

Medication Dosage Calculation: A Mathematical Intervention for Nursing Students

by  
Theresa Riggs Cowan, MSN, ACNS-BC, RN

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## **School of Health Management Approval of the Applied Dissertation**

### **Approval Page**

This applied dissertation was submitted by Theresa Riggs Cowan. Ms. Cowan's committee was composed of the individuals indicated below. The dissertation was submitted to the Dean of the School of Health Management and approved in partial fulfillment of the requirements for the Degree of Doctor of Health Education at A.T. Still University of Health Sciences.

#### **Dissertation Committee:**

Patricia Sexton, D.H.Ed., Chair

Cynthia Armstrong Persily, Ph.D., R.N., F.A.A.N.

Amanda Stewart, Ph.D.

#### **Approved by:**

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Kimberly O'Reilly, D.H.Ed., M.S.W.  
Interim Dean  
School of Health Management

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Date

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Higher education started for me as a means to a vocation. I realized very early on that lifelong learning was essential for professional viability. My experience with the faculty and exposure to nursing scholarship during graduate school triggered my desire to learn and to at some time earn a terminal degree.

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## Abstract

Nurse educators continue to express concern over the struggle that nursing students have with mathematical calculations necessary to compute medication dosage. This applied dissertation designed, implemented, and evaluated a structured program of mathematical remediation incorporating dimensional analysis.

This program targeted nursing students with demonstrated deficiencies in computation skills. The degree of mathematical preparation that the student was exposed to prior to enrollment into nursing courses was considered worthy of review. The age-old adage of gender differences that were theorized to affect the mathematical ability of students was taken into regard as well. Best practices included a curriculum devised to address the problem, evaluation tools to identify areas of computation deficits, and standard operating procedures designed to guide the initial offering as well as replication of the instructional process. The quantitative research method, specifically, the quasi-experimental design was implemented for the purpose of data collection. The non-randomized one student group was administered the nursing program designed Math Competency for Medication Administration assessment tool as a pre-test-post-test. The results of this applied research program revealed an increase in student scores on the math competency exam from pre to post- testing. Based on this project a recommendation would be to use dimensional analysis as a logical and sequential problem solving method for teaching medication dosage calculation to nursing students.

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## Chapter One: Introduction

*In April, 1997, a one-day-old infant dies after receiving an injection of penicillin via the wrong route and at 10 times the prescribed dose (Morris, 1999). In a Canadian hospital, a student nurse administers 10mg of morphine IV to a post-operative patient. The wife finds her husband not breathing and screams for help. The medication dosage was two times the amount ordered by the physician (Harding & Petrick, 2008).*

Nursing competency is a complex issue. Students enrolled in nursing must master the biological, psychological, and social sciences. Underlying these sciences is a demand for mathematical competency for medication dosage calculation. Nursing students have long struggled in performing medication dosage calculations (Bell & Rice, 2005). The administration of medications is a clinical skill that cannot be accomplished safely if the nursing student does not possess the ability to compute the correct dose. In addition, mathematical competency is required for successful completion of the National Council Licensure Examination for Registered Nurses (NCLEX-RN) (Pietsch, 2005). According to the NCLEX-RN test plan, pharmacological questions, including dosage calculations, constitute 13–19% of the test questions (National Council of State Boards of Nursing, 2007).

In clinical practice after licensure, medication computation accuracy is fundamental to safe professional practice (Capriotti, 2004; Greenfield, 2007; Pietsch, 2005). The inability to perform basic medication calculations for patient administration can turn a routine clinical procedure catastrophic occurrence (Gillham & Chu, 1995; Sandwell & Carson, 2005; Wright, 2005).

Students enter higher education from many different backgrounds and with different secondary education preparation. These differences in educational background and competence make it necessary to think creatively when searching for a method of instruction that can be grasped as a reasonable and capable application for all. The program proposed in this applied dissertation focused on instruction to provide a mathematical intervention for sophomore nursing students to facilitate accurate medication dosage calculation.

### *Problem Statement*

During the 2008-2009 academic year, the researcher will design, implement, and evaluate a medication dosage calculation program for students in a baccalaureate nursing program in West Virginia.

### *Sub-problems*

1. Does the gender of a nursing student impact the accuracy of medication dosage calculation?
2. Do math courses completed prior to nursing course enrollment influence the accuracy of medication dosage calculation?

### *Impact of the Problem*

The earliest nursing leaders saw accuracy in the dosage of medications as an important. Florence Nightingale, considered the first nursing theorist, wrote about the requirements of patient care that promoted recovery from disease processes. Regarding correct dosage in the administration of medications, Nightingale said, "I have known several of our real old-fashioned hospital sisters who could, as accurately as a measuring glass, measure out all their patients' wine and medicine by the eye, and never be wrong. I do not recommend this" (1859, p.64). Much later, Pietsch (2005) noted that the

teaching/learning processes for medication calculations continued to be an instructional dilemma for both the faculty and the student.

Patients are exposed to numerous events while hospitalized. The majority of the drugs administered illicit a favorable response and are not detrimental to the patient's health. Providing safe and accurate care is the guiding principle of all health care professionals (Taylor, 2007). A report prepared by the Institute of Medicine (2006) reviewed the type and number of possible errors involving hospitalized patients. The committee predicted that, based on the number of hospitalized patients in the United States each year, at least 1.5 million preventable "adverse drug events" occur (p.1). The report noted that medication administration is a common component of the treatment plan that every hospitalized patient receives. However, medication errors during prescription or administration occur on average once every day, which compromises patient safety (Institute of Medicine, 2006; Capriotti, 2004). Medication administration is a clinical skill all nurses perform and it can consume as much as one-third of a nurse's time during a workday. Pentin and Smith (2006) and Page and McKinney (2007), calculate nurses spend 40% of the clinical day preparing and dispensing medications. Kazaoka, Ohtsuka, Ueno, and Mori (2007) confirmed that administering medication is a primary responsibility of the practicing nurse regardless of geographical location. According to Maricle, Whitehead, and Rhodes (2006), medication errors are second only to falls in instances where nurses are sued. In reviewing documented research, Hodge (1999) found that of every five medications administered, one was given in error. Wright (2006) summarized the findings of a selection of studies and found repeated reports of nurses

experiencing difficulty with calculations. Wright (2006) reported that as many as 33% of the reported medication errors involved computational errors in calculating dosages.

The consensus of Wright's (2006) review was that a common causal factor in many of the documented medication errors was the inadequate mathematical skill of nurses solving medication dosage problems. Consideration of the consequences of poor mathematical ability on accurate medication dosage prompted this study's development of a program of instruction. The number and subsequent outcome of incorrect medication dosage was reviewed and found to affirm the need for a mathematics review program. This affirmed the need for a mathematics review program as a strategy to improve application and computation skills.

#### *Evidence of the Problem*

The study of patient safety involves complex analyses of predisposing factors that contributed to adverse events. The need for medication to be safely administered has been reviewed repeatedly with significant concern regarding the ability of nurses to compute and administer correct dosages (Polifioni, McNulty, & Allchin, 2003). The National Academy of Science Institute of Medicine, (IOM), (2006), the Joint Commission on Accreditation of Healthcare Organization, (JCAHO), (2006) and the National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP), (2007) have all issued reports on the continued occurrence of medication errors and the effect on society. Each of the reports addressed the discouraging number of medication errors in the United States. In addition to individual reports by institutions, the high incidence of medication errors or adverse drug events has been documented globally (Audit Commission, 2001; Kozer, Scolnik, Jarvis, & Koren, 2006; Oldridge, Gray,

McDermott, & Kirkpatrick, 2004; Trim, 2004). For example, a patient received 100 milligrams (mg) of morphine and died from an overdose caused by a mathematical miscalculation. The patient was ordered to receive 5 milligrams of the drug. The nurse administered 5 milliliters (ml) of a 20 mg/ml concentration of the narcotic. Inaccurate mathematical calculation led to the administration of a dose of 20 times the prescribed amount (Cohen, 2006). In a highly publicized incident, a Hollywood actor's newborn twins were given an overdose of the anticoagulant Heparin. Rather than administering the usual prescribed dose of 10 units of the drug, a nurse in the neonatal intensive care unit administered 10,000 units to the newborns (Cable News Network, 2007). The Institute of Medicine (2006) reported that during an average hospital admission, patients could expect to experience one adverse medication event every day of the stay. Madegowda, Hill, and Anderson (2007) compiled data reflecting the estimated cost of medication errors. According to these researchers, the total national cost for adverse medication events was "\$37-\$50 billion every year with \$17 to \$50 billion spent on preventable events" (p. 175). Every dollar spent on treatment for a medication error side effect equaled the same amount spent on the prescribed drug. Basically stated, the problem results in "double trouble for double the cost" for all parties affected (p. 175).

While the financial impact of dosage errors is noteworthy, the most significant issue is that adverse medication fatalities are a leading cause of deaths in the United States health care system (Hughes & Ortiz, 2005; Madegowda, Hill, & Anderson, 2007; JCAHO, 2006; IOM, 2006; National Coordinating Council for Medication Error Reporting and Prevention, 2002). According to Wolf (2007), medication incidents have continued to plague health care professionals in alarming numbers. Wolf reported that

one in every four hospitalized persons was involved in a medication error of some degree. JCAHO (2006) responded to the need to improve the quality of patient safety with a policy to investigate and document selected high impact incidents. These events were deemed “sentinel”, due to the unexpected occurrence that resulted in death or serious injury and the need for immediate investigation and response (JCAHO, 2002). Medication errors were identified by JACHO in 2006 as the fourth highest sentinel event reported. Fagin reported (as cited in Madegowda, Hill & Anderson, 2007) that as many as 98,000 hospitalized patients a year die because of an adverse medication event. Collectively, these organizations believe that adverse medication events, regardless of precipitating events, are not acceptable in health care.

Medication errors occur in the manufacture, prescription, dispensation, and administration of drugs. Despite the fact that the administration of medications to patients is viewed as routine or basic to nursing practice (Carlton & Blegen, 2006), adverse medication events still occur. Polifroni, McNulty, and Allchin (2003) identified the two most common medication errors made by nurses at the time of administration (right time) and errors in the correct amount of the medication (right dose). Medication administration is an activity nurses repeat many times in the course of a practice day. According to the IOM (2006), the opportunity for error and attention lapse is elevated any time an activity is found to be high-frequency or repetitive in nature. Medication administration encompasses a set of critical and inter-related thought processes which dictate nursing actions. Errors can result if crucial checkpoints in safe drug administration are overlooked. The nurse must assure that the right patient is administered the right drug, via the right route, at the right time, and in the right amount or dose (Taylor, Lillis, &

LeMone, 2007). This research project focuses on the ability to calculate the correct dose of medication. Medication dosage calculation cannot be performed accurately if the nurse does not have the mathematical background or ability to complete the computation.

Rice and Bell (2005) reported that the inability to correctly calculate the prescribed amount of a drug to administer was a significant reoccurring finding within the nursing student population. Compounding this issue is the fact that the nursing student carries the same degree of accountability as the licensed practicing registered nurses. For example, West Virginia Legislative Rules, Title 9, Section 19-1-12, states that student nurses in the educational setting abide by the same professional conduct and practice standards as the licensed registered nurse. The same disciplinary action for the commission of an error that would be applied to a registered nurse in clinical practice applies to a nursing student (West Virginia Nursing Code and Legislative Rules, 2002). This highlights the magnitude of accountability for the nursing student when calculating medication dosages.

The ability to structure a learning experience to assist nursing students in becoming proficient in medication dosage calculation has been a significant task for nurse educators. It is undoubtedly one of the most difficult assignments the nurse educator encounters with in the educational arena (Glaister, 2005). This applied research project focused on structuring a program that was specific to improving the mathematical accuracy of nurses' medication dosage calculation. To understand the importance of this program, the circumstances surrounding the sophomore nursing student experience was addressed.

### *Overview of the Research Environment*

The presentation of the history of nursing helps to define the unique educational process of nursing students specific to the educational consortium and program delivery in north central West Virginia. The need for students to accurately calculate medication dosage is a characteristic of north central West Virginia as well as nationally and internationally. The facets of history, background, and community specific to this project were discussed.

*History.* In the early 1980s, the United States in general and north central West Virginia specifically had a difficult time securing registered nurses for hospital employment (Peterson, 1999). To fill this critical need, a public state college and a university school of nursing proposed a collaborative educational plan of action to lessen the problem. Throughout 1982-83, these two institutions of higher education united to launch an inter-institutional offering of the university's school of nursing curriculum. The four-year basic baccalaureate in Nursing Program was inaugurated in the fall of 1984. According to the program inter-institutional memorandum of agreement, the first two years of the program would be conducted on the campus of the state college (Johnson, 1989). Students would participate in clinical experiences at local health care facilities including hospitals and clinics. To complete the junior and senior years of the program, the students would progress to the southern regional university campus. Clinical experience would include a broad range of acute and intensive care settings (Johnson, 1989).

This program had several unique aspects:

1. An established accredited professional program in nursing offered at a public college in north central West Virginia through an inter-institutional arrangement.



2. Due to the success of the initial collaboration, the consortium expanded to include five schools composed of the state college, three regional campuses of the university and the university itself.
3. Students complete the necessary pre-requisites course work prior to admission into the nursing program. The sophomore year of the nursing curriculum is completed at the state college. Junior and senior nursing curriculum sequences are completed at the southern regional campus of the state university. The appropriate university committee will make all textbooks, curricular issues, syllabi, and assessment decisions. All members of the consortia have representation on the appropriate committees.
4. A rotation in both urban and rural facilities provides unique clinical experiences for the students. All senior students complete the state mandated rural health rotation (West Virginia, 1991).
5. Students meet the graduation requirements for both the state college and university. The diploma will bear the name of the university and state college.
6. Faculty members have certification from the American Nurses Credentialing Center as Clinical Nurse Specialists.
7. The Commission on Collegiate Nursing Education (CNNE) was the sole accrediting agency that accredited only baccalaureate and higher degree programs. The new accrediting process was initiated in 1998 and West Virginia University School of Nursing was in the initial accreditation cycle. The School received a full, 10-year, accreditation for the baccalaureate. Prior to seeking CCNE accreditation, the university nursing program had been continuously accredited by the National League for Nursing, with the baccalaureate program receiving initial accreditation in 1964. The West Virginia State Board of Examiners for Professional Registered Nurses also accredited the program (West Virginia University School of Nursing Handbook, 2007-2008).

*Community.* The state college was founded in 1872 to serve the higher education needs of central West Virginia. The college gained recognition for its teaching excellence. By 1910, the college enrollment had exceeded the population of the local city and grown to a four-year college by 1931. Over the years, teacher preparation continued to be the central mission of the institution. The campus became known as ‘the Lighthouse on the Hill’, a tribute to both the quality of the teaching and the high caliber of preparation for graduates. In 2009, the state college continues to maintain a strong focus

on teacher preparation while offering additional degree programs that support the requirements of the workplace in the 21st century. The college has continued its commitment to its community roots. The college is accredited by the Higher Learning Commission and is a member of the North Central Association (NCA). The National Council for Accreditation of Teacher Education (NCATE) has approved the Teacher Education Programs for accreditation. The college is a member of the American Association of State Colleges and Universities, American Association of Colleges for Teacher Education, American Council on Education, and is recognized by the American Association of University Women. The music department offers one of the only two Bluegrass certificate programs in North America. The forestry program is recognized by the Society of American Foresters and represents one of only 24 recognized programs in the U.S. and Canada (Glenville State College Catalog, 2007-2008).

The city in which the college is situated (population 1,500) is located near the geographic center of West Virginia. The physical location of the town places it in the midst of what is described by local residents as “rolling hills”, which are readily viewed as mountains by those who come from neighboring states. The college overlooks the town that lies adjacent to the Little Kanawha River. The area is rich in Appalachian culture and the town is host to the West Virginia State Folk Festival, held each summer. The community and campus are mutually dependent for economic support in this informal and friendly setting.

*Background.* The educational process in nursing should provide more than enough opportunities for practice with mathematical computations in classroom and clinical settings. However, many students come to higher education with deficiencies in

mathematics, gender based expectations of mathematics competency or incompetence, and widely varying exposure to mathematics coursework. Many nursing students must work diligently to remediate their computational weaknesses and may experience calculation difficulties throughout their nursing program. The NCLEX-RN licensure examination was designed to confirm clinical competency (Pietsch, 2005; National Council of State Boards of Nursing, 2007). Mathematical calculations constitute only one variable, but are an important, aspect of the exam. Thirteen to nineteen percent of test questions on the exam have a pharmacological focus, including dosage calculation. Due to the random selection of test items, a weakness in mathematic calculation for medication administration has not always prevented a graduate nurse from securing a license. Depending on the selection process for test questions, medication calculation may not be heavily distributed within the NCLEX-RN examination. Therefore, weakness in mathematical calculation would not hinder licensure for many candidates. However, in clinical practice the inability of the nurse to perform basic mathematics in relation to calculating medications for patient administration can turn a routine skill into an emergent event. Thus, being able to complete basic medical mathematical techniques is imperative in the clinical education preparation for the NCLEX-RN exam and in real-life clinical practice as a licensed nurse.

The mission and goals of the state university nursing school and consortium were grounded in the importance of providing a service to the citizens of West Virginia and the global community. In order to facilitate and accomplish this charge, faculty within the consortium must focus on “high-quality student-centered programs of instruction at all levels” (WVU SON, 2007-2008, p. 2). Participation in research projects and advanced

educational studies are critical in meeting this professional standards set. This research project explored the factors that contribute to the inability of nursing students to complete the mathematical computations necessary for medication dosage determination. The development of a program of instruction for students with mathematical difficulties was speculated to create safer nursing students and practicing registered nurses. This study reflected the stated mission of the nursing consortium.

### *Limitations*

A limitation of this project was anticipated to be the administering of the program only at the public state college in West Virginia, which represented one of the 5-institution consortiums. The college's physical location, of more than 100 miles from any of the other participating institutions rules out the possibility of including additional participants. Other constraints included issues such as the sample size of the target population, which could result in a lack of randomization. The possibility of bias was considered a consequence that would occur from a purposive sample. The researcher considered the implication of the Hawthorne effect on posttest improvement. This postulated that any time that a participant in a study has knowledge of involvement, there may be improvement merely from the awareness of inclusion. This reaction was described by Polit & Beck (2008) as a placebo effect and arises from the person's anticipated expectations.

### *Resources*

The materials used for this program were relatively inexpensive and paid for by the college. Classroom usage and instruction time was included in the curricular structure and clinical contact hours. The use of statistical software for analysis and the statistician

was provided by the university component of the consortium. Microsoft Excel was utilized for tracking and compiling data. A computer with word processing capabilities for course material construction and interactive instruction was utilized from the college technology center.

### *Context*

The context of this applied research project was the sophomore nursing courses at a state college in north central West Virginia. The research site was a member of a consortium of five public institutions of higher education within West Virginia. One university and four state colleges comprised this group. The university is the implementing body of the program and dictates curriculum content and standards. The placement of this program at the Level II (sophomore) content point reflected the progression of outcome achievement. The school of nursing curriculum structure leverages student proficiency from “simple to complex” (WVU SON, 2007-2008, p. 4). The five core competencies that were noted to be the foundation of the nursing curriculum outcomes are: (a) nursing intervention; (b) critical thinking; (c) communication; (d) professional role; and (e) caring (WVU SON, 2007-2008). The ability of an entry-level nursing student to calculate a medication dosage accurately was correlated to the curricular threads of nursing intervention and critical thinking. The Commission on Collegiate Nursing Education (CCNE) and The West Virginia Board of Examiners for Professional Registered Nurses accredited the curriculum and structure of this nursing program.

The mission of this nursing program is to serve the people of West Virginia along with the regional and global community by providing education, implementing research,

and participating in nursing practice. Faculty within the program is charged with providing comprehensive educational instruction that prepares graduates to practice nursing safely. This project was a consequence of the need for an adjustment in the teaching strategies that have been utilized in medication dosage calculations instruction. Concentration on the basic clinical skill of accurate computation of medication doses correlated with the educational goal of the consortium; to address the core competencies necessary to practice safe nursing.

Total enrollment of the college was recorded to be 1441 full-time students. Currently, there were 85 students with a designated major of pre-nursing (Glenville State College Office of the Registrar, 2008). Nursing students struggle with the ability to calculate medication dosages correctly. It is one of the most difficult assignments the nurse educator encounters (Glaister, 2005). The focus of instruction concentrated on the teaching/learning process of the nursing student in order to facilitate mathematical computational understanding. The resultant indicator of success was anticipated to be accurate mathematical application to medication dosage problem sets. An organized system of performing mathematical computation for accurate medication dosage was stressed. Dimensional analysis, or the factor-label method, is one such approach (Bell & Rice, 2005). The context for this applied dissertation project mandated that the students participating were:

1. Enrolled in the Nursing 110 or Nursing 221 courses of the baccalaureate nursing consortium program in West Virginia;
2. Scored less than 100% on the Math Competency Examination for Medication Administration adopted by the university school of nursing faculty for sophomore level;

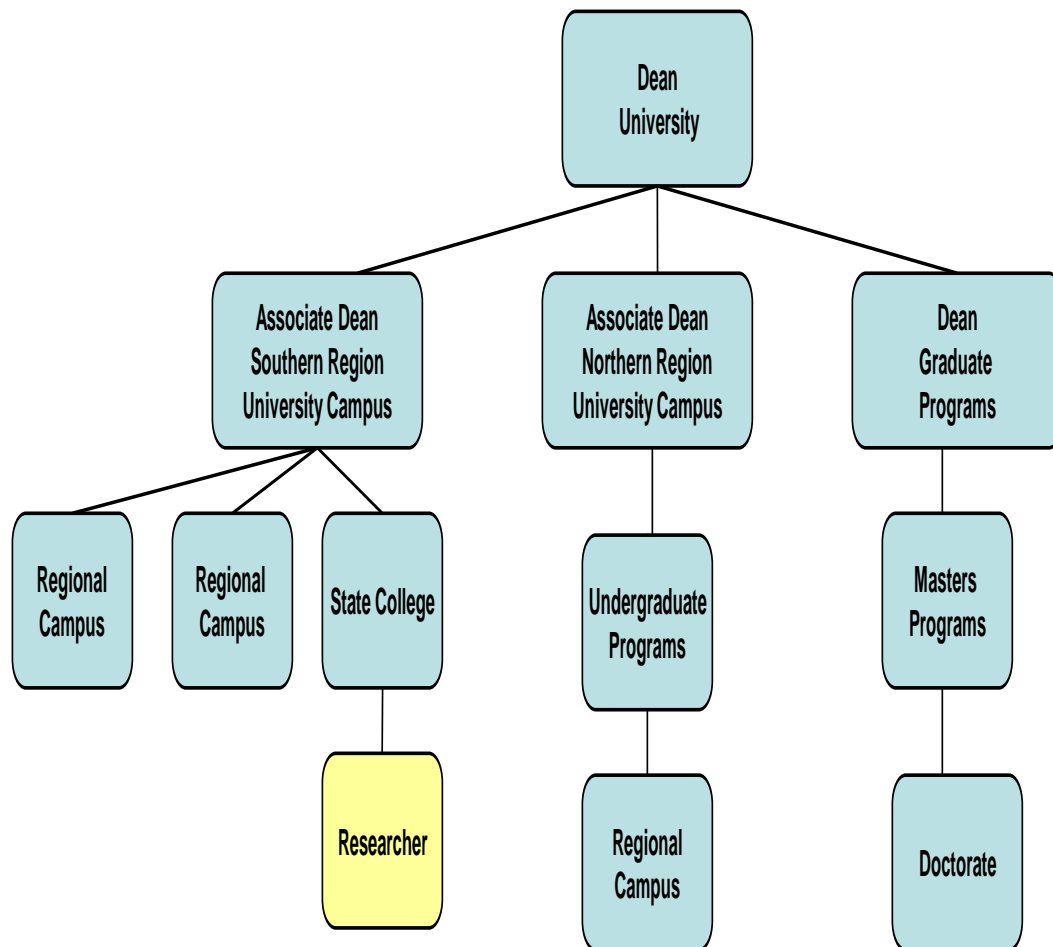
3. Agreed to participate in the mathematical instruction curriculum set forth within this project.

#### *Role of the Researcher within the Organization*

The role of faculty members at an institution of higher learning is diverse and fluid. This researcher has a variety of responsibilities within the nursing program and college alike. Within the nursing program, this researcher serves as coordinator between the college and university entities, and is the advisor for 75 pre-nursing and nursing students on campus as well as an additional 30 students completing the program at the southern regional university campus. Included in the faculty role is the sole lecture responsibility for the didactic courses during the sophomore year of the nursing curriculum. Representing the state college and nursing program on designated university school of nursing committees is imperative for a cohesive educational structure. This researcher is the chairperson of the science and mathematics department of the college and is coordinator of the joint nursing program. This entails scheduling of all courses within the department, budgeting, correspondence, and serving on respective committee memberships that are dictated by the chairpersonship as well as college assignments.

#### *Organizational Chart*

The governing body of the consortium is the School of Nursing within the State University. The subsidiaries are the five state colleges offering the School of Nursing curriculum. The conduct of all parties is delineated within the Memorandum of Understanding, which is reviewed and renewed annually. Figure 1 depicts the consortium structure and its relationship to the primary state university. The researcher's position within the consortium is delineated also.



*Figure 1* Organizational Chart

### *Purpose*

The doctorate of health education (D.H.Ed.) program of study is designed around an action-based applied dissertation. This research design focuses on finding a solution to an immediate and practical problem (Polit & Beck, 2008, p. 747).

Each student will:

1. Identify a problem in their work setting that will benefit from intervention
2. Design and implement a curriculum that impacts the problem



3. Evaluate the curriculum's impact on the identified problem and modify as warranted
4. Create a standard operating procedure to guide current or future execution of the curriculum.

The purpose of this applied research project was to implement and evaluate an intensive review program for medication dosage calculations for nursing students. This program of instruction included a method of calculation that was logical, sequential, and organized. Nursing students received instruction in the application of the dimensional analysis technique for dosage calculation. Consideration was given to the number and level of mathematics courses that the student had successfully completed prior to enrollment in the sophomore-level nursing course work. The relevance of gender and the related ability or inability to successfully compute medication dosage calculations was appraised. A review of terms and definitions significant to this applied dissertation project was conducted to provide for consistency in understanding and interpretation of the program.

### *Definition of Terms*

**Adverse Drug Event-** injuries resulting from medical interventions related to a drug, both appropriate and inappropriate (Carlton & Blegen, 2006). This term is synonymous with the term *medication error*.

**Consortium-** an organization that is composed of one state university and four public state colleges that are committed to the delivery of excellent, student-centered educational programs which address core competencies/elements. The consortium will focus on meeting the needs of the communities of interest served (WVU SON, 2007-2008, p. 2).

**Competency-** tasks that are fundamental to the profession and are measured by the standards of the profession.

**Core Competencies-** are the basis of measuring the outcomes of the nursing curriculum.

- Nursing Interventions- Actions based on theoretical knowledge, skills, and professional nursing judgment in the prevention of illness and the restoration and promotion of death.
- Critical Thinking- activity that reflects skills in reasoning, analysis, research, or decision making relevant to the discipline of nursing.
- Communication- the exchange of information within and between systems.
- Professional Role- internalization of a set of values, beliefs and leadership behaviors relevant to the discipline of nursing and consistent with standards of nursing practice.

- **Caring-** an inter-human process through which there is communication of a sincere interest and concern for well-being (WVU SON, 2007-2008, p.4).

**Dimensional Analysis-** also called the ‘factor-label method’, ‘conversion-factor’, ‘unit analysis’ and ‘quantity calculus’. This has been a method of computation that has been utilized in chemistry and physics courses since 1980 (Bell & Rice, 2005).

**Drug-** general term for any substance capable of producing a biological response by the body. The response may be therapeutic or adverse (Adams, Holland & Bostwick, 2008, p.4, 786).

**NCLEX-RN-** National Council Licensure Examination for Registered Nurses. This is the state licensure examination that determines whether a graduate nurse is minimally safe for practice.

**Nursing students** - defined as those students enrolled in the Nursing 110 or Nursing 221 courses in a baccalaureate nursing program located in north central West Virginia.

**Medication calculation pretest/post test** – The medication calculation pretest/post test is the medication calculation competency examination adopted by the school of nursing for all nursing students. This test contains a variety of calculation problems that a student nurse would encounter regarding medication administration in clinical nursing practice.

This is a paper and pencil test.

**Improvement** - a statistically significant increase in the total score on the medication calculation post test when compared with the total score on the medication calculation pre-test for the individual student.

**Scores** - the number of correct answers scored.

*Chapter Summary*

The mathematical difficulty many nursing students experience in the computation of medication dosage, if not conquered, will be a safety issue in their clinical practice. Diagnosing a calculation weakness and providing an appropriate intervention can only be a positive practice within the scope of nursing education. Continuance of this program was predicted to be a fruitful endeavor. The necessity for this research project, as well as a discussion of the community of impact, was included. The evidence of need was found to outweigh any projected cost. The benefit to the targeted population was deemed important. A review of the available literature influenced the design, implementation, and evaluation of this program.

## Chapter Two: Review of Related Literature

Medication computation accuracy is fundamental to safety in professional nursing practice. However, for many years, nursing educators have documented concerns regarding the number of nursing students that struggle with medication dosage calculations. The earliest nursing leaders saw accuracy in the dosage of medications as an issue that needed attention.

Medication calculation competency is more than a theoretical concern for nursing educators. If nursing students fail to compute correct dosages, administration of medications cannot be accomplished safely in the clinical setting. In addition, mathematical competency is required if students are to pass the NCLEX-RN, which is designed to predict minimal clinical competency (Pietsch, 2005). According to the NCLEX-RN test plan, pharmacological questions, including dosage calculations, constitute 13-19% of test questions (National Council of State Boards of Nursing, 2007). In clinical practice, the working nurse must use basic mathematics routinely when calculating medications for patient administration. Errors in this routine skill can result in life or death situations.

The educational process in nursing is designed to help students master medication calculation and to offer opportunities for practice with clinical computations. However, many students come to higher education with deficiencies in mathematics, gender-based expectations of mathematics competency or incompetency, and varying exposure to mathematics course work. These students may work diligently to remediate their computational weaknesses but still experience calculation difficulties throughout the nursing program. On graduation, they may have trouble when confronted with the

NCLEX or ultimately cause an adverse medication event. Thus, performing basic arithmetic computations accurately is imperative for success in clinical nursing education, for successful completion of the NCLEX-RN exam, and for safe clinical practice as a licensed professional nurse (Allen & Pappas, 1999).

### *Problem Statement*

During the 2008-2009 academic year, the researcher will design, implement and evaluate a medication dosage calculation program for students in a baccalaureate-nursing program in West Virginia.

### *Sub-problems*

1. Does gender of a nursing student influence the accuracy of medication dosage calculation?
2. Do math courses completed prior to nursing course enrollment influence the accuracy of medication dosage calculation?

A review of the applicable literature of this applied dissertation included the following:

- Medication dosage calculation as a basic requirement for safety in nursing practice
- Concerns about nursing student competency in medication dosage calculation
- Nursing student's gender and its impact on accuracy of mathematical calculations
- Prior mathematics course work completion as a factor influencing medication calculation competency
- Pedagogical approaches have been used in nursing curricula to improve mathematics calculation competency

The need to complete medication dosage calculations accurately has been identified as a basic requirement for safety in nursing practice. The fact that medication errors occur, the difficulty of accurately evaluating frequency, and the safeguards that should eliminate such incidents are included in this review. The contributing factors to

mathematical difficulties that nursing students experience was evaluated in relationship to competency of medication dosage calculation. Following this, factors of gender and mathematical coursework preparation was discussed in terms of their influence on student mastery of medication dosage calculations. Next, pedagogical approaches to improve mathematics calculation competency are addressed as a background to the development of the proposed medication dosage calculation program for students in a baccalaureate nursing program in West Virginia.

### *Safety in nursing practice*

Carlton and Blegen (2006) reported that, despite being considered a routine or basic nursing skill, medication administration involves “complex interaction of a large number of specific decisions and actions, often performed under less than ideal conditions” (p. 22). Due to the complexity of medication administration and the frequency of the activity, errors are likely to occur. For example, a medication error in a hospital neonatal intensive care unit resulted in the death of a newborn infant. The error involved the administration of a “ten-fold overdose of the intramuscular (I.M.) medication penicillin G benzathine by the intravenous (I.V.) route” (Smetzer, 1998, p. 48).

Accurate medication dosage calculation is a fundamental skill necessary for safe practice. Concern over the high number and frequency of medication errors or adverse drug events (ADEs) has promoted research and reporting within the United States health care system as well as internationally. According to Hughes and Ortiz (2005) all medication errors are, in theory, preventable. Adams, Holland, and Bostwick (2008) described the fundamentals of drug administration within traditional nursing curriculum.

The “five rights of drug administration” and “three checks” provide a system, which is easy to adhere to in the preparation, delivery, and administration of any medication (p. 29). The five rights are: (a) right client; (b) right medication; (c) right dose; (d) right route of administration; (e) right time of delivery.

The three checks of drug administration are used in combination with the 5 rights to make the safety of the administration of drugs certain, and include the following:

- Check the drug with the medication record system when removing from storage site.
- Check the drug to make sure it is the correct one when preparing for administration.
- Check the drug to make sure you are correct before administering to the patient (Adams, Holland, & Bostwick, 2008).

Consistent practice of the eight safe guards of medication administration would prevent an adverse medication event from every occurring. Wilkinson and Van Leuven (2007) pointed out that incorporating the check system into daily practice would add a safety measure that would protect one’s self and the patient. Capriotti (2004) cited the landmark document *To Err is Human* prepared by the National Academy of Sciences Institute of Medicine. From this report, Capriotti (2004) recounted that 7% of patients in the hospital experienced a medication error each year. Hughes and Ortiz (2005) reported an estimated five errors per 100 administered medications with seven out of 100 causing harm. Regardless, as the dispenser of the medication, the nurse must provide the “right” amount to guarantee patient safety (Wilkinson & Van Leuven, 2007).

In a fact sheet, the International Council of Nurses summarized medication error incidents and possible contributory factors. Human error is identified as contributing to adverse events in health care in 60-80% of episodes (The International Council of Nurses,



2002). Glaister (2005) made note of the probability of the incidence of medication errors being slightly higher than current statistics reveal due to reporting issues.

In a study investigating the common documentation practice of completing incident reports for medication errors, the findings revealed that 0.5% of observed dosage errors did not receive appropriate documentation, and therefore went unreported (Glaister, 2005). The practice of not documenting adverse medication events was collaborated by Friesen, Farquhar and Hughes (2007) who conducted an audit which focused on the reporting frequency of medication errors. In their review, Friesen et al. (2007) found only 60% of observed medication administration errors were reported by nurses. Hughes and Ortiz (2005) confirmed these findings and added not only the small percentage of reporting but included the tendency to disregard improper dose administration must be factored into the statistics.

The haphazard manner in which medication errors have been reported speaks to a much larger problem than previously thought. Barnes (2006) found many hospitals depend on spontaneous reporting by health care providers when a patient experiences an adverse event. One of the reasons found for the underreporting was the tedious process of completing the report (Barnes, 2006). Relying on a method of spontaneous reporting was identified as a major contributor to the underestimation of medication errors. Barnes (2006) added that many outpatient settings do not have an established format or system for reporting adverse medication events and do not allow for accurate reporting of errors.

Nurses are concerned for patient safety, however, the fear of disciplinary action from supervisors, along with scrutiny from peers, jeopardizes the reporting practice (Wolf, 2007). Lewis (2005) introduced the term “culture of safety” within the discussion

of the reasons for the lack of medication error reporting. Wolf (2007) expressed the need to change from a “culture of blame” in order to become a safe and just profession. It was theorized that documentation of events would occur spontaneously if the practitioner who made the error considered the reporting environment non-threatening and the process an opportunity for improvement (Wolfe, 2007; Lewis, 2005). This in turn would add to the knowledge basis of the providers along with fostering accountability in practice (Lewis, 2005; O'Shea, 1999; Wolf, 2007). Proper documentation would facilitate accurate and reliable data regarding adverse medication events (O'Shea, 1999).

Much money, time, and effort has been expended searching for the causes of and solutions to the mathematical deficiency plaguing nursing students and practicing nursing professionals. Glaister (2005) noted that drug errors from incorrect dosages are a global issue and common among students and practicing nurses. European reports documented that over one-quarter of observed medication errors are attributable to incorrect dosages. A government study by the United Kingdom reported that 25% of all litigation is a direct result of a medication error, and further referenced the particularly high incidence of these cases being the result of a drug calculation error (Wright, 2004). Grandell-Niemi, Hupli, Puukka, and Leino-Kilpi (2006) reported that nursing students and practicing nurses alike struggled with the accurate calculation of medication dosages.

The ability to accurately calculate medication dosages is paramount to patient safety and has been emphasized repeatedly in the research (Brown, 2006; Capriotti, 2004; Friesen, Farquhar, & Hughes, 2007; Glaister, 2005; Pietsch, 2005; Wright, 2006). Capriotti (2004) identified the mathematical skills found to be deficient during computation included knowledge of the metric system and the ability to convert different

base units within the system. Integration of the identified basic mathematical techniques into the nursing curriculum did not significantly influence the calculation ability of the nursing student. Calculation errors persisted and there was documented evidence of non-mastery (Capriotti, 2004). Wright (2006) affirmed that nurses' drug calculation skills have become a major concern. This study found many studies which examined nurses' calculation skills. Wright (2006) found that due to poor skills, nurses were making a large number of medication errors in practice. Hutton (1998) emphasized that inadequate use of mathematical skills was a contributing factor to calculation errors, and the overuse of calculators and technology was theorized by Hutton (1998) to have caused nurses to lose mathematical problem solving skills in the workplace.

Frisen et al. (2007) recommended that medication calculation accuracy be a parameter of the yearly employment evaluation process for the practicing registered nurse. Nurses identified with calculation deficiencies should participate in a remediation program. Targeting mathematical computation skills for medication dosage calculation on a yearly base provides as an intervention focuses on providing increased patient safety.

Medication dosage calculation has been documented by both the IOM and JCAHO as warranting attention and intervention (IOM, 2006; Maricle, Whitehead, & Rhodes, 2007; Polifroni, McNulty, & Allchin, 2003). Past practices addressing system issues have not resolved the problem. The recognition of the need to evaluate and address the mathematical ability of nursing students is necessary for successful educational interventions. This applied research project was linked to the extent that this clinical safety issue is a recurrent phenomenon in nursing practice. The need to review

contributing factors and the necessity for devising a strategy to decrease the number of mathematical calculation dosage errors guided review this literature.

### *Competency in Medication Dosage Calculation*

Wright (2004) noted that the medication calculation skills of nurses and students have been documented as poor in prior research. The literature addressed areas of mathematical weakness and the extent and significance of the concern. Numerous reports have been published highlighting the inability of nursing students to accurately calculate medication dosages (Allen, 1999; Glaister, 2005). Difficulties arise in the areas of basic arithmetic, computation, use of formulas, use of conversions, information interpretation and in the setting up of problems to be solved. Weeks (2000) addressed the need for innovative systems for teaching mathematical calculation to nursing students. Weeks reported that the relationship between basic arithmetic mastery and the calculation of medication dosage involves understanding how to problem solve in combination with computations. Specifically, being able to accurately add, subtract, multiply, divide integers as well as decimals and fractions. A frequent theme in existing research (Allen, 1999; Capriotti, 2004; Kelly, 2003) was that not only are students deficient in medication calculation skills, but that the severity of the problem exceeds expectations. Unfortunately, computational ability cannot be taken for granted with college students and the nursing student is not exempt from this group.

Learning to calculate drug dosages is a skill students should master during their nursing education (O'Shea, 1999). In a study conducted by Wright (2004), a diagnostic medication dosage calculation examination was administered to 70 students during their nursing program curriculum. Wright (2004) hypothesized that nursing students would

need remediation to improve mathematics skills. The results of the study were reported as “shocking” (p. 432). Over 50% of the students were unable to correctly perform even half of the calculation problems. Particular areas of difficulty were found to be multiplying fractions and interpreting formulas. In a study of second year nursing students, Gilham and Chu (1995) reported similar findings. They found students had a limited understanding of the basics of arithmetic. The most frequent errors detected by Gilham and Chu (1995) were in division, formula use, and multiplying fractions. Almost all the students made more than two errors and were deemed clinically dangerous.

Brown (2006) studied first-semester nursing students in a baccalaureate degree program and found similar issues to Gilham and Chu (1995) regarding mathematical calculation ability. The survey was completed in 1998 and again in 2003. The researcher described the “poor results as startling” (p. 99). Both groups of students had difficulty with addition, subtraction, multiplication, and division of fractions. There were also deficiencies with the calculation of decimals and percents. Brown (2006) noted that all of the calculations were necessary for medication dosage calculation. Based on the findings of the study, which supported prior conclusions, Brown (2006) cautioned faculty members about incoming students and math skills by stressing that one couldn’t assume students are proficient in the mathematical skills required for medication dosage calculation. Brown (2006) advocated for mandatory testing of students in basic mathematical computation skills. Due to the critical impact on clinical function, Brown (2006) adamantly proposed a structured support system of remediation for all deficient students.

Bell and Rice (2005) cited numerous authors and concluded that medication calculation deficiencies are an ongoing problem for nursing students and practicing nurses. Mathematical mistakes most often documented were due to the inability to set up the problem correctly followed by computation. Another area with significant errors was measurement conversion. The results of a literature review completed by Sander and Cleary (2004) verified that many undergraduate nursing students could not demonstrate basic mathematical skills. The ongoing problem propelled Sander and Cleary (2004) to conduct an ongoing study in an attempt to determine the best method for teaching medication calculation to undergraduate nursing students. The authors shared the opinion that teaching nursing students to be “proficient in medication calculations remains one of the strongest instructional challenges for nursing academics” (p. 46). Sander and Cleary (2004) reviewed 120 undergraduate nursing students, all of whom completed a supervised mathematics test. The examination assessed the students’ ability to solve problems using arithmetic, percentages, fractions, ratios, and units of measurement. The possible maximum score was 25 points. The results, as reported by Sander and Cleary (2004), found a mean total score of 63.3% accuracy, with the poorest performance in fractions and percentages. The authors predicted prior to the study that students would have difficulty with the medication dosage calculation examination, but were “surprised” at the number of students who were not proficient (p. 49).

Hutton (1998) evaluated the mathematical ability of nursing students in a diploma program. Two hundred and thirty-one nursing students were pre- tested with a 50-item test of nursing mathematics problems with a focus on word questions and problems converting decimals to percent. The results of the pre-test revealed 8%, of the nursing

students scored less than 75% on the exam. These students were enrolled in a nine-hour self-study program of instruction targeted at improving basic math skills. Fundamental computation skills were deemed essential to problem set accuracy. Upon completion of the program, a post test of the same examination was administered. Hutton (1998) reported the results as encouraging with improvement in scores of many students. However, regardless of the documented increase in several participants' results, the scores were still "poor" with difficulty in word problem test items prevalent (p.38).

The ability to calculate a medication dosage accurately is critical for patient safety. Many reports have been published which emphasize the frequency in which medication errors have occurred due to the wrong amount of a medication being administered to a patient. In light of this information, it is imperative to introduce and incorporate a change in strategy to the delivery of medication dosage calculation core content instruction.

#### *Gender and the Accuracy of Mathematical Calculations*

The belief that boys have better mathematics skills than girls has flourished in the social and natural sciences. Innate differences in mathematical ability between males and females were explored and any contradictory findings addressed. This applied dissertation considered the role of men in nursing and the relationship between nursing student gender and medication calculation proficiency. Historically, nursing has been a female intensive profession (Anthony, 2004; Phibbs, 2006). The number of men entering the profession has increased only modestly. The expectation of nursing as a career for unmarried Victorian women was established 150 years ago with the organized training strategies of Florence Nightingale (Anthony, 2004). During Nightingale's era, nurses

were trained and lived within the hospital setting, which excluded men and fostered the female domination of the profession (Doheny, Cook & Stopper, 1997).

Meadus (2000) considered the historical role men have had in nursing, noting that the contributions made by men in the profession were forgotten as nursing remained a female-dominated profession. Meadus (2000) found that men as far back as biblical times were involved in caring for the sick. Meadus noted the role of the priest included administering to the sick: during wartime especially, men were important caregivers for the wounded. Although not formally trained, the most famous male nurse during the American Civil War was Walt Whitman (Ahrens, 2002). Unfortunately, when reading fundamental nursing texts there is no mention of the important contributions men have made in its early history (Anthony, 2004).

*Gender and career choice.* Research conducted by Chou and Lee (2007) explored why men pursue nursing as a career. Chou and Lee (2007) surveyed male nursing students who had completed their first clinical rotation. All of the 12 students interviewed stated that they pursued nursing as a career due to inadequate academic preparation, which ultimately limited their choice of career within the health profession. The importance of mathematics and the mastery level accomplished were identified as critical factors in determining the vocational path that women pursue (Meece, 2006). The more limited the amount and level of mathematics education attained, the more restricted they were when deciding on an occupational pathway (Meece, 2006).

In a study of prior research participants, Benbow et al., (2000) included 2,752 of the original participants of a 1980 study. At the time of the 2000 study, the participants were 33 years of age and regardless of gender, exhibited high achievement. The male



participants were found to have acquired more credentials in the inorganic sciences and engineering. The females were found more often in the medical arts and biological sciences, with a heavy distribution in the social sciences, arts, and humanities. The participants 20 years later tended to bear out the results of the initial research, which found the males have a higher mathematical reasoning ability in the majority of careers that required mathematical proficiency.

The math disparity between girls and boys has been found to be lessening as noted in the research of Jacobs, Davis-Kean, Bleeker, Eccles, and Malanchuk (2005). However, the continued discrepancy in the number of men who pursued degrees in math-oriented professions compared to women remained (Jacobs, Chin, & Bleeker, 2006). Jacobs et al. (2005) studied hundreds of students in elementary school and followed them throughout secondary education and on to college. The focus of the study was on how the parent's attitudes and behaviors along with gender role expectations influenced math ability and subsequent career choice. Jacobs et al. (2005) pointed out that the importance science and math held for the parents was often translated into the number of science and math activities to which children were exposed.

*Gender Differences in Math Ability.* Whether boys have better mathematic skills than girls has been a topic that continues to generate much discussion and research (Nelson & Leganza, 2006; Standing, 2006). Gee (2002), discussed research that has attempted to establish and explain a difference in male and female mathematical ability. Gee quoted the writing of the German philosopher Immanuel Kant who wrote, "women might as well have beards rather than trouble their pretty little heads about mathematics" (p. 26). Gee used this quote to illustrate the changing attitude of society related to the

ideas of gender inequities. Research to establish scientific rationale to confirm or dispute Kant's early philosophy is constant. In a speech on January 14, 2005, the president of Harvard University said, "the innate differences in sex may explain why fewer women succeed in science and math careers" (Eccles, 2007; Pollitt, 2005; Summers, 2005).

In a study by Jacobs, et al. (2006) choice of occupation by young adults was found to be influenced by "gender-typed parental expectations" (p. 406). Parents and teachers both were found to provide significant external influences in the selection of an potential occupation. Both parties had imparted values and beliefs in the advisement process. Jacobs et al. (2006) reported that career selection was correlated to parental gender bias and was varied depending on the sex of the parent and the child. Fathers were more gender biased to toward the daughter's occupational choice than that of the son, whereas mother's occupational suggestions were equally gender stereotypical. Meece (2006) concurred with these findings and reported that the job market for women remains gender segregated.

Early research directed at solving the debate on mathematical ability and gender was manifested in 1972 with Stanley's Study of Mathematically Precocious Youth (SMPY). Leahey and Guo (2001) included a description of this report in an article which presented their own research findings. The SMPY continued to utilize the mathematics section of the Scholastic Aptitude Test (SAT) to measure mathematical computation ability of seventh-grade boys and girls. The SAT was selected because it was considered a test of reasoning skill comprised of material the students had not received instruction in to date. The testing continued for 11 years. The ratio of children who scored over 600 on the SAT was reported to be four boys to every girl. Boys scoring over 700 on the SAT

outnumbered girls 13 to 1. In the 11 years the testing was conducted, only 20 extremely mathematically gifted girls were found. The report concluded that boys have a significant gender advantage in mathematics by the time they are middle school age.

In the hope of gaining additional information to help clarify any mathematical computation differences, Leahey and Guo (2001) continued to evaluate boys' and girls' testing performance. Large national data groups and curvilinear growth models were accessed and the gender differences of mathematical trajectories from elementary school through high school were analyzed. The students had fairly equal starting points, and for the most part, equal slopes of growth progression. Leahey and Guo (2001) concurred with the early SMPY findings that middle school boys have a definite advantage in mathematical calculations.

Benbow et al. (2000) completed a follow-up study on 1980s in research that was the cause of much controversy about male and female mathematical reasoning ability. The initial study included 9,927 12-14 year-old mathematically sound students. Those students completed the SAT mathematics and verbal portions at a younger age than normal test takers. The results showed that the males scored higher in the SAT-mathematics portion, supporting the belief that males have better mathematical reasoning abilities than females. The initial research team continued testing males and females of this age group, and achieved a substantial sample of 40,000 participants. The results continued to reveal that there was little difference in male and female scores in the SAT-verbal but SAT-mathematics scores were higher in males.

Monastersky (2005) summarized the controversial assumption that it is a difference in biological structure that gives males the mathematical advantage over

females. One study of particular interest was based on cognitive research, which analyzed why boys and girls score differently on the same mathematical test. The difference was noted to be that girls performed better with arithmetic problems while the boys were more skilled in solving problems that required mentally visualizing a three-dimensional object. To give this information credence, a study published by Connellan, Baron-Cohen, Wheelwright, Ba'tki, and Ahluwalia (2001) analyzed the length of time that one-day-old infants looked at various objects. Both sexes were exposed to a three-dimensional mobile and a flat picture of a human face. Both objects were of the same size and same color to prevent bias. Boys looked longer at the multi-dimensional object whereas girls' vision fixed on the picture of the face. Lutchmaya, Baron-Cohen, and Raggatt (2002) conducted research to determine if a biological variant could be the causal factor for the observed focus difference in newborn infants. The research team measured the amount of testosterone found in amniotic fluid. Regardless of the sex of the infant, exposure to higher levels of testosterone was correlated with the child at 12 months of age, making less eye contact but being intrigued with spatial items. Monastersky (2005) and Lawrence (2006) cited this research in their explanation of why boys are born interested in solving problems of complexity or why systems work. It also provided a way to explain why girls innately focus on understanding. Relating this to process, boys were found to have a preference for mathematics.

The ability to retrieve math facts was identified by Royer and Wing (2002) as contributing to the differences in scoring on general assessment test between the sexes. This assumption was made based on the data of nine studies that tested the retrieval of various math facts. The studies were conducted on students from grade 5 to college entry.

The latter group provided data to draw the conclusion that speed of retrieval of mathematical information was a noteworthy forecaster of success on the SAT mathematical section. The studies compared males to females and found that within the upper distribution of participants, males were faster at math fact recall in all grade levels. Rationale for the differences in performance was partially attributed to the idea that boys and girls process spatial information in different ways. Carr and Jessup (1997) found that boys relied on memory for problem solving while girls relied on counting strategies to assist in mastery. Boys have spatial vision while girls of this age use counting aids such as their fingers. These findings reflected results reported by Connellan et al. (2001).

Nelson and Leganza (2006) stated that consideration of the different types of mathematical abilities possessed by males and females must be taken into account. For example, there may be certain computations the person excels in while other calculations are difficult to master. Correlating these to gender would give insight into the different abilities of each. The study completed by Nelson and Leganza (2006) revealed that, as the course became more complex, gender was less important as a forecaster of success. However, in the courses completed in the general education component, gender was a significant predictor for success. Contrary to speculation, women outperformed men in the study.

Hargittai and Shafer (2006) studied the literature on gender and the use of technology and found women and men differ significantly in their attitudes toward their technological abilities. Existing research on the science and math abilities of students suggests that such perceived differences do not always translate into actual disparities. One such area of concern identified was in the Internet-use ability. In particular, how

self-perceived usage abilities were in comparison to actual abilities. This information was then correlated to differences in gender. Exposure to internet service and time spent online were considered more realistic influences on ability.

*Environmental factors and gender.* The amount of disparity in mathematical ability between males and females was determined by many researchers to be an outcome of environmental exposure, not biological tendencies. Good, Aronson, and Harder (2008) reviewed the causal factors for math course disparity and pointed out that while nature may be involved, the impact of nurturing the child was important. The amount of exposure to mathematics that children have will influence their mathematical ability. Gender stereotyping was considered by Cavanagh (2007) to affect the manner and amount of parental encouragement.

Jacobs, et al. (2005) reported that many parents held to the gender stereotype that boys were better at math than girls were. More “math supportive” games, activities, and conversations were provided for boys than girls in the home (p. 255). One point of interest was the father’s gender typecast, which was found to be a solid predictor of how much the child would like math. The more gender biased the father, the less likely it was that the female child would be a good math student. The boy’s interest in math increased in the same scenario. This study determined that parents communicate the significance of math to their children through gender specific predispositions and supportive activities. Jacobs et al. (2005) concluded that if girls did not receive sufficient encouragement to participate in math activities at an early age, they were less apt to excel in the subject, and subsequently would not pursue vocations that were math and science intense.

*Gender and academic preparation.* Linver, Davis-Kean, and Eccles (2002)

supported the theory that gender influences the choice to enroll in mathematics courses. Linver, et al. discussed the degree of interest that boys and girls had in math courses in the junior and senior high school years. The focus of Linver, et al. (2002) then shifted to emphasizing the need to encourage more female students to continue in mathematic courses with the outcome of pursuing math and science occupations. This group of researchers found that the achievement level of boys and girls were similar in math courses if they were a high achieving student. If the student, regardless of gender, enjoyed math, they would continue the course of study. However, female students lacked the incentive to continue post-secondary education in math intense fields of study, related to gender stereotyping of how successful they would be in higher-level mathematics courses. The researchers recommended that early intervention was needed to thwart this message.

Riegle-Crumb, Farkas, and Muller (2006) explored what motivated girls and boys to enroll in advanced courses. The role of friends and course enrollment was considered due to the influence of peers during this developmental stage of adolescence. Both genders were studied. The results reported by Reigle-Crumb et al. (2006) found that same-sex friends of similar academic ability were a deciding factor in the course selection of girls but not boys. On the other side, of course enrollment, Watt, Eccles, and Durik (2006) identified the trend of girls and women choosing not to enroll in mathematics courses as soon as the opportunity arose. One reason identified by the researchers in both Australia and the United States was the gender-stereotype response of

counselors, parents, and students. Another contributor was the anticipated limitations on career choices, for many of which mathematic ability was not a pre-requisite.

Review of the literature was inconclusive in establishing a concrete reason why females tend to struggle with courses in math and science. This applied dissertation considered the variable of gender as a factor that could be related to mathematical computation difficulty. The next step was to consider if a difference in ability to calculate medication dose relationship existed and to what degree if any between the male and female nursing students. The students were full-time enrollees in the bachelor of nursing program. Consideration of the importance and impact of experience in mathematical application which was to be evaluated in terms of completed mathematics courses prior to enrolling into the nursing program would warrant investigation.

*Prior mathematics course work.* College students must be able to complete basic mathematical equations to complete a college degree. The general education requirements for the bachelor degree in nursing identified the importance of mastering mathematical computations. Therefore, standardized college entrance examination scores are considered prior to enrolling students into respective mathematics courses. If the student is deemed deficient in mathematics per test scores and/or placement test performance, the student is assigned to the appropriate remediation. Mathematics and the teaching of this subject have a strong history in education (Pugh & Lowther, 2004). The mathematical background that nursing students have acquired in the pursuit of higher education and its effect in the calculation of medication dosages were considered. The number and type of mathematics courses completed was also reviewed as an important determinant within this applied dissertation.



Historically, American students have not experienced high levels of success or comfort in mathematic courses (U.S. Department of Education, 2006). Several sources documented concern over the low math scores and ability of graduating high school students (Field, 2005; Hagedorn, Siadat, Fogel, Nora, & Pascarella, 1999; Hoyt & Sorensen, 2001). Preparation of entering students is an area of concern for many colleges (Walker & Plata, 2000). A report prepared by ACT (2006) detailed the reoccurring theme of graduating high school seniors being mathematically unprepared for entering the workforce or post-secondary education. Hagedorn et al. (1999) noted that the limitation of skills in math would be detrimental to the preparation of the work force of the future. The ability of American high schools to prepare students adequately for post-secondary education has had implications across all curricula. Lerner and Brand (2006) reported on the linkage of secondary and postsecondary education and found that of all high school seniors in the United States only 70% graduated. Of these, 53% entered college following graduation, with a resultant 30% completion rate for the bachelor's degree (Lerner & Brand, 2006, p. 7). Adleman (2006) summarized the findings of a study that included math proficiency of high school seniors and college readiness. The number of advanced mathematics courses completed was found to be a vital indicator of college impetus. Completion of Algebra II in high school was a predictor of bachelor degree pursuit (Adleman, 2006).

The low performance of United States high school students in mathematics in comparison to industrialized countries has been noted by many researchers (Gonzales, P., Guzman, J. C., Partelow, L., Pahlke, E., Jocelyn, L., Kastberg, D., et al., 2004; Hagedorn et al., 1999; Standing, 2006). Bozick and Ingels (2008) reported on the

results of the Program for International Student Assessment (PISA) testing of 15-year-olds from 30 industrialized countries (p. 3). In the areas of problem solving and mathematical ability, American youth ranked 24<sup>th</sup> of the 30 nations participating (Bozick & Ingels, 2008; American School Board Journal, 2008). Field (2005) noted that even when a student has completed advanced courses in mathematics, documented test results indicate substantially lower performance scores than other countries.

The math skills many students were lacking was confirmed by Hagedorn et al. (1999) as problem solving and analytical reasoning (p. 262). Polifroni, McNulty and Allchin (2003) noted that the “required mathematical competence for medication administration is at the seventh grade level” (p. 458). Latif and Grillo (2002) reported that “only 60% of 17-year-old students” could work problems with fractions, decimals, simple percentages, and simple equations (p. 18). Standing (2006) administered a 10-item test that was constructed from a 1932 third-grade arithmetic curriculum to 75 students enrolled in undergraduate programs. The test-takers had unlimited time in which to complete the examination. The participants were men and women. Two-thirds or 66% of the students scored 8 or less, failing the test. The explanation offered by Hoyt and Sorensen (2001) was that the lack of attention paid to teaching basic arithmetic was translated into unprepared students. Hoyt and Sorenson (2001) reported that a student’s math preparation in high school, combined with grades, was a reliable forecaster for math remediation. Many college instructors indicated that entering college students possessed a high school transcript which included advanced math course completion. Unfortunately, the students did not understand the process or application of the subject. Kinney (2001) corroborated this finding and added the lack of content mastery and the inability to retain

information was a prime definer for needing developmental course work. Hoyt and Sorensen (2001) reported that 29% of students enrolling in college for the first time required remediation in mathematics. Hagedorn et al. (1999) noted that 46% of students in the United States are mandated to complete remedial courses in math. Hall and Ponton (2005) found that three out every 10 college freshman are enrolled in developmental mathematics upon college admission (p. 26).

Colleges and universities have found it necessary to expand offerings to include more developmental or remedial courses. Kinney (2001) found that development mathematic programs were designing instructional methods that focused on student “weakness or deficiencies” (p. 10). Needed concepts and applications were determined by placement examinations that were specific to the university population. Ninety-four percent of public colleges were found to offer remedial or developmental courses. At this public state college, 65% of all entering freshman were found to test at the level that required enrollment in developmental mathematics (D. O’Dell personal communication, January 30, 2008). This was determined by ACT or SAT mathematics sub-set scores of the individual student. Any student that scored 18 or less on the ACT examination was required to complete a placement test. The Acuplacer general arithmetic test was administered and, depending on the resultant score, a second test in algebra may required (Glenville State College, 2007-2008). Courses commonly found to be included in the mathematics remediation sequence were noted by Hagedorn et al. (1999) to include arithmetic, algebra, and geometry (p. 264). The textbook for remedial mathematics courses was identified as one of the biggest sellers on college campuses (Field, 2005).

The gender of the student and mathematical course work completed was a point of interest. Meece (2006) focused on women's participation in mathematics and science courses. Research indicated that the decision to enter a career in science or mathematics was determined for both men and women well before the college years (Good, 2008). This finding was guided by the course selection that students were directed to during high school (Meece, 2006). Many more boys completed additional mathematics courses prior to college enrollment, allowing for an increased ability to master computations. Watt, et al. (2006) found that girls stopped enrolling in mathematic courses in high school as soon as the minimum requirement necessary for graduation was completed. Women struggling in mathematics courses were found to have only two years of mandatory mathematics courses in high school (Meece, 2006). The result of this practice was deemed a limiter when weighing career choices. Watt, et al. (2006) identified math as the "critical filter" or gateway to many professional careers. By limiting the number of math courses, the student narrows potential occupational venues. Updegraff, Eccles, Barber, and O'Brien (1996) reported that deciding which courses to enroll in during high school is the most important activity in which a student participates. The group of researchers reported that the reluctance of women to continue math education has contributed to the absence of women in higher education mathematics courses. Of the students that enrolled in developmental math programs, women fail at a higher rate (Hagedorn et al., 1999). Updegraff, et al. (1996) concluded that students have a tendency to continue to enroll in subject areas that they have experienced prior success in. If the student was earning good grades in mathematics courses, there was the tendency for the student to want to continue

enrollment in subsequent courses. This provided the student with the opportunity to enhance their knowledge and skills of mathematical applications.

Hoyt and Sorensen (2001) reported that to be successful in college math courses students needed a minimum of three years of math at the Algebra II level and higher. High school juniors and seniors were found to be reluctant to enroll in math courses after the minimal graduation requirement was met (Pugh & Lowther, 2004; Perkins, 2004). This was attributed to wanting to avoid computation struggles and possibility of a negative outcome. The Center for Public Education (2007) interpreted the findings of the ACT National Curriculum Survey 2005-2006 and reported that students in high school need to complete math courses to be prepared for and succeed in college. The minimum level of mathematics recommended was Algebra II.

Hoyt and Sorensen (2001) recommended that college bound students receive better preparation in basic subjects, specifically math. Adelman (2006) commented on the need for schools in the United States need to remedy the math deficient issue of pre-college students. Kirst and Venezia (2006) expanded the need for improvement to include the entire education system. In a research brief prepared by the Public Policy Institute of California (2001), facts were reported on the correlation between mathematic course completion and employment earnings. The message delivered was basic, but was chronicled by numerous reports and researchers as math matters. The purpose of this literature review was to determine the influence enrollment and prior experience in mathematics courses have on the nursing student's ability to accurately calculate medication dosages.

*Pedagogical approaches.* Pedagogical approaches have been used in nursing curricula to improve mathematics calculation competency. The profession of nursing is well aware of the need to prevent medication dosage calculation errors. The increasingly diverse educational preparation that students bring with them into the nursing program has contributed to the need to develop a teaching plan for math competency that can be readily adapted to individual needs. The ability to devise an intervention strategy that can accommodate the learning styles of the individual and best practices of the nursing profession has been challenging. Sabin (2002) noted that the methodology of instruction in medication dosage calculations varies from nursing school to school without documented adoption of a specific process. Weeks (2000) asserted that regardless of methodology, the chasm formed by the application of theory to practice must be narrowed. This applied dissertation focused on the development of a program of instruction that is logical and sequential in application, and the educational processes attempted will be appraised.

Kelly and Colby (2003) employed constructivist educational theory to teach students how to solve medication dosage calculation problems. This method emphasized the ability of the student to incorporate past learning experiences into an action or activity. No set formula or pattern was applied to the problem solving. With this instructional style, Kelly and Colby (2003) focused on the thought process of the student, rather than their achievement of the correct answer. Evaluating the breakdown in thought processes allows the instructor to structure open-ended questions that will engage the students' thinking. Ultimately, the process would allow the student to find a unique tactic in problem solving that made "sense" to them. According to Kelly and Colby (2003), the

course was centered on the identified important facts necessary for medication calculation, such as data interpretation, which lead to calculation. The study also was conducted in a small group setting to maximize the ability to complete problem sets with instructor monitoring. Traditional instruction, which is the formula approach, was considered a “mimetic activity”, where students copied the instructor without understanding why, or how the answer was achieved (Kelly & Colby, 2003, p. 468). The success of this type of instruction is grounded in the ability of faculty to espouse the underlying concepts of the educational concept (Weeks, 2000). Faculty that adhered to this instructional sequence has documented success, however, Kelly and Colby (2003) noted that this methodology is only as effective as the participants taking part.

Another constructivist teaching strategy, problem-based learning (PBI), was integrated into the curriculum of first year nursing students at Thomas Jefferson University (Papastrat & Wallace, 2003). The methodology was introduced in an attempt to increase nursing students’ knowledge of mathematical computation and enhance the ability to accurately solve medication dosage problems. Faculty developed patient situations, which contained drug calculation problems, and this was the construct of the program. The principle of problem-based learning, according to Johnson, Dupuis, Musial, Hall, and Gollnick (2003) was that the student would learn the subject matter and related skills from synthesis of the problem scenario presented. Papastrat and Wallace (2003) noted that an important assertion within this modality is that students are actively engaged in the learning process, not disengaged observers of the presentation. Students were given the dual task of opportunity and responsibility within the learning process (Papastrat & Wallace, 2003). Problem-based learning, according to Haidar (2007), can be

time consuming in the student mind, but will enhance subject knowledge often by default. Papastrat and Wallace (2003) conveyed positive experiences of faculty and students alike. Both were attracted to the clinical application link of the instructional modality, and a decrease in errors was connected to the motivation and performance of the participants).

The triangle technique is an evidence-based course that incorporates guided imagery into the learning process (Sredl, 2006). Within this program, Sredl (2006) considered the different learning styles of students in the employment of a technique for information retention of evidence-based content. The technique was grounded in the ability of the student to conceptualize the isosceles triangle as a mountain. The patient and their needs were visualized to be at the top of the mountain. In this particular situation, the pediatric patient weight is included at the top. The two sides of the mountain become the mathematical process necessary to complete the problem. The medication dosage problem was at the base of the mountain, with the acceptable dosage on one side of the river and the inappropriate dosage on the opposite (Sredl, 2006, p.87). Sredl (2006) identified the straightforwardness of the approach and the ability to use this process with any subject matter as a positive factor.

Edmondson (2005) noted that developing an educational strategy that makes all learners happy is frustrating and challenging. The importance of options to enhance the learning process, such as study sessions and tutorials, were deemed beneficial. Consideration of maintaining standards when teaching methodologies needs to be emphasized. The need to develop a program of instruction that is sequential and logical is a basic approach to providing an intervention for nursing students with mathematical



computation difficulty. The effect of such a program will be considered in this research study.

### *Chapter Summary*

The issue of competency in the calculation of medication dosage has been documented as an area of concern for nursing students and practicing nurses. Professional responsibility and accountability govern safe nursing practice. The affect of gender differences on the ability to complete mathematical computations has been discussed for some time. Research to date has found that gender may be an influence, but competence can also be influenced by the course work a student completes due to cultural direction to the academic majors. The mathematical experience a student enters the nursing program with does impinge on the ability of the student to perform accurate medication dosage calculations. Regardless of the background of the nursing student, the method of instruction must be adaptable to the diverse academic experiences of the participants.

Chapter three presents the methodology and strategies that guided this applied dissertation. Chapter three includes a curriculum design for the identified problem and sub-problems. A measurement of the effectiveness of the project was implemented. The guiding policy and procedure are also included.

### Chapter Three: Methodology

The purpose of this study was to evaluate the effectiveness of a program of instruction in mathematical computations necessary for medication dosage calculation for nursing students using quantitative research. In Chapter One of this applied dissertation, the significant problem of medication error or adverse events was introduced. The fact that medication errors and adverse events occur with not only nursing students but also registered nurses in clinical practice was demonstrated. Chapter Two provided a comprehensive review of the literature, supporting the need for a mathematics intervention. The methodology to target the mathematical computation deficits of nursing students is addressed here.

Elliott and Joyce (2005) stressed the importance of nursing students mastering the essential clinical skill of medication calculation prior to graduation. Medication administration is a “high-risk task” which can be the catalyst for detrimental consequences if incorrect (Elliott & Joyce, 2005, p. 225). Nursing is a discipline in which competency is paramount for practice. Every state legislature enacts a code that defines what nursing practice is and what competencies are necessary to be licensed to practice nursing in that state. Jones (2007) summarized the various state codes in terms of adeptness to practice. The generic definition that is most used is “the skill and behavior required to perform the role of a nurse” (p. 75). Jones (2007) added that skill acquisition starts in nursing school and is a lifelong process. Nursing students are required to administer medications in the clinical setting with supervision as early as the first semester of the curriculum in many programs. Registered nurses dispense medications

independently in the employment practice setting on day one of employment (Elliott & Joyce, 2005). This safety of this task depends on the mathematical computation skills of the nurse.

The student or nurse struggling with mathematical computations cannot be allowed to assume the mindset that over time the skill will be perfected. Exposure to the medication administration process is not the simple solution to computation deficiencies. Jones (2007) referred to the work of Benner who, in 1984, considered different stages of skill acquisition and critical thinking to be a leveling process. The levels were identified as novice, advanced beginner, competent, proficient, and expert (Jones, 2007). To apply theory to practice in an effective and safe manner requires that one continue to participate in the learning process after completing basic nursing education. This course of action will propel the novice to the level of higher skill mastery and allows the competent nurse to maintain a high level of knowledge and skill. The literature review confirmed the need for improvement in the mathematical computation skills of both the nursing student and practicing nurse.

This chapter contains the proposal for an instructional program that addresses the need to enhance the mathematical ability of nursing students as early as the first two semesters of the nursing curriculum. Included are the methodology, best practices, sample procedure, instrumentation, data collection with subsequent analysis, and ethical consideration including the Institutional Review Board (IRB) criteria. The Standard Operating Procedure (SOP) is provided to assure accurate future replication.

## *Proposal*

### *Introduction*

For many years nursing educators have documented their concerns regarding the number of nursing students who struggle performing medication dosage calculations (Gillham & Chu, 1995; Hutton, 1998, December; O'Shea, 1999; Polifroni, McNulty, & Allchin, 2003; Priest, Roberts, & Knipe, 2006). Administration of medications is a clinical skill that cannot be performed safely if the student cannot compute the correct dose. In addition, mathematical competency is required for successful completion of the NCLEX (National Council of State Boards of Nursing, 2007). Students come to higher education with different backgrounds and secondary level preparations. This diversity makes it necessary to think creatively and search for a method of instruction that can be grasped and applied by all. The focus of this applied research project was to provide and evaluate an intensive mathematics program of instruction for nursing students. The method of calculation introduced was designed to be logical, sequential and organized. In real-life clinical practice after licensure, medication computation accuracy is fundamental to patient safety in professional practice. The ability to perform basic mathematics in relation to calculating medications for patient administration can turn a routine skill into a life and death occurrence.

### *Problem Statement*

During the 2008-2009 academic year the researcher will design, implement, and evaluate a medication dosage calculation program for sophomore students in a baccalaureate nursing program in West Virginia.

*Sub-problems*

1. Does the gender of a nursing student impact the accuracy of medication dosage calculation?
2. Do math courses completed prior to nursing course enrollment influence the accuracy of medication dosage calculation?

*Methodology*

Leedy and Ormrod (2005) specifically identified the process and activities necessary to conduct a research activity. It is a well choreographed process and with each advancing step nears the stated outcome. Methodology of research is the systematic approach of moving towards an outcome. Priest, Roberts, and Knipe (2006) concluded that research is a process with a series of steps that begins with planning and ends with the report of the findings. This applied dissertation used a quantitative research method, specifically, the quasi-experimental design. O'Connor (2008) described the word "quasi" as "as if or almost" (p. 3). The implication for this study was that the quasi-experiment is an experimental design with a modification. According to Trochim (2006), adaptation to the design is the absence of randomization in the selection process of the research sample. Therefore, the experimental approach operationalized in this applied dissertation was a non-randomized one-group pretest-post test design. The focus of this applied research project was to evaluate the nursing student's mathematical ability as applied to the calculation of medication dosages for patient administration. This ascertained computation accuracies and errors. A program was developed and implemented that provided instruction in the basic mathematical skills utilized for calculating medication dosage problems. Re-evaluation of calculation proficiency was conducted upon

completion of the program. The gender of the student was recorded and considered in terms of its relationship to mathematical computation ability. Enrollment in preparatory mathematics courses prior to enrollment in the nursing curriculum was reviewed for possible correlation to accuracy of computation.

The program was integrated into the Nursing 110 – Health and the Caring Professions, Nursing 225 – Nursing Interventions I and repeated in Nursing 245 – Nursing Interventions II course if necessary. The students met with this researcher one time a week for 5 weeks during the semester. In class white-board work along and out-of-class assignments was accomplished. A pre-test and post test was administered to the students. The pretest and post test examination included the computations that a basic nurse is required to master, which included fractions, place value, percentages, metric and household conversions, ratios, and interpreting information (appendix E). The purpose of this design was to determine if computation accuracy improves as a result of the program.

Polit and Beck (2008) stated that the quasi-experimental approach is a practical methodology when an exact experimental design would be impossible to conduct. When the population is not available or is fluid, randomization of subjects or numbers to support the control group is not feasible. The number of students available for the research study was limited by the enrollment of the state college and its rural location in north central West Virginia. The quasi-experimental methodology provided structure for the study with a generalization to the population in the results. This being noted, the small sample size and lack of randomization was considered in the interpretation of the results and the reporting of such (Polit & Beck, 2008).

### *Best Practices*

Best practices are the activities that advance the teaching, research, and practice of nursing (American Association of College Nursing, 1999). The American Association of College Nursing (1999) identified program development the transfer of essential knowledge from the classroom to the practice setting as imperative to the process of developing essential clinical skills. A.T. Still University (2006) identified the best practices of an applied dissertation to be:

1. Proposal to resolve a work related issue including budget, implementation timelines, and audience affected
2. Curriculum designed to support the change process identified in [the] applied dissertation
3. Evaluation tools designed to measure the outcomes of the recommended best practice and ongoing program/institutional effectiveness
4. Support materials in the form of Standard Operating Procedures and Policies including any limitations, conditions, restrictions, or constraints that may affect implementation of your dissertation's recommendations (p. 6).

The best practices were designed to improve the ability of the nursing student in calculating medication dosages accurately through an enhanced teaching/learning experience. These experiences will include:

1. Curriculum that is designed to address the problem
2. Evaluation tools that identified areas of computation deficits, prior mathematical experience, gender of the participant, but most importantly the effectiveness of the instructional process
3. Standard operating procedures (SOP) designed to serve as an implementation guide to replicate any improvements that the teaching/learning scenario has provided.

The design of effective curriculum and subsequent course work requires dedication to the task (Diamond, 1998). Diamond stressed that planning, organization, and teaching ability have significance on students' accomplishing educational goals. Simply stated, curriculum is the information or material about which students will be receiving instruction. Curriculum includes theory, application, and outcomes. The curriculum for this program included the outline of course content along with outcomes and objectives. Content was selected and based on the review of the literature. This identified mathematical computations that nursing students and registered nurses in practice struggle to apply. The instructional activities were selected to streamline the mathematical computation process into a logical, sequential, and organized method.

Curriculum design and instruction is how material is communicated to the learners (Karni, et al. 1998). The effectiveness of the program hinged on the integrated interaction for the student. The ability of the teacher to incorporate this link will enhanced the acquisition of information. The dimensional analysis or factor-label method of problem solving was selected to be the computation strategy employed within this program. This method is logical, sequential, and easily mastered. Greenfield (2006) explained dimensional analysis as a process that "conceptualizes the principles of the problem solving and supports critical thinking, while providing students with one method for solving *all medication calculation* problems" (p. 92). The 6 steps to skill development for mathematics were incorporated (Zeigler et al., 2000). This is an exaggerated teach/re-teach style structured presentation. Students participated in problem solving activities that are computational based and take part in patient medication dosage scenario problem sets. Ultimately, with this coordinated effort, students will acquire the knowledge and



skills to aid them in the completion of their educational (Weimer, 2002). The effectiveness of the program in assessment-centered learning environments allows for testing of new technologies or knowledge, along with the opportunity to receive feedback (National Research Council, 2002).

Standard operating procedures are informational and served as the best practices directional guide. This is an indispensable pre-requisite for program delivery, as it standardizes the content and method. The essentials of the format necessary to implement and maintain consistency within the curriculum are crucial to program replication. Kanchak and Eggen (1998) included the specific program strategies that direct program delivery, which include content, student activities and assessment as the foundation for implementation and important for inclusion. Assessment strategies, which included individual unit pre-testing, individual unit worksheets with feedback, and subsequent post tests, was outlined and appropriate documents attached. The success of the program was directly related to the degree of clarity that was provided in the outlined operating procedures and processes.

### *Sample*

This project used a single group sample. The participants were students who met the criteria for admission and enrolled in Nursing 110 or Nursing 225 of a baccalaureate degree-nursing program in West Virginia. This college and four other higher education state institutions form a nursing program consortium. The major state university is the coordinating member, which dictates curriculum and standards. The structure of this nursing program is such that the pre-nursing or freshman and sophomore students are only on the West Virginia state college campus. The enrolled students progress to a

consortium campus in a larger, more populated city. This supports the junior and senior curricular content application of tertiary care and clinical experience. The number of students enrolled in the identified nursing courses influence sample size. Those who achieved a score of less than 100% on the pre-test instrument dictated the potential number of participants. The anticipated number of participants was in the range of 20 to 25 nursing students.

### *Instrumentation*

In the research process, consideration and scrutiny must be given to the manner of data collection. A pre-test-post-test medication dosage calculation examination and demographics questionnaire was administered. Leedy and Ormrod (2005) and Salkind (2008) stressed the importance of the selected instrument measuring the intended parameters. The pre-test-post-test tool administered was the Math Competency for Medication Administration exam. This is a school of nursing faculty constructed examination for nursing students.

Leedy and Ormrod (2005) noted that an instrument utilized as a predictor of performance needs test item-analysis by a panel of subject experts to validate content. The selected pre-test-post-test instrument for this action research was constructed and reviewed by nursing experts in both the clinical and teaching fields. This process validated that content represents the mathematical calculations necessary in medication administration. The examination has been replicated and administered for five academic years and has been deemed a reliable predictor of safe clinical practice related to medication dosage calculation. Salkind (2008) indicated that the correlation of scores obtained from test-retest provides documentation of stability and reliability of the

instrument. This instrument has been administered to all nursing students prior to administering medication to patients in a clinical setting. The student must score 100% on this examination due to the critical nature of drug administration. Students who do not score at this mastery level were targeted for a remediation program of instruction. Test questions had been designed to use specific basic mathematic skills common to professional nursing practice. An item analysis of student exams allowed for qualifying specific areas of deficiency in computation skills for individual participants. Subsequently, results from the post-program evaluation was anticipated to reveal if improvement in mathematical skill has resulted and specifically, which computation.

In the process of gathering information, the instrument must be functional and user friendly. Motivating the individual to respond with accuracy is a challenge for any information-seeking project. Regardless of the research tool selected, content must be presented in a manner that negates incomplete or haphazard work of the participant. For the purpose of this study, the content and construction was based on basic questionnaire construction. Leedy and Ormrod (2005) identified the impact the construction of the document charged with solicitation of pertinent respondent feedback or information can have on the research outcome. It was considered crucial in the development of the research tool or tools to keep the question content as minimal as possible without sacrificing results. The crux of question construction is not to overwhelm the participant with the volume or magnitude of its appearance. Respondents can become reluctant or biased simply by the visual presentation of the tool, or overwhelmed prior to actually attempting the required activity (Diamond, 1998). Demographic data on the participating students was collected. The information provided by the student participants provided

individual-specific information such as gender of the test taker and mathematic courses completed prior to nursing program admission.

### *Data Collection*

Leedy and Ormrod (2005) discussed data collection and recommended that the researcher give careful consideration to the necessary data to target in the compilation process. Key to collection was deciding what data were needed and their location. The data was collected from the students enrolled in nursing courses at the college at which the researcher is employed. According to the school of nursing's *Standards for Safe Practice*, students are expected to engage in clinical practice that "promotes health while preventing harm" (West Virginia University School of Nursing, 2007-2008, p. 54). In order to participate in the clinical practicum students must accurately calculate medication dosages for patient administration. A requirement for mastery of course objectives was that students must have documented competency of this skill prior to clinical participation. The tool to evaluate attainment of this skill is the Math Competency for Medication Administration exam and was administered in the seventh week of the 15-week semester (Glenville State College/West Virginia University Joint Nursing Program, 2006). The test instrument utilized the paper and pencil approach for the completion of the examination. Students who did not score the set achievement score of 100% was invited to participate in a program of instruction.

The designed program of this dissertation, Dimensional Analysis and Medication Math (DAMM) was provided for all consenting students. Students were told that participation in the program was voluntary. The opportunity for subsequent retesting would in no way be influenced by non-participation in this study. An explanation of the

program and process was made to the students and included the purpose, instructional design, and projected benefits. Students who agreed were given a packet containing a description of the program, course objectives, content map, class attendance schedule, and consent form. Instruction was accomplished in the traditional classroom setting and was delivered by this researcher. Formative feedback was provided following each unit of instruction to better guide individual instruction.

The Math Competency for Medication Administration exam, required by the School of Nursing for clinical practice, was adopted as the research tool for this investigation. The scores of this examination was the pre-test data gathered for this study. During the pre-test event, demographic information was collected following the examination. The demographic survey included age, gender, mathematical course completion, and ACT/SAT score prior to college enrollment. This information could also be readily retrieved from college online sources. Students were asked to have researched this information and ensured its accuracy prior to the pre-test event. All student participants were invited, which allowed sufficient opportunity to verify any questions or gaps in information that a student may experience. Validation of information could be acquired from student enrollment only after the participant grants permission for such.

Confidentiality was maintained by providing each participating student with a security code. This was one letter of the alphabet and one number. The list of student names and identity codes were provided prior to the pre-test. Clinical faculty were cognizant of the data collection for research, which utilized the medication competency examination. The test data obtained from both pre and post-testing was reviewed by the

clinical faculty member and this researcher. Student results were housed in a locked filing cabinet in the science and math department.

### *Pilot Testing*

Polit and Beck (2008) stated that information generated through research should reveal the “best evidence.” Unfortunately, many studies yield minimally useful results regardless of investigative discipline. Pilot testing is not designed to solve the research problem but explores the feasibility of the effort. The faculty of the nursing consortium designed the mathematical examination that had been administered as the pre and post test for this program. It had been utilized within the consortium for five semesters prior to being identified as the instrument for this action research program. To appraise this instrument prior to application, Polit and Beck (2008) suggested consideration be given to the structure and content of the items included. This included reviewing the information presented and the requested responses. Content was compared to current structure of the NCLEX testing for licensure of the registered nurse. Question structure encompassed the Bloom learning domain of cognitive knowledge with the taxonomy of application integrated into the problem stem (Kanchak & Eggen, 1998). The student had the reference point of past learning of basic math concepts and applied these to a new method or process of problem solving. For this program, it was dimensional analysis. The cognitive application of knowledge was transferred to the application of problem solving.

Table 1 *Mathematical Computation Item Analysis*

Problem	Frac- tions	Deci- mals	Per- cent	House- hold	Metric	Oral	Paren- teral	IV	Con- version
1		X					X		
2		X					X		
3		X			X			X	
4		X			X				X
5						X			
6		X					X		X
7		X						X	X
8		X					X		
9						X			
10				X	X				X
11		X				X			X
12				X					X
13	X	X	X				X		X
14	X		X		X				X
15								X	X
16								X	X
17				X	X			X	X
18		X			X			X	X
19		X			X			X	X
20	X				X			X	X

*Note:* This item analysis tracks the application of the identified mathematical computations noted as deficient. These were based on literature review of nursing students' abilities to calculate medication dosages.

### *Data Analysis*

Organizing and grouping the data was the first step necessary in the interpretative process. Important to this procedure is creativity and imagination. Reviewing the data repeatedly will aid in the detection of patterns within the collection. Leedy and Ormrod (2005) encouraged the researcher to keep in mind that how the data is organized will effect what will be revealed about the project. To organize the data, a spreadsheet was created in Microsoft Excel. This software program sorted, searched, and graphed the data for further interpretation. The Statistical Package for the Social Sciences (SPSS) was utilized to further summarize, correlate, and display data (Polit & Beck, 2008).

Descriptive statistics are helpful in describing the sample within the research study. The parameters of mean, percentage, frequency distribution, and central tendency were found beneficial in explaining the mathematical ability and experience of the participants. In addition, variability and correlations summarized the relationship of course work to ability. A student's t-test was employed to compare mean pre and post test results and assess for significant differences in student calculation abilities. A level of  $p < 0.05$  was set with a 95% confidence interval for significance testing. An analysis of variance (ANOVA) was applied to compare changes between the pretest and posttest results.

Inferential analyses were drawn upon to provide simple summaries about the students. This method places data in useful and significant order. Inferential statistics investigate and makes judgments of the probability of measured differences occurring by chance. Inferential statistics consider if the correlation established is a dependable one or one that might have happened by chance in the project. A statistician was retained for assistance in the interpretation of the results.



*IRB/Ethical Considerations* The research plan was submitted to the A.T. Still University Institutional Review Board (IRB). This was necessary due to the utilization of human subject participants. It was not necessary to duplicate this process with the Institutional Review Panel of the state college where the project will be administered. However, documentation was housed at both institutions of the IRB approval from A.T. Still University.

When planning the design of any research project, one must take into account the structure and if it will generate significant results. A design that is loosely structured and poorly monitored will not glean evidence that is beneficial to the profession. The time and effort that is devoted to the project by the participants should not be in vain. The researcher has an ethical responsibility to plan and conduct research that will be accurate and concise (Polit & Beck, 2008).

All participants were given a verbal explanation regarding the program and its relationship to this study. This discussion contained information about student willingness to participate in the program, agreed consent, anonymity, confidentiality, and any possible risks and/or potential benefits of participating in the program. A packet containing a written consent to participate form (Appendix N), written explanation of the program and this study (Appendix M), course objectives (Appendix C), content map (Appendix D), and class attendance schedule was distributed to the study members. Students were made aware of expectations that accompany the research program. Students were told that participation is strictly voluntary.

Each student was given a security code that consists of one letter of the alphabet and one number. This has a two-fold ramification for this study. First, it protected the

confidentiality of the student who agreed to be a study participant. Next, it provided a critical reference point for connecting test results of the student to specified demographic variables. All data were accessible only to the researcher, clinical course instructor and the statistician throughout this study. This information was shared with the clinical instructor to certify medication math competency for clinical participation.

*Role of the Researcher* The role of the researcher for this applied dissertation will be that of strategist, designer, implementer, and reviewer. The literature review documented the difficulty students have performing the simplest mathematical calculations. Many students come to higher education with deficiencies in mathematics. The completion of prescriptive coursework designed to alleviate or reduce the deficient may not provide a total correction. The calculation difficulty many times manifest later in the subsequent curriculum. The inability complete mathematical computation within the nursing course work is very problematic. (Brown, 2006). This program provided instruction on the basic math required in the calculation of medication dosage. The researcher utilized textbook problems to provide the instruction and remediation needed. Pre and post-testing of the program participants was conducted. Data analysis of the examination results was conducted to gain insight into the impact of the mathematics program as an intervention.

*Budget* Program materials were relatively inexpensive and was absorbed by the nursing department. The projected cost for the replication of the program is outlined.

Table 2 *Budget*

Cost for Instructor per Semester:				
\$30 per hour	×	10 hours	=	\$300
Cost for classroom usage:				
\$50 per session	×	5 sessions	=	\$250
Duplicating fees:				
20 students	@	\$.10 per page	× 10 pages =	\$200
Total estimated cost			=	\$750

*Timeline* This program was administered in conjunction with the nursing curriculum during the 2008/2009 academic year. The academic semester was fifteen (15) weeks in length. A breakdown of the timeline design for the program follows.

Table 3 *Timeline for Program Delivery*

Instruction for Academic Year:		5 sessions		
2 hours per session	X	1 session per week	=	2 hours per week
Total instructional time			=	10 hours

The pilot testing for the Math Competency for Medication Administration exam was completed in the prior administration sessions by the faculty of the School of Nursing. The test utilized within this program of study was the standard for validating medication math competency of all sophomore level students in the consortium over a

five-year span. The test was discontinued when the main university campus adopted a self-paced computerized study program. Data analysis was completed upon completion of the five instructional units. A separate testing time was included in the course schedule. Data analysis was completed immediately following the administration of the post test examination.

Nursing students must re-qualify every semester for medication administration in the clinical setting. The ability to compute medication dosage calculations at the 100% mastery level must be maintained. This level of competency was indicated in all course documentation, including student handouts. This will serve as the follow-up checkpoint for this research project.

*Summary* This applied dissertation project addressed the difficulty many nursing students experience in computing medication dosage calculations. Administration of medications is a clinical skill that cannot be accomplished safely if the nursing student cannot calculate the correct dose. Diagnosing computation weaknesses and providing appropriate intervention can only be a positive practice within the scope of nursing education. Considering specific population characteristics was strategized to be valuable diagnostic information when considering factors that may influence mathematical computation proficiency. Accurate medication dosage calculation is a clinical skill that the practicing nurse must accomplish in order to provide safe patient care. Best practices for continuing this program were outlined to provide a roadmap for a fruitful endeavor. The next step in addressing the identified problem of this applied research was curriculum design. The blueprint for the course content can be found in Appendix D.

### *Curriculum*

The course Dimensional Analysis and Medication Math (DAMM) was designed to provide remediation of the mathematical computation skills necessary for calculating accurate medication dosage. It is a mathematics review course for those students who do not successfully complete the Math Competency for Medication Administration exam. It was designed to facilitate and improve student ability to safely calculate, prepare, and administer medications. The course focused on practical and useful applications of mathematics necessary within the nursing profession. The content included five units of mathematical instruction and application. These were math review, dimensional analysis, systems of measurements, oral medication dosage calculations, and parenteral medication dosages. The course met in a structured classroom setting with instructor/student interaction. The delivery format was identified as a traditional classroom setting with lecture, discussion, group work on content, workbook assignments, and tests. Each class period consisted of discussion and group work along with individual pre/post-testing on the unit. Class attendance was mandatory.

Students were expected to have read chapters and attempted to solve practice problems prior to attending class. Areas of confusion or misunderstanding pertaining to the assigned math practice problems were discussed during the sessions. The length of the course was identified as five instructional weeks to allow for the preparation of the student for the Math Competency for Medication Administration exam and subsequent remediation as necessary. A time frame of two hours of instructional/placement time was scheduled. Pre-requisites were identified as enrollment in the nursing courses of Nursing 110, Nursing 225, and Nursing 245 if needed. A score of less than 100% on the Math

Competency for Medication Administration exam was also identified as a qualifying fact. The score of 100% was identified due to the ramifications of administering inaccurate medication dosages.

### *Theoretical Framework*

Higher education is a dynamic venture. Societal advances dictate the interpretation and subsequent attention to delivery be revised in consideration of the current trends. The scholarship of integration, according to Boyer (1998) gives meaning and a sense of connectedness across disciplines. This principle takes what has been learned or discovered via experience or research and adapts essential elements to the needs of the time, and populates. This holds true with the remediation of nursing students in mathematical computations.

Learning for the most part has been historically summarized as any process that instigates “change in behavior” (Smith, 1999/2007, p. 1). Bransford, Brown, and Cocking (2000) acknowledged the “new science of learning is focused on the processes of knowing” (p. 10). In a description of learning, Trotter (2006) summarized that regardless of age, learning continues. Trotter focused on identifying problems, concerns or common practices and their correlation to learning needs and chronological age. Examining adult learning provided an array of differences but also defined similarities as well. Gaining information on the demographic background of participating students revealed this information and served as the building blocks for individualized and group instruction.

Lieb (1999) and Russell (2006) emphasized the characteristics that adult learners exhibit. Those characteristics included being ‘self-directed and autonomous’ with the teacher as a facilitator of learning. The accumulated “life experiences and knowledge” of

the adult learning when properly guided will bridge and connect the past to new information. Lieb (1999) was in agreement with Russell (2006) in their belief “goal-oriented” adult learners know what they want to learn and why. They also concluded the “relevancy-oriented” learner could visualize the reason for the quest for new information and its application to work or other life responsibilities. The adult learner was found to be ‘practical’ in focus as many aspects of learning were readily applicable to current life. Lastly, the mature student must be shown the ‘respect’ that is required of any learner. According to Russell (2006), adult learners engage in the learning experience to create change. Diagnostic testing of basic skills for adequate placement in course work to facilitate both remediation and positive outcomes nurtures self-concept (Russell, 2006).

Knowles (as cited in Smith, 2002), emphasized that with adult learners, the need to consider self-concept, experience, readiness to learn, orientation to learn, and motivation was important to the learning process. With this in mind, the ability of the adult to acclimate to structured learning can be facilitated by a caring presence. This is a concept that is prevalent in nursing education and is a key thread within many curriculums. Watson’s theory of caring (as cited in Taylor, Lillis, & LeMone, 2001) is based on 10 factors, which include concern and respect for others, using problem solving in decision making and providing supporting environments. In education, the ability to care that the student is struggling is an important attribute of the teacher. If left unheeded, circumstances can and often do spiral out of control with a resultant negative situation. Assisting the struggling student can be accomplished by providing alternative assignments or tutoring. Wright (2005) emphasized instructional content can be solidified and goal attainment realized in the proper learning environment.

The progressive learning approach is applicable for modeling teaching methods. This approach connects students' interest and experiences to the curriculum taught. Using this style also instills the understanding of adapting to change, solving problems and discovering new knowledge. Havinghurst (as cited in Cornell & Malcolmson, 2004), in his work, identified 'teachable moments' (p.1). These can occur in a formal or informal setting. Maximizing the moment when a trigger occurs is significant to teaching/learning experience. This is the opportune time to provide important instructional concepts. It is important to grasp the moment and to share information and concepts with students. It is often difficult for students to transfer learning to application in the best of settings. The chance to have students experience the "ah-hah" moment is rare in the structured educational experience and must not be neglected.

According to Clendaniel (2003), the taxonomy of learning designed by Bloom in 1956, established a frame of reference to explain the premise of cognitive educational goals and objectives. Clendaniel's work with two additional psychologists added affective and psychomotor domains. Student learning in nursing education consists of the didactic and application components. Students are actively engaged in the learning process due to the intense clinical experience that is required. Bloom's Taxonomy (Taylor et al., 2001), provides a framework for addressing curricular content in a multidimensional mode from the cognitive, psychomotor, and affective perspectives. Incorporating these principles into each lesson provided for better instructional delivery and assessment.

Cognitive theory provided a solid basis for active learning strategies and the adult learner. Wolfe (2007) noted that previous learning and past experience were fundamental



to Brunner's constructivist approach to cognition. This occurred when the instructor encouraged the adult student to solve problems by going beyond their current knowledge level in a process of self discovery (Wolfe, 2007). Important to this theory were the constructs of structure, discovery, and intuitive thinking (Smith, 2002; Takaya, 2008). The use of dimensional analysis as the method of instruction for solving medication dosage calculation problems is reflective of cognitive theory. This method is founded on *how* to learn. It is a process that is logical and sequential in application. Kauchak and Eggen (1998) explained that teaching and learning in a curriculum influenced by Brunner is learner centered with active student involvement.

In the process of implementing this course of instruction, the focus was directed to student needs and the learning process. Sprinthall, Sprinthall, and Oja (1998) stressed the "four-way agenda" to be imperative to the process of teaching (p. 24). This agenda included the pupils, the teacher, teaching strategies, and subject matter (Sprinthall et al. p. 24). Being able to use newly learned concepts in novel situations with multiple strategies solidifies retention. Variation in application of information, allows for numerous reference points for future recall. This is a point that is consistent with cognitive theory.

## Course Content

### *Narrative*

The need to provide remedial instruction in basic mathematical computations for nursing students is a documented challenge for educators (Gillham & Chu, 1995; Hutton, 1998, December; O'Shea, 1999; Polifroni et al., 2003; Priest et al., 2006). The administration of medications is a clinical skill that cannot be accomplished safely if the nursing student cannot compute the correct dose. In addition, mathematical competency is required for successful completion of the National Council Licensure Examination for Registered Nurses (NCLEX) (National Council of State Boards of Nursing, 2007). It has been necessary to think creatively and explore various instructional strategies in the development of this program. The DAMM course would provide remediation of the mathematical computation necessary for calculating accurate dosages of medications. This method of instruction can be grasped easily with instruction and subsequent practice. The process is reasonable and can be readily applied by all.

### *Goals*

The goal of this program was to facilitate an understanding of mathematical computation with accurate application to medication dosage calculations. The student would demonstrate the knowledge and skills in theoretical and mathematical concepts related to the calculation of medication dosage.

### *Audience Description*

The audience consisted of nursing students in a consortium program which is a joint offering of a state college and university. This state college is located in a rural area of north central West Virginia.

### *Societal Factors*

Article 30 of the West Virginia state code states that nursing students are held to the same standard for safe practice as those of a licensed registered nurse in the clinical setting (*West Virginia Nursing Code and Legislative Rules*, 2002). The ability to accurately calculate medications for patient administration is a requirement for participation in the clinical experience (West Virginia University School of Nursing, 2007-2008)

### *Delivery Format*

This course involved interpreting medication dosage requirements and accurately calculating medical dosages. The content included math review, systems of measurements, medication dosage calculations, and dimensional analysis. This course was held in a traditional classroom setting with instructor/student interaction.

### *Length*

This course met for two hours per week for five weeks. The rationale was that students engaged in a full-time academic curriculum could more easily incorporate this time frame into their schedules. Many students are also employed or have responsibilities outside of the educational environment and the weekly delivery was agreeable to these demands. The instructional activities were structured to fully maximize the specified time frame.

### *Prerequisites*

Any student scoring less than 100% on the Math Competency for Medication Administration Examination was requested to participate in 10 hours of mathematic remediation. This was strictly voluntary, without repercussions for non-participation.

*Coreq: Nursing 110, Nursing 221 and Nursing 225 (1<sup>st</sup> Semester) Nursing 241 and Nursing 245 (2<sup>nd</sup> Semester) if need be.*

### *Course*

It was anticipated that the participants would benefit from an increase in cognitive knowledge and structured application of clinical medication dosage problems. It was believed this would increase the accuracy of the mathematical processes. The practice of medication administration is a high-skill competency of nursing students within the curriculum. The ability to calculate medication dosages accurately correlates with patient safety and professional accountability. It was anticipated that at the conclusion of this educational intervention, students that participated would be able to:

1. Calculate mathematical problems working with fractions, decimals, and percents.
2. Solve drug dosage problems using dimensional analysis.
3. Use system conversions (metric and household) for volume and weight problems.
4. Calculate oral and parenteral dosage problems in the same system and in different systems.

### *Assessment*

The pre-test and post-test examination included computations that a nurse is required to master which include fractions, place value, percentages, metric, and household conversions, and interpreting information. Differences between pre and post-test assessments would measure student learning and course effectiveness. .

*Formative Assessment.* Practice exercises during the course would keep the students advised of any gaps in their conceptual or procedural knowledge. This information would also be important in refining instruction and providing appropriate remediation strategies as warranted. The ability to accurately complete computations

does not guarantee that the student will select and apply mathematical operations to subsequent problems.

*Summative Assessment.* This was accomplished with the comprehensive final examination, which was administered following the completion of the program. The student was expected to score 100% or they would not qualify to administer medications to patients in the clinical setting. The student that scored less than 100% would not complete all the required components of the course and would receive a grade of “F” (Refer to the WVU SON Admission and Progression Policy).

#### *The Active Learner Centered Environment*

Consideration was given to the capacity, needs, and background of the students. In the work of McCombs and Whisler (1997) one of the basic assumptions of the learner-centered model was the importance of planning to engage the learner in the curriculum. This was viewed as an important facilitator in the promotion of self-responsibility in the acquisition of knowledge. Learner-centered instructional environments focus on what the individual needs and desires in order to receive information deemed critical to course objectives. DeRoma and Nida (2004) utilized the hallmarks of the learner-centered environment in restructuring conventional classroom settings. In doing so, the idea of student “engagement in learning” was central (p.39). The premise that learning is ongoing and not limited by the walls of a classroom was incorporated in the plan. Clark (2000) commented that the informal setting for teaching and learning where the instructor and student are one-on-one is often a richer experience than the formal classroom setting. Planning and sequencing the curriculum to build concept upon concept was encouraged in the method proposed by DeRoma and Nida (2004). The benefit of prompt student

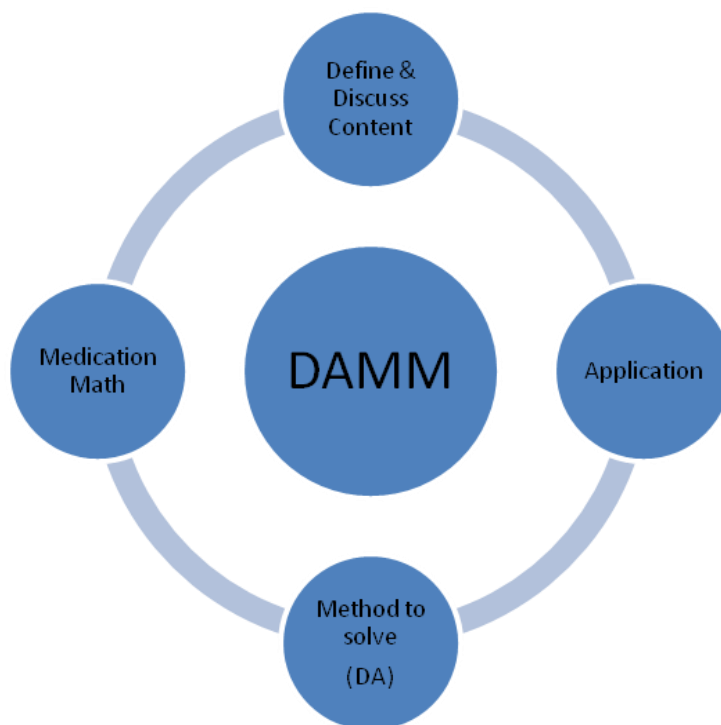
feedback to address individual learning needs, and lastly, collaboration through student/teacher and student/student interaction was a strategy for maximizing instruction for the individual (DeRoma & Nida, 2004).

Nursing education has experienced an epiphany regarding its structure according to Whitehead (2005). Historically, the process of educating professional health care providers has actively engaged the student in the learning process. The realization was that designing curriculum to include a variety of teaching modalities would address the different learning styles of the individual students. The process of formative and summative feedback in a timely fashion facilitates the curricular adjustments needed to address individual learning needs. According to Whitehead (2005), learning is sequential and essential to the mastery of prerequisite knowledge mandatory for progression to clinical practice. This allows the student to test knowledge and apply skills in a variety of situations. The student learns not only the “how” but also the “why” of concepts as they develop metacognitive skills. The application of theory to practice in a safe and accurate manner is the premise of the educational intervention of this applied dissertation.

Weimer (2002) compiled a list of suggestions which, when applied, create a classroom structured around the learner. Before any of these can be applied, however, the topics for teaching and learning deemed appropriate are selected. Curricular content must prepare and sustain the learner for the fluid nature of the practice arena. Societal advances dictate the interpretation and subsequent attention to delivery be revised in consideration of the mainstream vogue. Having a solid foundation is mandatory for subsequent mastery of knowledge and skills. This will foster future learning when it is necessary. Suggested by Weimer (2002), was the formation of the syllabus structured to

alert students to all curricular expectations, pre-determined course assignments with a variety of student activities for application of course content, formative assessment with feedback, and concluding with the summative evaluation.

It was the intent of the structure of this educational intervention to actively engage the learner. Sprinthall, Sprinthall, and Oja (1998) stressed the “four-way agenda” to be imperative to the process of teaching (p. 24). This agenda included the students, instructor, teaching strategies, and subject matter (Sprinthall et al, 1998). All of which was outlined in the curriculum for Dimensional Analysis and Medication Math for Nursing.



*Figure 2* Dimensional Analysis and Medication Math

The educational intervention DAMM design was discussed in length. The purpose of this project was to provide an intensive mathematics program of instruction for nursing

students. This method of calculation must be logical, sequential, and organized. In actual clinical practice, after licensure, medication computation accuracy is fundamental to patient safety in professional practice. The ability to perform basic mathematics in relation to calculating medications for patient administration can turn a routine skill into a life or death occurrence.

Regardless of discipline, the research process is a purposeful activity. It is implemented in the hopes of discovering characteristics or relationships that will contribute to a resolution if not solve the identified problem. Trochim and Connelly (2007) noted that regardless of strategy, the challenge is to design a process that would yield useful data. The process of evaluation will be outlined with regard to meaningful interpretation of the acquired data.

#### Evaluation Tools

The time and energy invested in the development and delivery of a course is intensive to the point that it seems to take on a life of its own. The course content and design have been presented along with a discussion of student-centered instruction with practical application. The anticipation of the impact that this production would have on student learning was wrought with uncertainty. The strategy to ascertain the impact and effectiveness of this educational intervention will be discussed.

Wilkes and Bligh (1999) noted the importance of evaluation in the quest to improve both teaching and learning. Regardless of format, assessment is an essential part of the teaching/learning process. Knight (2004) identified the need for this process in evaluating “knowledge, understanding, conceptualization and critical thinking” of



students (p.63). Assessment is an important tool for both the teacher and student in measuring progress or the need for remediation.

This applied research project evaluates an intensive mathematics program of instruction for nursing students. The program was titled, Dimensional Analysis and Medication Math (DAMM). The resultant indicator of success would be the reporting of accurate mathematical computation of medication dosage problem sets. Selecting appropriate evaluative processes was paramount to the successful completion of the project.

With the development of a new course comes the component of instituting an evaluation process that is inventive and progressive. The ability to institute a method that will provide feedback from day one to the professor and student is one that is worthy of investigation. Wilkes and Bligh (1999) advocated for a modality that would bring formative and summative feedback to the instructional arena. Guskey (2008) addressed the process of formative evaluation relative to the current state of learning. This process was described as the ability to inform the student and teacher in the here and now when the learning is new and fresh of both accomplishments and needs. This helped to delineate the areas of achievement and those of concern. Students and teachers alike are motivated by positive results. Combined with difficulty, this helps in keeping both inspired and committed to the learning process (Kelly, 2006). Both participants realistically understand that there will be complications that need to be addressed. However, these tend to appear less threatening, and manageable when a notable degree of success has also been experienced (Kelly, 2006).

*Quantitative evaluation.* Quantitative evaluation used a pre-test-post-test medication dosage calculation examination and demographics questionnaire. The pre-test-post-test tool was the Math Competency for Medication Administration exam. This is a school of nursing faculty constructed examination for nursing students. The instrument has been subjected to test item analysis by a panel of nursing experts in both the clinical and teaching fields. This process verified that the content represents the mathematical calculations necessary in medication administration. The examination has been replicated and administered for five academic years and has been deemed a reliable predictor of safe clinical practice. A researcher-constructed demographic instrument was administered in conjunction with the medication calculation examination.

*Formative evaluation.* Guskey (2008) emphasized the importance of regular checks on the learning progress as being imperative in the learning process. Formative evaluation will occur throughout the five weekly educational offerings. It will be in the context of pre-testing/post-testing of the assigned topic for the session (see Standard Operating Procedures). This was a paper/pencil examination of mathematical problems pertaining to hypothetical clinical scenarios of medication administration. The exam encompassed five problems that were calculated individually during the class session. Problem sets were reviewed and the class session ensued with discussion and application. At the conclusion of the meeting, a five-question post-test was administered. These were collected and scored by this investigator. Students were able to review the post-test the following day in the nursing skills lab with this researcher. Guskey (2008) stressed the benefits of providing feedback regarding individual student progress in the mode of formative assessment. As the title of the technique implies, informing the student of

strengths and identifying areas of concern enhances the educational experience (Guskey, 2008).

*Summative evaluation.* Summative evaluation included a school of nursing identified medication dosage examination with some revision to support course structure. Re-evaluation of the calculation proficiency was conducted upon completion of the program. The results have a two-fold ramification. First, the evaluation of the effectiveness of the educational program, DAMM, on student mathematical calculation ability will be ascertained. Secondly, it will document mathematical computation proficiency, which is necessary for successfully accomplishment of the clinical course objective for administration of medications.

*Statistical Analysis.* Descriptive statistics are numbers that are used to describe and summarize data ( Leedy & Ormrod, 2005). The parameters of mean, percentage, frequency distribution, and central tendency will be beneficial in explaining the mathematical ability and experience of the participants. In addition, variability and correlations will summarize the relationship of course work to ability. A student's t-test was used to compare pre and post test results and assess for significant differences in student calculation abilities. A level of  $p < 0.05$  has been set as significant with a 95% confidence interval. An analysis of variance (ANOVA) was used to compare changes prior to intervention implementation and after intervention has been administered.

*Demographic Questionnaire.* In the process of gathering information, the instrument must be functional and user friendly. Motivating the individual to respond with accuracy is a challenge for any information-seeking project. Data collection facilitated by the research instrument of the questionnaire modality must be constructed

with this in mind. Leedy and Ormrod (2005) identified a guideline that provided guidance in the development of the questionnaire. This information is geared to ease the work involved by the participant, with consideration given to the precision of the answer. A demographic instrument will be administered in conjunction with the medication calculation examination. This will provide individual specific information such as gender of the test taker and mathematics courses completed prior to nursing program admission.

*Summary* Many students come to higher education with pre-existing deficiencies in mathematics and must work diligently to remediate and many times manifest with calculation difficulties throughout the course work (Brown, 2006). This program provided instruction in the basic math computations required in the calculation of medication dosage. Pre and post-testing was conducted by the researcher and followed by data analysis.

Regardless of format, evaluation is an essential part of the research process. Knight (2004) identified the need for this process in evaluating “knowledge, understanding, conceptualization and critical thinking” of students (p.63). Muirhead (2002) determined that the data collected for evaluation needs to be gathered from multiple sources to gain a more conclusive understanding of student progress. This is the underlying premise of the usage of the evaluation tools and process presented in this study. With the analysis of the data, the anticipated benefits of increase in cognitive knowledge and application accuracy of mathematical processes can be confirmed or negated. The Standard Operating Procedures for this educational program would provide the guidelines and procedure that steer the course culminating with the evaluation

process. To ensure consistency, documentation, which would direct future replication of this educational intervention, will be addressed.

### Standard Operating Procedures

Standard operating procedures are the information that serves as the best practices directional guide. This is an indispensable pre-requisite for program delivery, which standardizes the content and method. This written guide provides the essentials of the format necessary to implement and maintain consistency within the curriculum, which are crucial to program replication. Recommendations for further research that has been considered plausible as the result of this project will be presented.

### *Limitations*

Persons implementing research are in the best position to identify any shortfalls that exist within the research sequence. Polit and Beck (2008) applauded the researcher who provided discourse on any areas of concern. These authors deemed that the researcher is demonstrating that the concerns have been contemplated in the design and interpretation of the study. Limitations identified include:

1. The study uses a convenience sample. Due to the small sample size results may not be generalized beyond the specific population from which the sample was extracted.
2. The location of the college in a rural setting limits the involvement of students from the total consortium from participation in this study.
3. The gender ratio of participants may be disproportionate due to the historically low number of male students enrolled in nursing programs.

### *Assumptions*

Basic to the research process is the expectation of results. The assumptions for this study were related to the nursing student's ability to accurately complete the

mathematical computations required to calculate medication dosages. These included but were not limited to:

1. Nursing students will have an increase in understanding of mathematical computations that are necessary for medication dosage calculation.
2. The knowledge base related to the process needed for calculation of medication dosages will be enhanced.
3. Nursing students will demonstrate a significant improvement in pre-test scores on post-testing following an education intervention which includes instruction in the dimensional analysis technique for medication dosage calculation.

The first limitation identified was that of convenience sampling. This has historically been the most economical and opportune group to involve in a research study. However, this method of selection is likely to provide a sample bias of participants and limited generalization of the results. Coinciding with this point in this research study is sample size. Polit and Beck (2008) stated that a formula has not been written to determine how large the ideal quantitative sample need be. The advice given by these veteran researchers was to obtain the largest sample possible in order to gain the best representation of the entire population. The number of participants in this study were limited due to unavailability. The college has a limited total student body enrollment. The sample, however, was reflective of the total group of nursing students. A comment by Polit and Beck (2008) worthy of noting was that when utilizing the convenience sample, large numbers do not guarantee accuracy any more than having a small research population.

The second limitation is the rural location of the college, This prohibited participation by the entire School of Nursing consortium. Practical constraints such as location are as important as theoretical concerns and can account for in inclusion or

exclusion criteria. Failure to do so can have implications for both the interpretation and the validity of the results.

Lastly, the final limitation was the anticipated inequity in distribution of male and female participants. Even though the number of men enrolling in nursing programs has and continues to increase (Phibbs, 2006), there remains a significant discrepancy in the total. The disproportion of numbers is more pronounced in a rural area within a small public liberal arts college. This will be considered when generalizations about the findings are made.

### *Maintaining Best Practices*

The scholarship of integration, according to Boyer (1998) is to give meaning and a sense of connectedness to the learning process (p. 19). This principle takes what has been learned or discovered via experience or research, adapts the elements to the needs of the time, and populates. Best practice is a method that provides guidance for process delivery to ensure that optimal directives avail. Common to the best practices of the applied dissertation was:

1. A curriculum designed to support the problem statement identified in the applied dissertation
2. Evaluation tools designed to measure weakness and improvement respectively in mathematical computation ability
3. Documentation that designed to guide the replication of the process with replication when deemed necessary

In particular, the best practices for this project were the identified program components that were set forth to orchestrate an improvement in the mathematical computation ability of the nursing student. This was operationalized through an enhanced teaching /learning experience designed to facilitate accurate calculation of medication

dosages. This intensive mathematics program of instruction incorporated a method of calculation that is logical, sequential, and organized. Dimensional analysis was the calculation prescriptive applied.

Administration of medications is a clinical skill that cannot be accomplished safely if the nursing student cannot compute the correct dose. It was a goal that a program similar to the one in this study be available to nursing students and practicing registered nurses alike that are struggling with mathematical computation. An educational intervention emphasizing the application of mathematical concepts in structured medication dosage problem solving will provide needed remediation for many. Benefits to society and the participating nurse are articulated in Article 30 of the West Virginia state code, which states that nursing students and registered nurses are held to the same standards for safe clinical practice as those of a licensed registered nurse in the clinical setting (*West Virginia Nursing Code and Legislative Rules*, 2002).

#### *Policies.*

All institutions have protocols and instructions to facilitate proceedings. A project that is an artifact of an applied research dissertation is no different. In this case, the policy and procedure will serve as a resource and guide for implementation and subsequent future replication. The policy for this project will serve as the structure outline, while the procedures, when warranted, will be the step-by-step instructions for completion of a lesson or task. Both are necessary appendages as they serve to clarify lines of communication, define responsibilities, increase the ease of access, maximize cost effectiveness, and outline processes all in the name of accountability to the institution and



project participant. The standard operating procedure is the documentation that provides the direction and understanding for the implementation of this educational intervention.

*Policy and Procedure: Informed Consent.* The designed program of this dissertation, DAMM, was provided for all consenting students (Appendix C). The researcher provided an explanation of the program along with process and procedures to the participants. This included the purpose, instructional design, projected benefits, the fact that no student will be penalized for choosing not to participate and alternative math tutoring opportunities. Students that agreed were given a packet containing a written description of the program, course objectives, content map, class attendance schedule. The consent form was included in the documents and was reviewed by the participant and once signed returned to this investigator. The original consent form is housed in the locked file of the Science and Math Department. A copy of this document was returned to the appropriate student. This process will occur in the traditional classroom setting.

*Summary* The ability to fully implement an educational intervention that will have a significant effect on the critical clinical competency of medication dosage calculation relies on the clarity of available instruction and guidance. The standard operating procedures for this program entail best practice content to include policies for delivery, course content map, and participant packet and evaluation instruments. This information has been influenced by the goal of improving the mathematical computation ability of nursing students as they calculate medication dosages for patient administration. This will provide the foundation for safe clinical practice of future registered nurses.

*Chapter Summary*

Chapter three has presented the methodology for this research study. A review of the design, procedures, setting, sample, and data collection method were discussed. Ethical considerations were addressed and data analysis procedures were summarized. The standard operating procedures for implementation and future replication of the educational intervention Dimensional Analysis and Medication Math were outlined. As the research study evolves, collected data will be compiled and analyzed. These findings will be reviewed along with noted implications and conclusions in Chapter Four.

## Chapter Four:

### Discussion

The purpose of this action research study was to evaluate through quantitative research the effectiveness of a program of instruction in mathematical computations for medication dosage calculation for nursing students. The need for this study was identified from the many studies that have detailed the concerns of nursing educators and health care regulating agencies regarding the number of nursing students and practicing registered nurses who struggle when performing medication dosage calculations. This applied research project provided an intensive mathematics program of instruction for nursing students. The method of calculation introduced and taught to the students was logical, sequential, and organized. In real-life clinical practice, after licensure, medication computation accuracy is fundamental to patient safety in professional practice. The ability to perform basic mathematics in relation to calculating medication dosages for patient administration can turn a routine skill into a life or death occurrence. The program, titled DAMM was offered to qualifying nursing students.

The need for a mathematical intervention for nursing students was established in the preceding chapters. This chapter will provide an overview of the applied dissertation in its totality. A discussion of best practices identified for a mathematical remediation instructional program and relativity of such following implementation will be included. The study's findings will be compared to those reported within the literature review of Chapter Two. The limitations of the study will be addressed. Lastly, recommendations and suggested modifications that may enhance future offerings will be included.

*Summary of problem*

Nursing competency is a complex issue. Students enrolled in nursing must master the biological, psychological and social sciences. They must also demonstrate mathematical competency in medication dosage calculation, which is required for the completion of the NCLEX-RN (Pietsch, 2005). Nursing students have long struggled in performing medication dosage calculations (Bell & Rice, 2005). The administration of medications is a clinical skill that cannot be accomplished safely if the nursing student does not possess the ability to compute the correct dose (Greenfield, Whelan, & Cohn, 2006).

In real-life clinical practice following licensure, medication computation accuracy is fundamental to safety in professional practice (Capriotti, 2004; Greenfield, 2007; Pietsch, 2005). The inability to perform basic mathematics in relation to calculating medications for patient administration can turn a routine clinical skill into a life or death occurrence (Gillham & Chu, 1995; Sandwell & Carson, 2005; Wright, 2005). Students enter higher education with many different backgrounds and secondary education preparations. These differences in educational background and competencies make it necessary to think creatively when devising a plan of remediation. When considering a method of instruction the process must be one that can be grasped as a reasonable application by all. Greenfield et al. (2006) considered “dimensional analysis as a method of calculating medication administration dosages that uses critical thinking, removes the need for memorizing formulas, and enhances accurate computation” (p. 91). The program of this applied action research focused on instruction that would provide a mathematical intervention for sophomore nursing students. The objective to facilitate accurate

medication dosage calculation found it necessary to identify one method of problem solving. Based on the review of the literature summarizing various strategies the decision was made to integrate dimensional analysis into the mathematical intervention.

### *Problem Statement*

During the 2008-2009 academic year, the researcher will design, implement, and evaluate a medication dosage calculation program for students in a baccalaureate nursing program in West Virginia.

### *Sub-problems*

1. Does the gender of a nursing student impact the accuracy of medication dosage calculation?
2. Do math courses completed prior to nursing course enrollment influence the accuracy of medication dosage calculation?

Kazaoka, Ohtsuka, Ueno, and Mori (2007) made note of the fact that medication is prescribed by the health care provider and dispensed by the pharmacist. It is the nurse however is the principal in the administration of the drugs. Kazaoka et al. (2007) found this to be an accurate observation of practice regardless of geographical location. Medication errors are second only to falls in reasons that nurses are sued (Maricle, Whitehead & Rhodes, 2006). In his review of documented research Hodge (1999) found that of every five medications administered, one was given in error. Wright (2006) reviewed and summarized the findings of several researchers concerned with the adverse medication events. The analysis of the documentation found repeated reports of nurses experiencing dosage calculation difficulty. Hodge (1999) reported that as many as 33% of the reported medication errors involved mathematical computation to arrive at the correct medication dosages.

The consensus of this literature review was that of the many documented medication errors, a common causal factor was inadequate mathematical skills of nurses when solving medication dosage problems. Consideration of the consequence of poor mathematical ability on accurate medication dosage prompted the development of a program of instruction. A review of the magnitude of improper medication dosage validated the necessity of a programmed intervention.

### *Purpose of Work*

The ability to structure a learning experience that will assist nursing students in becoming proficient at medication dosage calculation has been a task that continues to haunt nurse educators. Glaister (2005) commented that finding a way to combat mathematical inaccuracies was undoubtedly one of the most difficult assignments the nurse educator encountered. This applied research project focused on structuring a program specific to improving mathematical computation skills and accuracy when calculating medication dosage. Bell and Rice (2005) found that in the studies reviewed, calculation error occurred in a range from 68% to 91% due to a lack of knowledge and process. Meyer (2004) expressed surprise at how inept he found nursing students to be at mathematical computation. He was interested in determining if the prerequisite math course work completed prior to enrollment in nursing courses could be correlated with this flaw. Meyer (2004) postulated that if so, it would be an important fact to consider when ascertaining a starting point in the remediation process. This action research project incorporated the premise that mathematical prerequisite coursework could be an important construct to consider. The comparison of coursework or lack of was thought significant in establishing possible contributing factors to this quandary. Likewise, the

consideration of student gender and level of mathematical preparation as a predisposition to computation struggle was thought worthy of investigation.

### *Best Practices*

Best practices are the activities that advance the teaching, research, and practice of nursing (American Association of College Nursing, 1999). The American Association of College Nursing (1999) identified program development to enhance the transfer of essential knowledge from the classroom to the practice setting as imperative in the process of developing essential clinical skills. The best practices were designed to improve the abilities of the nursing student when calculating medication dosages accurately through an enhanced teaching/learning experience. These included:

1. Curriculum designed to address the problem
2. Evaluation tools that identified areas of computation deficits, prior mathematical experience, gender of the participant, but most importantly the effectiveness of the instructional process
3. Standard operating procedures (SOP) designed to serve as an implementation guide for replication and to reflect any improvements that the teaching/learning scenario provided.

The program, DAMM, was delivered in five instructional sessions that included pre-testing to establish baseline abilities and post-testing for ascertaining areas needing additional clarification. Twenty students participated in the program. There was no attrition. This mathematical intervention provided the student participants the opportunity to:

1. Calculate mathematical problems working with fractions, decimals, and percents.
2. Solve drug dosage problems using dimensional analysis.
3. Use system conversions (metric and household) for volume and weight problems.

4. Calculate oral and parenteral dosage problems in the same system and in different systems.

Students were given the opportunity to practice calculations and receive immediate instruction, guidance, and feedback during the session. This provided opportunity to review medication dosage calculation issues of student work in real time. Wright (2005) found this attention to detail was often neglected or overlooked in the structured the traditional classroom setting. DeRoma and Nida (2004) also advocated instruction that encouraged the active involvement of the learner in a setting that would provide for instructor interaction imperative to student success.

#### *Analysis of Best Practices*

The need for a more efficient method of acclimating all health care providers to the mathematical computations specific to medication dosage is a subject that is reiterated often in the literature (National Coordinating Council for Medication Error Reporting and Prevention, 2002). The mathematical intervention DAMM, implemented within this program, was based on the premise that learning is a recompilation of stored facts and ideas. Reactivating these stored processes can occur in the context of active learning (Billings, 2000; Guilbert, 2002).

In this program of instruction, the pre-testing provided the opportunity to identify where there were gaps between content and computation when solving problems. The DAMM course strategies were structured to actively engage the student in solving clinical medication calculation problems common to the practice setting. A pre-test of willing participants was administered. This allowed for identification of students that could benefit from a revisit in the use of mathematical applications. Twenty students volunteered to sit for the testing. All scored less than 100% on the screening tool,



qualifying them for the remediation program. The students were given the opportunity to decline the instruction. All 20 students agreed to participate in the five learning sessions.

DAMM curriculum design was inspired by the literature review. Specific areas of mathematical computation difficulty that were noted repeatedly in the review of past research studies were considered worthy of inclusion as instructional content. These included fractions, decimal placement, percents, household measurement, the metric system, and conversion (Glaister, 2005; Greenfield et al., 2006; Pietsch, 2005; Weeks, 2005). The degree of mathematical experience, which can be attributed to course work, was identified within the reviewed literature to influence student success. This, however, was found to be a non-factor within this applied research as did the difference in gender of the instructional participants.

### *Results*

*Introduction.* The main objective of this study was to examine the effectiveness of the DAMM program for improving medication dosage calculation for nursing students. Fundamental to design of this project was the establishment of a problem statement, which would anchor this undertaking.

### *Problem Statement*

During the 2008-2009 academic year, the researcher will design, implement, and evaluate a medication dosage calculation program for students in a baccalaureate nursing program in West Virginia.

To narrow the agenda of the topic and focus the action research project, two research questions were generated.

1. Does the gender of a nursing student impact the accuracy of medication dosage calculation?

2. Do math courses completed prior to nursing course enrollment influence the accuracy of medication dosage calculation?

Prior to answering the two research questions, descriptive statistics were performed on the population sample. A dependent samples *t*-test for correlated means was deemed appropriate for two samples that can be matched on a particular characteristic (Pagano, 1999). The first question queried whether disparity of the population was of any significance. To validate a rejoinder, an independent samples *t*-test was conducted on DAMM pre scores by gender. An independent sample *t*-test was conducted to assess if differences existed on a dependent variable by a grouping variable (Pagano, 1990).

To answer the third research question, a Pearson's product moment correlation was conducted between number of math courses taken and DAMM pre scores. Polit and Beck (2008) stated that the "Pearson's *r*" index is considered an acceptable standard in determining whether a link exists between variables and to what degree. Pagano (1990) confirmed the appropriateness of using correlation as a statistical measure for research purposes. Specifically, Pagano (1990) stated that correlation is appropriate when the researcher is "concerned primarily with finding out whether a relationship exists and with determining its magnitude and relationship" (p.117). These analyses are presented in the section after the descriptive statistics.

*Description of the Sample and Study Variables.* The sample was comprised of 20 students enrolled in nursing courses in a baccalaureate-nursing program located in north central West Virginia. Table 4 depicts the range of age of the students, which was from 18 to 45 years of age.

Table 4 *Age of Participants*

Age	Number (N)	Percentage (%)
18	2	10
19	6	30
20	4	20
21	2	10
22	2	10
26	1	5
30	1	5
32	1	5
45	1	5
<b>TOTAL</b>	<b>20</b>	<b>100%</b>

This study population reported in Table 4 was not reflective of the age of students in medication math instructional programs significant to this literature review. The majority of the students participating were all under 30 years of age. Program participation in studies reviewed were typically over 30 with the mean age being 35 years of age (Allen, 1999; Bell & Rice, 2005; Brown, 2006; Greenfield, 2006; Hodge, 1999; Weeks, 2000). Recent experience with mathematical computation in the younger participants of this study would have been expected to contribute to problem solving accuracy. However, this did not prove accurate. The participants of this study had recently moved from high school into higher education reflecting current mathematical coursework. The students failed to achieve the set score on the pre test and had qualified for this program of instruction.

The frequency counts and percentages for the sample demographics are presented in Table 5.

Table 5 *Frequency Counts and Percentages for Demographic Variables (N = 20)*

Variable	Frequency	Percentage
Gender		
Male	3	15.0
Female	17	85.0
Age		
Twenty and younger	12	60.0
Twenty-one and older	8	40.0

There were three (15.0%) males and 17 (85.0%) females. Schwirian (1998) discussed the increase in the number of men that are enrolling in nursing education programs.

Regardless of the reported increase in the number, men in nursing reflect only 19% of the members in the profession (National League for Nursing, 2009). This is reflective of the male participants of this study. There were three male participants within the study. This is opposed to the 17 female students involved. This study did not consider the correlation of age and gender of the participants. This information would have been helpful in the review of gender and mathematical accuracy when solving medication dosage problems. More than half of the sample consisted of participants aged twenty and younger (60.0%) and a smaller portion consisted of participants aged twenty-one and older (40.0%). The distribution of the age of the students has been discussed in association with the findings displayed in Table 4.

The frequency counts and percentages of the program-related variables used in the study are presented in Table 6. The mean, standard deviation, and skew values of the continuous variables used in the study are presented in Table 7. Half of the participants in the study had taken additional college courses (50.0%). A similar percentage had taken

four years of high school math courses (45.0%) and one participant had taken three years of high school math courses. Nearly all participants had no college degree (95.0%) while one participant had a bachelor's degree (5.0%). More than half of participants had only taken one college math course (55.0%) while the rest of the participants had taken between two and four college courses

Table 6 *Frequency Counts and Percentages for Program Related Variables (N = 20)*

Variable	Frequency	Percentage
Years High School Math Courses		
Three	1	5.0
Four	9	45.0
Additional College	10	50.0
College Degree		
None	19	95.0
Bachelors	1	5.0
Number of College Math Courses		
One	11	55.0
Two	2	10.0
Three	3	15.0
Four	4	20.0

The findings in Table 7 indicate that the study variables had a slightly negative skew, meaning that among the 20 participants several scored lower than the rest of their peers. The possibility for a skewed results is more probable in smaller samples because it takes fewer participants to change the distribution of scores either positively or negatively. For example, if most participants score highly on a particular item of the medication calculation competency exam, the distribution of scores will be negatively skewed (Statsoft, 2007). The findings also show that the mean scores of the medication calculation competency exam increased from pre to post-testing.

Table 7 *Descriptive Statistics for Study Variables*

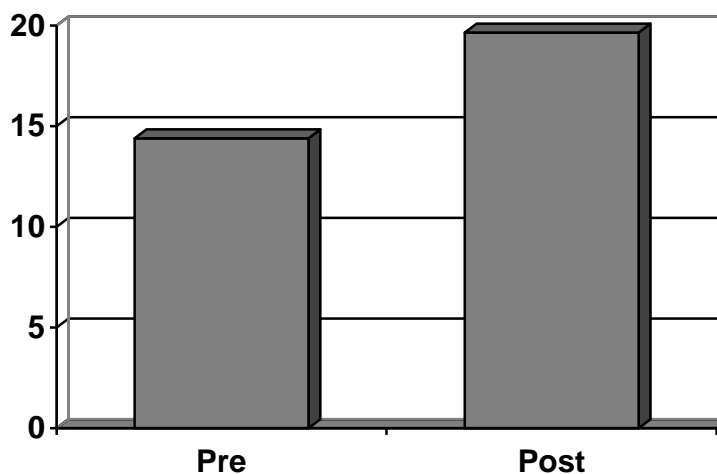
Variable	N	Mean	SD	Skewness
ACT/SAT	20	18.90	7.12	-1.89
Pretest	20	14.40	2.48	-.604
Posttest	20	19.65	.74	-1.847

### *Intervention Effectiveness Results*

*Relationship between Scores and Intervention.* A dependent samples *t*-test was conducted on DAMM scores from pre to post-testing. A dependent samples *t*-test is appropriate when comparing mean differences from time one to time two. This test is valid when the same participants are compared to each other and provides a tactic to explain discrepancy within the population (Hill & Lewicki, 2006). With one group sampling the degree of error noted will be “attributed to the initial individual differences

between subjects” (Hill & Lewicki, p. 26). The dependent t-test considers only the difference of the score as opposed to the total raw scores in pre and post-testing to evaluate statistical significance (Polit & Beck, 2008). Hill and Lewicki (2006) noted that this application has been found to provide “better” results for comparison purposes (p. 27). Post-testing scores ( $M = 14.40$ ,  $SD = 2.48$ ) were significantly higher than pre testing scores ( $M = 19.65$ ,  $SD = .74$ ),  $t(19) = -11.76$ ,  $p < .001$ . An evaluation, the scores revealed a significant difference in the mean scores of DAMM from pre to post-testing (Figure 3).

This suggests the remedial intervention to be effective in improving medication dosage calculation abilities of the participating nursing students. Results, however, must be interpreted with caution due to the limited sample size. Thus, further studies would be necessary with larger samples to interpret the generalizability to nursing students deficient in medication calculation at large.



*Figure 3 DAMM Scoring Pre / Post Testing*  
*Relationship between Gender and Dosage Calculation Proficiency. Descriptive*

statistics for study variables by gender are presented in Table 8 and Figure 4. An

independent samples *t-test* was conducted on DAMM pre-testing scores by gender (male vs. female). On the DAMM, males ( $M = 13.00$ ,  $SD = 3.00$ ) did not score significantly higher than females ( $M = 14.65$ ,  $SD = 2.40$ ),  $t(18) = -1.06$ ,  $p = .301$ , meaning there was no mean difference between male and female study participants. An independent sample *t-test* is appropriate when comparing mean differences between different groups (Hill & Lewicki, 2006). In this research study, participants could be in one group or another (i.e. male vs. female), meeting the criteria for independent *t-test* application. An independent samples *t-test* was conducted on the DAMM post-test scores by Gender (male vs. female). On the DAMM, males ( $M = 13.00$ ,  $SD = 3.00$ ) did not score significantly higher than females ( $M = 14.65$ ,  $SD = 2.40$ ),  $t(1283) = -1.06$ ,  $p = .301$ , meaning there was no observed mean difference between males and female. Results based on gender would have been more likely with a larger sample. Objectively, females did score higher than males; however, with a small sample such this it cannot be said to be statistically significant (Polit & Beck, 2008).

An independent samples *t-test* was conducted on ACT/SAT scores by Gender (male vs. female). On ACT/SAT scores, males ( $M = 11.67$ ,  $SD = 10.21$ ) scored significantly lower than females ( $M = 20.18$ ,  $SD = 5.97$ ),  $t(18) = -2.06$ ,  $p = .05$ , meaning there was a mean difference between males and female.



Table 8 *Descriptive Statistics for Study Variables by Gender*

Variable	Mean	SD	Mean	SD
ACT/SAT	11.67	10.21	20.18	5.97
Pretest	13.00	3.00	14.65	2.40
Posttest	19.00	1.00	19.76	.66

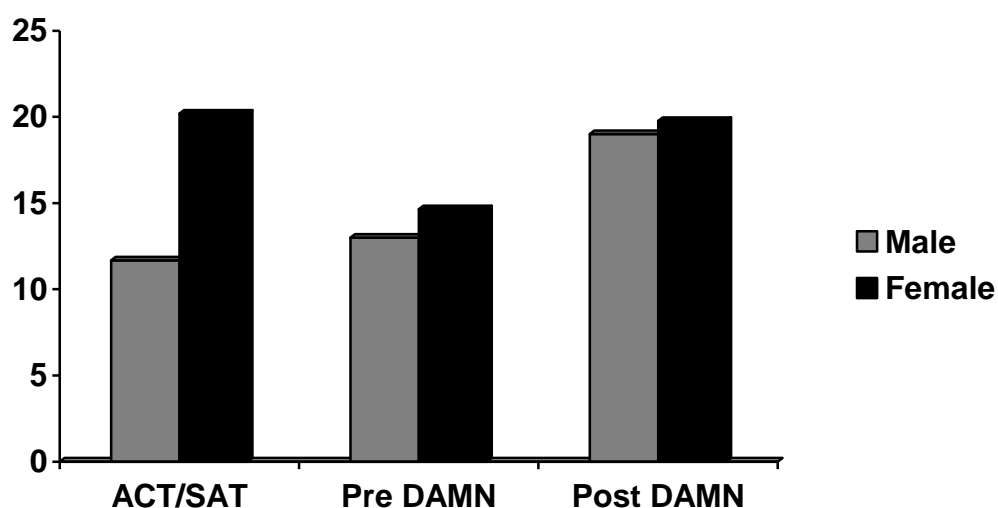


Figure 4 Study Variables by Gender

#### *Correlations between Previous Math Courses and Dosage Calculation*

*Proficiency.* To investigate if there is a significant association between the number of college courses taken and DAMM pre-testing scores, a Pearson's correlation was conducted. The variable number of college courses taken was computed from the

addition of variables MTHF001, MTHF002, MATH110, MATH102, and MATH 256.

Table 9 supplies the information regarding college math courses completed by the participants.

Table 9 *College Math Courses Completed by Participants*

Course	Number (N)	Percentage (%)
MTHF 001	9	45
MTHF 002	7	35
MATH 110	3	15
MATH 102	16	80
MATH 256	5	25

There was no significant linear relationship between number of college courses taken ( $M = 2.00$ ,  $SD = 1.26$ ) and DAMM pre testing scores ( $M = 14.40$ ,  $SD = 2.48$ ),  $r(18) = -.30$ ,  $p = .192$ . Thus, taking more college courses does not appear to be related to better medication dosage calculation. Results, however, must be interpreted with caution due to the limited sample size. Further studies would be necessary with larger samples to interpret the generalizability to nursing students deficient in medication calculation at large.

To investigate if there was a significant association between how many years of high school math the student participated in and DAMM pre-testing scores, a Pearson's correlation was conducted. There was no significant linear relationship between the number of high school years that math was taken ( $M = 4.45$ ,  $SD = .60$ ) and DAMM pre-testing scores ( $M = 14.40$ ,  $SD = 2.48$ ),  $r(18) = -.06$ ,  $p = .81$ . Thus, taking more years of high school math does not appear to be related to better medication dosage calculation. Results, however, must be interpreted with caution due to the limited sample size. Again,

further studies would be necessary with larger samples to interpret the relevance to all nursing students deficient in medication calculation at large.

### *Discussion*

A drawback of this project was the constraints of the instructional program, which was only administered in one public state college. The study population represented one body in the five -institution consortium. The college's physical location of being more than one 100 miles from any of the other participating institutions negated the possibility of additional participants. Other limitations included sample size of the target population, which resulted in a lack of randomization. The bias that can occur with a purposive sample was a consequence that anticipated but did not manifest. The researcher considered the implication of the Hawthorne effect on post-test improvement. Any time that a participant in a study has knowledge of involvement, there may be improvement from merely the awareness of inclusion. This reaction was described by Polit & Beck (2008) as a placebo effect and arises from the person's anticipated expectations).

The intervention program, DAMM, was found to provide an improvement in the mathematical calculation ability of the majority of the participants. The process of formative and summative assessment with feedback that occurred each session was a hallmark of the program. This allowed for curricular adjustments that addressed individual learning needs. A clinical scenario highlighting medication dosage calculation was presented each session. Solving the problem provided the opportunity for task and performance application of dimensional analysis.

Jackson (1998) applauded mathematic education in its evolution to include practical content and application when assessing student achievement. This author emphasized that often students complete computations with a great degree of accuracy but struggle in the application of the processes in the “life after math class” world (p. 171). Wiggins (1998) stressed the need for authentic assessment, which he defined as activities that replicate real life or professional experiences. This construct was incorporated into the design of this mathematical intervention.

It was determined that experience with mathematics courses prior to the nursing curriculum could be a positive event. The students of this study all had multiple math course experiences. Wright (2006) reported finding that students completing the majority of math courses suffered fewer errors when completing medication dosage calculations. State boards of education mandates curriculum within public elementary and secondary school settings. All students receive instruction in like subjects. Cavanagh (2008) reported that the media continues to address the inequity between the genders in math education, however studies find that girls are completing as many higher level math courses as boys (U.S. Department of Education, 2006). Hyde (2008, cited in Cavanagh, 2008) scrutinized the results of standardized math testing of over 7 million students in 10 states. Hyde emphasized that the results found that boys and girls are attaining the same level of achievement of mathematical ability regardless of computational level. These findings are aligned with the results of this applied study. Conversely, Catsambis (2005) found that girls more often than boys end their math education careers with the completion of Algebra II. The demographics of this study found that there was equal representation of the genders in higher level math courses. However, the anticipated

increase in mathematical ability of males compared to female students however was not substantiated as predicted for this program.

### *Chapter Summary*

The mathematical difficulty that many nursing students experience in the computation of medication dosage has been noted in many forms of media (Allen & Pappas, 1999; Glaister, 2005; Wright, 2004). The literatures reviewed for this applied dissertation confirmed that a sentinel issue exists for many nursing professionals. Specifically, the basic mathematical skills necessary to calculate medication dosage accurately is deficient. Allen and Pappas (1999) pointed out that substantial errors in medication dosage calculations were found to be the result of conceptual errors. Greenfield, Whelan, and Conn (2006) reported that “1 in 6 medication errors involve miscalculations (p. 91). Students and practicing nurses alike did not know the steps necessary to perform the necessary calculation. The adoption of dimensional analysis the method of calculation provided the students with a methodology that is applicable to all types of medication dosage issues (Bell & Rice, 2005). The process consisted of five steps that were sequential and self-defining. This gave the students the knowledge, ability, and confidence to calculate correctly.

The program *Dimensional Analysis and Medication Math (DAMM)* was administered to 20 students for this applied research dissertation resulted in an increase in all students medication dosage calculation exam scores. Greenfield, et al. (2006) as well as Rainboth and DMasi (2006) emphatically stressed the importance of devising a program of instruction that used one formula and incorporated critical thinking skills. Both identified dimensional analysis of being the method of choice. Rainboth and

DeMasi (2006) supported the need to identify mathematical computation and concept deficient early on during the nursing education curriculum. The program *Dimensional Analysis and Medication Math (DAMM)* incorporated these recommendations. The instruction provided nursing students with a structured learning program that featured a one method to solve medication dosages accurately. Over one hundred years ago, Florence Nightingale addressed the principles of teaching nurses. “I do not pretend to teach her [the nurse] how, I ask her to teach herself and for this purpose I venture to give her some hints” (Nightingale, 1859). With this instructional program, *Dimensional Analysis and Medication Math (DAMM)*, students have been given the “hints” to deliver safe nursing care through the accurate calculation of medication dosages.

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Appendix A:  
Standard Operating Procedures

## Standard Operating Procedures

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- XI. Policy and Procedure: Informed Consent
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- XIII. Pretest/Posttest/Demographics/Educational Program Statement

Appendix B:  
IRB Notification

Department of Pharmacology

Tel: [REDACTED]

Fax: [REDACTED]

September 2, 2008

Theresa Riggs Cowan  
Health Education Doctoral Student  
School of Health Management  
PO Box 92  
Smithville, WV 26178

Dear Ms. Cowan:

The IRB is in receipt of the Individual Investigator Assurance Form. This letter is to inform you that your project entitled, "Medication Dosage Calculation: A Mathematical Intervention for Nursing Students" was reviewed and found to be in the exempt category effective the date of this letter.

Therefore, no further review of this project is necessary. The IRB appreciates your notification of this project. If anything further changes that may alter the status of this project, please advise us immediately so we can reassess the protocol.

If you have any questions concerning these matters, please feel free to contact me. Good luck with your research project.

Sincerely,

[REDACTED]  
Robert J. Theobald, Jr., Ph.D.  
Chairman, IRB

RJT:rc

cc: Patricia Sexton, DHED

800 W. Jefferson St.  
Kirksville, MO 63501

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Appendix C:  
Course Syllabus

*Course Syllabus*

STATE COLLEGE / UNIVERSITY JOINT NURSING PROGRAM

**Course Syllabus**

**Dimensional Analysis and Medication Math (DAMM)**

Fall 2008

**Placement:** 2008-2009 Academic Year

**Faculty:** Theresa Cowan, MSN, APRN, BC

Campus e-mail: [REDACTED]

Office: [REDACTED] – Phone: [REDACTED]

Office hours as posted and by appointment.

**Course Description:**

Special Topics – Dimensional Analysis and Math in Nursing

This course will provide remediation of the mathematical computation necessary for calculating accurate dosage of medications. It will focus on practical and useful applications of mathematics that are necessary within the nursing profession. The content includes math review, systems of measurements, medication dosage calculations, and dimensional analysis. This course will be in a traditional classroom setting with instructor/student interaction.

*Prerequisite:* Any student scoring less than 100% on the Math for Meds Competency

Examination will be required to complete 10 hours of mathematic remediation.

*Coreq:* Nursing 110 and Nursing 225 (Nursing 245 if necessary)

**Campus:** State College

**Class Time:** To be announced

**Class Location:** Science Hall – Nursing Skill Laboratory

**Course Learning Outcomes:** The student will:

1. Solve fundamental mathematical problems dealing with fraction dosages and perform computations accurately using fundamental math concepts.
2. Solve fundamental mathematical problems dealing with decimal problems and decimal point reduction accurately using fundamental math concepts.
3. Utilize dimensional analysis to calculate medication.
4. Convert between decimals, ratio, and percent and accurately calculate medication dosages.
5. Convert within and between the metric and household systems and perform accurately utilizing the appropriate conversion.
6. Apply dimensional analysis to oral medications that are to be administered.



7. Apply dimensional analysis to parenteral medications that are to be administered.
8. Discuss age-specific variations for consideration of dosage accuracy.
9. Calculate infusion rates.

**Course Competencies:** Upon successful completion of this course, the student will be able to –

1. Calculate mathematical problems working with fractions, decimals, and percents.
2. Solve drug dosage problems using dimensional analysis.
3. Use system conversions (metric and household) for volume and weight problems.
4. Calculate oral and parenteral dosage problems in the same system and in different systems.

**Course Objectives:** Upon successful completion of this course the student will –

**Caring:**

1. Discuss the application of the ANA Code of Ethics and ramifications of accurate medication dosage.
2. Recognize the inconsistencies when calculating between systems

**Communication:**

1. Describe the theoretical foundations of basic professional communication.
2. Describe place value
3. Express answers to the nearest tenth and hundredth
4. Write conversion factors as fractions
5. Explain dimensional analysis
6. List the commonly used units of measure in the metric system
7. Describe the parts of a medication order.
8. Explain the process of drug reconstitution.

**Critical Thinking:**

1. Utilize the terms denoting fractional forms of numbers
2. Interpret fractional equations
3. Recognize the significance of units assigned to numbers
4. Interpret weight/volume, volume/volume, and weight/weight percent solutions
5. Solve conversion equations within the household measurement system.
6. Identify symbols and interpret measures in the metric, apothecary and household system

**Nursing Interventions:**

1. Add decimals with 100% accuracy
2. Subtract decimals with 100% accuracy
3. Perform all mathematical operations on decimals with 100% accuracy
4. Convert between fractional and decimal forms of numbers with 100% accuracy
5. Reduce fractions using common denominators with 100% accuracy
6. Reduce common fractions that end in zero with 100% accuracy
7. Identify and solve conversion equation with 100% accuracy
8. Convert between decimal, percent and ratio notations
9. Identify the parts of solution
10. Apply the principles of dimensional analysis to the household measurement system
11. Convert metric weights and volumes within the system
12. Apply dimensional analysis to oral medication calculation and assess appropriateness of answers.

13. Apply dimensional analysis to parenteral medication calculation and assess appropriateness of answers.
14. Calculate dosages utilizing dimensional analysis based on body weight/mass and body surface.
15. Calculate intravenous solution rates, settings, and duration utilizing dimensional analysis.

**Professional Role:**

1. Utilize and interpret fractional number forms when reading patient care orders
2. Interpret the concentrations of the major intravenous solutions
3. Recognize the value of prefixes and suffixes used in the metric system.
4. Convert a unit of measure from one system to another in commonly used medication dosage
5. Interpret a given medication dosage order with 100% accuracy
6. Describe the nursing responsibility for medication administration
7. Describe the five rights of medication administration
8. Explain the three check method utilized to prepare medications for administration

**Teaching Methods:**

Discussion/Problem-Solving, Lecture, Audio-Visual Materials, Exercises, Quizzes with discussion.

**Required Textbook:**

Curren, A. M. (2006). *Dimensional Analysis for Meds* (3rd ed.). Clifton Park, NY.: Thomson Delmar Learning.

**Course Requirements:**

**Class Attendance:** The State College and University School of Nursing faculty believes class attendance contributes significantly to academic success and is expected of students in professional fields. Students will be expected to attend every class and to participate fully in all course activities. Class attendance and participation will be recorded. Students

should notify faculty prior to class by phone or email, if they must be absent. Also refer to the State College Catalog 2007 - 2008 pg. 52-53.

### **Evaluation:**

The pretest and post test examination will include the computations that a basic nurse is required to master which include fractions, place value, percentages, metric and household conversions, and interpreting information. The premise of this design is to determine if computation accuracy improves as a result of the program.

*Formative Assessment:* Practice exercises will be utilized throughout the course to keep the student advised of any gaps in conceptual or procedural knowledge. This information will also be important in refining instruction and providing appropriate remediation strategies as warranted. The ability to accurately complete computations does not guarantee that the student will select and apply mathematical operations to subsequent problems.

*Summative Assessment:* This will be the comprehensive final examination that will be administered following the completion of this program. The student will be expected to score 100% or they will not qualify to administer medications to patients in the clinical setting. If this occurs the student will not be able to complete all the required components of the course and will receive a grade of "F". (Please refer to the SON Admission and Progression Policy).

### **E-mail accounts:**

The faculty will be corresponding with students via email. Therefore, all students will be required to activate their State College email accounts. If you have other email accounts or computer services, technology support will be able to assist you in accessing your State College email accounts through the outside server.

### **IMPORTANT INFORMATION FOR BEGINNING NURSING STUDENTS:**

1. In order to progress within the SON, a student must:
  - a. Maintain a cumulative 2.8 or better in all course work attempted
  - b. Pass all courses with a grade of C or better.
2. Students are expected to be committed to honesty and integrity in their work. Academic dishonesty, including plagiarism, cheating, and other forms of representing someone else's work as your own is a serious transgression and severe consequences may result. Refer to the Health Sciences Center Catalog , 2006-2008, pg 36-38 and State College Catalog 2007-2008 pg. 56-57.
3. Nursing students are often asked to evaluate courses and instructors. Your assessments are considered valuable and given serious consideration. You will be asked to do evaluations for this course and instructor at the end of the semester.

### **Social Justice**

It is the policy of State College to provide reasonable accommodations for qualified individuals with documented disabilities. This college will adhere to all applicable federal, state, and local laws, regulations and guidelines with respect to providing reasonable accommodations as regards to affording equal educational opportunity. It is the student's responsibility to contact the Academic Support Center, located in Louie Bennett Hall, and to provide documentation of a disability. The Director of the Academic Support Center will assist students and faculty in arranging appropriate accommodations. This is in accordance with Section 504 of the Rehabilitation Act of 1973 and the American with Disabilities Act of 1990.

### **Academic Dishonesty**

State College requires adherence to the College's standards of academic integrity. Refer to the State College Catalog 2007-08 pg. 60-61 for the full policy. Policy attached also.

### **Professional Conduct**

The role of the professional nurse involves demonstrating attitudes, values, and behaviors consistent with professional nursing practice (School of Nursing Undergraduate Handbook). In the classroom setting, an environment conducive to learning is fostered through mutual respect among students, their peers, and faculty. Any behavior that jeopardizes that environment is inconsistent with professionalism and will not be tolerated.

You are expected to comport yourself as a professional in class, professional meetings (ie. PIN), and clinical settings. This means professional attire, even when not in uniform, professional language, and respect for your clients, your peers, and other professionals. To ensure an environment that is conducive to learning, several areas must be addressed. You may take notes on a laptop computer during class, but you may not watch movies, play games, connect to the internet or use email. Cell phones must be turned **OFF** during class. No text messaging is allowed during class. Other electronic devices, including IPODs, PDAs, etc. may not be used during class, unless you are directed to do so. Use of these devices, including the ringing of a cell phone, may result in dismissal from the class for the rest of the semester. Any other behavior which is distracting or inappropriate may result in dismissal from the class for the semester.

Students shall adhere to the standards for professional conduct as stated in 19CSR10, Standards for Professional Nursing Practice, and are subject to disciplinary action by the Board (West Virginia Legislative Rule S19-1-12 in state of West Virginia, Code and Legislative rules, Registered Professional Nurses, 2002).

### **HIPAA Regulations**

All students and faculty must follow HIPAA guidelines with all communications.

Appendix D:  
Course Content

### Course Content

Topic	Content
<b>Unit 1 – Fractions</b>	<p>Describe place value</p> <p>Perform all mathematical operations on decimals with 100% accuracy</p> <p>Convert between fractional and decimal forms of numbers with 100% accuracy</p> <p>Simplify common fractions containing decimal numbers in assigned problems with 100% accuracy</p> <p>Reduce fractions using common denominators within problem sets with 100% accuracy</p> <p>Reduce common fractions that end in zero with 100% accuracy upon the completion of assigned problem sets</p> <p>Express answers to the nearest tenth and hundredth with 100% accuracy in the assigned problem sets</p>
<b>Decimals</b>	<p>Describe place value</p> <p>Perform all mathematical operations on decimals with 100% accuracy</p> <p>Convert between fractional and decimal forms of numbers with 100% accuracy</p> <p>Simplify common fractions containing decimal numbers in assigned problems with 100% accuracy</p> <p>Reduce fractions using common denominators within problem sets with 100% accuracy</p> <p>Reduce common fractions that end in zero with 100% accuracy upon the completion of assigned problem sets</p> <p>Express answers to the nearest tenth and hundredth with 100% accuracy in the assigned problem sets</p>
<b>Unit 2 - Dimensional Analysis</b>	<p>Write conversion factors as fractions</p> <p>Explain dimensional analysis</p> <p>Recognize the significance of units assigned to numbers.</p> <p>Identify conversion equation and solve with 100% accuracy.</p>

<b>Unit 3 – Percents, Household Measurement and Metric System</b>	<p>Convert between decimal, percent and ratio notations.</p> <p>Identify the parts of solution</p> <p>Interpret weight/volume, volume/volume and weight/weight percents solutions</p> <p>Interpret the concentrations of the major intravenous solutions</p> <p>Apply the principles of dimensional analysis to the household measurement system.</p> <p>Solve conversion equations within the household measurement system.</p> <p>Recognize the value of prefixes and suffixes used in the metric system</p> <p>List the commonly used units of measure in the metric system with 100% accuracy</p> <p>Identify symbols and interpret measures in the metric, apothecary and household system with 100% accuracy</p> <p>Convert metric weights and volumes with the system with 100% accuracy</p> <p>Convert a unit of measure from one system to another in commonly used medication dosage with 100% accuracy</p> <p>Interpret a given medication dosage order with 100% accuracy</p> <p>Recognize the inconsistencies when calculating between systems</p>
<b>Unit 4 – Oral Medications</b>	<p>Describe the parts of a medication order</p> <p>Describe the nursing responsibility for medication administration</p> <p>Describe the five rights of medication administration</p> <p>Describe the three check method utilized to prepare medications for administration</p> <p>Apply dimensional analysis to oral medication calculation examples</p> <p>Assess the appropriateness of calculated answers</p>
<b>Unit 5- Parental and IV Medications</b>	<p>Apply dimensional analysis to parenteral medication calculation examples</p> <p>Assess the appropriateness of calculated answers</p> <p>Explain the process of reconstitution</p> <p>Calculate dosages based on body weight/mass and body surface</p>



	<p>Calculate hourly infusion rates</p> <p>Calculate rate settings for infusion pumps</p> <p>Calculate the duration of infusions.</p> <p>Recognize the different types of infusion</p>
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Appendix E:  
Course Instructional Content Map

## Course Instructional Content Map

<b>Unit 1: Decimals</b>	
<b>Outcomes:</b>	The student will solve fundamental mathematical problems dealing with decimal problems and decimal point reduction accurately using fundamental math concepts.
<b>Objectives:</b>	<p>At the completion of the unit the student will be able to:</p> <ul style="list-style-type: none"> <li>• Describe place value</li> <li>• Perform all mathematical operations on decimals with 100% accuracy</li> <li>• Convert between fractional and decimal forms of numbers with 100% accuracy</li> <li>• Simplify common fractions containing decimal numbers in assigned problems with 100% accuracy</li> <li>• Reduce fractions using common denominators within problem sets with 100% accuracy</li> <li>• Reduce common fractions that end in zero with 100% accuracy upon the completion of assigned problem sets</li> <li>• Express answers to the nearest tenth and hundredth with 100% accuracy in the assigned problem sets</li> </ul>
<b>Instructional Activities:</b>	<p>Student Assignment: Textbook: Curren – Chapter 1 and 2 Start the session with a current news item that is an example of medication error and its results to accentuate seriousness of med error</p> <p>Explanation and demonstration of concept. Problem set worksheet for student completion.</p> <p>Teach / Re-teach activities if necessary. Utilization of the “Horizontal Skill Development for Mathematics” instruction guide. Teaching guide attached Key Words or Symbols: Interpretation of Decimals Tool or setup: Whiteboard Example: Drug order for patient You are to give four (4) tablets of Adrug with a dosage strength of 0.04 mg each. What total dosage are you giving? (Answer - 0.16 mg) 1<sup>st</sup> time: model; no pencils for students 2<sup>nd</sup> time: guided practice giving instructions 3<sup>rd</sup> time: guided practice using questioning strategies 4<sup>th</sup> time: turn paper over and students try independently 5<sup>th</sup> time: same problem different numbers 6<sup>th</sup> time: Introduce how the same skill would look using a word problem, a table, a number line, or a graph. Make sure to FOCUS on the KEY WORDS! The</p>

	idea here is to show the similarity between the mediums even though they appear differently
<b>Student Assessments</b>	Pre/Post Test on activity to evaluate learner ability to solve the variety of math problems.

<b>Unit 1: Fractions</b>	
<b>Outcomes:</b>	<p>The student will solve fundamental mathematical problems dealing with fraction dosages forms.</p> <p>The student will perform computations accurately using fundamental math concepts.</p>
<b>Objectives:</b>	<p>At the completion of the unit the student will be able to:</p> <ul style="list-style-type: none"> <li>• utilize the terms denoting fractional forms of numbers</li> <li>• Add decimals with 100% accuracy</li> <li>• Subtract decimals with 100% accuracy</li> <li>• Interpret fractional equations</li> <li>• Utilize and interpret fractional number forms when reading patient care orders</li> </ul>
<b>Instructional Activities:</b>	<p>Student Assignment: Curren – Chapter 3</p> <p>Start the session with a current news item that is an example of medication error and its results to accentuate seriousness of med error.</p> <p>Explanation and demonstration of concept.</p> <p>Problem set worksheet for student completion</p> <p>Teach / Re-teach activities if necessary.</p> <p>Utilization of the “Horizontal Skill Development for Mathematics” instruction guide. (Teaching guide attached.)</p> <p>Sample of application of Horizontal Skill Development Tool follows: Key Words or Symbols: Fractions – Interpretation</p>

	<p>Tool or setup: Whiteboard</p> <p>Example: Drug order for patient</p> <p>Give: Atropine gr 1/150</p> <p>You have: Atropine 300mg/milliliter.</p> <p>How many milliliters will you give? (Answer- 1 milliliter)</p> <p>1<sup>st</sup> time: model; no pencils for students</p> <p>2<sup>nd</sup> time: guided practice giving instructions</p> <p>3<sup>rd</sup> time: guided practice using questioning strategies</p> <p>4<sup>th</sup> time: turn paper over and students try independently</p> <p>5<sup>th</sup> time: same problem different numbers</p> <p>6<sup>th</sup> time: Introduce how the same skill would look using a word problem, a table, a number line, or a graph. Make sure to FOCUS on the KEY WORDS! The idea here is to show the similarity between the mediums even though they appear differently.</p>
<b>Student Assessments</b>	Pre/Post Test on activity to evaluate learner ability to solve the variety of math problems.
<b>Unit 2: Dimensional Analysis</b>	
<b>Outcomes:</b>	The student will utilize dimensional analysis to calculate medication dosages.
<b>Objectives:</b>	<p>At the completion of the unit the student will be able to:</p> <ul style="list-style-type: none"> <li>• Write conversion factors as fractions</li> <li>• Explain dimensional analysis</li> <li>• Recognize the significance of units assigned to numbers</li> <li>• Identify conversion equation and solve with 100% accuracy</li> </ul>
<b>Instructional Activities:</b>	<p>Student Assignment: Curren – Chapter 11 (p. 139)</p> <ul style="list-style-type: none"> <li>• Start the session with a current news item that is an example of medication error and its results to stress the seriousness of medication dosage calculation error</li> <li>• A conversion factor includes a value (a number) and a label (the units)</li> <li>• Dimensional analysis is the multiplication of a series of fractions in which the numerator and denominator contain related conversion factors</li> <li>• Identify! Determine what you want to know</li> <li>• Instruct the students to do the following: <ul style="list-style-type: none"> <li>-Read the problem</li> <li>-Rephrase the problem if you need to do so</li> </ul> </li> </ul>

	<ul style="list-style-type: none"> <li>Determine what you already know</li> </ul> <ol style="list-style-type: none"> <li><b>Identify two things:</b> <ul style="list-style-type: none"> <li>Units given</li> <li>Units of the answer</li> </ul> </li> <li><b>Make a plan:</b> <p>Ask the students:</p> <p>“What were you given in the problem?”</p> <p>“How do you get from the units given to the units required in the answer?”</p> </li> <li>Instruct students to <b>identify the units given</b> in the problem</li> <li><b>Arrange the conversion factor(s).</b> <p>Instruct students to arrange the conversion factors so that the units of the answer are the only units that remain after cancelling.</p> <p>“Is there more than one conversion needed?”</p> </li> </ol> <p>Solve for the answer by the shortest route or least steps. (There may be several methods to solve but use the one with the least steps!</p> $\frac{\text{units given}}{1} \times \frac{\text{other unit}}{\text{units given}} \times \frac{\text{units of answer}}{\text{other unit}} = \text{units of answer}$ <p>Teach / Re-teach activities if necessary. Utilization of the “Skill Development Instructional Strategy”. Teaching guide attached.</p>
<b>Student Assessments</b>	Pre/Post Test on activity to evaluate learner ability to solve the variety of math problems.

<b>Unit 3: Percents, Household Measurement System, and Metric International System</b>	
<b>Outcomes:</b>	<p>The student will convert between decimals, ratio and percent and accurately calculate medication dosages.</p> <p>The student will convert within and between the metric, apothecary and household systems and perform computations accurately utilizing the conversions.</p>
<b>Objectives:</b>	<p>At the completion of the unit the student will be able to:</p> <ul style="list-style-type: none"> <li>Convert between decimal, percent and ratio notations</li> <li>Identify the parts of solution</li> <li>Interpret weight/volume, volume/volume and weight/weight percents solutions</li> <li>Interpret the concentrations of the major intravenous solutions</li> <li>Apply the principles of dimensional analysis to the household measurement system.</li> </ul>

	<ul style="list-style-type: none"> <li>• Solve conversion equations within the household measurement system.</li> <li>• Recognize the value of prefixes and suffixes used in the metric system</li> <li>• List the commonly used units of measure in the metric system with 100% accuracy</li> <li>• Identify symbols and interpret measures in the metric, apothecary and household system with 100% accuracy</li> <li>• Convert metric weights and volumes with the system with 100% accuracy</li> <li>• Convert a unit of measure from one system to another in commonly used medication dosage with 100% accuracy</li> <li>• Interpret a given medication dosage order with 100% accuracy</li> <li>• Recognize the inconsistencies when calculating between systems</li> </ul>
<b>Instructional Activities:</b>	<p>Student Assignment: Curren – Chapter 4 &amp; 5</p> <p>Remind students that to convert from a <b>percent to a decimal</b>:</p> <ol style="list-style-type: none"> <li>1. Drop the % sign</li> <li>2. Divide by 100 – move the decimal point two spaces to the left</li> <li>3. Place a zero in front of a the decimal point for clarity</li> </ol> <p>Site examples and have student return demonstration</p> <p>Remind students that to convert from <b>decimals to percentages</b>:</p> <ol style="list-style-type: none"> <li>1. Multiply by 100 – move the decimal point two places to the right</li> <li>2. Append the % sign</li> </ol> <p>Site examples and have student return demonstration.</p> <p>Remind students to convert from <b>ratio to percent notation</b>:</p> <ol style="list-style-type: none"> <li>1. Replace the colon with a division sign</li> <li>2. Convert the fraction to decimal notation</li> <li>3. Convert the decimal to a percent.</li> </ol> <p>Site examples and have student return demonstration</p> <p>Solutions are utilized in health care in various areas of care. In order to understand the product, the concentration of solution supplied and how to administer product, need to be aware of what the signs and numbers represent.</p>

	<p>Site examples of solutions:</p> <p>Nutritional – total parenteral nutrition (TPN) or hyperalimentation. A hypertonic solution that consisting of glucose, protein substances, minerals, and vitamins.</p> <p>Other solutions:</p> <p>Formulas for feeding, irrigating solutions, and antiseptic cleansing agents. It may be necessary to instruct families in the preparation of percent solutions to be used in the home setting</p> <p>What does percent (%) solution mean?</p> <p>The percent refers to the part or substance per 100 parts of solution.</p> <p>There are X number of parts in every 100 parts. A solution is considered a uniform mixture with two parts. Solute and solvent.</p> <p>Solute – is smaller part which is the solid that is dissolved and usually measured in grams.</p> <p>Solvent – does the dissolving and is the larger quantity</p> <p><b>Key point:</b> A concentration is equal to:</p> $\frac{\text{amount of solute (mass or volume)}}{\text{total volume of solution (mass or volume)}}$ <p>Think of all the ways to express 2% :</p> $2\% = 0.02 = \frac{2}{100} = \frac{1}{50} = 1:50$ <p><b>Remember !!</b></p> <p>A solution is a uniform mixture of two or more substances, meaning that the solute is dissolved in the solvent.</p> <p>Intravenous therapy solutions used in acute patient care to replace body fluids and electrolytes are percent solution. Composed of various solutions to produce a specific effect on the fluid compartments of the body.</p> <p>Teach / Re-teach activities if necessary. Utilization of the “Skill Development Instructional Strategy”. Teaching guide attached.</p>
<b>Student Assessments</b>	Pre/Post Test on activity to evaluate learner ability to solve the variety of math problems.



<b>Unit 4: Oral Medications</b>	
<b>Outcomes:</b>	<p>The student will be able to calculate simple dosages from reconstituted drugs for oral administration with accuracy using dimensional analysis.</p> <p>The student will be able to locate dosage strengths from a physicians order and calculate simple dosages utilizing dimensional analysis accurately.</p> <p>The student will calculate dosages based on body weight/mass for oral administration using dimensional analysis with 100% accuracy.</p>
<b>Objectives:</b>	<p>At the completion of the unit the student will be able to:</p> <ul style="list-style-type: none"> <li>• Describe the parts of a medication order</li> <li>• Describe the nursing responsibility for medication administration</li> <li>• Describe the five rights of medication administration</li> <li>• Describe the three check method utilized to prepare medications for administration</li> <li>• Apply dimensional analysis to oral medication calculation examples</li> <li>• Assess the appropriateness of calculated answers</li> </ul>
<b>Instructional Activities:</b>	<p>Student assignment: Curren – Chapter 12 Remind students:</p> <p>Medications are prescribed by a qualified physician, dentist or his or her designee.</p> <p>The parts of the medication order include the information needed for calculation of the medication dosage.</p> <ol style="list-style-type: none"> <li>1. Name of the medication – generic or trademark</li> <li>2. Dosage: <p>The dosage reflects the mass or quantity of medication that has been prescribed.</p> <p>Mass is expressed in micrograms, milligrams, grams, and grains.</p> <p>Mass refers to the amount of medication.</p> <p>Medications are ordered according to the established average dose.</p> <p>Learn to question orders for more than three tablets or capsules. Any unusual number of tablets or capsules could be a warning or an error in prescribing, transcribing or your calculations.</p> </li> <li>3. Route: <p>This is the form that the patient is to receive the medication ordered.</p> </li> </ol>

	<p>Once a volume is calculated it must be congruent with the form supplied.</p> <p>4. Frequency or Time</p> <p>This is the time that the medication is to be administered</p> <p>Refers to how often the medication should be administered</p> <p>5. After reading the order ask yourself what you will administer and what is the amount to be prepared</p> <p>The goal of medication administration is to administer an <i>accurate dose</i> of the correct medication by the <i>ordered route</i> at the <i>appropriate time</i> to the <i>correct patient</i>.</p> <p><b>Key Point:</b></p> <p><b>Five Rights of Medication Administration</b></p> <ol style="list-style-type: none"> <li>1. The right PATIENT</li> <li>2. The right MEDICATION</li> <li>3. The right DOSE</li> <li>4. The right ROUTE</li> <li>5. The right TIME</li> </ol> <p>It is the nursing responsibility to read and understand the medication order. This includes why and what the drug is used for and all side effects or adverse reactions.</p> <p><b>Key Point:</b></p> <p>Check the medication order three times with the prepared medication before administration.</p> <ol style="list-style-type: none"> <li>1. When removing the medication package from the drawer</li> <li>2. Prior to pouring the medication</li> <li>3. After preparing the medication</li> </ol> <p><b>REMEMBER !!</b></p> <p>Safety Parameters for Administration</p> <p>If the amount to be administered is calculated to be:</p> <ul style="list-style-type: none"> <li>• More than two tablets orally (po)</li> <li>• 1-2 ounces orally (po)</li> </ul> <p>Teach / Re-teach activities if necessary. Utilization of the “Skill Development Instructional Strategy”. Teaching guide attached.</p>
<b>Student Assessments</b>	Pre/Post Test on activity to evaluate learner ability to solve the variety of math problems.

<b>Unit 5: Parental and IV Medications</b>	
<b>Outcomes:</b>	<p>The student will calculate parenteral dosages in metric, milliequivalent, unit, percentage strengths for administration with accuracy using dimensional analysis.</p> <p>The student will calculate simple dosages from reconstituted drugs with accuracy using dimensional analysis.</p> <p>The student will calculate flow rates for IV therapy using dimensional analysis with accuracy.</p> <p>The student will calculate medications for parental administration using dimensional analysis accurately.</p>
<b>Objectives:</b>	<p>At the completion of the unit the student will be able to:</p> <ul style="list-style-type: none"> <li>• Apply dimensional analysis to parenteral medication calculation examples</li> <li>• Assess the appropriateness of calculated answers</li> <li>• Explain the process of reconstitution</li> <li>• Calculate dosages based on body weight/mass and body surface</li> <li>• Calculate hourly infusion rate</li> <li>• Calculate rate settings for infusion pumps</li> <li>• Calculate the duration of infusions</li> <li>• Recognize the different types of infusion</li> </ul>
<b>Instructional Activities:</b>	<p>Student Assignment: Curren – Chapter 16 and 17 for review</p> <p>Remind students –</p> <p>A providers order for IV fluid therapy must include:</p> <ul style="list-style-type: none"> <li>• Type of solution</li> <li>• The quantity of solution</li> <li>• The time period for administration</li> <li>• and in some cases – the milliliters per hour</li> </ul> <p>The nurse is responsible for regulating flow rate by:</p> <ul style="list-style-type: none"> <li>• calculating milliliters per hour (mL/h)</li> <li>• checking for the drop factor of the IV tubing</li> <li>• calculating the drops per minute (gtt/min) that are needed to deliver mL/h</li> <li>• regulating the number of drops entering the drip chamber (counting the number of drops per minute if it is a roller clamp set)</li> </ul>

	<p><b>REMEMBER !!</b></p> <ul style="list-style-type: none"> <li>An infusion is calculated based on various quantities per amount of time:             <ul style="list-style-type: none"> <li>➤ cc/hr – infusion pumps provide monitoring of the hourly rates and info regarding the volume infused or to be infused</li> <li>➤ gtt/min – the drop factor must be known in order to calculate the drop rate</li> </ul> </li> </ul> <p>Calculation of <b>gtt/min</b> Rates</p> <ul style="list-style-type: none"> <li>The size of IV drops is regulated by the IV administration set being used, which is calibrated in number of gtt/mL. Not every set is the same! The package that the set comes in will have the gtt/mL information.</li> </ul> <p>When using dimensional analysis for IV calculation – two values are being calculated –</p> $\frac{\text{gtt}}{\text{min}} = \frac{\text{drop factor}}{1 \text{ mL}} \times \frac{\text{mL to infuse}}{\text{time to infuse}} \times \frac{1 \text{ hour}}{60 \text{ min}} = ? \frac{\text{gtt}}{\text{min}}$ <p><b>Example:</b>        Order – 1 L Normal Saline at 75 mL/ Hour        Tubing label: 15 gtt/mL</p> $\frac{\text{gtt}}{\text{min}} = \frac{15 \text{ gtt}}{1 \text{ mL}} \times \frac{75 \text{ mL}}{1 \text{ hour}} \times \frac{1 \text{ hour}}{60 \text{ min}} = ? \frac{\text{gtt}}{\text{min}}$ $\frac{\text{gtt}}{\text{min}} = \frac{15 \text{ gtt}}{1 \text{ mL}} \times \frac{75 \text{ mL}}{1 \text{ hour}} \times \frac{1 \text{ hour}}{60 \text{ min}} = ? \frac{\text{gtt}}{\text{min}}$ $\frac{\text{gtt}}{\text{min}} = \frac{15 \text{ gtt}}{1 \text{ mL}} \times \frac{75 \text{ mL}}{1 \text{ hour}} \times \frac{1 \text{ hour}}{60 \text{ min}} = \frac{1125}{60}$ $1125 \div 60 = 19$ $19 \frac{\text{gtt}}{\text{min}}$ <p>Teach / Re-teach activities if necessary. Utilization of the “Skill Development Instructional Strategy”. Teaching guide attached.</p>
<p><b>Student Assessments</b></p>	<p>Pre/Post Test on activity to evaluate learner ability to solve the variety of math problems.</p>

## Appendix F:

### Teaching Guide: Horizontal Skill Development for Mathematics

## Teaching Guide

## Horizontal Skill Development for Mathematics

Skill:

Key Words or Symbols:

Tool or setup:

Example:

Instructional Sequence and Activity:

1<sup>st</sup> time: model; no pencils for students

2<sup>nd</sup> time: guided practice giving instructions

3<sup>rd</sup> time: guided practice using questioning strategies

4<sup>th</sup> time: turn paper over and students try independently

5<sup>th</sup> time: same problem different numbers

6<sup>th</sup> time: Introduce how the same skill would look using a word problem, a table, a number line, or a graph. Make sure to FOCUS on the KEY WORDS! The idea here is to show the similarity between the mediums even though they appear differently.

Zeigler, J., Secret, B., Myer, T., Daquilante, R. R., & Harris, R. (2000). *Horizontal skill development for mathematics*. Paper presented at the Teaching Remedial Mathematics.

## Appendix G:

### Student Handout: Dimensional Analysis

## Student Handout

**DIMENSIONAL ANALYSIS: THE BASICS****Steps for Dimensional Analysis:**

1. Carefully read the problem. Determine the **GIVEN QUANTITY** (which is given to you in the problem)
2. Determine what unit the **WANTED QUANTITY** (answer) is supposed to be in (ml or mg or minutes, etc)
3. Determine what **CONVERSION FACTORS** you will need to use. Some may be given to you in the problem (like how many mg/ml) while others we expect you to know (like how many cc in a teaspoon)
4. **SET UP:** Dimensional Analysis problems are set up like fractions, with a numerator (top number/s) and a denominator (bottom number/s). You need to set up the problem so that the unwanted units are canceled out. If you are given mg on top, and you really want the answer in ml, you would set up the problem using a ml to mg conversion (given in the problem) and place mg on the bottom, so the mg cancel out. (THIS MAY SOUND CONFUSING, BUT JUST STICK WITH ME. IT WILL GET EASIER AS YOU WORK THE PROBLEMS).
5. **CROSS OUT** the units which cancel out, leaving nothing but the **WANTED QUANTITY**.
6. **DO THE BASIC MATH.** Solve the problem by using basic math (no algebra required). Multiply the numbers across. Divide the top number by the bottom number. THAT'S ALL THERE IS TO IT.

**Sample Problems Using Dimensional Analysis**

The health care provider ordered ceclor 500mg. On hand is ceclor 400mg in 5 mL. How many ml(s) will you give?

- GIVEN QUANTITY – 500 mg
- WANTED QUANTITY - \_\_\_\_\_ mL
- CONVERSION FACTOR – 400mg / mL (Given in the problem)
- SETUP

$$\frac{500 \text{ MG} \times 5 \text{ mL}}{400 \text{ MG}} = \text{_____ mL}$$



- CROSS OUT the units which cancel out, leaving no units except the WANTED QUANTITY unit (In this case, you want the answer in mL)

$$\frac{500 \text{ ~~MG~~} \times 5 \text{ mL}}{400 \text{ ~~MG~~}} = \underline{\hspace{2cm}} \text{ mL}$$

- DO THE BASIC MATH

Multiply the numbers across, then divide the number on top by the number on the bottom. (500 X 5) divided by 400 = **6.25 mL**.

The healthcare provider ordered Tylenol 10 grains. On hand is Tylenol 160mg in 1.6mL. How many ml will you give?

- GIVEN QUANTITY 10gr.
- WANTED QUANTITY \_\_\_\_mL
- CONVERSION FACTORS 60mg in 1gr (we expect you to know this) and 160 mg in 1.6 mL (given in the problem)
- SETUP

$$\frac{10 \text{ gr} \times 60 \text{ mg} \times 1.6 \text{ mL}}{1 \text{ gr.} \times 160 \text{ mg}} = \underline{\hspace{2cm}} \text{ mL}$$

- CROSS OUT the units which cancel out, leaving nothing but the WANTED QUANTITY

$$\frac{10 \text{ ~~gr~~} \times 60 \text{ ~~mg~~} \times 1.6 \text{ mL}}{1 \text{ ~~gr~~} \times 160 \text{ ~~mg~~}} = \underline{\hspace{2cm}} \text{ mL}$$

- DO THE BASIC MATH

Multiply the numbers across, then divide the number on top by the number on bottom. (10x60x1.6) divided by (1x160) = **6mL**

## Appendix H:

Example: Unit Pre and Post Test

**Example:****Unit 1 – Pre-Test**

## Chapter 1

## Relative Value, Addition and Subtraction of Decimals

In the space provided give the correct answer for each problem.

**Identify the decimal with the highest value in the following.**

- |         |         |         |          |
|---------|---------|---------|----------|
| _____1. | a) 1.74 | b) 1.69 | c) 1.86  |
| _____2. | a) 2.22 | b) 2.25 | c) 2.1   |
| _____3. | a) 0.25 | b) 0.35 | c) 0.125 |

**Add the following decimals.**

- |         |                        |
|---------|------------------------|
| _____4. | $2.8 + 0.03 =$         |
| _____5. | $4.32 + 2.01 + 0.04 =$ |

**Unit 1 – Post-Test**

## Chapter 1

## Relative Value, Addition and Subtraction of Decimals

**Subtract the following.**

- |         |                  |
|---------|------------------|
| _____6. | $10.25 - 1.47 =$ |
| _____7. | $0.75 - 0.5 =$   |

**How many tablets will be needed to give the following dosages?**

- |          |  |
|----------|--|
| _____8.  | The tablets are labeled 1.2 mg. The order is for 3.6 mg. |
| _____9.  | The order is for 0.3 mg. The tablets are labeled 0.6 mg. |
| _____10. | The order is for 1.5 mg. The tablets are labeled 0.75mg. |

Appendix I:  
Demographic Data Sheet

## Demographic Data Sheet

Date: \_\_\_\_\_

Code Number: \_\_\_\_\_

## Directions:

A quantitative study is being conducted exploring factors that could contribute to an individual's mathematical calculation ability.

Please answer the following questions by marking all that apply.

Enter the date and your code number in the space provided. Please answer every question by circling the answer that best describes you. When indicated select all responses that apply to you and your college experience.

Q-1 What is your age today? \_\_\_\_\_

Q-2 Identify your gender:

1. Male
2. Female

Q-3 How many years of high school mathematics did you complete?

1. one
2. two
3. three
4. four
5. four plus college course

Q-4 What was your composite ACT/SAT score on college admission? (best guess)

\_\_\_\_\_

Q-5 If you have obtained a college degree prior to enrollment in this nursing program, please indicate all that apply.

1. Associate degree
2. Bachelor degree
3. Master degree

Q-6 Of the college mathematics courses listed, circle all that you have completed.

1. MTHF 001 Developmental Arithmetic
2. MTHF 002 Developmental Algebra
3. MATH 110 The Nature of Math
4. MATH 102 College Algebra
5. MATH 256 Probability and Statistics

## Appendix J:

### Pre Test / Post Test Instrument

## Pre Test / Post Test Instrument

## Math Competency for Medication Administration Examination

Date: \_\_\_\_\_

Code Number: \_\_\_\_\_

**Multiple Choice:**

Work each medication calculation problem on the paper provided. Provide the letter of the correct dosage response in the space provided.

- \_\_\_\_ 1. The provider orders penicillin G 1,000,000 units IM q 12 hours. The nurse has 1,200,000 units per 2 mL. The nurse correctly prepares
- A. 0.15 mL
  - B. 0.16 mL
  - C. 1.5 mL
  - D. 1.7 mL
- \_\_\_\_ 2. The provider orders Epogen 4000 units subQ twice a week. Epogen comes in 10,000 units per mL. The nurses correctly gives \_\_\_\_\_ per dose.
- A. 0.4 mL
  - B. 1.25 mL
  - C. 0.25 mL
  - D. 1.3 mL
- \_\_\_\_ 3. The provider orders potassium chloride (KCL) 40 mEq added to each 1000 mL of IV solution. The nurse has KCL 1.5 mEq/mL. the nurse correctly adds \_\_\_\_\_ of KCL to each 1000 mL of IV solution.
- A. 2 mL
  - B. 2.7 mL
  - C. 26.7 mL
  - D. 28 mL

- \_\_\_\_\_4. The provider orders gemfibrozil 1.2 g PO daily. The nurse has gemfibrozil 600 mg per tablet. The nurse correctly gives
- A. 1 tablet
  - B. 2 tablets
  - C. 1.5 tablets
  - D. 2.5 tablets
- \_\_\_\_\_5. The provider orders Neurotin 750 mg PO daily. The nurse has Neurotin 250 mg per 5 mL. The nurse correctly gives
- A. 3 mL
  - B. 5 mL
  - C. 10 mL
  - D. 15 mL
- \_\_\_\_\_6. The drug label reads, “Depo- Provera 100 mg/mL”. The nurse practitioner orders Depo-Provera 0.3 g IM stat. The nurse correctly gives \_\_\_\_\_ of the drug.
- A. 0.3 mL
  - B. 0.5 mL
  - C. 3 mL
  - D. 2.8 mL
- \_\_\_\_\_7. The provider orders Cleocin 1.5 g IV q6 hrs. The drug label reads “Cleocin 900 mg/mL.” The nurse correctly gives
- A. 1.9 mL
  - B. 1.7 mL
  - C. 1.2 mL
  - D. 1.5 mL
- \_\_\_\_\_8. The order reads, “Give 0.5 mg Robinul IM stat”. The nurse has Robinul 0.2 mg/mL. The nurse correctly gives
- A. 2.5 mL
  - B. 0.25 mL
  - C. 2.4 mL
  - D. 0.4 mL



- \_\_\_\_9. The order reads, "Give 500 mg Dilantin PO q6 hrs". The nurse has Dilantin 125 mg per 5 mL. The nurse correctly gives
- A. 12.5 mL
  - B. 2 mL
  - C. 20 mL
  - D. 4 ml
- \_\_\_\_10. The recommended daily dosage of Gantrisin is 75 mg/kg PO daily. The client weighs 187 pounds. The provider ordered Gantrisin 4.5 g daily in four divided doses. The nurse should
- A. Administer 1125 mg per dose
  - B. Question the order
  - C. Administer half of the dose without checking with the provider
  - D. Administer a different drug
- \_\_\_\_11. The order reads, " Give aspirin 0.6 g PO q4 hours prn for headache". The nurse correctly gives
- A. 300 mg per dose
  - B. 600 mg per dose
  - C. 30 mg per dose
  - D. 60 mg per dose
- \_\_\_\_12. The order reads, "Give Robitussin, 15 mL PO q4 hours prn cough". The nurse instructs the patient that at home this would equal
- A. 1 ounce per dose
  - B. 1 tablespoon per dose
  - C. 1 teaspoon per dose
  - D. 2 drams per dose
- \_\_\_\_13. The order reads, "Give Atropine gr 1/150 IM on call". The nurse has Atropine 0.4 mg per mL. The nurse correctly gives
- A. 2 mL
  - B. .5 mL
  - C. 1 mL
  - D. 10 mL

**Completion: (questions 14 – 20)**

Work each medication calculation problem on the paper provided. Provide the correct dosage response in the space provided.

14. 250 mL of a 1% solution contains \_\_\_\_\_ g of a drug.
15. The order reads, “Infuse 1000 ml of D/NS @ 125 mL/hr”. The infusion set is calibrated at 20 gtt/ mL. The client should receive \_\_\_\_\_ gtt/min .
16. The order reads, “Administer D/W @ 30 mL/hr”. The infusion set is calibrated at 60 gtt/mL. The client should receive \_\_\_\_\_ gtt/min.
17. An IV started at 1300 with an infusion time of 6 hours and 20 minutes will finish at \_\_\_\_\_ military time.
18. A rate of 15 mL/hr is ordered for a total volume of 60 mL. The infusion time will take \_\_\_\_\_ hour(s).
19. The provider prescribed 500 mg of Cefizox IM, every 12 hours for a genitourinary infection. The medication is available as a powder in a 2 gram vial. Reconstitute with 6.0 mL of sterile water for injection and shake well. Solution concentration will provide 270 mg/mL. The nurse will correctly give \_\_\_\_\_ mL.

20. Refer to the displayed drug label. The provider ordered furosemide 2mg/kg/day IV for a 16 pound infant with a heart defect. The infant should receive \_\_\_\_\_mg per day.



### Appendix K:

#### Pre Test / Post Test Instrument Answer Key

## Math Competency for Medication Administration Examination

Date: ANSWER KEY

Code Number: \_\_\_\_\_

**Multiple Choice:**

Work each medication calculation problem on the paper provided. Provide the letter of the correct dosage response in the space provided.

- D** 1. The provider orders penicillin G 1,000,000 units IM q 12 hours. The nurse has 1,200,000 units per 2 mL. The nurse correctly prepares
- A. 0.15 mL
  - B. 0.16 mL
  - C. 1.5 mL
  - D. 1.7 mL
- A** 2. The provider orders Epogen 4000 units subQ twice a week. Epogen comes in 10,000 units per mL. The nurses correctly gives \_\_\_\_\_ per dose.
- A. 0.4 mL
  - B. 1.25 mL
  - C. 0.25 mL
  - D. 1.3 mL
- C** 3. The provider orders potassium chloride (KCL) 40 mEq added to each 1000 mL of IV solution. The nurse has KCL 1.5 mEq/mL. the nurse correctly adds \_\_\_\_\_ of KCL to each 1000 mL of IV solution.
- A. 2 mL
  - B. 2.7 mL
  - C. 26.7 mL
  - D. 28 mL
- B** 4. The provider orders gemfibrozil 1.2 g PO daily. The nurse has gemfibrozil 600 mg per tablet. The nurse correctly gives
- A. 1 tablet
  - B. 2 tablets
  - C. 1.5 tablets
  - D. 2.5 tablets

- D** 5. The provider orders Neurotin 750 mg PO daily. The nurse has Neurotin 250 mg per 5 mL. The nurse correctly gives
- A. 3 mL
  - B. 5 mL
  - C. 10 mL
  - D. 15 mL
- C** 6. The drug label reads, "Depo- Provera 100 mg/mL". The nurse practitioner orders Depo-Provera 0.3 g IM stat. The nurse correctly gives \_\_\_\_\_ of the drug.
- A. 0.3 mL
  - B. 0.5 mL
  - C. 3 mL
  - D. 2.8 mL
- B** 7. The provider orders Cleocin 1.5 g IV q6 hrs. The drug label reads "Cleocin 900 mg/ml." The nurse correctly gives
- A. 1.9 mL
  - B. 1.7 mL
  - C. 1.2 mL
  - D. 1.5 mL
- A** 8. The order reads, "Give 0.5 mg Robinul IM stat". The nurse has Robinul 0.2 mg/mL. The nurse correctly gives
- A. 2.5 mL
  - B. 0.25 mL
  - C. 2.4 mL
  - D. 0.4 mL
- C** 9. The order reads, "Give 500 mg Dilantin PO q6 hrs". The nurse has Dilantin 125 mg per 5 mL. The nurse correctly gives
- A. 12.5 mL
  - B. 2 mL
  - C. 20 mL
  - D. 4 ml

- B 10. The recommended daily dosage of Gantrisin is 75 mg/kg PO daily. The client weighs 187 pounds. The provider ordered Gantrisin 4.5 g daily in four divided doses. The nurse should
- A. Administer 1125 mg per dose
  - B. Question the order
  - C. Administer half of the dose without checking with the provider
  - D. Administer a different drug
- B 11. The order reads, “ Give aspirin 0.6 g PO q4 hours prn for headache”. The nurse correctly gives
- A. 300 mg per dose
  - B. 600 mg per dose
  - C. 30 mg per dose
  - D. 60 mg per dose
- B 12. The order reads, “Give Robitussin, 15 mL PO q4 hours prn cough”. The nurse instructs the patient that at home this would be equal to
- A. 1 ounce per dose
  - B. 1 tablespoon per dose
  - C. 1 teaspoon per dose
  - D. 2 drams per dose
- C 13. The order reads, “Give Atropine gr 1/150 IM on call”. The nurse has Atropine 0.4 mg per mL. The nurse correctly gives
- A. 2 mL
  - B. .5 mL
  - C. 1 mL
  - D. 10 mL

**Completion: (Questions 14 – 20)**

Work each medication calculation problem on the paper provided. Provide the correct dosage response in the space provided.

14. 250 mL of a 1% solution contains 2.5 g of a drug.

15. The order reads, “Infuse 1000 ml of D/NS @ 125 mL/hr”. The infusion set is calibrated at 20 gtt/ mL. The client should receive \_\_\_\_\_42\_\_\_\_\_ gtt/min .
16. The order reads, “Administer D/W @ 30 mL/hr”. The infusion set is calibrated at 60 gtt/mL. The client should receive \_\_\_\_\_30\_\_\_\_\_ gtt/min.
17. An IV started at 1300 with an infusion time of 6 hours and 20 minutes will finish at \_\_\_\_\_1920\_\_\_\_\_ military time.
18. A rate of 15 mL/hr is ordered for a total volume of 60 mL. The infusion time will take \_\_\_\_\_4\_\_\_\_\_ hour(s).
19. The provider prescribed 500 mg of Cefizox IM, every 12 hours for a genitourinary infection. The medication is available as a powder in a 2 gram vial. Reconstitute with 6.0 mL of sterile water for injection and shake well. Solution concentration will provide 270 mg/mL. The nurse will correctly give \_\_\_\_\_1.8\_\_\_\_\_ mL.
20. Refer to the displayed drug label. The provider ordered furosemide 2mg/kg/day IV for a 16 pound infant with a heart defect. The infant should receive \_\_\_\_\_14.5\_\_\_\_\_ mg per day



Appendix L:  
Item Analysis of Pretest / Posttest

### Item Analysis of Pretest / Posttest

Problem	Pretest Incorrect	Post- test Incorrect	Fractions	Decimals	Percent	House	Metric	Oral	Parenteral	IV	Convert
1	7			X					X		
2	3			X					X		
3	9			X			X			X	
4	4			X			X				X
5	5							X			
6	2	1		X					X		X
7	6			X						X	X
8	4			X					X		
9	6							X			
10	4	1				X	X				X
11	3			X				X			X
12	5					X					X
13	11	3	X	X	X				X		X
14	10	1	X		X		X				X
15	4									X	X

Problem	Pretest Incorrect	Post- test Incorrect	Fractions	Decimals	Percent	House	Metric	Oral	Parenteral	IV	Convert
16	11									X	X
17	3					X	X			X	X
18	1			X			X			X	X
19	7			X			X			X	X
20	8	1	X				X			X	X

This item analysis tracks the pattern of incorrect responses per question of students completing the pre and posttest.

Appendix M:  
Letter of Introduction

*Letter of Introduction*

Date

Nursing Students:

Many studies have detailed the concerns of nursing educators and health care regulating agencies regarding the number of nursing students and practicing registered nurses that struggle in performing medication dosage calculations. Article 30 of the West Virginia State Code states nursing students are held to the same standard for safe clinical practice as that of a licensed registered nurse in the clinical setting (*West Virginia Nursing Code and Legislative Rules*, 2002). The ability to accurately calculate medications for patient administration is a requirement for participation in the clinical experience (West Virginia University School of Nursing, 2007-2008).

The purpose of this study is to evaluate the effectiveness of a program of instruction in mathematical computations necessary for medication dosage calculation for nursing students. The program will utilize dimensional analysis as the problem solving method for this research study.

You have been provided with instruction and review in preparation for accurately calculating medication dosages. During the seventh week of this semester, you were tested for this clinical skill with the Math Competency for Medication Administration exam. This is to certify competency for medication administration in the clinical setting. Unfortunately, not all students were successful and obtained the necessary score.

To facilitate your success in the calculation of medication dosages, you are being invited to participate in an educational intervention and this subsequent research study. The designed program of this dissertation, Dimensional Analysis and Medication Math(DAMM) will be provided for will all consenting students. You will participate in 10 hours of instruction. This will be divided into five 2-hour sessions. You will be expected to complete assignments pertinent to the unit topic prior to attendance. Worksheets with problem sets will be completed during the instruction time to reinforce mathematical concepts and procedure. Formative feedback will provided following each unit of instruction to better guide individual instructional needs.

This is a voluntary study. Your participation in this study is strictly voluntary and you are free to discontinue attendance at any time. If you make the decision not to participate, it will in no way jeopardize any future attempts on the medication math competency exam or your grade in the nursing course of that you are enrolled in. If you prefer mathematical remediation from the Academic Support Center of Glenville State College, a referral will be provided.

Your signature on the consent document will acknowledge your agreement to participate in this study. You have received a code that was utilized on your Math Competency for Medication Administration exam. This will be your identifier on the demographics questionnaire and post test. This is for correlating information in the research process. Your results will only be shared with the appropriate faculty to verify your competency of the clinical skill of medication dosage calculation.

If you would like a summary of the findings of this study, a copy can be obtained from the researcher or participating college. If you require additional information or have any questions, please do not hesitate contacting me.

Sincerely,

Theresa Riggs Cowan, MSN APRN BC  
Office – Science Hall [REDACTED]  
Telephone: [REDACTED]  
Email- [REDACTED]

Appendix N:

Consent Form



## CONSENT FORM

### Pretest/Posttest/Demographics/Educational Program

#### Principal Investigator:

Theresa Riggs Cowan  
Health Education Doctoral Candidate  
A.T Still University

██████████ work)

██████████ (home)

#### Research Site:

Glenville State College  
Science Hall – ██████████  
200 High Street  
Glenville, WV. 26351  
██████████

**IRB Protocol Title:** Medication Dosage Calculation:  
A Mathematical Intervention for Nursing Students

#### Research Purpose:

Many studies have detailed the concerns of nursing educators and health care regulating agencies regarding the number of nursing students and practicing registered nurses that struggle in performing medication dosage calculations.

The purpose of this study is to evaluate the effectiveness of a program of instruction in mathematical computations necessary for medication dosage calculation for nursing students. The program will utilize dimensional analysis as the problem solving method for this research study.

#### Information on Research:

The program will be integrated into the Nursing 110 – Health and the Caring Professions and Nursing 225 – Nursing Interventions I and repeated in Nursing 245 – Nursing Interventions II course if necessary. The project will have four components: a pretest, demographics questionnaire, 10 hours of mathematical remediation /instruction and posttest. Your participation in this research activity is voluntary. The activity will progress as follows:

Phase I - You will complete the Math Competency for Medication Administration examination during regular class time.

Phase II – You will be asked to complete a 6-question demographics survey. This information is important in the attempt to determine if any related factors could influence math ability.

Phase III – You meet with this researcher one time per week for five weeks during the semester. You will requested to complete out-of-class assignments and participate in structured classroom white board work and problem solving activities.

Phase IV – You will asked to complete the Math Competency for Medication Administration examination upon the completion of the educational program.

All information will be confidential, as you will use a security code on all test items for correlation purposes. All documents involved in this research process will be maintained in the Department of Science and Math in a locked filing cabinet.

The premise of this design is to determine if computation accuracy improves as a result of the program.

### **Risks:**

There are no anticipated risks to the participant. The intervention will be conducted in pre-scheduled course time that is agreeable to all. Participation in this research activity is voluntary and there is no monetary compensation associated with this activity. Opting out of participation will not jeopardize future re-take attempts of math competency for medication administration examinations. You have the right to exit this study at any point. Answers to the pretest, posttest, and demographics questionnaire will be secured in a locked filing cabinet in the Science and Math Department. This investigator will have access to this information only. At the conclusion of this research project, all examinations and the questionnaire will be destroyed.

### **Benefits:**

Benefits anticipated will be an increase in cognitive knowledge and application accuracy of mathematical processes. This will be applied to the calculation of medications for patient administration. The practice of medication administration is a high skill competency expected of nursing students within the curriculum. The ability to calculate medication dosages accurately correlates with patient safety and professional accountability.

**Alternative Procedures:**

This has been deemed a voluntary study. It will be emphasized that the decision to attend or not to do so would not jeopardize any future attempts medication math competency exam attempts. Students wanting to receive mathematical remediation from the Academic Support Center of Glenville State College will be provided a referral.

**Compensation:**

You will not receive any monetary payment for participating in this activity.

**Voluntary Participation:**

Participation in this research activity is voluntary and there is no monetary compensation associated with this activity. Opting out of participation will not jeopardize future re-take attempts of math competency for medication administration examinations. You have the right to exit this study at any point.

### Pretest/Posttest/Demographics/Educational Program

#### Statement of Consent:

As a student in Nursing 110 and Nursing 225, I voluntarily agree to participate in this research study. I have carefully read the information provided and understand the context as well as the purpose of this activity. I have discussed the information relating to this process with the investigator and have been provided the opportunity to ask questions pertaining to my involvement. All answers supplied by the investigator were clear and distinct.

I understand that I have the option of participating or not in this educational program. I also understand that I may terminate my involvement at any time. The decision to withdraw from this program will not affect my status in my enrolled course or nursing program.

By signing this document, I verify that I have scored less than 100% on the Math Competency for Medication Administration Examination, which is the pretest for this research study. I further verify that I agree to participate in the educational activity entitled, **Dimensional Analysis and Medication Math(DAMM)** and to complete all requirements set forth in the informational content. I have not waived any legal rights in regards to this research activity.

The Internal Review Board (IRB) at A.T. Still University of Health Sciences has approved this research. Any questions can be addressed to the IRB Chairperson, R.J. Theobald, Jr., Ph.D. at [REDACTED].

I understand that I will receive a copy of this informational document and signed consent to retain in my personnel documents.

---

Signature of Subject

---

Date

I have provided the participant a copy of the consent information and signed consent form.

---

Signature of Investigator

---

Date

## Appendix O:

### Policy and Procedure: Informed Consent

### **Policy and Procedure: Informed Consent**

The designed program of this dissertation, Dimensional Analysis and Medication Math(DAMM) will be provided for all consenting students. This researcher will provide an explanation of the program along with process and procedures process to the participants. This will include the purpose, instructional design, projected benefits, the fact that no student will be penalized for choosing not to participate and alternative math tutoring opportunities. Students that agree will be given a packet containing a written description of the program, course objectives, content map, class attendance schedule. The consent form will be included in the documents and will be reviewed by the participant and once signed returned to this investigator. The original consent will be housed in the locked file of the Science and Math Department. A copy of this document will be returned to the appropriate student. This process will occur in the traditional classroom setting.

Appendix P:  
Summary of Results - DAMM

### Summary of Results – DAMM

STUDENT	AGE	GENDER 1= Male 2= Female	# HI SCHOOL MATH 1= One Yr 2 = Two Yrs 3 = Three Yrs 4 = Four Yrs 5 = 4 + College Course	ACT/ SAT COMP	COLLEGE DEGREE 0 = NONE 1 = ASSOC. 2 = BACHLOR 3= MASTER	COLLEGE MATH COURSES 1 = MTHF 001 2 = MTHF 002 3 = MATH 110 4 = MATH 102 5 = MATH 256	PRETEST SCORE (20)	POSTTEST SCORE (20)
001	21	2	4	23	0	4	16	20
002	20	2	5	19	0	4 and 5	16	20
003	20	2	5	20	0	1, 2, 4 and 5	16	20
004	20	2	5	21	0	4	18	20
005	21	2	5	21	0	2,3,4,5,	15	20
006	19	2	4	30	0	4 (credit due to ACT)	16	20
007	30	2	4	0	0	1,2,4,5	9	18
008	32	2	4	21	3	1,2,3,4	12	20
009	19	2	4	19	0	1	12	18
010	18	2	5	23	0	4	15	20
011	19	2	5	25	0	4	12	20
012	26	2	5	20	0	1	15	20
013	19	1	4	19	0	1,2,4	12	19
014	19	2	4	17	0	1	17	20
015	22	2	4	22	0	2,3,4	15	20
016	20	2	4	20	0	4	18	20
017	45	1	5	0	0	4,5	10	18
018	19	2	5	19	0	1	13	20
019	18	2	5	23	0	4	14	20
020	22	1	3	16	0	1,2,4	16	20