-Dosage Calculation Test

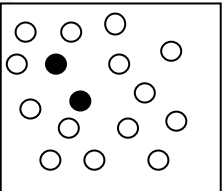
Instructions: You are preparing all of the following medications. The physician's orders are shown with each question along with an image of the medication. The medications are given by pills, liquid suspension, subcutaneously, intramuscularly, intravenously, or by tube feeding. The appropriate equipment to give these types of medications is shown. You will calculate the correct dosages **and** indicate on the equipment how much you will give. Each part is worth 1 point. Directions for each of the medications are within each drug box.

Examples:


 IM or IV pushes


 Liquid Suspension


 IV infusion


 Oral tablets

A calculator will be provided for you. The score on this test will not impact your grade. However, if you score 100% it will count for the ProCalc test that is required for this course. You will be notified of your grade after all of the data for this research project has been collected.

Question 1



Image reprinted with permission from AHRQ

PHYSICIAN'S ORDERS

Zofran 6 mg IM now and then Q 6h PRN nausea

a. How many mL will you draw up in the syringe? _____

b. Please indicate on the syringe how much volume you will give by coloring the syringe in up to the correct dose.



Research ID number _____

Question 2

Image reprinted with permission from Bedford Labs.

PHYSICIAN'S ORDERS

Haldol 3 mg IM now and then Q 12 hours

- a. How many mL will you draw up in the syringe? _____
- b. Please indicate on the syringe how much volume you will give by coloring the syringe in up to the correct dose.

**Question 3****PHYSICIAN'S ORDERS**

Lanoxin 0.5 mg PO now

- a. How many tablets will you give? _____
- b. Please indicate how many tablets you will give by coloring in the correct number of pills in the picture.

**Question 4****PHYSICIAN'S ORDERS**

Synthroid 0.15 mg PO now and then QD

- a. How many tablets will you give? _____
- b. Please indicate how many tablets you will give by coloring in the correct number of pills in the picture.



Research ID number _____

Question 5**PHYSICIAN'S ORDERS**

Dilantin 3 mg/kg PO (Patient Weight = 220 lbs)

- How many tablets will you give? _____
- Please indicate how many tablets you will give by coloring in the correct number of pills in the picture.

**Question 6****PHYSICIAN'S ORDERS**

Amikin 125 mg IV push now and then QD

- How many mL will you draw up in the syringe?
_____
- Please indicate on the syringe how much volume you will give by coloring in up to the correct dose.

**Question 7****PHYSICIAN'S ORDERS**

Symmetrel 66 mg NGT liquid suspension

- How many teaspoons will you give?
_____
- Please indicate on the medicine cup how much volume you will give by coloring in the medicine cup in up to the correct dose.



Research ID number _____

Question 8

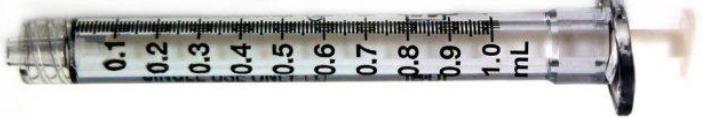


PHYSICIAN'S ORDERS

Heparin 50 units/kg SQ now and then Q12 hrs
(Pt. Weight = 150 lbs)

a. How many units will you draw up? _____

b. Indicate on the syringe how much volume you will draw up by coloring in the syringe to the correct spot.


Question 9



PHYSICIAN'S ORDERS

Aminophylline 6 mg/kg NGT liquid suspension
(Pt. Weight = 115.5 lbs)

a. How many mL will you give? _____

b. Please indicate on the medicine cup how much volume you will give by coloring in the medicine cup in up to the correct dose.


Question 10



PHYSICIAN'S ORDERS

Vincristine 0.8 mg/m² in 250 NS at 100 mL hr IV infusion (BSA = 3.2)

a. How many mL will you draw up into the syringe? _____

b. Please indicate on the syringe how much volume you will give by coloring the syringe in up to the correct dose.



Research ID number _____

Question 11



PHYSICIAN'S ORDERS

Insulin drip (Novulin R 500 units/500 mL NS) at 0.1 units/kg/hr
(Pt Weight = 242 lbs)

- How many units/hr will it take to deliver the prescribed dose? _____
- Please indicate how many mL/hr you will set the IV infusion pump by writing in the calculated rate into the white screen of the pump.



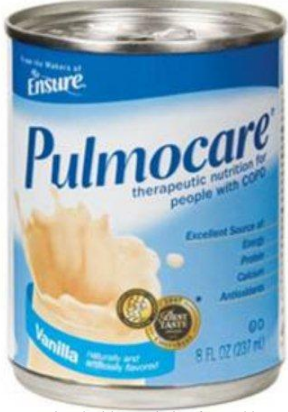
Question 12

- Indicate on the Kangaroo pump bag how much Pulmocare you will add to the bag.
- Indicate on the Kangaroo pump bag how much water you will add to the bag.

PHYSICIAN'S ORDERS

Pulmocare ½ strength tube feeding (200 mL total) at 50 mL/hr





Example:

**Kangaroo
Pump Set**

Water

Pulmocare

Reprinted with permission from Abbott Nutrition

Research ID number _____

Question 13



PHYSICIAN'S ORDERS
 Ranitidine 300 mg in 500 mL D5W at 45.5 mg/hr now

- How many mL/hr will it take to deliver the prescribed dose? _____
- Please indicate how many mL/hr you will set the IV infusion pump by writing in the calculated rate into the white screen of the pump.



Question 14



PHYSICIAN'S ORDERS
 0.9% NS at 27 mL/30 minutes intravenous pump

- How many mL/hr will it take to deliver the prescribed dose? _____
- Please indicate how many mL/hr you will set the IV infusion pump by writing in the calculated rate into the white screen of the pump.



Question 15



PHYSICIAN'S ORDERS
 D5NS at 500 mL/4 hrs intravenously with IV set that delivers 15 gtts/mL

- How many gtts/min will it take to deliver the prescribed dose? _____
- How many mL/hr will infuse? _____

APPENDIX G

SELF-PERCEIVED JUDGMENT IN DOSAGE CALCULATION SCALE (SPJDCS)

Student name: _____ (This will be removed before giving to researcher)

Self-Perceived Judgment in Dosage Calculation Scale (SPJDCS)

Please answer the following question for each one of the calculations you have just completed. You may look back at your responses to answer the questions.

Judging by your calculated answer to the dosage calculations <u>and</u> the route the medication is to be administered; how logical does the amount of medication you calculated seem to be in your opinion?					
	Highly Illogical	Illogical	Neutral	Logical	Highly Logical
1. Zofran	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
2. Haldol	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
3. Lanoxin	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
4. Synthroid	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
5. Dilantin	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
6. Amikacin	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
7. Symmetrel	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
8. Heparin	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
9. Aminophylline	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
10. Vincristine	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
11. Insulin	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
12. Pulmocare	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
13. Ranitidine	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
14. NS	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
15. D5NS	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

APPENDIX H

SATISFACTION AND SELF-CONFIDENCE IN LEARNING TOOL

Student Satisfaction and Self-Confidence in Learning

Instructions: This questionnaire is a series of statements about your personal attitudes about the instruction you receive during your simulation activity. Each item represents a statement about your attitude toward your satisfaction with learning and self-confidence in obtaining the instruction you need. There are no right or wrong answers. You will probably agree with some of the statements and disagree with others. Please indicate your own personal feelings about each statement below by marking the numbers that best describe your attitude or beliefs. Please be truthful and describe your attitude as it really is, not what you would like for it to be. This is anonymous with the results being compiled as a group, not individually.

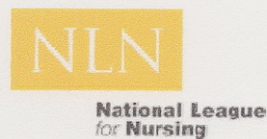
Mark:

- 1 = STRONGLY DISAGREE with the statement
- 2 = DISAGREE with the statement
- 3 = UNDECIDED - you neither agree or disagree with the statement
- 4 = AGREE with the statement
- 5 = STRONGLY AGREE with the statement

Satisfaction with Current Learning	SD	D	UN	A	SA
1. The teaching methods used in this simulation were helpful and effective.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
2. The simulation provided me with a variety of learning materials and activities to promote my learning the medical surgical curriculum.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
3. I enjoyed how my instructor taught the simulation.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
4. The teaching materials used in this simulation were motivating and helped me to learn.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
5. The way my instructor(s) taught the simulation was suitable to the way I learn.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Self-confidence in Learning	SD	D	UN	A	SA
6. I am confident that I am mastering the content of the simulation activity that my instructors presented to me.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
7. I am confident that this simulation covered critical content necessary for the mastery of medical surgical curriculum.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
8. I am confident that I am developing the skills and obtaining the required knowledge from this simulation to perform necessary tasks in a clinical setting	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
9. My instructors used helpful resources to teach the simulation.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
10. It is my responsibility as the student to learn what I need to know from this simulation activity.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
11. I know how to get help when I do not understand the concepts covered in the simulation.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
12. I know how to use simulation activities to learn critical aspects of these skills.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
13. It is the instructor's responsibility to tell me what I need to learn of the simulation activity content during class time..	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

APPENDIX I

CONSENT LETTER FROM THE NATIONAL LEAGUE FOR NURSING



October 7, 2009

Jaclynn Huse, MSN, RN
Southern Adventists University
PO Box 370
Collegedale, TN 37315-0370

Dear Ms. Huse,

Thank you for your email requesting permission to use one of our three instruments developed for the NLN/Laerdal Simulation study. It is my pleasure to grant you permission to use the "Student Satisfaction and Self-Confidence in Learning" in your dissertation entitled "*Comparison of Teaching Strategies on Teaching Drug Dosage Calculation Skills in Fundamental Nursing Students*".

In granting permission to use the instrument noted above, it is understood that the following assumptions operate and "caveats" will be respected:

- ✓ The instrument will be used strictly for the purpose noted above.
- ✓ The instrument will not be edited in any way.
- ✓ The National League for Nursing is the sole owner of these rights being granted and must be acknowledged as the source of this item.
- ✓ You own a copy of Simulation in Nursing Education: From Conceptualization to Evaluation, and are familiar with the three-year multi-site project for which this instrument was developed.
- ✓ Your membership in the NLN entitles you to use of these instruments at no charge

I am pleased that material developed by the National League for Nursing is seen as valuable as you evaluate ways to enhance learning and I am pleased that we are able to grant permission for use of the "Student Satisfaction and Self-Confidence in Learning" instrument. Should you have any questions, please feel free to contact me at mrizzolo@nlcn.org. Thank you.

Best,



Mary Anne Rizzolo, EdD, FAAN
Interim Chief Program Officer
National League for Nursing
61 Broadway, 33rd Floor
New York, NY 10006
Phone: 212.812.0315 | Fax: 212.812.0391
Email: mrizzolo@nlcn.org

APPENDIX J

LETTER OF APPRECIATION

POLYA'S FOUR STAGES OF PROBLEM-SOLVING FRAMEWORK HANDOUT



Project Title: Adding up to patient safety: Implementation of Polya's four phases of problem-solving framework as a teaching strategy to improve drug calculation skills in fundamental nursing students

Researcher: Jaclynn Huse, MSN, RN, Graduate Student, Department of Nursing
Phone Number: 423-396-2824

Dear Nursing Student,

I just wanted to thank each one of you for taking the time to participate in this research study. Over the course of this study, I am hoping to find out how useful Polya's Four Phases of Problem-Solving Framework is as a teaching strategy to help you improve your dosage calculation skills and help you think about what it is that you are calculating and whether or not the answer you come up with makes sense. Giving medications in a clinical setting is a big responsibility and it is my goal that you feel more confident and competent to do this in a safe manner once you get into a real clinical setting.

I also wanted to find out how you felt about using different teaching strategies. I hope that you found that getting to collaborate with your classmates was a fun way to learn all types of concepts in nursing and I hope that this experience has sparked an interest in organizing more collaborating learning experiences with your peers whether it be in the classroom or the simulation lab.

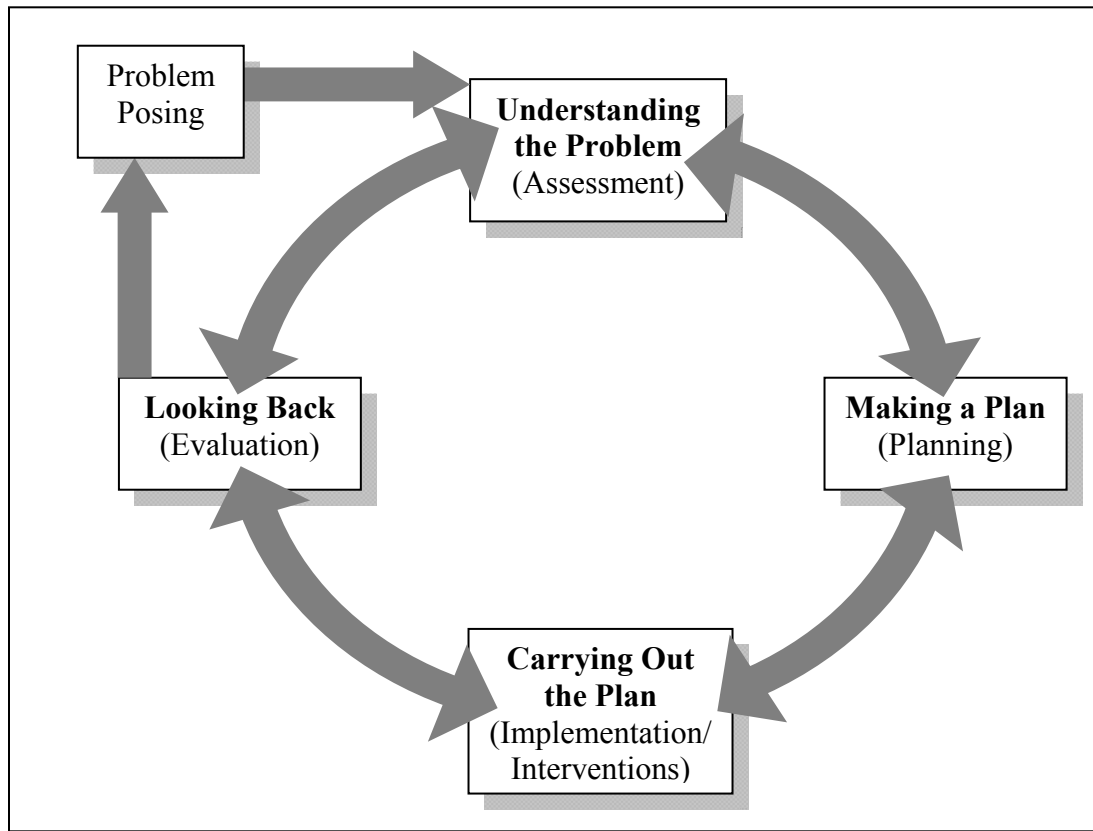
If you have any concerns about how this study was conducted please notify my research supervisor, Dr. Debra Leners, at (970)351-2293. You may also contact her by mail at the University of Northern Colorado, School of Nursing, Campus Box 125, Greeley, CO 80639.

Please note that you will find a copy of Polya's Four Phases of Problem-Solving Framework attached with this letter so that you can use it again whenever you need to dosage calculations again in the future. Again, I appreciate your participation in this study.

Sincerely,

A handwritten signature in black ink that reads "Jaclynn Huse". The signature is written in a cursive, flowing style.

Polya's Four Phases of Problem-Solving Framework



1. Understanding the problem

- a. What is the problem asking you to solve?
- b. What will your solution tell you? e.g volume to administer, drips per minute, units per hour?

2. Devise a plan

- a. How will you solve the problem?
- b. Are there several steps I need to solve? Which steps do I need to do first?
- c. Do you recognize the problem type?
- d. Have you solved this problem before? What worked then? Can you use this method?
- e. What method do you think you need to use to solve?

3. Carry out the plan

- a. Carry out the plan for your solution
- b. Check each step for accuracy and to ensure that it makes sense and will help you solve the problem

4. Examine the solution obtained

- a. Does the solution seem logical and reasonable using your clinical knowledge?
- b. What would you estimate your solution to be? Does your solution fit with this estimate?
- c. Does your solution make sense as a solution to the problem using your understanding of the problem?

Polya, G. (1973). *How to solve it: A new aspect of mathematical method*. Princeton, NJ: Princeton University Press.