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The Effectiveness of an Interactive Multimedia Learning Explanation on Baccalaureate Nursing Students' Mathematical Achievement and Self-Efficacy

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THE EFFECTIVENESS OF AN INTERACTIVE MULTIMEDIA LEARNING EXPLANATION ON BACCALAUREATE NURSING STUDENTS' MATHEMATICAL ACHIEVEMENT AND SELF-EFFICACY

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This dissertation, written under the direction of the candidate's dissertation committee and approved by the members of the committee, has been presented to and accepted by the Faculty of the School of Education in partial fulfillment of the requirements for the degree of Doctor of Education. The content and research methodologies presented in this work represent the work of the candidate alone.

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"The deepest roots sustain the greatest trees."

-John Steinbeck

For my parents,
Christina and Leonard,
two lovely people

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INTRODUCTION

How do nurse educators provide remedial math instruction to students with low knowledge of the learning material? How do nurse educators change the students' negative affect toward math remediation and increase the students' motivation to learn medication dosage calculations that are essential in order to provide optimal patient care? Is it possible to create effective interactive multimedia instructional tools that will enable unskilled students to learn an essential ability at the university level? This study addresses these questions.

Statement of the Problem

The ability to perform precise mathematical calculations is a core competency skill that nurses must demonstrate while administering pharmacological agents to patients. A nurse needs to be proficient in mathematical calculations in order to regulate intravenous (IV) drips, administer medications via various routes, prepare electrolyte replacement solutions, convert temperature scales between Fahrenheit and Celsius, and determine accurate fluid intake and output. Nurses' deficiencies in mathematical concepts and calculations lead to incorrect dosage calculations of a medication and constitute one type of a medication error according to the American Society of Hospital Pharmacists (ASHP, 1982). Phillips, Beam, Brinker, Holquist, Honig and Lee (2001a) reported the most common type of medication error is the administration of an improper dose. Medication dosage errors are attributed to poor math skills, the use of an incorrect math formula, and/or the lack of ability to apply theory to practice in a clinical setting (Gillham & Chu, 1995).

Nursing students' lack of mathematical proficiency continues to be demonstrated in today's nursing programs around the world (Bindler & Bayne, 1984; Blais & Bath, 1992; Hodge, 1997, 1999; Pozehl, 1996; Segatore, Edge & Miller, 1993; Weeks, Lyne & Torrance, 2000). Thirty-eight percent of junior-level baccalaureate nursing students attending a university in the state of Washington is unable to pass a seventh-grade mathematics test (Bindler & Bayne, 1984). In addition, less than one quarter of a nursing student cohort at a large Midwestern university demonstrated the ability to pass an algebra test in comparison with 71% of non-nursing majors (Pozehl, 1996). Furthermore, mathematical calculation deficiencies among students are noted in 83% of the accredited nursing programs in the United States (Worrell & Hodson, 1989). Weeks and associates (2000) described the arithmetic errors made by a group of beginning nursing students attending a large British School of Nursing and determined a need for a program that would provide an alternative way of learning calculation skills.

Students lacking the necessary mathematical skills are faced with the threat of clinical failure and lowered math self-efficacy. Therefore, nurse educators have the responsibility and challenge to develop and evaluate innovative medication dosage calculation instructional methods, provide review of arithmetic and basic mathematical concepts, and evaluate the mathematical capabilities of nursing students. However, empirical research investigating instructional methods, practice time or helpful solutions that strengthen and enhance students' medication calculation capabilities is lacking (Allen & Papas, 1999; Bayne & Bindler, 1997; Craig & Sellers, 1995; O'Shea, 1999).

Nurse educators suggested increasing the practice time and frequency of testing students' mathematical skills throughout the curriculum in order to improve the students' cognitive abilities. The amount of time spent during nursing education in providing dosage calculation instruction to undergraduate nursing students is not well documented in the literature. Also, the opportunity to practice dosage calculations in the clinical setting is minimal due to modern unit dosing of medications (individually wrapped and labeled medications), automated IV pump administration of medications, and the lack of faculty time to review basic mathematics (Allen & Papas, 1999; Segatore et al., 1993).

Computer-assisted instruction (CAI) has been suggested in the nursing literature as an effective adjunct to math instruction for nursing students because of the lack of faculty time, and as a cost-effective strategy (Allen & Papas, 1999). Traditional classroom learning environments have been compared with Web-based courses for cognitive effectiveness, increased computer skills in a technologically-rich practice setting, and self-reported affective outcomes (Leasure, Davis & Thievon, 2000; Ryan, Carlton, & Ali, 1999). How can nurse educators individualize instruction to meet the learning needs of today's nursing student and decrease the shame of not knowing mathematical concepts? Are nurse educators aware of the cognitive outcomes associated with multimedia learning environments?

Purpose of the Study

The purpose of this dissertation study was to investigate the effectiveness of a one-hour interactive multimedia learning explanation compared to a one-hour explanation delivered via text only, text and image, and text, image and animated self-study format as a method of medication dosage calculation instruction for baccalaureate nursing students. This study was important for three reasons. First, the failure to correctly calculate and administer a medication dosage to a patient may result in a life-threatening or non-therapeutic situation. The Institute of Medicine (IOM) (2001) proposed: "Patients should be safe from injury caused by a care system. Reducing risk and ensuring safety require greater attention to systems that help prevent and mitigate errors" (p. 8). Therefore, demonstration of expertise in calculating medication dosages is paramount for patient safety and therapeutic outcomes. Second, nursing faculty has reported frustration because they do not have enough time to instruct students lacking ability to solve clinical math problems. Currently, there is a lack of research that supports effective remedial and instructional methods to strengthen students' knowledge of mathematical structures and medication dosage computation. Therefore, instructors do not have the resources needed to assist the students in need of cognitive reinforcement and remedial practice. Third, while the use of multimedia learning in nursing education has escalated during the past few years, the effects of interactive multimedia instruction needs to be evaluated with regard to students' retention of content and transfer of meaningful learning (Bell, Fonarow, Hays & Mangione, 2000; Berge, 1990; Eidson & Simmons, 1998; Kennerly, 2001).

One of the most important goals of educational technology is to bridge the gap between instructional design and learning theories in order to develop knowledge-based learning environments that assist learners in obtaining problem-solving abilities and enhance learning of a particular subject (Forcheri & Molfino, 1991). Furthermore, Mayer (2001) described the need for more educational research in the areas of personalization and user interactivity in multimedia learning:

> Increasing interest on personalizing instructional episodes – such as the use of on-screen-pedagogic agents – suggests the need for additional research on the role of

> personalization in multimedia design. Often, multimedia presentations allow for user interaction and exploration, so additional research is needed on the role of interactivity in multimedia learning. (p. 194)

This study investigated the effects of an interactive multimedia learning explanation on nursing students' cognitive retention of mathematical structures and medication dosage calculations, and the effects of instructional design on nursing students' mathematical self-efficacy. This study also obtained information regarding students' satisfaction with the four different methods of instruction presented during the research study. The sample was comprised of undergraduate nursing students at two universities in northern California. A pretest-posttest design was implemented. The study consisted of four different treatment groups: (a) text only; (b) text and image; (c) text, image, and animation; and (d) text, image, animation and interactivity. The learning material presented in each treatment group was the same; however, the presentation method differed. The first treatment group (T) received three learning modules that contained text only (see Appendix A). The second treatment group (TI) received three learning modules that contained text and images (see Appendix B). The third treatment group (TIA) viewed text, image, and animated-based learning modules via a computer screen (see Appendix C). The fourth treatment group (TIAI) received the same presentations as group three, but in addition required user interactivity in a computer-based learning environment (see Appendix D, E, F). The multimedia presentations viewed by the third and fourth groups were accessed via the Internet using a Web-based browser (e.g. Internet Explorer).

Each student received a 34-item Mathematical Self-Efficacy Scale (MSES) (five sample questions are presented in Appendix G), and a 25-item pre-treatment math test (see Appendix H) one week prior to the research treatments. Directly following each treatment (within 3 minutes) the students took the MSES and a parallel post-treatment math test (see Appendix I). Following two weeks, the students answered the questions on the MSES and took another parallel follow-up treatment math test (see Appendix J) in a university classroom environment. Directly after the administration of the follow-up treatment math test the students answered eight student-satisfaction questions regarding the treatment they received during the study (see Appendix K). A time-line of the research data collection process is provided in Table 1.

Table 1
Research Data Collection Process

Day 1	Day 2 One Week Later	Day 3 Two week Follow-Up
Introduction of the Study	Participants randomly assigned to one of four groups: A: Text (T) B: Text & Image (TI) C: Text, Image & Animation (TIA) D: Text, Image, Animation & Interactivity (TIAI)	Follow-Up Visit
Math Self-Efficacy Scale (5 minutes)	Math Self-Efficacy Scale (5 minutes)	Math Self-Efficacy Scale (5 minutes)
Pre-Treatment Math Test (40 minutes)	Post-Treatment Math Test (40 minutes)	Follow-Up Treatment Math Test (40 minutes) Student Satisfaction Survey (5 minutes)

Theoretical Rationale

The cognitive frameworks for this research study were Paivio's (1986) dual coding theory, Mayer's (2001) cognitive theory of multimedia learning, Sweller's (1988) cognitive load theory, and Bandura's (1977) social cognitive theory.

Dual Coding Theory

The dual coding theory postulated by Paivio (1986) has been applied to cognitive phenomena, such as mnemonics, evaluative functions, motivational-emotional factors, and problem solving. Paivio hypothesized that there are verbal and nonverbal subsystems that are structurally and functionally distinct at the cognitive level. Paivio's diagram of verbal and nonverbal subsystems and how these subsystems interact with one another is illustrated in Figure 1. Individuals create internal verbal symbols (logogens) from verbal stimuli, internal visual images (imagens) from existing visual representations, and referential connections between the two subsystems.

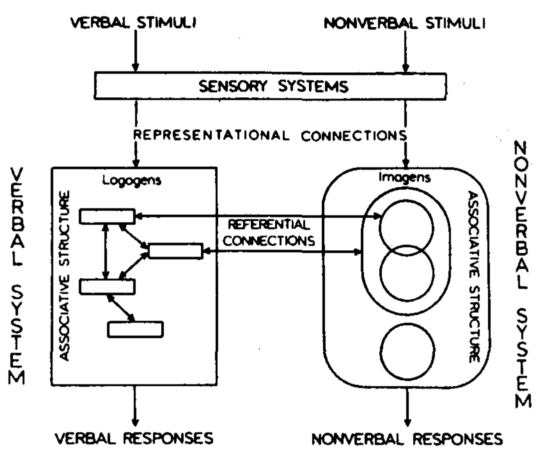

Figure 1. Paivio's (1986) diagram of verbal and nonverbal subsystems.

Note. From *Mental Representations: A Dual Coding Approach* (p. 67), by A. Paivio, 1986, New York: Oxford University Press. Copyright 1986 by Oxford University Press. Reprinted with permission.

Although distinct, at the same time the verbal and non-verbal subsystems can be considered interconnected because one system can set off activity in the other subsystem. Furthermore, Paivio indicated that a cross-channel representation of a single sensory stimulus can occur, such as a mental representation of a spoken word and vice versa (Mayer, 2001).

Paivio (1986) explained:

> Human cognition is unique in that it has become specialized for dealing simultaneously with language and with nonverbal objects and events. Moreover, the language system is peculiar in that it deals directly with linguistic input and output (in the form of speech or writing) while at the same time serving a symbolic function with respect to nonverbal objects, events, and behaviors. Any representational theory must accommodate this dual functionality. (p. 53)

A dictionary defines a system as "an assemblage or combination of things or parts forming a complex or unitary whole" (Braham, 1999, p.1326). The human sensorimotor systems include visual, auditory, touch, taste, and smell. Paivio (1986) described an "orthogonal conceptual relation between symbolic systems and sensorimotor systems with examples of types of modality-specific information represented in each subsystem" (p. 57). According to Paivio, the verbal subsystem includes visual and auditory words and writing patterns, whereas the nonverbal system includes visual objects, environmental sounds, feel of objects, taste, and olfactory memories. Each of these subsystems may be mapped onto one another. An example would be the bilingual individual who can switch from one language to another while changing from one sensory system to another.

Paivio (1986) explained that verbal and nonverbal cognitive processes encode sensory stimuli. "The implication has always been that imaginal and verbal systems have important functions in the encoding, storage, and retrieval of episodic information" (p. 75). When the verbal and nonverbal processes are combined in an instructional format, learning, problem solving, and memory are improved (Romero, Berger, Healy & Aberson, 2000). Research conducted by Paivio supports the significance of imagery in cognitive functions. In one experiment, participants saw pairs of items that differed in roundness (e.g. tomato and drinking glass) and were asked to indicate which member of the pair was rounder. The objects were presented as words, pictures, or word-picture pairs. Response times were slowest for word-word pairs, intermediate for picture-word pairs, and fastest for picture-picture pairs. (Kearsley, 2001). This finding supports the dual-coding suggestion that pictorial representations are quicker to remember than words and data encoded in both systems are simpler to recall than information solely learned via the verbal system (Presno, 1997). Burton, Moore, and Glen (1995) found that printed materials lacking pictures were more difficult to comprehend and remember than the same text offered after the presentation of an organizing illustration.

The use of pictures and words, as described by Paivio (1986), to enhance cognitive coding provides a framework for the construction of multimedia design that is delivered via computerized technology. Also, a computer system is comprised of hardware and software. The hardware includes input devices, such as a keyboard or voice recognition, as well as output devices, such as a monitor screen or printer. This human interaction with the computer's hardware and software involves the kinesthetic, auditory and visual sensorimotor systems. Therefore, one can deduce from Paivio's dual coding theory that the use of a computer as a cognitive learning tool assists with encoding verbal and nonverbal messages for the learner and could enhance learning.

The use of interactive imagery when teaching encourages the creation of images in the student's nonverbal system (Paivio, 1986). The creation and implementation of verbal and pictorial representations while designing a remedial math tutorial is supported by Paivio's dual coding theory because the separate channels for processing visual and auditory information are stimulated while the learner actively interacts with the computer program. Paivio's theory of dual coding supports the design of three of the four treatments used in this study: text and images; text, image, and animation; and text, image, animation, and interactivity. Furthermore, empirical research supported the use of pictures and text when designing instructional materials in order to assist people with their learning (Mayer & Anderson, 1992; Mayer & Sims, 1994; Mayer & Chandler, 2001; Mayer, Heiser, & Lonn, 2001).

Cognitive Theory of Multimedia Learning

Mayer (2001) extended the central concepts of Paivio's (1986) dual coding theory and presented a cognitive theory of multimedia learning. This theory supports research on how multimedia instruction can enhance meaningful connections between verbal and pictorial representations (Baddeley, 1992; Chandler & Sweller, 1991). The central theme of Mayer's theory is the idea that students can develop a clearer understanding of a concept when they make a connection between words and pictures. Mayer expanded upon Paivio's idea of pictures to include "animation" and text as "narration" and applies the theory to computer-based multimedia presentations.

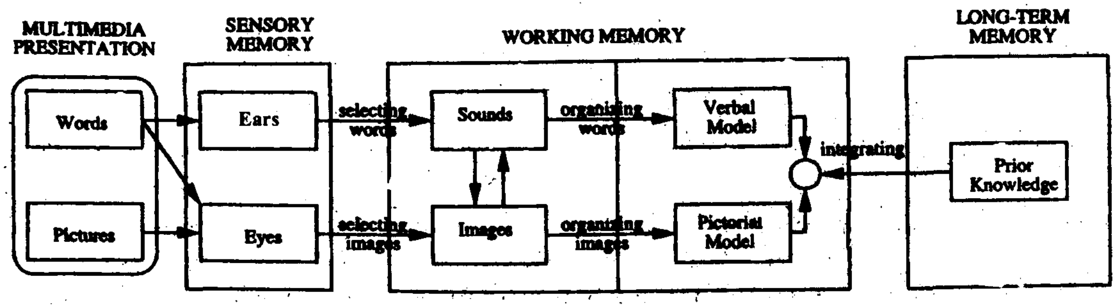

Figure 2. Mayer's (2001) cognitive theory of multimedia learning.

Note. From *Multimedia Learning* (p. 44), by R. Mayer, 2001, Cambridge: Cambridge University Press. Copyright 2001 by Cambridge University Press. Reprinted with permission.

Mayer's (2001) cognitive theory of multimedia learning model is presented in Figure 2. The three boxes represent sensory, working, and long-term memory. Prior knowledge stored in the long-term memory influences the integration of words and pictures in the working memory. As depicted in Figure 2, the "working memory" box is divided into two sections. The left section contains the two sensory modalities, whereas the right section symbolizes the knowledge created in working memory via the verbal and pictorial model. Mayer purported the core of multimedia learning takes place in the working memory.

The three assumptions that underpin Mayer's (2001) theory are dual channels, limited capacity, and active processing. Learning material can be presented verbally as on-screen text or by voice and graphically as images or animation in computer-based multimedia (Mayer, 2001). The "dual channel" assumption is based upon the idea that animation or on-screen text is processed in the visual/pictorial channel, whereas the spoken word or a non-verbal sound (e.g. non-lyrical music) is processed by the auditory/verbal channel. The results of a study conducted by Mayer and Sims (1994) support the dual-channel assumption of multimedia learning. College students possessing small amounts of domain-specific knowledge (low-experience learners) demonstrated an increased ability, when compared to a control group, to transfer what they had learned about the human respiratory system when imagery and oral explanations were presented simultaneously in a 4-minute computer-generated animation. This finding supports Mayer's "presentation mode" of multimedia that focuses on the method the information is presented to the learner.

An extension of Baddeley's (1986) and Chandler and Sweller's (1991) models of working memory provides the foundation for Mayer's (2001) second assumption of "limited capacity." The limited capacity assumption is that individuals do not have unlimited capacity to process information in the auditory/verbal or the visual/pictorial channels of working memory at any given time. Mayer and Chandler's (2001) assumption that learners' sensory channels must not be overloaded with information at any given time during multimedia instruction is important when designing instructional media. If on-screen text is provided with animation, the visual/pictorial channel may become overloaded, but when narration is provided with animation, both channels are stimulated and equally loaded. Furthermore, experimentation conducted by Mayer, Heiser, and Lonn (2001) indicated better retention and cognitive transfer of information when words were presented as narration versus on-screen text along with animation.

Mayer's (2001) last assumption is "active processing" and this pertains to the idea that individuals keenly participate in learning in order to make meaningful experiences. Learners try to make sense of multimedia presentations by paying attention, organizing information, and combining new information with previous knowledge from long-term memory. This constructivist idea conflicts with the traditional notion of learners being passive participants in any given learning situation. The results associated with active learning are the creation of "mental models" that portray essential elements of the material presented and how they are related to one another. Mayer described how this process can lead to the "cause-and-effect" construction of an idea and the importance of this creation when considering multimedia design. Moreover, this assumption suggests two significant inferences for multimedia design. First, the existing material should have a coherent structure. Second, the presented idea should provide guidance to the learner on how to interact with the program (Mayer, 2001).

Mayer and Chandler (2001) argued that there are benefits to the learner when "simple user interaction" (a modest amount of computer-user interactivity) is offered in a multimedia explanation. Based upon Mayer's "active processing" hypothesis, "simple user interaction" enhances the learner's engagement in cognitive processing. The multimedia learning explanation used in this present study included "high user interaction" that enticed the participant to actively participate and process the learning material presented in the computer-based learning modules. The learner clicked on radio buttons and images to select mathematical answers to presented practice problems (see Appendix D). If an error was made, an explanation of the mathematical concept appeared on the computer screen so the student could retry the problem until the correct answer was obtained.

Cognitive Load Theory

Sweller (1988) explained the mental processes of learning, problem solving, and human memory in his cognitive load theory. Sweller (1999) focused on the idea of increased schema acquisition in order to increase learning. Units of organized information, or schemas, make up a person's knowledge base and allow individuals to think, recognize, and solve problems. These cognitive structures are acquired over a lifetime, and schema allows individuals to treat multiple elements as a single idea (Solomon, 2002).

Our working memory is responsible for intellectual tasks at the conscious level; therefore, from an instructional point-of-view, learning material must be first processed by working memory. The long-term memory acts as a shell that holds hierarchical automated schemas that can be effortlessly pulled up to the working memory whenever necessary. A single schema can be retrieved and minimal stress is placed on the working memory. However, since the working memory has a limited capacity to attend to information, instructional design must not place too heavy of a load on the working memory. This theory has supported instructional design strategies that have demonstrated empirically effective learning outcomes (Cooper, 1998; Mayer, 1989; Mayer & Chandler, 2001)."Cognitive load theory aids instructional design because it specifies in very precise ways how to design technically difficult materials to facilitate learning when certain conditions are met (cognitive overload)" (G. Cooper, personal communication, June 4, 2002).

Certain learning material produces higher "intrinsic cognitive load" simply because of the inherent difficulty of the learning material (e.g. quantum physics), while "extraneous cognitive load" occurs as a result of the type of teaching materials used in a learning environment. When simple subject matter is to be learned the student might be able to learn from any type of instructional method, even that which places a high extrinsic load (Cooper, 1998). However, if the difficult learning content is combined with a high extraneous cognitive load, then the total sum of the cognitive load will exceed intellectual resources and learning may not occur. When there is complex material to be learned, such as technically challenging material, and an instructor engineers a learning environment that facilitates a lower level of extraneous cognitive load, the learner will have a decreased total cognitive load and the mental resources will be extended. Cooper's (1998) rendition of cognitive load theory is shown in Figure 3.

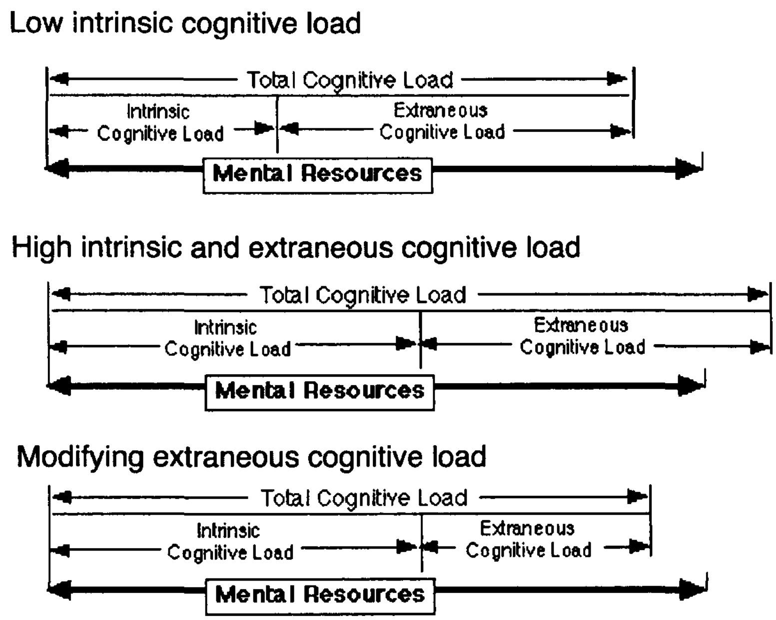

Figure 3. Cooper's (1998) version of cognitive load theory.

Note. From "Research into Cognitive Load Theory and Instructional Design at UNSW," retrieved June 4, 2002 from http://www.arts.umsw.edu.au/education/CLT_NET_Aug_97.html. Reprinted with permission.

For example, if a student is to learn about the blood flow through the human heart by referring back and forth between text and labels on a model, the student would be forced to carry an extra cognitive load. If the model of the heart is not self-explanatory, research has shown that the processing of the text, located away from the diagram, places an unnecessary burden on the individual's working memory. The use of arrows within a diagram of the heart, to point out the direction of blood flow, would decrease the students' split-attention requirements during the learning task, and thereby enhance the learning process. If text is absolutely necessary, it is recommended to be placed on the diagram because this method would reduce the students' cognitive load related to the task of searching for relations between the text and the model of the heart (Solomon, 2002).

Social Cognitive Theory

The last theoretical foundation for this study is Bandura's (1977) concept of self-efficacy within social cognitive theory. Betz and Hackett (1993) reported that Bandura's concept of self-efficacy expectations was "one of the most theoretically, heuristically, and practically useful concepts formulated in modern psychology" (p. 1). An individual's belief in their ability to be successful for any given behavior or task has a direct influence on their performance, persistence, and behavioral choices (Bandura, 1977).

Bandura (1977) asserted that there are four sources of information that influence an individual's self-efficacy expectations. These sources of information are: (a) performance accomplishments, such as mastering a skill; (b) modeling or learning by watching others successfully perform a given task; (c) verbal persuasion or the support and encouragement from others; and (d) emotional stimulation, such as anxiety, in connection with a certain behavior. In this case, anxiety is considered a "coeffect" and is inversely related to self-efficacy expectations. For example, if a student's mathematical self-efficacy expectations heighten by reaching a certain level of competency, their anxiety level should decrease. These four areas are important when trying to teach a new skill or to alter someone's learning behaviors.

Furthermore, Bandura (1986) contends that individuals must possess self-belief of efficacy and skill in order to be deemed competent at a certain given task. Madorin and Iwasiw (1999) found statistically significant increases in an experimental group's self-efficacy scores immediately following the completion of a 30-minute computer simulation of the care of a surgical patient. Madorin and Iwasiw's study suggests that CAI may enhance performance accomplishments. This is congruent with Bandura's (1977) position that performance mastery has a strong influence on individual self-efficacy expectations. It is predicted that nursing students with a strong sense of self-efficacy will seek out challenging experiences in the workplace and be less intimidated when faced with problems that are not easy to solve. However, since many nursing students are unskilled in working with fractions, remedial work in mathematics may trigger previous experiences of failure in this subject matter, leading to feelings of low math self-efficacy. Therefore, it was necessary to evaluate the nursing students' self-efficacy prior to this research study, following the treatments, and at the two-week follow-up period. It was hypothesized that the instructional design used in the interactive multimedia (TIAI) presentation of learning material would increase the nursing students' mathematics self-efficacy.

These four theoretical frameworks functioned as cornerstones for this study by supporting the development and implementation of an interactive multimedia explanation of mathematical structures and the investigation of nursing students' math self-efficacy in relation to mathematical achievement. Careful attention was given to principles of mental processes of learning, memory, and problem solving as outlined in Paivio's (1986) dual coding theory, Sweller's (1988) cognitive load theory, and Mayer's (2001) cognitive theory of multimedia learning.

Background and Need

The research focusing on nurses' medication errors dates back to the early 1960s. Barker and McConnell (1962) followed a small convenience sample of 18 registered nurses in a hospital setting and found that, on average, a nurse made approximately one medication error for every six medications given to a patient. This study conducted by pharmacists appears to be one of the first to identify a serious problem in the nursing profession 40 years ago and it paved the way for further research in nursing education.

Nurse educators have been researching nursing students' ability to calculate medication dosages over the past 30 years. Early researchers analyzed nursing students' basic mathematical skills by administering mathematical proficiency exams (Bindler & Bayne, 1984; Blais & Bath, 1992; Segatore et al., 1993). These pencil-and-paper tests measured students' ability to add, subtract, divide, and multiply fractions, decimals, percentages, and whole numbers. Results from these early research findings indicated a surprisingly large number of baccalaureate nursing students as being unable to achieve a 70% mastery level on a seventh-grade math proficiency test. These early research findings primarily focused on the nursing students' computational ability and concluded that mathematical ability was the root of the medication dosage calculation problem (Bindler & Bayne, 1984). Subsequently, the alarming results of these math tests propelled nurse educators teaching at the Intercollegiate Center for Nursing Education (ICNE) in Spokane, Washington to require prospective nursing students to pass a general math test before being admitted as an upper division nursing major.

Other empirical studies examined the type and frequency of mathematical errors being made on medication dosage calculation exams (Blais & Bath, 1992; Bliss-Holtz, 1994; Gillham & Chu, 1995; Segatore et al., 1993). The different type of errors were typically classified as either conceptual, mathematical, or measurement conversion errors. The majority of the errors made by the students were conceptual (incorrect set up of the problem). Many nursing students were unable to demonstrate the necessary math achievement upon entering an undergraduate nursing program, but what is even more troubling is that many nursing students were unable to achieve a 90% mastery level on a mathematics exam before college graduation (Chenger, Conklin, Hirst, Reimer & Watson, 1988).

Prior knowledge of mathematics, as measured by the American College Test (ACT), has been associated with nursing students' mathematical achievement. Munday and Hoyt (1965) and Hodge (1997) found that nursing students' with higher ACT-Math test results scored higher on math achievement tests given in the university setting. Throughout the nursing literature it is recommended that nurse educators examine students' standardized test scores as benchmarks for acceptance into nursing programs across the nation. The results from standardized test scores, the number and type of math classes, and students' math scores obtained at the high-school level may be possible predictors of success on mathematical exams given at the college level.

Since nursing students demonstrated a weakness in conceptualizing mathematical problems it was necessary to explore mathematical structures, such as fractions, and learn how to provide remedial math instruction to students with high-prior knowledge of the material, but demonstrated low-skill level. These low-proficient students were exposed to the mathematical concepts in high school, but never really learned the material. Subsequently many of the students developed a negative affect toward the subject matter.

Research also has found that mathematical self-efficacy contributes to mathematical achievement outcomes (Hackett & Betz, 1989). Male and female students that reported taking many math courses in high school demonstrated higher scores on mathematics self-efficacy measurements (Lussier, 1996). Throughout the educational literature are studies identifying gender, age, selection of college major, test anxiety, and attitudes toward mathematics as factors contributing to self-efficacy (Betz & Hackett, 1983; Hodge, 1997 & Lussier, 1996). Based upon results from previous studies and experience working with nursing students in clinical settings, nursing students' math self-efficacy was investigated during this current study while evaluating students' math achievement in a predominantly female sample (Betz & Hackett, 1983; Hodge, 1997; Lussier, 1996; Pozehl, 1996). The research findings supported the premise that unskilled nursing students, requiring remedial math review, and feeling like failures at mathematics leads to a decrease in math self-efficacy judgment. Is it possible to create effective instructional tools that can assist students who are unskilled in mathematics and have a negative affect toward the subject matter?

Research Questions

This study was undertaken to determine if a one-hour interactive multimedia learning explanation is an effective remedial learning tool for nursing students to review basic mathematical skills as they relate to medication dosage calculations. The students' satisfaction with the different methods of instruction was investigated as well. Specifically, this experiment was designed to answer the following research questions.

1. Does the use of an interactive multimedia to present content result in greater achievement and retention when compared with text only; text and image only; text, image, and animated only self-study modules?
2. Does interactive multimedia to present content result in higher post- and follow-up treatment math self-efficacy mean scores when compared with text only; text and image only; text, image, and animated only self-study modules?
3. Does interactive multimedia to present content result in greater student satisfaction scores at the completion of the study when compared with text only; text and image only; text, image, and animated only self-study modules?

Definition of Terms

The following definitions are intended to clarify and provide procedural terms for particular words or concepts used in this study.

Computerized Assisted Instruction: The use of the computer as an instructional tool. This may include, but is not limited to, the use of a compact disk (CD).

Interactive multimedia learning explanation: User interactivity with computer-based on-screen text, images, narration, and animation launched via an Internet browser.

The learning explanation provides remedial review of mathematical structures and instruction of medication dosage calculations for nursing students.

Mathematical structures: Basic mathematical concepts, such as addition, subtraction, multiplication, and division of fractions, decimals, and ratio problems.

Nursing students: Junior-level baccalaureate nursing students at two universities in Northern California. Many of the learners are full-time students majoring in nursing and have completed two semesters of undergraduate nursing courses.

Posology: "The study of dosages of medicines and drugs" (The American Dictionary of the English Language, 2000).

Schema: "The abstract but organized set of ideas that reflect an individual's understanding of a phenomenon, situation, or event" (Gage & Berliner, 1998).

Simple user interaction: An individual who moderately interacts with a computer program by "clicking" on links embedded in a multimedia program. "Simple user interaction in a multimedia explanation refers to user control over the words and pictures that are presented in the multimedia explanation" (Mayer & Chandler, 2001, p. 390). When a user clicks on a computer screen button, the computer presents the next section of a learning explanation.

High user interaction: An individual, who shows high interaction with learning content presented in a multimedia environment by using a cursor and keyboard to interact with computer on-screen text, images, audio, and animation. The user clicks the computer screen button on more than 16 computer frame segments in the multimedia-learning environment.

Text-Based Module: One of three text-based mathematical instructional methods.

Text and Image-Based Module: One of three text and image-based mathematical instructional methods.

Text, Image, and Animated Based-Module: One of three text, image, and animated-based mathematical instructional method.

CHAPTER II

REVIEW OF THE LITERATURE

This literature review is presented in four sections: Mathematical Achievement, Achievement on Standardized Tests, Mathematical Self-Efficacy and Computer-Based Learning. The first two sections provide background information regarding nursing students' mathematical achievement and posology errors. The remaining two sections present research on one aspect of motivation, self-efficacy and the research intervention, computer-based learning with an emphasis on interactive multimedia learning.

Mathematical Achievement

Throughout the nursing literature are studies documenting basic math proficiency and medication dosage calculation (posology) errors by nursing students and nurses in the United States and other countries around the world. When a human life hinges on the critical thinking and problem-solving ability of another individual, serious attention needs to be paid to the education and evaluation of the individual providing care to the patient. Medical errors are on the rise in the United States and they are unnecessary, costly, and unacceptable. In 2000, the IOM issued a report stating that unnecessary harmful actions by health care professionals are a leading cause of death in the United States. The IOM called national attention to the numerous medical mistakes made in hospitals and major changes in the United States healthcare delivery system were demanded. Based upon data collected from hospitals throughout the country in 1997, at least 44,000 Americans die each year as a result of medical errors, and the number of fatalities may be as high as 98,000 (IOM, 2000). These statistics represent hospitalized patients, a small proportion of the total population at risk, and do not include all clients receiving medical treatment outside the hospital setting. Furthermore, drugs are the leading cause of medical errors in hospitals and during 1993 medication errors accounted for approximately 7,000 deaths in the United States (Bond, Raehl & Franke, 2001; IOM, 2000).

Early in the 1960s, a small observation and survey study conducted by Barker and McConnell (1962) assessed methods of detecting medication errors made by nurses (n = 18) in a hospital setting and determined the factors involved in motivating nurses to report the incidence of such errors. The researchers observed nurses, investigated self-reported medication errors made by nurses, and studied records of incident reports filed by nurses. The frequency of observed medication errors, by error type, and the percentage of medication errors made per nurse were reported. The most frequently observed medication errors were omission of prescribed medication (37%) and unordered medications (18%) given to a client. Findings from this study revealed that 8% of the nurses administered an overdose of a medication and 13% an under dose of a medication (Barker & McConnell, 1962).

Assessing nursing students' mathematical capabilities is a challenge because students are typically admitted into a nursing program according to general university admission standards. The students arrive at the learning institution with different mathematical capabilities and past educational experiences. A "Mathematics Proficiency Test" and a 20-item "Medication Calculation Test" were developed by Bindler and Bayne (1984) in order to test undergraduate nursing students' math proficiency. Following consultation with mathematics professors, the researchers developed the proficiency exam in order to assess the student's ability to add, subtract, multiply and divide whole numbers, fractions, decimals, and percentages. The math proficiency exam was administered to approximately 700 junior-level baccalaureate-nursing students over a three-year period in the Pacific Northwest. Successful completion of the proficiency exam was expected before administering medications and was a requirement for passing the first clinical course.

Results from this longitudinal study revealed that during any academic year 9 to 38% of the students could not pass all sections of the proficiency test at the 70% level. When the researchers raised the passing standard to 80%, the number of students failing one or more parts of the proficiency exam was between 26 and 43% of the sample. Bindler and Bayne (1984) convinced the Academic and Admissions Standards Committee at ICNE to require undergraduate nursing students to demonstrate mathematical proficiency before being accepted into the school of nursing. Since 1983, students have been required to pass this entrance exam as a requirement to enter the baccalaureate-nursing program (registered nurse) at ICNE.

The "medication calculation test" was developed one year after the proficiency exam was developed in order to evaluate the students' medication dosage calculation skills (Bindler & Bayne, 1984). The researchers tested the undergraduate nursing students' medication calculation skills over a 5-semester time period in an attempt to evaluate the students understanding of apothecary, metric, and household measurement. At the 70% pass level, 91% of the students were able to demonstrate competency. Consideration of the low pass rate standard should be acknowledged when evaluating the results of Bindler and Bayne's research. A 70% pass rate is not accepted in many schools of nursing. The results of Bindler and Bayne's study are important because they can be compared to the results of this current study, and one can determine if a change in nursing students' overall math proficiency has occurred since 1984.

In order for nurse educators to understand the reason why nursing students struggle with mathematical structures and dosage calculations it is necessary to investigate the types of medication dosage errors made by students. Chenger and colleagues (1988) researched the mathematical skill ability of 210 entering nursing students and 145 exiting nursing students in various schools across Alberta, Canada. Participant characteristics such as gender, age, previous math courses, attitudes toward mathematics, and high-school grade point averages were investigated and correlated with math achievement.

Chenger et al. (1988) used a math test consisting of computational and problem-solving sections, and mastery of the test items was determined at the 90% level. A nurse and mathematics content experts determined the content validity, and the reliability index was established ($r = .84$). The results indicated that 61% of the entry-level students did not fulfill the mastery level requirements, and 43% of the students graduating were unable to achieve the expected outcomes. Results indicated that both groups, entering and graduating students, demonstrated higher scores on the computational section of the test.

One limitation to this study was the unequal number of problem-solving questions in comparison to computational problems presented on the test. There were 15 less problem-solving questions, therefore the students were not given an equal chance to show their mathematical skills in both areas. In addition, the volunteers were not previously informed of their involvement in the study. Despite the limitations of this study, some improvement in math achievement was noted after students progressed through the nursing program, but the improvement was not significant. These researchers concluded that both groups of nursing students had difficulty in performing mathematical calculations and highlighted the importance of such elementary skills in nursing practice. The results indicated that these nursing students had difficulty retaining instruction in medication dosage calculation, and it may be necessary to provide frequent post-educational review sessions to maximize students' performance in the clinical setting. Unfortunately, the authors did not report all of the study's results.

Perlstein, Callison, White, Barnes and Edwards (1979) reported the unfortunate deaths of three infants and one young child related to the incorrect calculation and administration of medications by registered nurses and other health care professionals. These tragic and untimely deaths spurred Blais and Bath's (1992) interest in researching the number of undergraduate nursing students, at a large public university, lacking the necessary skills to calculate medication dosages. In addition, these researchers looked at the type and frequency of errors occurring during dosage computations. Findings showed that 66 junior-level baccalaureate-nursing students' dosage calculation errors stemmed from either conceptual, mathematical, or measurement standpoints. Of the 431 conceptual errors, 241 errors were the result of setting up the math problem and 190 errors were related to "form" (wrong form of medication administered). Mathematical errors accounted for 19% of the total mistakes, and some participants could not demonstrate knowledge of how to divide by a two-digit number. Those mathematical errors resulting from fraction or decimal errors accounted for 46% of the total errors (Blais & Bath, 1992). Lethal mistakes can occur due to the incorrect placement of a decimal when calculating drug dosages (Timpke & Janney, 1981). These results illuminated the lack of retention of mathematical concepts learned earlier in life, and the need for remedial work. Segatore and associates (1993) argued that posology problems are not the result of ignorant or lackadaisical students. These researchers blamed the educational system's failure to adhere to necessary educational standards.

The results from both of these studies indicated that conceptual errors are made more frequently than mathematical computation errors. Students failed to demonstrate the ability to set up problems correctly, therefore a calculator would not assist these students in arriving at the correct answers. Furthermore, those problems requiring multi-step math procedures were the source of most difficulties. Blais and Bath (1992) provided a measurement conversion table on a test and mistakes still occurred, thus indicating that the students were still not able to conceptualize the problem presented on the written exam. Many of these same participants were unable to demonstrate problem solving on their tests because their problems were not set up in a neat manner (Blais & Bath, 1992). These researchers recommended that nurse educators closely follow students' mathematical conceptual, computational, and measurement conversion capabilities throughout the nursing student's career.

Why are post-secondary students arriving at the gates of a university with such deficiencies? Mervis (2001) discussed the current report from the National Academy of Sciences on how children learn math and the national call for improvement in how math is taught in the United States' elementary and middle schools. President George W. Bush and congressional Democrats supported major educational reform plans to improve math instruction in the United States. At the national and state level there is a movement to bridge both mathematical conceptual learning and procedural capability of students by improving professional development and math instruction in this country. This is definitely going to take some time, but it is apparently necessary when only 24% of 8th graders and 37% of high school seniors in a study could estimate the answer to the addition of "12/13 and 7/8" (Mervis, p. 808). Therefore, it is clear that nursing students' inability to conceptualize or compute mathematical problems when they arrive at the university level possibly has its roots in their early childhood education. There are too many elementary and middle school age students graduating with inadequate mathematical information, proficiency, and self-reliance for our nation to be satisfied with the status of math education in this country (Kilpatrick, 2001).

Pozehl (1996) explained that a sample of nursing students' mathematical capabilities is less than non-nursing groups. A small comparative descriptive study conducted by Pozehl (1996) compared the differences between nursing ($n = 56$) and non-nursing majors' ($n = 56$) mathematical test score results. The non-nursing group consisted of biology, criminal justice, social work, and psychology majors. Math and computer anxiety, as well as the number of algebra courses taken prior to admission to the university were taken into consideration. The 25-item multiple-choice algebra test, developed by the authors, was administered via computer. The test included items that required solution of algebraic equations, fractions and decimals. These are the predominate skills required when nurses calculate dosages of medications and determine IV drip rates. The algebra test reliability coefficient alpha ($r = .82$) was determined, and a panel of math and nurse experts examined the algebra test's content validity.

Pozehl (1996) performed a one-way multivariate analysis of covariance (MANCOVA) in order to determine group differences in math skills' outcomes and anxiety toward mathematics. The data analysis (univariate ANCOVA) indicated a significant finding ($p < .01$) for the algebra skills' test outcomes that contributed to the overall multivariate significance. Furthermore, it was discovered that only 18% of the nursing group passed the algebra test with a score of 70% or better, compared to 71% of the non-nursing group passing the same exam at the same level. The nursing group reported higher anxiety toward math, higher mean pre-test anxiety, and higher anxiety toward computers when compared to the non-nursing cohort. However, these reported scores were not significantly higher than the non-nursing group and a sampling error could account for this finding. The limitations to this study were the sample size and the **lack** of demographic information about the participants.

Achievement on Standardized Tests

In light of the literature, nursing students' mathematical calculation skills may be considered prior to admission to schools of nursing across the nation. Educational opportunities could be offered to increase math proficiency early in the undergraduate curriculum for those students who require remedial attention. The majority of universities today rely upon the results from standardized tests while assessing students' educational maturity and cognitive potential for success in college. The ACT is taken by high-school students and tests a student's knowledge of mathematics, English, social studies, and natural science. Many schools of nursing use the test across the nation to predict a student's academic success at the university level (McGovern & Valiga, 1997; Hesser, Pond, Lewis & Abbott, 1996). Munday and Hoyt (1965) collected data from seven schools of nursing located across the United States to determine the effectiveness of ACT results in predicting grades obtained in courses within the nursing school curricula. The nursing students' first year GPA was correlated with ACT sub-test score results, and these outcomes indicated that the students' ACT mathematics mean test scores were the lowest of all four ACT sub-test results. Moreover, the students' ACT results were outstanding predictors of general grades obtained during the first year of nursing school.

Hodge (1997) studied the connection between prior knowledge (standardized test results) in mathematics and math achievement (drug dosage examination) of baccalaureate nursing students (*n* = 55). Once again the students' ACT mathematical scores were analyzed by Hodge and correlated with current mathematical achievement. Predictably, there was a statistically significant correlation between the student's previous math knowledge and current math competency ($r = 0.46, p < .01$). The results indicated that 21% of the difference in the students' mathematics achievement was explained by the correlation between prior math understanding and current math accomplishment.

A follow-up study by Hodge (1999) determined if certain variables, such as math self-efficacy, gender, test anxiety and previous knowledge of mathematics were related to baccalaureate-nursing students' abilities to accurately calculate medication dosages. Findings from this study indicated test anxiety, math self-efficacy, and previous knowledge of mathematical structures had an effect on the students' math competencies. The gender factor did not have an effect in Hodge's study, however gender did have a significant effect on math competency in other studies (Betz & Hackett, 1983; Ethington & Wolfle, 1986; Junge & Dretzke, 1995; Lussier, 1996). Results from these studies indicated that nursing students demonstrating low-math achievement scores on earlier math exams might benefit from taking remedial courses in basic math concepts before considering entry into nursing programs. The identification of nursing students with low ACT math scores will enable faculty members to provide remedial intervention and ultimately decrease the chance of potential medication errors.

Mathematical Self-Efficacy

Bandura (1977) stated that an individual's belief in their ability to be successful for any given behavior or task has a direct influence on their performance, persistence, and behavioral choices. Anxiety is considered a "coeffect" and is inversely related to self-efficacy expectations. If a student's mathematical self-efficacy expectations heighten by reaching a certain level of competency, their anxiety level should decrease. Many nursing students have a negative affect toward mathematics and it influences their ability to perform dosage calculations (Hodge, 1997). "Nursing students remark that they went into nursing because they liked science but they hated math and didn't think you needed math to be a nurse" (Hodge, 1997, p. 28). These students were exposed to fractions and ratios in high school, but for whatever reason they never completely learned the mathematical concepts and with low proficiency a negative affect toward the subject matter developed.

According to Stipek (2002), an individual's self-efficacy is related to their judgment of performance ability on a specific task at an exact moment. This judgment is frequently observed in performance-based assessments in the clinical setting. Students that have practiced a certain skill or posses recent experience gain the belief they can demonstrate the skill in a performance assessment compared to those individuals that lack practice or belief they can perform the skill successfully. Furthermore, studies have demonstrated that self-efficacy is a better predictor of academic performance than general measures of academic aptitude (Pajares, 1996; Pajares & Miller, 1994). Pajares (1996) reported from a previous study conducted in 1994 that students' math self-efficacy had a stronger influence on mathematics problem solving than the students' self-concept, perceived usefulness, or prior math experience ($\beta = .55$). Therefore, do nursing students lack the ability to show knowledge of mathematics due to decreased mathematical self-efficacy?

Educational research regarding an individual's self-efficacy and mathematical ability attempted to explain the correlation between this motivational concept and mathematical aptitude (Betz & Hackett, 1983; Hodge, 1997, 1999; Lussier, 1996; Junge & Dretzke, 1995; Malpass, O'Neil & Hocevar, 1999). Betz and Hackett (1983) looked at the correlation of mathematics self-efficacy with the selection of science-based majors among college females and males. This study involved the development of the "Mathematics Self-Efficacy Scale" (MSES) that is grounded in Bandura's (1977) self-efficacy theory. Betz and Hackett (1993) found males' math-related self-efficacy expectations were significantly stronger ($t = -3.4$, $p = .001$) than those of females attending college. The MSES (Betz & Hackett, 1993) was used in this current study in order to determine if the treatment levels had an effect on the students' mathematical self-efficacy. In the current study, students' mathematical self-efficacy scores (pre-treatment) were used as a covariate and dependent variable (post- and follow-up) in the study. Most importantly, will the students' self-efficacy increase with the use of a computer-based interactive multimedia presentation?

According to Junge and Dretzke (1995), gifted/talented adolescent males demonstrated higher mathematics self-efficacy expectations than their gifted/talented female counterparts. The findings from their study revealed that seven of the mean gender differences were discovered to be significant on the MSES mathematics tasks subtest, and six of these differences favored males. The effect sizes were from .50 to 1.12 within-group standard deviations. One would assume that gifted/talented learners would exhibit stronger self-efficacy toward academics in general. However, the findings from this study explained that high-school females demonstrated less confidence in calculating mathematical problems used in traditionally male areas of interest (e.g. calculating wood necessary to build a dining-room table). Moreover, the talented females reported lower confidence levels in completing mathematics-related university coursework (e.g. computer science, statistics, algebra, geometry, and advanced calculus) than the gifted male students (effect size = .61 to 1.02) (Junge & Dretzke). These results are important because educators and counselors need to pay close attention to the self-efficacy expectations of all students irregardless of their aptitude and achievement levels demonstrated at the high-school level. These researchers conferred that the MSES was a valid and practical tool for the collection of self-efficacy expectations.

Lussier (1996) reported findings indicating that gender and mathematical background are related to mathematical self-efficacy. The study by Lussier showed that women with strong mathematical backgrounds provided self-reported scores on math anxiety and self-efficacy that were comparable to their male counterparts. Apparently, if women take more courses in math, their self-efficacy will increase and the reported gender gap may be minimized. Lussier reiterated that a person's self-efficacy in mathematics depends upon their feeling of competency and capability in this field of study; the person's perception is directly related to their overall performance.

Research conducted by Hodge (1997) found that baccalaureate-nursing students' mathematical self-efficacy was not a significant contributing factor for medication dosage calculation outcomes ($r = .20, p < .01$). Hodge predicted that self-efficacy would be correlated with mathematical achievement based on the fact that 80% of the participants in her study were women, however this was not illustrated in Hodge's research findings. In addition, the study conducted by Hodge (1997) considered the influence of personal attributes, such as gender, mathematical test-anxiety, and previous math knowledge on drug dosage calculation competencies of nursing students. Gender did not play a significant role in Hodge's (1997) study's results ($r = .05, p = .36$). However, Hodge (1999) acknowledged Sax's (1994) research findings on gender differences in mathematical ability and concluded that issues of math self-concept and self-efficacy need further investigation in a primarily female dominated profession instead of just focusing on gender differences in mathematical ability.

In a small quasi-experimental study conducted by Madorin and Iwasiw (1999), the influence of CAI on second-year nursing students' ($n = 23$) self-efficacy for caring for post-surgical patients was investigated. The researcher's hypothesis, grounded in Bandura's (1977) self-efficacy theory, was that the CAI would increase the nursing students' clinical performance activities and enhances their levels of self-efficacy regarding the care of the post-surgical client. The authors of this study wanted to explore the possible link between CAI and self-efficacy based upon the processes of learning stipulated in Bandura's self-efficacy theory. Two groups of undergraduate nursing students residing in Ontario, Canada were randomly assigned to a control or experimental group. Participants in the experimental group were given a researcher-developed self-efficacy survey and a 30-minute CAI regarding the nursing care of a patient undergoing lung cancer surgery. During the CAI the students were required to interact with the computer program by developing a plan of care for the patient. The students in the experimental group completed the self-efficacy questionnaire. The control group answered the same survey questions on a pretest at the beginning of the study and directly following the eight-week clinical rotation.

Results of Madorin and Iwasiw's (1999) study pointed out a significant increase in the experimental group's self-efficacy scores directly following the use of the CAI. A one-way repeated measures analysis of variance was computed and the experimental groups' results were significantly different among the pretest, post-simulation posttest, and post-clinical posttest ($p < .001$). For the control group, there were no significant changes in self-efficacy scores. Eighty-two percent of the students reported the CAI to be "somewhat helpful," and 19% found it to be "very helpful" (Madorin & Iwasiw).

Despite the limitation of the small sample size, the findings do shed some insight on the contributions made by computer-based learning in nursing education. The significant increase in the experimental group's self-efficacy scores could be aligned with Bandura's (1977) idea that self-efficacy information is parallel to performance accomplishments. "The computer simulation gave students the opportunity to increase their performance accomplishments by successfully working through a plan of nursing care for a surgical patient" (Madorin and Iwasiw, 1999, p. 284). Furthermore, these authors correlated Bandura's ideas of "efficacy expectations" with the significantly increased participants' scores because their self-efficacy developed while working on the CAI simulations. The connection of this study's results with a reliable theory supported the authors' ideas that students empowered with a strong sense of self-efficacy would look for challenging learning situations and be less intimidated when faced with new learning opportunities. The results of this study contributed to the application of CAI in clinical nursing education, however further research is needed in order to determine the effectiveness of CAI as a learning tool used in enhancing cognitive transfer, retention and student self-efficacy in other areas of nursing education.

Computer-Based Learning

The literature to date indicates many nursing students' ineptitude at demonstrating proficiency in solving mathematical problems and adequate performance on medication dosage examinations. Educators have administered pretests consisting of basic mathematical problems with follow-up counseling and textbook assignments as a solution to the ongoing math calculation problem. There are very few empirical studies demonstrating the effectiveness of educational interventions attempting to solve the medication dosage calculation problem (O'Shea, 1999).

Mayer (2001) expanded upon Paivio's theory (1986) to develop his own cognitive theory of multimedia learning. This cognitive theory is based upon the idea that the human brain has two channels to process information. One channel is the "visual/pictorial" (text and images) and the other channel is the "auditory/verbal" (audio and narration). Furthermore, Mayer stated that his definition of multimedia learning included the idea of "multimodal," which means the learner uses two sense modalities - visual and verbal - to interpret information.

Mayer (2001) defined the term "multimedia" in three different ways: (a) the delivery media view, (b) the presentation modes view, and (c) the sensory modalities view. Multimedia from the "delivery media view" is the physical system implemented to deliver information, such as computer screens, projectors, speakers, and/or human voice boxes. Mayer does not consider an ordinary textbook as a mode of multimedia delivery because it involves static ink printed on paper. The second view of multimedia involves the presentation of information by using two or more presentation modalities. For example, a lecture based multimedia presentation may include on-screen text and animation in a video or PowerPoint presentation format. The "presentation modes view" is learner-centered because the learner incorporates various coding systems in order to process information. This view is consistent with the idea that humans have different channels to process verbal and pictorial information while developing knowledge of a subject. The final view is the "sensory modalities view" and it is learner-centered as well, however this point-of-view involves the sensory receptors (visual and auditory senses) that the learner uses during the learning process. An example of this view of multimedia would be narration and animation in a computer-based learning environment.

Mayer and his colleagues' early research investigated the dual-coding theory of multimedia learning pertaining to "scientific systems," such as automobile braking systems, the human respiratory system, and the basic bicycle tire pump (Mayer & Anderson, 1992; Mayer & Sims, 1994). In an attempt to close the gap between the advancements of educational technology and educational theory, Mayer and Sims looked at college students' spatial abilities in learning from words and pictures. The first experiment ($n = 86$) involved participants learning how a simple bicycle pump functions, and the second experiment involved students ($n = 97$) learning how the human respiratory system functions. Both groups lacked basic knowledge about the technical systems presented in the study's multimedia learning explanations. The treatment involved in both experiments was a computer-based animated presentation consisting of two or three very short (e.g. 30 seconds each) programs. These researchers were interested in learning about the effects of a multimedia explanation that presented visual and verbal explanations simultaneously (described as a "contiguity effect") versus the presentation of information given separately (visual then verbal). Their hypothesis was that the coordination of visual and verbal explanations (congruent group) when compared to the uncoordinated multimedia presentation (successive group) would lead to improved problem solving transfer.

During the first experiment, the college students (n = 86) were randomly assigned to treatment groups directly following the completion of a questionnaire asking their previous experience with mechanical devices. The students took a mental rotation test lasting 3 minutes and a paper-folding test lasting the same amount of time. Depending upon their scores on these two tests the students were categorized as "high-or low-spatial ability learners." There were 10 high-spatial ability and 12 low-spatial ability students in the "concurrent group," and 21 high-spatial ability and 22 low-spatial ability students were in the "successive group." The concurrent group received learning explanations that consisted of animation and narration simultaneously. The students in the "concurrent group" were asked to complete three, 30-second each, computer-based multimedia presentations (animation and narration) on how a bicycle pump functions.

Approximately one-half of the "successive group" received narration followed by animation and the other half of this same group of students received animation followed by narration. A control group consisted of seven high-spatial ability and 14 low-spatial ability students. These students did not receive any instruction, therefore their knowledge regarding a bicycle pump system served as a baseline for the general college population. Directly following the multimedia presentation all of the students were required to take a problem-solving transfer test consisting of four questions.

The same researchers conducted a second experiment that involved low-experience college students (n = 97) who scored either low or high in the spatial ability tests and these participants were given content about the human respiratory system (Mayer & Sims, 1994). Like the cohort of students involved in the first experiment (bicycle pump system), the learners were exposed to multimedia presentations concurrently, successively, or not at all (control group). There were 17 high-spatial ability and 15 low-spatial ability students in the "concurrent group," and there were 15 high-spatial ability and 18 low-spatial students in the "successive group." The control group consisted of 17 high-spatial ability and 15 low-spatial ability students. Since the order of the content presented to the "successive group" in the first experiment (bicycle pump function) did not have a significant effect on learners' test performance, the multimedia presentation of content viewed by the "successive group" in the second experiment included only narration followed by animation.

Mayer and Sims (1994) acknowledged that the results derived from both experiments indicated that the students with "high-spatial ability" scored higher on a problem-solving test than did students reported to have "low-spatial ability." The mean score results reported for the high-spatial ability students in experiment one were concurrent group, M = 8.70, SD = 2.58; successive group, M = 6.10, SD = 3.15: and the control group, M = 4.72, SD = 1.60. However, for the low-spatial ability students in the first experiment, the mean score results were concurrent group, M = 5.42, SD = 2.34; successive group, M = 5.05, SD = 2.46; and control group, M = 5.00, SD = 2.32. The high-spatial ability participants' mean score results from experiment two were concurrent group, M = 5.53, SD = 2.04; successive group, M = 3.53, SD = 1.25; and control group,

$M = 2.45$, $SD = 1.32$. The low-spatial students' mean score results were, concurrent group, $M = 4.07$, $SD = 1.58$; successive group, $M = 4.06$, $SD = 1.92$; and control group, $M = 1.93$, $SD = 1.10$ (Mayer & Sims, 1994).

These findings indicated that the students with high-spatial ability who received a concurrent multimedia presentation (animation and narration) faired better on a transfer problem test than those high-spatial students who were presented with a successive learning explanation or no explanation at all. An analysis of variance (ANOVA) was computed for the high-spatial ability learners to look at the differences among groups and the results were, $F(2, 46) = 14.15$, $p < .001$, $MSE = 43.75$ (Mayer & Sims, 1994). A supplemental Tukey test ($\alpha = .05$) indicated that the concurrent group scored higher than the successive and control groups. The results from this study supported the dual-coding theory of multimedia learning. Also, those students who have domain-specific knowledge may not need visual aids when listening to a verbal presentation, however inexperienced students might benefit from concurrent multimedia explanations. When students were exposed to learning presentations that included verbal and visual explanations concurrently there was a better chance for them to construct multimodal connections. Mayer's research participants in these two studies were students with low prior knowledge. But the research participants in this present study were low-proficient or unskilled nursing students requiring remedial review of mathematical concepts.

The length of treatment time used in this current study was determined based upon the review of previous studies conducted by Mayer and Sims (1994), Mayer and Chandler (2001), and Madorin and Iwasiw (1999). One hour seemed realistic because these cited researchers' multimedia designs or CAI programs ranged from four to 30-

minutes in length and resulted in significant cognitive outcomes. The participants in the present study had high-prior knowledge with low-math skill ability. This type of remedial learner is different from Mayer and Sims' low-experience learners. Therefore, the students in the current study may require more exposure to the content presented in the multimedia-learning tool in order to increase their math test scores.

Also, the average time spent instructing nursing students was not clearly reported in the nursing education literature. Based upon discussions with nurse educators, as little as 15 to 30 minutes is spent reviewing math concepts and medication dosage calculations with students during the course of an academic semester. In some situations, the student is left alone with a book to review the necessary material with no instruction from professors. Some clinical instructors take it upon themselves to instruct the students during post-clinical conference time (e.g. 45 minutes), and the students state it is not enough time for remedial review. Therefore, based upon the lack of reported time spent on math and medication dosage calculation instruction, and conversations with nurse educators over the years, it was determined that one hour would be a sufficient amount of time for the treatment in the present study.

Interactive Multimedia Learning

Reeves (2002) reported that in 1997 the United States President's Committee of Advisors on Science and Technology suggested an in-depth research project be conducted on the use of educational technology within our nation's schools, its efficacy, and cost effectiveness. The credibility of the effects of computer-based learning and teaching has surfaced over the past decade (Neal, 1998; Oppenheimer, 1997). Such claims that computers reduce individuals' writing, reading, and self-expression skills while extinguishing their imaginative capabilities are reported in the literature (Reeves). However, various educators refute these negative claims and are pursuing interactive learning research to demonstrate the educational efficacy of technology-based learning as the demand for student-centered learning increases (Aberson, Berger, Emerson, & Romero, 1997; Aberson, Berger, Healy, Kyle, & Romero, 2000; Aberson, Berger, Healy, & Romero, 2001; Bell et al., 2000; Moursund, 2001; Hemphill, 2000; Kennerly, 2001; Romero, et al., 2000).

The term "interactivity" as it relates to computer-based learning environments is not always a clear concept. Liaw and Huang (2000) explained Weller's (1988) description of "interactivity in computer-mediated teaching" as one in which "the learner actively adapts to the information presented by the technology, which in turn adapts to the learner, a process more commonly referred to as feedback" (p. 41). Merril, Li, and Jones (1990) stated that "interactivity" in learning environments is the fostering of a give-and-take relationship between the learner and the instructional system.

Gilbert and Moore (1998) listed taxonomy of types of interactivity in instructional settings. These types of activities, characteristics, and examples of technologies available to deliver social and instructional interactivity are presented in the literature (Zhang & Fulford, 1994). These researchers distinguished between the definitions of interactivity at the social and instructional level. A type of "social interactivity" would be body language; this type of interactivity is generally characterized in a "real-time" or synchronous interaction. Technology that supports this type of activity is face-to-face (FTF) contact via a video camera and screen. An example of instructional interactivity would be communication of learning content that is characterized by learning goals. The type of technology that supports this type of instructional interactivity is a shared whiteboard or even electronic mail (Gilbert & Moore).

Mayer and Chandler (2001) defined "simple user interaction" in their study as the "user control over the words and pictures that are presented in the multimedia explanation" (p. 390). This "simple user interaction" is further explained as a method entailing "click here to continue" on a computer screen "button" in order to advance to the next segment. In such a situation the user has control over the pace, but not the words and pictures. This current study looked at the effectiveness of "high user interaction" that entailed more than the “simple user interaction” described by Mayer and Chandler. The participants in this present study had control over their learning by interacting actively with (a) their responses that correspond to the application, (b) access to "previous" pages for review of mathematical concepts, (c) movement of a cursor on a computer screen to highlight learning concepts, (d) retry guidance (learner is given textual guidance and allowed to try again), (e) advancement to another module, and (f) learning situations that required the student to perform a skills-based task (select the better answer to a multiple-choice type question after reviewing a basic math concept). Clark and Dwyer (1998) explained the reasons why feedback is critical in CAI. First, the feedback verifies that the learner's response was correct and second, it offers explanations to assist the learner in arriving at the correct response on the next try. This interaction may be more valuable for improving performance (Clariana, 1993).

A small descriptive study by Timpke and Janney (1981) described positive cognitive outcomes associated with the use of a CAI program consisting of three diagnostic tests. Thirty-two nursing students at a large public university in southern

California were participants in the study. Unfortunately, the authors provided very little information about the characteristics of the participants in the study. The computerized review and diagnostic tests included material on basic math review, conversions of one measurement system to another system, and medication dosage calculations. The authors set the pass rate at 100% before the student was allowed to progress to the next review session and test on the CAI. The diagnostic sections were grouped in such a manner that the computer analyzed the student's responses and provided feedback to the student and results to the instructor.

Timpke and Janney (1981) reported that as a result of the CAI, the total cohort of nursing students passed the final mastery exam in posology on the first attempt. Two semesters prior to the use of the CAI program, 11 students out of a group of 28 failed the final dosage calculation exam. Following the use of the CAI, the students' remarked that their math comprehension improved, hence they were able to focus more on studying Pharmacology. The program was praised for its convenience, privacy, and specificity. The limitation to this small study was its lack of comparison to another teaching method and information regarding the participants.

There are three other empirical studies involving the use of computers as learning tools in areas other than medication dosage calculation. These areas included pharmacology, statistics, and instructional training of nurses working in a surgical intensive care unit (SICU). The overall responses and ratings made by the participants involved in each of these studies were positive. The participants responses' to the computer learning format included such themes as usefulness; increased understanding, learning, and application of knowledge; clarity; and highly effective (Aberson et al., 1997; Aberson et al., 2000; Gee, Peterson, Martin, & Reeve,1998; Sery-Ble, Taffe, Clarke, & Dorman, 2001).

A special commissioned report, mandated by the Australian Government, indicated the need to improve medication use in the hospital and community settings within Australia. Nurses were given the directive to promote safe and effective administration of medications. Therefore, a group of researchers focused their energies in the development of a CAI in an attempt to improve undergraduate-nursing students' knowledge of clinical pharmacology and enhance their practice of safe medication administration. Fifty-four nursing students enrolled in a pharmacology course in Tasmania, Australia participated in a subjective evaluation study of a CAI program called "Pharma Cal" (Gee, et al., 1998). Results showed the CAI program was well received by the nursing students, easy to use, and the program should continued to be used in the undergraduate nursing course. In general these participants reported that the CAI increased their attentiveness to the importance of pharmacology in nursing practice and they were able to transfer knowledge obtained from the CAI to nursing practice. The majority of these nursing students rated themselves as having adequate knowledge of how to use a computer and did not feel uneasy using the program. The researchers chose the CAI method of presentation of content with the belief the program would be an interesting and creative adjunct to the pharmacology courses. These same researchers claimed that the use of CAI in nursing education is expanding gradually.

Gee and colleagues (1998) administered a questionnaire to assess the users' opinions of the CAI program and a validated multiple-choice test on pharmacology was given to 24 third-year undergraduate nursing students before and after the students used the "Pharma Cal" computer package. A control group consisting of 28 third-year undergraduate nursing students received the same pre and posttest without any exposure to the CAI program. Both groups did not participate in any other pharmacological instruction while they were involved in the study. The pharmacology test-scores significantly improved after exposure to the computer software program and were higher than the control group. Following an ANOVA, the results indicated significant differences between the two groups for both the pretest (F (4,100) = 84.9, $p < .0001$) and posttest (F (4, 77) = 66.6, $p < .0001$) scores (Gee et al., 1998). This study is not directly connected with medication dosage calculations or mathematical structures, however the CAI program demonstrated a positive affect on nursing students' knowledge of clinical pharmacology and revealed users' positive opinions of a CAI program.

Sery-Ble and associates conducted a study in 2001 involving 36 surgical intensive care unit (SICU) nurses that investigated the effectiveness of a computerized learning tool used while teaching the nurses how to use of the APACHE III medical information system. The teaching tool was a Web-based Microsoft PowerPoint presentation that included 30 slides explaining the data collection and resourcefulness of the medical system being introduced to these critical care nurses. The nurses viewed the PowerPoint presentation on computers located at the SICU nursing stations and conference room. Before they viewed the presentation they were asked to complete a pretest to gather information about their baseline knowledge of the medical information system. Directly following the presentation, the nurses were required to take a posttest. The pre and posttests contained the same items and the test questions were grouped in two categories, "methodology" and the "use of the information system." Following the posttest, the nurses were requested to fill out a questionnaire that rated their overall satisfaction with the use and intuitiveness of the online teaching tool, their computer skills, and preferences regarding classroom-based instruction versus computerized-based learning sessions (Sery-Ble et al., 2001).

The same researchers analyzed the pretest and posttest "methodology" scores and determined that the posttest mean test scores ($M = 69$, $SD = 10.0$) were significantly higher ($p < 0.001$) when compared to the pretest scores ($M = 63$, $SD = 11.5$). Limitations to the study were the small convenience sample and the researchers' failure to include the participants' previous experience with other medical information systems. Moreover, the researchers failed to have a control group, thus rendering the design of the study as non-scientific. The results of the survey completed by the participants indicated many advantages to the use of computers as teaching tools. "They provide an effective way to deliver new information, are capable of presenting information that is easily modified as technology and medical knowledge advances, allow flexibility in training schedules for healthcare professionals, and can save money in training costs" (Sery-Ble, et al., p. 83). In conclusion, the results of these three studies were encouraging and supported the need for further research on the effects of interactive multimedia learning opportunities in various disciplines.

Computer-Based User Interactivity

The creative use of a Web-based interactive tutorial to teach the central limit theorem in a statistics course was developed by researchers. Aberson et al., (2000) reported the implementation of the Web Interface for Statistics Education (WISE) project that incorporated an Internet-based tutorial to supplement the teaching of an introductory and intermediate statistics course, as well as a research methods course at two colleges. These researchers described the Internet-based interactive tutorial as a paper-based activity that guides learners through the use of an interactive applet. An applet is a small computer program that can perform interactive animations. The WISE tutorials were developed by researchers in order to allow students to actively interact with various statistical concepts and enhance their problem-solving capabilities (Berger, 2002). Students studying statistics used the interactive applet "to compare the population distribution with sampling distributions for samples of various sizes drawn from several different population distributions" (Aberson et al., p. 289).

This small descriptive study conducted by Aberson and his colleagues (2000) included 111 students (34 men and 77 women) enrolled in three sections of an introductory statistics course, one section of an intermediate statistics course, and one section of a research methodology course. These students were enrolled at a large state university (n = 73) and a large community college (n = 38). There were 12 freshmen, 28 sophomores, 29 juniors, 33 seniors, and nine graduate students. All of the students were randomly assigned to either a "lecture with demonstration group" (n = 56) or a "tutorial group" (n = 55). Aberson created the lecture and demonstration content for the lecture-based group and was involved with his colleagues in the development of the interactive tutorial used by the experimental group. Those students involved in the tutorial group went to the computer lab and worked independently on the interactive Web-based tutorial. Unfortunately, Aberson and his associates did not report the treatment time used during the study.

The interactive aspect of the tutorial was the user's manipulation of the WISE applet that was a specially designed interactive Java program. For example, the student was asked to select a box that would display "Normal, Binomial, or Uniform" in the upper left corner of the of the Java applet. This displayed box allowed the learner to actively select the type of population distribution presented in the tutorial. Assistance was given in navigating the tutorial, but they were not given any assistance with the statistical concepts presented within the online tutorial. Pre- and post-test quizzes included questions assessing the students' knowledge of calculation procedures, definitions, theory, and application of statistics. The students took the pretest immediately prior to the "tutorial" or "lecture format" treatment. In addition, the students completed the posttest directly after the lecture or tutorial intervention.

Results from Aberson's et al. (2000) study indicated that both groups learned similar amounts, and confidence intervals around improvement in scores for each group showed that both groups' scores improved significantly (tutorial group, 95% CI = 1.48 to 2.67; lecture group, 95% CI = 2.09 to 3.06). On average, the overall performance improved by 2.3 points on a 9-point quiz scale, $F(1,109) = 148.5, p < .001, \eta^2 = .58$. The mean post-test score for the tutorial group was 6.73 compared to the lecture/demonstration group's mean score of 6.79. Since there was no interaction between the pre-test and post-test quiz scores and learning condition there were no significant differences found in the amount each group improved (Aberson et al.).

The findings from the above mentioned study showed no significant differences between the online tutorial and the lecture groups' test scores. But the results of the study conducted by Aberson and his colleagues (2000) were encouraging because they showed that online instruction can be implemented as an effective supplement to classroom instruction or even as a replacement for traditional learning environments. The tutorial could be used to present material generally introduced in the classroom setting, hence allowing for more time to discuss certain topics or allow for other classroom activities. Most importantly, the student could use the Web-based program at their convenience and at their own pace, permitting a computer is available to the student. The same researchers predicted that there would be a broader acceptance of Web-based learning environments as more students are exposed to this learning medium and gain more experience working with interactive tutorials. The Pew Internet and American Life Project (2002) reported that 86% of the students attending universities in the United States have accessed the Internet, compared with 59% of the general population. Besides, 79% of college students stated the use of the Internet has had a positive impact on their overall learning.

The study conducted by Aberson and colleagues did not involve nursing students, but it was noteworthy for students studying statistics at the university level. Also, this study was important because it demonstrated that the tutorial group had similar learning outcomes as those students participating in the traditional learning environment. The interactive tutorial was not detrimental to the students' learning. Educators at the university level are busy teaching new concepts and often do not have time for remedial instruction (e.g. review of math ratios); therefore, the use of a computer-based interactive multimedia tutorial could be considered convenient and just as effective as face-to-face lecture-based instruction.

In addition, an evaluation of the WISE by 23 first-year psychology students indicated that the majority of the students reported the "tutorial was more effective in establishing the importance of data cleaning, fostering an understanding of the process of data analysis, and asking thought-provoking questions" (Aberson et al., 1997, p. 220). The tutorial was rated "easy to use," and the students stated they would like to see more tutorials developed for statistic's courses and launched via the Internet. These themes were congruent with the feedback received from the nursing students who viewed the interactive multimedia program during the pilot study conducted by this investigator during the fall 2001 academic semester at a private university. A nursing student reasoned that the tutorial was “very challenging and it made me think of all my previous math skills and put them to use. It was easy to move from one area to the next. I also enjoyed the advantage of using the computer to study" (Anonymous nursing student, personal communication, September, 12, 2001).

Mayer and Chandler (2001) conducted a study to determine the potential benefits of using "simple user interaction" within a multimedia explanation of lightning formation and examined the results of cognitive retention and transfer tests administered directly after the multimedia presentation. These researchers defined "simple user interaction" in a computer-based multimedia learning explanation as the user's physical manipulation of objects presented on a computer screen by moving the computer's cursor and clicking on buttons presented on the computer screen. Mayer and Chandler hypothesized that in order to enhance cognitive processing during learning the simple user interaction will decrease the students' cognitive load on working memory, therefore allowing the learner to better construct mental models. This premise is consistent with Sweller's (1988) cognitive load theory and a two-stage theory of mental model construction (Mayer & Chandler, 2001).

Mayer and Chandler's (2001) first experiment involved 30 college-age students at the University of Santa Barbara who lacked "high familiarity" with meteorology. These students were randomly assigned to one of two groups and received separate introductions to a multimedia presentation on lightning formation. Each presentation was 140-seconds long. The first group, known as the “WP group,” (*n* = 15) was exposed to a “whole presentation” (continuous explanation) and then to a second exposure, “part presentation,” that was a non-continuous explanation. The “part presentation” involved the learner because the student had to click a button to view 16 successive computer screen segments in order to receive the learning explanation.

The second group of students, known as the “PW group,” (*n* = 15) received the “part presentation” followed by the “whole presentation.” The authors hypothesized that when the “WP” students would view the entire learning content continuously it would allow the learners to form contexts of the learning content that could be further enhanced by the subsequent "part presentation" of the learning material. However, the “part presentation” followed by the “whole presentation” of the learning material, presented to the “PW group,” would allow the learners to stagger the learning segments first and then view a continuous explanation without interruptions. Although the PW presentation is based on the tenets of the cognitive load theory (Sweller, 1988), Mayer and Chandler hypothesized that when the "parts" presentation was illustrated first, the student could form separate elements for each important part of the learning explanation.

Review of the literature showed that despite the use of the “WP” approach there was no conclusive evidence of its effectiveness (Mayer & Chandler, 2001). Mayer and Chandler thought that the PW group should fair better then the WP group on understanding lightning formation, even though both groups were presented the identical multimedia explanations.

The results from the first experiment, conducted by Mayer and Chandler (2001) indicated that both groups demonstrated knowledge of more than 50%, on average, of the major learning concepts presented in the multimedia explanation of lightning formation. There were no significant differences between the two groups for cognitive retention of learning materials based upon results from a retention test administered directly following the multimedia presentations. However, the research question for the first experiment focused on the learner's "deep understanding" of the material presented in the multimedia productions, and the results were significant ($p < .01$) for transfer of knowledge. Moreover, these results supported the idea that a multimedia production that progresses from "part" to "whole" puts less cognitive load on working memory and allows the student to relate new material with prior knowledge. This was demonstrated by the students' improved performance on "problem-solving transfer" tests (Mayer & Chandler).

The second experiment conducted by Mayer and Chandler (2001) used the identical materials as in the first experiment, however the students received two exposures to a 140-second multimedia program on lightning formation. The participants received either two "part presentations" (PP) or two "whole presentations" (WW). The PP group consisted of 15 college students and the WW group had 14 college students. The researchers did not specify if these college students were undergraduate or graduate students, however the participants were identified as being from the Psychology Subject Pool at the University of Santa Barbara. The researchers hypothesized that the PP group would out perform the WW group on tests of problem-solving transfer based upon the theory that learners have a better chance of constructing sound mental models when their working memory is not overloaded. Mayer and Chandler's (2001) hunch proved correct since the results from the second experiment indicated that the PP group's mean "transfer" test scores ($M = 5.73$, $SD = 2.09$, $p < .01$) were superior to the WW group's test scores ($M = 3.71$, $SD = 1.49$). Once again these results are supported by Sweller's (1999) cognitive load theory. Both of these experiments, conducted by the same researchers, demonstrated how a modest amount of user interactivity can enhance deeper learning from a multimedia explanation of how a system functions. "Interactivity improved learner understanding only when it was used in a way that is consistent with how people learn (i.e. in a way that minimized cognitive load and allowed for the two-stage construction of a mental model)" (Mayer & Chandler, p. 396).

The limitations of Mayer and Chandler's (2001) work involved the limited nature of the multimedia presentations. The productions provided only a few minutes of intense instruction; therefore, longer presentations may render different results. Also the narrow type of instruction (cause-and-effect explanation) may lend different outcomes when compared to other kinds of instructional ideas. Other limitations included the immediate nature of the test (e.g. given directly following the multimedia presentation) and the context of the groups (e.g. these were students participating in a required psychology experiment). Furthermore, the retention test consisted of a single recall item and future research could include more test items. The authors suggested that future researchers consider the theory of "parts-whole presentation" of multimedia learning explanations when producing interactive tutorials.

Also, a confounding variable of this study was the "part presentation" treatment received more time overall than the "whole presentation" method of displaying learning content. Therefore the same researchers did not actually know if the positive outcomes of the "part presentation" were related to the user's control over the presentation or simply a result of the learner having more time to study the individual parts of the presentation. Mayer and Chandler (2001) encouraged future research be conducted in order to determine if slowing the rate of a presentation or adding scheduled pauses between learning segments would have a similar effect as the "part presentation" used in their study.

Based upon Mayer and Chandler's (2001) study of the effects of "simple user interaction" on the retention and transfer of learning about lightning formation this current study went beyond the use of simple user interaction and investigated the effects of "high user interactivity" on nursing students' retention of mathematical structures. Mayer and Chandler founded that by incorporating a modest amount of user interactivity learners demonstrated a deeper learning of concepts pertaining to a system based upon Sweller's cognitive load theory. This was demonstrated when both the PW and WP groups were exposed to the same amount of interactivity, and yet the PW group demonstrated deeper understanding of the concepts because the interactivity was used according to how people learn. The interactivity minimized the cognitive load and enhanced the two-stage construction of mental models or schema. In addition, the PP group demonstrated deeper understanding compared to the WW group, once again based upon the views of cognitive load theory. Supported by these empirical findings, this current study investigated the cognitive effects of students' actively responding to mathematical questions following detailed explanations in a multimedia environment.

A chemistry professor, teaching at the University of Illinois, stated that her online students learned more and retained organic chemistry models better than her 200 lecture-hall students did during one semester (Brown, 2001). In addition, the professor reported that fewer students dropped the avant-garde online course at midterm compared to previous years, and the students' test scores were considerably higher. Researchers have shown that online interactive explanations of learning content are effective, efficient, and enhance learning in the fast-paced medical environment (Bell et al., 2000). With increased access to computers in educational and workplace settings, online interactive tutorials are available, self-paced, and simple to use. These modern applications promote increased computer skills and enhance cognitive outcomes (Mayer, 2001). Furthermore, interactive tutorials provide thought provoking questions and a safe environment for students to make mistakes without the risk of a grade penalty or humiliation. The instructor can easily assess the students' mistakes and misconceptions while providing immediate feedback based upon the accuracy of the student answers. The ability to present information in multimedia formats, such as Java, Flash and Director, allow aesthetic learning formats to be presented to students.

Will high user interactivity within a multimedia explanation of mathematical content enhance undergraduate-nursing students' retention and promote deeper understanding of mathematical concepts? Mayer (2001) suggested that additional research be done on the effects of multimedia learning because such presentations encourage user interaction and exploration. The goal of this present study was to compare four methods of teaching medication dosage calculations to undergraduate nursing students at two universities. This study was unique because it looked at the effects of interactive computer-based learning outcomes for nursing students attempting to review mathematical structures in order to become more proficient in medication dosage calculations. Will the high user interactivity reduce cognitive load on their working memory and enhance a deeper understanding of mathematical concepts?

According to Ryan and associates (1999), "Higher education is moving with deliberate speed to an electronic classroom. Much has been published on faculty experiences with WWW course delivery. However little research exists on the evaluation of these methods" (p. 272). Traditionally, nursing education has taken place in the classroom and hospital setting. "The National League of Nursing (NLN) passed a resolution in 1991 that required computer technology to be a component of the educational accreditation criteria for schools of nursing across the nation" (Hebda, T., personal communication, May 18, 1999).

Nursing students' responses to Web-based education requires frequent evaluation, and the effectiveness of multimedia learning tools require further qualitative and experimental research in order to be deemed acceptable methods of instruction. Thiele, Allen, and Stucky (1999) reminded nurse educators to pay careful attention to the development of effective Web-based instruction. "As more people come to rely on Web resources as teaching tools, it is important that we consider what distinguishes effective instructional Web applications" (Romero et al., 2000, p. 246). The results of the small studies conducted and published in recent years are proof that there is a movement toward the testing of the effectiveness of education being provided via multimedia modalities launched by Internet browsers. More research regarding the effectiveness of Web-based learning explanations is needed as we move ahead in a technology rich learning environment. According to Carty and Phillip (2001) research is lacking regarding the use of computers as cognitive tools in nursing education and in health care arenas. This study added to the current body of educational research and the results showed the effectiveness of the interactive multimedia online tutorial directed at improving nursing students' mathematical and medication dosage calculation capabilities.

CHAPTER III

METHODOLOGY

The purpose of this study was to determine if a one-hour interactive multimedia online learning tool (TIAI) would serve as an effective learning method when compared with three other methods of teaching medication dosage calculations to undergraduate nursing students. The four methods of instruction were (a) text only (T); (b) text and image (TI); (c) text, image, and animation (TIA) and; (d) text, image, animation, and interactivity (TIAI). The text-based treatment is the standard method of instruction used in most schools of nursing across the United States. This conventional method of instruction can include text only or text and images combined. This chapter includes a description of the research design, the characteristics of the participants, the instruments employed in the study, the interactive multimedia treatment used in the study, methods used in data analyses, and human subject protections that were implemented during the data collection process.

The learning tool developed by the researcher, "Web Tutorial for Medication Dosage Calculation," is an interactive multimedia tool consisting of three learning modules. The modules contain mathematical learning materials, animated medication dosage explanations, and an interactive applet that the students can use to assist in their learning of medication dosage calculations. This study investigated the following questions: (a) Does the use of an interactive multimedia to present content result in greater achievement and retention when compared with text only; text and image only; or text, image, and animated only self study modules? (b) Does the use of an interactive multimedia to present content result in higher math self-efficacy mean scores when compared with text only, text and image only, or text, image, and animated only self study modules posttest and at the two-week follow-up measurement? (c) Does the use of an interactive multimedia to present content result in greater student satisfaction scores when compared with text only; text and image only; or text, image, and animated only self-study modules at the two-week follow-up measurement?

Research Design

The study was an experimental multi-factorial design using two independent variables (school and treatment) and three dependent variables (post- and follow-up treatment math test scores, post- and follow-up math self-efficacy scores, and student satisfaction). Mathematical achievement and math self-efficacy were measured one week before the treatments began and were used as covariates. The study was designed to use these covariates in a 2 X 4 analysis of covariance (ANCOVA). Because there were no suitable covariates, student satisfaction scores were analyzed by using a one-way analysis of variance (ANOVA).

Participants

Ninety-six fifth-semester baccalaureate-nursing students attending two California Universities participated in the study. The groups of students were of mixed gender, ethnically diverse, and their ages ranged from 19 to 42 years. Data collection took place at one small private university ($n = 50$) and at one large public university ($n = 46$). Both of these universities were located in large cities with culturally-diverse populations in northern California. The researcher was given permission to invite students to participate in the study by a faculty member working in each school of nursing. The convenience sample ($n = 96$) consisted of first-semester junior-nursing students enrolled at both universities. These nursing students have completed two semesters of pre-requisite course work before entering their respective nursing programs and two semesters of nursing courses (e.g. pathophysiology, pharmacology, and nursing theory) during their sophomore year.

There were 84 (87.5%) female and 12 (12.5%) male students who participated in the study. These statistics are representative of the profession as a whole, and according to the California Board of Registered Nursing Annual School Report (2000-2001) the number of female students enrolled in baccalaureate nursing programs (BSN) is 88% and the number of male students is 12%. The percentage of females and males in all entry-level nursing programs in the State of California is similar (females = 86.06% and males =13.94%). Therefore this sample of interest is a good representation of the statewide student body.

The participants recorded their age and gender on the MSES forms during the data collection process. The average age of the participants attending the private university was 21 years versus 25 years at the public university. Means and standard deviations of the participant's age are provided in Table 2. Statewide, 50% of the nursing students enrolled in BSN programs are between the ages of 18 and 25 years. However, all nursing programs in California report 37% of the students are 18 to 25-years-old (California Board of Registered Nursing Annual School Report, 2000-2001). None of the students in the current study were Registered Nurses.

Table 2
Participants' Demographic Data: Age

Gender	School	*M*	*SD*	*n*
Male	Private	20.40	.89	5
	Public	25.57	4.12	7
	Total	23.42	4.08	12
Female	Private	21.40	2.67	45
	Public	24.97	5.86	39
	Total	23.06	4.77	84
Total	Private	21.30	2.56	50
	Public	25.07	5.60	46
	Total	23.10	4.67	96

Since the state of California is known for its culturally-diverse populations, nursing schools located in California may be more diverse than other nursing programs in other states across the nation. Therefore, gender and ethnic diversity limit the generalizability of the research findings. Approximately 25% of the nursing students residing in the state of California attend a baccalaureate-nursing program versus an Associate Degree program, and this fact also may affect the generalizability of the research findings (California State Board of Registered Nursing, 2000-2001).

Protection of Human Subjects

An oral description of the study and a written informed consent form was presented to the participants during an informational meeting before the study started. The Consent to be a Research Subject Form (see Appendix G) was written according to the requirements of the Institutional Review Board for the Protection of Human Subjects (IRBPHS) at the University of San Francisco. The study received approval from the IRBPHS at the private university (see Appendix H) and received exempt status from the public State University (see Appendix I). All of the participants at both universities signed consent forms granting permission for data collection.

The students were assured that their participation was entirely voluntary and would not affect their grade or standing in their current or future classes at the university, or their employment at the university. The students were asked to write the last four digits of their social security number on all testing materials and were assured that the data collected would be kept confidential. The participants were given the opportunity to decline participation and/or withdraw from the study at any given time during the course of the research.

Treatment

The treatments used in this study focused on providing basic math review and medication dosage calculation instruction for undergraduate nursing students. There were four treatment groups in the study. All of the treatments were of one hour in duration and contained the exact same learning material. The first treatment group (T) consisted of participants independently reading and learning from three text-based mathematical modules. An example of these modules is presented in Appendix A. The text-based instrument was 24-pages long. The modules contain a review of mathematical structures, metric and apothecary measurement conversions, and medication dosage calculations.

In the second treatment group (TI), participants independently read the same modules as the first group; however, these modules were enhanced with images. An example of these modules is shown in Appendix B. The third treatment cohort (TIA) consisted of participants who viewed the same three modules as the T and TI groups. But these students viewed the three modules via a computer screen and these modules contained text, images, and animation. A screen shot of an example of these modules is presented in Appendix C. The three modules were on one page and the participants scrolled down as they viewed the information provided on the computer screen. These participants were physically separated from the fourth group. The fourth treatment group (TIAI) also viewed three mathematical online learning modules via a computer screen, but the multimedia learning modules consisted of text, image, animation, and interactivity. A screen shot of these modules is shown in Appendix D. The tutorial consists of three interactive multimedia modules and can be viewed at http://maagnursing.com/MedCal using Internet Explorer as a browser. At the beginning of each module the student had access to specific learning objectives. Each interactive module builds upon previous learning material and contains interactive review questions following the introduction of each mathematical or medication dosage calculation concept. The student must answer the review questions before advancing to the next page of the tutorial. Immediate cognitive feedback is given to the student once the student answers a review question.

The interactive multimedia-learning tool encourages the student to interact with the learning content and actively solve mathematical problems and practice medication dosage calculations. The high-user interaction includes moving the computer cursor over various images to obtain information, clicking on a particular item on the computer's screen, and typing in answers to a mathematical problem. In addition, the user can click on "next page" at the bottom of the page following the review of the section and this allows the user to move forward to the next screen once they have answered the question correctly. Screen shots of these examples are provided in Appendixes D, E, and F. The computer lets the user to advance to the next segment and waits until the user's next click of the mouse. This enables the user to have control over the pace of the presentation and his or her learning. In order to track the students' time of completion of each treatment, the students were asked to write down the page number and time-on-task at the one-hour completion point.

Instrumentation

The instruments implemented in this study were three criterion-based tests involving basic math problems and medication dosage calculations, the MSES, and an eight-item Likert-type student satisfaction survey. A description of each instrument is provided below.

Mathematical Achievement

The researcher constructed three tests in order to determine the participants' mathematical abilities. The textbook, *Clinical Calculations* (Kee & Marshall, 2000), was referenced during the construction of the math tests. These tests are presented in Appendixes J, K, and L. Each test consists of 25 multiple-choice questions of essentially identical difficulty. Eleven of the 25 questions pertain to the multiplication and division of fractions and decimals, conversion of percentages to fractions and ratios, and conversion of metric and household systems problems. These tests were determined by the researcher to be of similar difficulty as the "Bindler-Bayne Mathematics Test for Nursing." Samples of similar test questions are shown in Table 3. Bindler and Bayne (1984) reported that 91.6% of the students ($n = 548$) in their study were able to achieve a 70% or higher score on the math test they developed.

Table 3
Math Test Problem Comparisons

Bindler and Bayne Mathematics Test	Medication Dosage Calculation (Test A)
Section III: Problem 8	Problem 1
1/8 x 3/4	1/4 x 4/5
Section II: Problem 8	Problem 4
613 ÷ 13	70 ÷ 4.5
(Carry out to hundredths and reduce to tenths)	(Round to the nearest tenth)
Section III: Problem 20	Problem 7
Write 1/5% as a fraction	Convert 0.45% to a ratio
Section VI: Problem 10	Problem 12
A child is being given Tempra syrup for a fever. The syrup contains 2 grains of drug in 5 milliliters. In order to administer the required dose of 3 grains, the mother will need to give the child_____milliliters of Tempra syrup.	A physician's order is to administer 0.2 oz. of liquid Tylenol every 4-6 hrs. for a temperature greater than 101.5 F. The nurse has a measuring cup in mL calibrations. How many milliliters will the nurse administer to the client? (1 oz = 30mL)

Note. Permission to copy test questions received from Bindler and Bayne (1983).

Each medication dosage calculation test, developed by the researcher, contains different mathematical questions, but the tests were constructed in a parallel manner by the researcher to measure similar skills. This was accomplished by using different numerical values while maintaining the same mathematical problem from the previous test design. The algebraic math portion of the examination includes (a) problems of multiplication and division of fractions; (b) conversion of percentages to decimals and ratios; and (c) conversion of metric, apothecary, and household systems of measurement. The medication dosage calculation part of the examination includes questions about oral, parenteral and intravenous medication calculations. Three nurse educators from two universities, as well as a math expert teaching in a university setting, determined the content validity of the medication dosage calculation tests and concluded the tests to be valid based upon content matter. Calculators were not allowed during the testing in order to assess students' abilities to conceptualize and perform simple mathematical questions.

The math tests were graded by the researcher following each phase of the data collection process. Each test question was worth one point and the total score was calculated on the number of questions answered correctly. The mean test scores were based on 24 math-test items (instead of 25 items) due to an invalid test question (number 24) on the follow-up treatment math test. In order to maintain direct comparability between the three math tests, question 24 on all tests were eliminated from the data analyses.

The test-retest reliability coefficient (coefficient of stability) was measured by performing a Pearson product-moment correlation. Rank orders were preserved from one testing period to another indicating stability over a period of time. The values for the reliability coefficient ranged from .77 to .82 (all significant at the .05 level) indicating satisfactory reliability. According to Huck and Cormier (1996) an instrument is considered to be better if the reliability coefficient result is closer to the upper limit of the final scale of 0.00 and +1.00. The Kuder-Richardson Formula 20 reliabilities were relatively high and ranged from .78 for pre-treatment math test, .79 for post-treatment math test, and .80 for follow-up treatment math test.

Mathematics Self-Efficacy Scale

The Math Self-Efficacy Scale developed by Betz and Hackett (1993), measured students' mathematical self-efficacy and a sample of the questions are shown in Appendix M. This tool is based on Bandura's (1997) concept of self-efficacy expectations and was initially developed to measure a population of undergraduate college students' mathematical self-efficacy. The current version of the MSES (1993) was developed to be used in research and counseling situations. The 34-item Likert-type measure includes two subscales that assess confidence in successfully accomplishing math-related tasks and math-related school subjects. For example, the items written for the "Mathematics Task Self-Efficacy" (SE1) of the MSES (18 items) were taken from "Dowling's Mathematics Confidence Scale." These items represent mathematical comprehension, computational ability, and application of mathematical principles. The "Math-Related School Subjects Self-Efficacy" (SE2) of the MSES (16 items) requests students to report their confidence level in receiving a letter grade of an "A" or "B" in college mathematical coursework. Betz and Hackett (1983) reported an overall coefficient alpha of .96 on a sample of 262. The "Mathematics Task Self-Efficacy," consisting of "math tasks" (coefficient alpha = .92) and "math problems" (coefficient alpha = .96). The "Math-Related School Subjects Self-Efficacy" coefficient alpha was .92.

Two questions (question one and five) pertaining to math problems were eliminated from math SE1 by the researcher because the participants in this study rated such high confidence in completing these everyday tasks. An internal consistency estimate of reliability was calculated for math SE1 (after eliminating question one and five) and math SE2 by using the coefficient alpha. These coefficients ranged from .92 to .95 for SE 1 (median = .94) and from .94 to .95 for SE 2 (median = .94) based on the 96 participants in this study. The coefficient alpha for the whole MSES was .94. These results are similar to those reported by Betz and Hackett (1983) and indicated high reliability.

A Pearson product-moment correlation was computed between math SE1 and math SE2 in order to determine the correlation between the set of scores obtained in this study. The MSES was intentionally divided into two parts for the purpose of looking at the students' beliefs about their ability to successfully complete everyday math problems and to look at the students' confidence level in completing college level math courses with an above average grade.

Each item on the 34-item MSES requires the respondent to specify their level of confidence on a 10-point scale from No Confidence at All to Complete Confidence (Betz & Hackett, 1993). Final self-efficacy scale scores represent average item scores and range between zero and nine. There are three scores affiliated with the MSES: (a) a Mathematics Task Self-Efficacy score (SE1), (b) a Math-Related School Subjects Self-Efficacy score, and (c) a Total Mathematics Self-Efficacy Scale score. Since this study was focused primarily on nursing students' math-computational skills, the researcher decided to use the students' math SE1 scores during data analyses (pre-, post- and follow-up treatment).

Student Satisfaction Survey

An eight-item Likert-type satisfaction survey was created by the researcher. This instrument measured participants' satisfaction with the instructional method they received during the study and the survey is shown in Appendix N. The participants were asked to rate aspects of the learning modules on a scale of 1 to 5 (one equaling "strongly disagree" and five equaling "strongly agree"). Average item scores were obtained. Coefficient alpha was .95 based on the 93 participants in the study. A professor teaching in a school of education at one university reviewed the Student Satisfaction Survey for content validity and concluded the survey to be valid based upon content matter.

Procedures

Pilot Study

Following Institutional Review Board for the Protection of Human Subjects (IRBPHS #01-085) approval, semester-five nursing students (*n* = 37) at a private university were invited to participate in a pilot study during the fall 2001 academic semester. Permission to access the prospective participants was obtained from a professor teaching in the School of Nursing. The professor allowed the study to be conducted during the last hour of two of her regularly scheduled class times. The purpose and background of the pilot study was explained to the students by the researcher. Copies of the informed consent form and the Research Subjects' Bill of Rights were given to the prospective participants on August 29, 2001.

On September 5, 2001 the research participants were randomly assigned to two groups following the collection of their informed consent forms. The first group (*n* = 17) was escorted to an on-campus computer lab and these students were given access to the computer-based interactive multimedia learning explanation by the researcher. Participants viewed the interactive multimedia tutorial at independent workstations in a computer lab setting. The researcher stayed with the participants and answered students' questions as necessary. The second group (*n* = 20) stayed in the classroom setting and took the medication dosage calculation tests. There were two parallel versions of the 27-item test named "Test A" and "Test B." The first test given was Test A (*n* = 20) and then the professor of the course gave Test B (*n* = 19) to the students directly (within 2 minutes) after Test A. The professor reported that the participants were able to complete each test during a 30-minute time frame; however, many of the Scantron sheets indicated that the participants did not complete the last five questions. The mean test score for Test A was 14.88 (*SD* = 3.99) and for Test B was 12.21 (*SD* = 3.18).

On September 12, 2001 the researcher returned to the same classroom and escorted the research participants (*n* = 20) who took the medication dosage calculation tests the previous week to an on-campus computer lab. Once again, participants worked at independent workstations in the computer lab and viewed the interactive multimedia online tutorial. The students who viewed the interactive online multimedia tutorial the previous week stayed in their classroom and took Test B (*n* = 15) and then Test A (*n* = 15) while the student's professor proctored the test environment. This was done in order to reverse the order the tests were given the previous week. The mean test score for Test A was 16.81 (*SD* = 3.36) and for Test B it was 12.26 (*SD* = 3.10). Each test consisted of 27 multiple-choice questions. Once the students finished viewing the online interactive multimedia tutorial, students in each group returned anonymous comment forms regarding the interactive treatment to the researcher.

The researcher analyzed the quantitative and qualitative data obtained from the pilot study. The test results were reviewed and specific changes were made based on content analysis. Some of the questions were not answered on the tests even though the professor proctoring the students during the test period claimed the students had sufficient time (30 minutes for each test) to complete the tests. The last two items were deleted from each test because they required the participants to respond to fill-in-the-blank questions at the end of the test. The researcher realized that these questions did not pertain to math problem solving or medication dosage calculations and determined they would not be used in the actual study.

The qualitative results obtained from the students' feedback on the comment forms were informative and the general feedback assisted the researcher in making necessary changes in the multimedia interactive tutorial before the research started in the fall 2002. Typical students' responses to the question, "What did you like best about the online tutorial?" were "Very animated and helpful hints on how to solve the problems," "The program will not let me go on until I get the correct answer," "Giving us the conversions and the way to do the calculations step-by-step," and "It started with the basics and gradually got more difficult (Anonymous students, personal communication, September 5, 2001). Some of the student responses to the question, "What did you like the least about the online tutorial?" were "It was very strict on the decimal points, it would say that it was wrong if I had .8 instead of 0.8. Also, the label part...I just gave up;" "Getting stuck on a problem and not knowing what to do. For instance if I was unable to answer a question correctly, I would try over and over and still not get it correct;" "Reading the long introductions, but I guess there is really no getting around that" (Anonymous students, personal communication, September 5, 2001).

Based upon the qualitative data received from the students participating in the pilot study and observations made over the months of review, the following aspects of the interactive multimedia learning explanation were changed before the research started. First, the technical errors throughout the tutorial were corrected and hints on how to solve certain problems were provided. Second, the interpretation of the drug labels was eliminated from the math tests because this exercise did not pertain to the solution of mathematical structures or medication dosage calculations. In addition, there was more animation added to the three modules. These changes were made over the course of the summer of 2002 in order that the treatment would be ready for the proposed study in the fall of 2002.

Current Study

An adult-health professor at each School of Nursing at the two universities was contacted regarding this research study. Permission to conduct research during the professor's weekly course at the private and public university was obtained through letters of support. These letters are provided in Appendixes O and P. The participants in this study were given verbal and written information about the research following approval from the IRBPHS at each university. Participation in this research was purely voluntary and the outcomes of the study were not used in the grading process. The participants in this study had received previous instruction on medication dosage calculations during past academic courses; however, IV drip-calculations were a new concept introduced to these participants during the beginning of their junior-one semester in nursing school.

During the first class meeting, the participants were given the MSES (Betz & Hackett, 1993) first and then the 25-item pre-treatment math test. On average the participants completed the MSES in five minutes. The students were allowed 40 minutes to complete all math tests given during the study, and the majority of the students took the full 40 minutes to complete the pre-treatment math test.

One week later, the students who volunteered to participate in the study were randomly assigned to one of four treatment groups. The random assignment was accomplished by giving the students an index card that was labeled with the letter "A, B, C, or D," as they entered the classroom. Group A read three text-based (T) mathematical explanation modules in a classroom setting, and were physically separated from other participants. Group B read three text- and image-based (TI) mathematical explanation modules in a classroom setting (separate from Group A). Group C viewed three-multimedia mathematical explanation modules that included text, image, and animation (TIA) in a university computer lab. Group D used the interactive multimedia-learning tool (TIAI) in a university computer lab. The private university participants were escorted from their classroom to a university computer lab, however the participants enrolled in the public university were given maps of the university in order to locate the computer labs on campus.

Each group was given one hour to complete the instructional treatment and the amount of time required to complete the treatments was recorded for each participant. Directly following each treatment, the participants were administered the MSES and then within 2 or 3-minutes time a post-treatment math test was administered to each student. Research assistants were present during the procedures to answer any participants' questions.

The third phase of the data collection process occurred two weeks following the treatment phase at each university. The researcher returned to the classroom and administered the MSES, and a follow-up treatment math test was administered within 1 or 2 minutes following the completion of the MSES. Directly following the follow-up treatment math test the students completed a Student Satisfaction Survey. Ninety-six students completed the three MSESs and math achievement tests. Three students chose not to complete the satisfaction survey; therefore, the satisfaction survey results were analyzed based on 93 instead of 96 students' responses.

The introduction to the study, administration of the MSES, and pre-treatment math test took approximately 60 minutes of class time. The treatments, post MSES, and post-treatment math test took approximately 1 hour and 45 minutes. The subjects were given 1 hour to complete the treatment and on average each student completed their assigned treatment within 1 hour. The treatment and test times were time stamped for each participant by asking the students to record their start and stop time for the tests and treatments. The administration of the follow-up treatment MSES, math test, and Student Satisfaction Survey two weeks following the treatment took approximately 40 minutes or less. Therefore the total testing and treatment time took approximately three and a-half-hours.

CHAPTER IV

RESULTS

The results of the study are presented in four sections: pre-treatment math achievement and self-efficacy, post-treatment math achievement and self-efficacy, follow-up treatment math achievement and self-efficacy, and student satisfaction survey results. The data was analyzed in three ways. First, descriptive statistics were computed for the five dependent variables (post-, follow-up treatment math test and self-efficacy scores, and student satisfaction scores). Second, a one-way analysis of covariance (ANCOVA) was carried out for the main effect (treatment) and the covariates (pre-treatment math test and math self-efficacy results) on the dependent variables (post-, and follow-up treatment math achievement and self-efficacy and student satisfaction). Third, a one-way analysis of variance (ANOVA) was done to determine overall significance of the outcome variable, student satisfaction scores. The level of significance was set at $p \leq .05$.

Descriptive Statistics

An overview of the descriptive statistics obtained from the pre-, post-, and follow-up treatment math tests and self-efficacy, as well as student satisfaction survey results are presented in Table 4 as an introduction to the more detailed analyses of the results in the subsequent sections. The results show that the math test and math self-efficacy scores did not increase significantly over the course of the study.

Table 4
Results Overview

Variables	*M*	*SD*
Math pre-	16.56	4.04
post-	17.43	3.81
follow-up-	18.35	3.98
SE 1 pre-	6.27	1.37
post-	6.29	1.46
follow-up-	6.57	1.37
Student Satisfaction	3.57	0.99

Note. Math total score = 24. SE1 total score = 9. Student Satisfaction total score = 5. *n* = 96 for Math and SE1 and 93 for Student satisfaction.

Pre-Treatment Results

Math Achievement

The means and standard deviations for pre-treatment math-test scores as a function of the treatment groups and universities are presented in Table 5.

Table 5
Mean Pre-Treatment Math-Test Scores

Treatment Group	Private University			State University			Total		
	M	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
T	13.50	4.13	14	18.40	3.31	10	15.54	4.47	24
TI	17.85	4.24	13	17.08	3.71	13	17.46	3.92	26
TIA	17.36	4.11	11	15.22	3.93	9	16.40	4.07	20
TIAI	17.50	3.66	12	16.07	3.77	14	16.73	3.72	26
Total	16.44	4.34	50	16.70	3.73	46	16.56	4.04	96

Note. T=Text; TI=Text & Image; TIA=Text, Image & Animation; TIAI=Text, Image, Animation & Interactivity. Maximum total score = 24.

The students attending the private (*n* = 50) and public (*n* = 46) university demonstrated similar mean pre-treatment math-test scores (number correct out of 24 questions) of 16.40 (*SD* = 4.34) and 16.70 (*SD* = 3.73) respectively. The mean test score for the Text (T) treatment group (*n* = 14) at the private university was 13.50 (*SD* = 4.13). These students had the lowest mean test score when compared with the other groups at both universities, but the students (n = 10) learning from the same method at the public university demonstrated the highest mean score of 18.40 (SD = 3.31).

An independent-samples t test was carried out to determine if mean pre-treatment math-test scores differed significantly between universities. The differences were insignificant (t = -.31, p =.76). These results illustrated no significant mean pre-treatment math-test score difference between the two universities, therefore the researcher decided to combine the two samples of students before conducting further data analyses.

Math Self-Efficacy

The means and standard deviations for the pre-treatment math SE 1 scores as an outcome of the treatment groups and universities are illustrated in Table 6.

Table 6
Mean Pre-Treatment Math SE1 Scores

Treatment Group	Private University			State University			Total		
	M	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
T	6.23	1.14	14	6.40	1.28	10	6.30	1.17	24
TI	7.04	1.32	13	5.51	1.24	13	6.28	1.48	26
TIA	6.11	1.24	11	6.29	1.94	9	6.19	1.55	20
TIAI	6.19	1.60	12	6.38	1.14	14	6.29	1.35	26
Total	6.41	1.35	50	6.13	1.39	46	6.27	1.37	96

Note. T=Text; TI=Text & Image; TIA=Text, Image & Animation; TIAI=Text, Image, Animation & Interactivity. Maximum total score = 9.

Students participating in the Text and Image (TI) group (n = 13) at the state university reported the lowest mean pre-treatment math SE 1 score (M = 5.51, SD = 1.24) indicating some confidence in completing every day math tasks and problems, but the students assigned to the TI (n = 13) group at the private university demonstrated the highest mean pre-treatment math SE 1 score (M = 7.04, SD = 1.32) indicating much confidence in completing math related tasks and behaviors on a routine basis. The results showed that the lowest reported pre-treatment math SE1 score was 3.0 and the highest score was 9.0. The majority of the students reported a pre-treatment math SE1 score of between 5.50 and 7.00, with a mean score of 6.27 (*SD* = 1.37), therefore indicating that the students at both universities had a moderate belief in their ability to complete the math tasks listed in the measure before the study started.

An independent-samples *t* test was computed to determine if mean pre-treatment math SE 1 scores differed between universities. The differences were insignificant ($t = 1.00, p = .32$). These results illustrated no significant mean pre-treatment math SE 1 score differences between the two universities, therefore the researcher decided to combine the two samples of students before conducting further data analyses.

Post-Treatment Results

Math Achievement

The means and standard deviations for the post-treatment math-test scores as an outcome of the treatment groups are presented in Table 7.

Table 7
Mean Post-Treatment Math-Test Scores

Treatment Group	Total		
	M	*SD*	*n*
T	17.25	3.50	24
TI	17.31	4.61	26
TIA	18.00	3.63	20
TIAI	17.27	3.48	26
Total	17.43	3.81	96

Note. T=Text; TI=Text & Image; TIA=Text, Image & Animation; TIAI=Text, Image, Animation & Interactivity. Maximum total score = 24.

A one-way analysis of covariance (ANCOVA) was computed to determine if the use of an interactive multimedia learning explanation would result in greater post-treatment math achievement scores when compared with text only, text and image only, or text, image, and animated only self-study modules. The independent variable, treatment, included four levels: text, text and image, text, image and animation, and text, image, animation and interactivity. The dependent variable was the post-treatment math-test scores, and the covariates were pre-treatment math-test results and pre-treatment math SE1 scores. The homogeneity of regression slope assumption for ANCOVA was tested for both covariates: pre-treatment math, $F(3, 88) = 2.49, p = .07$; and pre-treatment math SE1, $F(3, 88) = 1.67, p = .18$. The slope of each of the four levels of the independent variable was homogenous enough, both for pre-treatment math and math self-efficacy. Therefore, the assumption of homogeneity of slopes was met and a one-way ANCOVA was computed. The ANCOVA was non-significant except for the pre-treatment math test covariate ($p = .00$) and the results are shown in Table 8.

Table 8
Analysis of Covariance: Post-Treatment Math-Test Scores

Source of Variation	*SS*	*df*	*MS*	*F*	*Sig.*	η^2
Pre-SE 1	9.08	1	9.08	1.20	.28	.01
Pre-Math	617.30	1	617.30	81.34	*.00	.48
Treatment	29.71	3	9.90	1.31	.28	.04
Error	681.34	90	7.57			
Total	1357.49	95				

*p < .05

Green and Salkind (2003) stated the general ranges for small, medium, and large values for a partial η^2 are .01, .06, and .14 in that order. As determined by eta squared, the strength of the relationship between the treatment factor (between subjects) and the dependent variable was weak ($\eta^2 = .04$). The treatment factor accounted for 4% of the variance of the dependent variable while keeping the pre-treatment math SE1 and pre-treatment math-test scores constant. The relationship of the covariate, pre-treatment math-test scores, and the dependent variable was strong ($\eta^2 = .48$). These empirical results showed that 48% of the variability among post-treatment math-test scores could be accounted for by the covariate data. But the strength of the relationship between the pre-treatment math SE1 scores and dependent variable was very weak ($\eta^2 = .01$), with the covariate scores accounting for 1% of the variance on the dependent variable. Moreover, the results of the one-way ANCOVA do not support the hypothesis that the interactive multimedia learning explanation resulted in greater mean math achievement scores, and the results showed that the null hypothesis $M_{postmath}\text{T} = M_{postmath}\text{TI} = M_{postmath}\text{TIA} = M_{postmath}\text{TIAI}$ should not be rejected.

Math Self-Efficacy

The means and standard deviations for the post-treatment math SE1 are provided in Table 9.

Table 9
Mean Post-Treatment Math SE1 Scores

Treatment Group	Total		
	M	*SD*	*n*
T	6.33	1.41	24
TI	6.32	1.33	26
TIA	6.48	1.33	20
TIAI	6.59	1.52	26
Total	6.29	1.46	96

Note. T=Text; TI=Text & Image; TIA=Text, Image & Animation; TIAI=Text, Image, Animation & Interactivity. Maximum total score = 9.

A one-way analysis of covariance (ANCOVA) was computed to determine if the use of an interactive multimedia learning explanation would result in higher math-self efficacy scores when compared with text only, text and image only, or text, image, and animated only self-study modules. The independent variable, treatment, included four levels: text; text and image; text, image and animation; and text, image, animation and interactivity. The dependent variable was the post-treatment math SE1 scores, and the covariates were pre-treatment math-test results and pre-treatment math SE 1 scores. The homogeneity of regression slope assumption for ANCOVA was tested and a non-significant interaction between the pre-treatment math-test covariate and the factor was determined, $F(3, 88) = .30, p = .84$. The same analysis was computed for the pre-treatment math SE1 covariate and a significant interaction between this covariate and the factor was found, $F(3, 88) = 3.83, p = .01$. A one-way ANCOVA was computed using pre-treatment math test scores as a covariate and the results were non-significant. The results are shown in Table 10.

Table 10

Analysis of Covariance: Post-Treatment Math SE1 Scores

Source of Variation	*SS*	*df*	*MS*	*F*	*Sig.*	η^2
Pre-Math	1.77	1	1.77	.80	.40	.01
Treatment	1.96	3	.65	.30	.83	.01
Error	201.18	91	16.30			
Total	204.83	95				

The strength of the relationship between the treatment factor (between subjects) and the dependent variable was very weak, as determined by eta squared, with the treatment accounting for 1% of the variance of the dependent variable while keeping the pre-treatment math-test scores constant. The relationship of the covariate, pre-treatment math-test scores, and the dependent variable was very weak ($\eta^2 = .01$). The results showed that 1% of the variability among post-treatment math SE1 scores were accounted for by the covariate data. Since the pre-treatment math SE1 covariate was deemed not possible, assuming homogeneity of slopes, a one-way ANOVA to compare treatment group effects on the dependent variable was computed. The ANOVA was not significant, F (3, 92) = .30, p = .84, MSE = 2.21, η^2 = .01. Therefore, the results of the one-way ANCOVA and ANOVA do not support the hypothesis that the interactive multimedia learning explanation resulted in greater mean math SE1 scores, and the results showed that the null hypothesis $M_{post\text{SE1}}\text{T} = M_{post\text{SE1}}\text{TI} = M_{post\text{SE1}}\text{TIA} = M_{post\text{SE1}}\text{TIAI}$ should not be rejected.

Follow-Up Treatment Results

Math Achievement

The means and standard deviations for the follow-up treatment math-test scores as a function of the treatment groups are presented in Table 11.

Table 11
Mean Follow-Up Treatment Math-Test Scores

Treatment Group	Total		
	M	*SD*	*n*
T	19.08	3.69	24
TI	18.88	4.23	26
TIA	17.80	4.52	20
TIAI	17.57	3.52	26
Total	18.35	3.62	96

Note. T=Text; TI=Text & Image; TIA=Text, Image & Animation; TIAI=Text, Image, Animation & Interactivity. Maximum total score = 24.

A one-way analysis of covariance (ANCOVA) was computed to determine if the use of an interactive multimedia learning explanation would result in greater follow-up treatment math-test scores when compared with text only, text and image only, or text, image, and animated only self-study modules. The first independent variable, treatment, included four levels: text, text and image, text, image and animation, and text, image, animation and interactivity. The dependent variable was the follow-up treatment math-test scores, and the covariates were the pre-treatment math-test results and pre-treatment math

SE1 results. The homogeneity of regression slope assumption for ANCOVA was tested for both covariates: pre-treatment math, $F(3, 88) = 2.11$, $MSE = 9.03$, $p = .11$, and pre-treatment math SE1, $F(3, 88) = .42$, $MSE = 16.16$, $p = .74$. The slope of each of the four independent variables was homogenous enough, both for pre-treatment math and math self-efficacy. Therefore, the assumption of homogeneity of slopes was met and a one-way ANCOVA was computed. There The ANCOVA was not significant except for pre-treatment math test covariate ($p = .00$) and the results are shown in Table 12.

Table 12
Analysis of Covariance: Follow-Up Treatment Math-Test Scores

Source of Variation	*SS*	*df*	*MS*	*F*	*Sig.*	η^2
Pre-SE 1	.58	1	.58	.06	.81	.00
Pre-Math	592.02	1	592.02	62.58	*.00	.41
Treatment	69.56	3	23.19	2.45	.07	.08
Error	851.45	90	9.46			
Total	1503.96	95				

*p <.05

The strength of the relationship between the treatment factor (between subjects) and the dependent variable was moderate ($\eta^2 = .08$) with the treatment factor accounting for 8% of the variance on the dependent variable, while keeping the pre-treatment math SE1 and pre-treatment math-test scores constant. The relationship of the covariate, pre-treatment math-test scores, and the dependent variable was strong ($\eta^2 = .41$), thereby indicating that 41% of the variance on the dependent variable was due to the students' pre-treatment math-test scores. But the strength of the relationship between the pre-treatment math SE1 scores and the dependent variable was very weak ($\eta^2 = .00$) with the pre-SE1 scores accounting for 0% of the variance on the dependent variable. Moreover, the results of the one-way ANCOVA do not support the hypothesis that the interactive multimedia learning explanation resulted in greater post-treatment mean math achievement scores, and the results showed that the null hypothesis $M_{f\text{-}u\ math}$T=$M_{f\text{-}u\ math}$TI=$M_{f\text{-}u\ math}$TIA=$M_{f\text{-}u\ math}$TIAI should not be rejected.

Math Self-Efficacy

The means and standard deviations for the follow-up treatment math SE 1 scores are provided in Table 13.

Table 13
Mean Follow-Up Treatment Math SE1 Scores

Treatment Group	Total		
	M	*SD*	*n*
T	6.67	1.40	24
TI	6.43	1.32	26
TIA	6.90	1.26	20
TIAI	6.36	1.52	26
Total	6.57	1.37	96

Note. T=Text; TI=Text & Image; TIA=Text, Image & Animation; TIAI=Text, Image, Animation & Interactivity. Maximum total score = 9.

A one-way analysis of covariance (ANCOVA) was computed to determine if the use of an interactive multimedia learning explanation would result in higher follow-up treatment math-self efficacy scores when compared with text only, text and image only, or text, image, and animated only self-study modules. The independent variable, treatment, included four levels: text; text and image; text, image and animation; and text, image, animation and interactivity. The dependent variable was the follow-up treatment math SE 1 scores, and the covariates were the pre-treatment math-test results and pre-treatment math SE 1 scores. The homogeneity of regression slope assumption for ANCOVA was tested and a non-significant interaction between the pre-treatment math test covariate and the factor was determined, $F(3, 88) = .30, p = .83, \eta^2 = .01$. The same analysis was computed for the pre-treatment math SE1 covariate and a non-significant interaction between this covariate and the factor was found, F (3, 88) = 1.50, p = .22, η^2 = .05. Assuming homogeneity of slopes an ANCOVA was computed, but the findings were non-significant except for pre-treatment math SE1 (p = .00). The results are shown in Table 14.

Table 14
Analysis of Covariance: Follow-Up Treatment Math SE1 Scores

Source of Variation	*SS*	*df*	*MS*	*F*	*Sig.*	η^2
Pre-SE1	106.62	1	106.62	143.31	*.00	.61
Pre-Math	.01	1	.01	.01	.91	.00
Treatment	4.77	3	1.60	2.14	.10	.07
Error	201.18	91	16.30			
Total	204.83	95				

*p < .05

The strength of the relationship between the treatment factor (between subjects) and dependent variable was moderate (η^2 = .07) with the treatment accounting for 7% of the variance of the dependent variable while keeping the pre-treatment math-test and SE1 scores constant. The results showed that 61% of the variability among follow-up treatment math SE 1 scores could be accounted for by the pre-treatment math SE1 covariate data collected in the study. However, the relationship between the pre-treatment math-test covariate and the dependent variable was very weak (η^2 = .00). This result indicated that the pre-treatment math-test scores were not a good predictor of the students' scores on the follow-up math SE1 scale. Furthermore, the results of the ANCOVA do not support the hypothesis that the interactive multimedia learning explanation resulted in greater mean math self-efficacy scores, and the results showed that the null hypothesis $M_{f\text{-}u\mathrm{SE1}}$T=$M_{f\text{-}u\mathrm{SE1}}$ TI= $M_{f\text{-}u\mathrm{SE1}}$ TIA=$M_{f\text{-}u\mathrm{SE1}}$ should not be rejected.

Bivariate Correlations

A Pearson product-correlation coefficient was computed between the three math tests and the three math self-efficacy scale results. The pre-math SE1 correlated with pre-and post-treatment math tests ($r = .20$ to $.22, p <. 05$) demonstrating a significant correlation. The post-treatment math SE1 correlated with the post-treatment math test ($r = .28, p <. 01$). Also, the follow-up treatment math SE 1 correlated significantly with the post-treatment math-test results ($r = .31, p <. 00$). The correlations of math self-efficacy with math achievement were significant for 4 out of the 9 correlations. In this study, math self-efficacy was in general a good predictor of math achievement.

Student Satisfaction Survey

The means and standard deviations for the students' satisfaction scores are provided in Table 15.

Table 15
Students' Satisfaction Survey Scores

Treatment Group	Total		
	M	*SD*	*n*
T	3.53	1.09	24
TI	3.42	0.94	26
TIA	3.52	1.05	19
TIAI	3.83	0.89	24
Total	3.58	1.00	93

Note. T=Text; TI=Text & Image; TIA=Text, Image & Animation; TIAI=Text, Image, Animation & Interactivity. Maximum total score = 5.

The results indicated that the highest mean score of 3.83 ($SD = .89$) was reported by the students participating in the Text, Image, Animation and Interactivity (TIAI) method of instruction, indicating a moderately high satisfaction with the method of delivering the learning material. In order to determine if the interactive multimedia-learning tool used by the students in the TIAI group yielded significantly higher student satisfaction scores a one-way ANOVA to establish overall significance was computed. The independent variable, treatment, included four levels: text, text and image, text, image and animation, and text, image, animation and interactivity. The outcome variable was student-satisfaction scores. The ANOVA was non-significant, $F(3, 89) = .76$, $MSE = .99$, $p = .52$. Based upon the fact that ANOVA tests only display differences between group means, an effect size was calculated and the result was .30. According to Cohen (Huck & Cormier, 1996), this is a small effect size. In order to explore further, post hoc comparisons were made with Tukey's procedure. This analysis compared the TIAI group satisfaction scores against the three other treatment groups' scores combined. The results of the ANOVA were tested at the .05 level and no significant findings were found ($t = 1.43$, $p = .15$) for student satisfaction scores.

Because the sample size was limited, it might be beneficial to reassess the students' satisfaction in future studies in order to determine statistical significance versus practical significance. Furthermore, it would be helpful to find out why the students in the TIAI group rated their experience higher than the TIA group. Both of those groups were computer-based in nature, however the TIAI group expressed a bit higher satisfaction.

Summary

The purpose of the study was to determine the effectiveness of a one-hour interactive multimedia-learning tool on nursing students' post- and follow-up treatment math test results, students' post- and follow-up treatment math SE1 scores and student satisfaction scores at two universities in northern California. In an attempt to answer the first research question the researcher conducted descriptive statistics and a one-way ANCOVA using one independent variable: treatment (four levels). The dependent variables were the students' post- and follow-up treatment math test scores. The covariates used throughout the analyses were the students' pre-treatment math-test scores and students' pre-treatment math SE1 scores. The ANCOVA results indicated that the students' pre-math test results were statistically significant, however the treatment factors' results were not significant. The math test results indicated that a trend for improvement of mean test scores over the course of the study was most notable for the Text group, however the results were not significant. These results are particularly driven by the private university students' (T) low mean test score on the pre-treatment math test (M = 13.50, SD = 4.13) and the public university students' (T) high mean test score on the follow-up treatment math test (M = 20.04, SD = 3.13). The null hypothesis for the first research question was: $M_{postmath}$ T = $M_{postmath}$ TI = $M_{postmath}$ TIA = $M_{postmath}$ TIAI and $M_{f\text{-}u\ math}$T=$M_{f\text{-}u\ math}$TI=$M_{f\text{-}u\ math}$TIA=$M_{f\text{-}u\ math}$TIAI. The calculated results indicated that the researcher was unable to reject the null hypotheses at this time.

Descriptive statistics and a one-way ANCOVA were conducted in an effort to answer the second research question posed in the study. The researcher was interested in finding out what the participants' math self-efficacy scores were post- and follow-up treatments because it was expected that the math SE1 scores would increase following the treatment and at the completion of the study. A one-way ANCOVA was computed by using one independent variable: treatment (four levels). The dependent variable was the students' post- and follow-up math SE1 scores. The covariate data were pre-treatment math SE1 and math achievement scores.

The covariate scores and the treatment factor were not statistically significant for the post-treatment math SE1 scores. However, the pre-treatment SE1 covariate data was statistically significant and a good predictor of the students' follow-up treatment SE1 scores. The pre-treatment math-test covariate data and the treatment factor were non-significant for the follow-up treatment outcomes. The null hypothesis for the second research question was: $M_{post\mathrm{SE1}}\mathrm{T} = M_{post\mathrm{SE1}}\mathrm{TI} = M_{post\mathrm{SE1}}\mathrm{TIA} = M_{post\mathrm{SE1}}\mathrm{TIAI}$ and $M_{f\text{-}u\mathrm{SE1}}\mathrm{T} = M_{f\text{-}u\mathrm{SE1}}\mathrm{TI} = M_{f\text{-}u\mathrm{SE1}}\mathrm{TIA} = M_{f\text{-}u\mathrm{SE1}}\mathrm{TIAI}$. The results showed that the null hypothesis should not be rejected, thus indicating that the treatment factor did not have a significant effect on the students' math self-efficacy.

The last research question pertained to the students' satisfaction with the learning methods used in the study. A one-way ANOVA was conducted in order to determine if there were any mean differences between the four treatment groups. The independent variable, treatment (four levels), was used in the analysis. The dependent variable was the student satisfaction scores at the end of the study. Following the calculation of the ANOVA the researcher calculated an effect size and this result was .30. In order to explore further, a post hoc Tukey test was used to determine statistical significance of the TIAI group scores compared with the three other combined groups' scores. This post hoc comparison did not gleam any significant differences. Therefore, the null hypothesis for the student satisfaction, $M_{\mathrm{stusat}}\mathrm{T} = M_{\mathrm{stusat}}\mathrm{TI} = M_{\mathrm{stusat}}\mathrm{TIA} = M_{\mathrm{stusat}}\mathrm{TIAI}$, was not rejected. In conclusion, the overall results of the study indicated that the nursing students at both universities had low math test scores at the onset of the study ($M = 68.0\%$) and there appeared to be a slight trend toward improvement over the course of the study. The students' math self-efficacy results indicated that the students had a fairly moderate opinion about their belief to complete routine math problems and this assessment did not change significantly over the course of the study. The student-satisfaction mean score for the TIAI group showed practical significance and further research is needed in this area in order to obtain more feedback from a larger sample.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary of Study

An experimental factorial design was used to determine the effectiveness of an interactive multimedia-learning tool on students' math test scores, math self-efficacy results, and student satisfaction. A convenience sample of 96 (12 men and 84 women) fifth-semester baccalaureate-nursing students at two northern California universities completed three parallel math tests, three identical math self-efficacy scales, and a student satisfaction survey during the study. The independent variable was treatment (four levels) with "school" eliminated as an independent variable following consolidation of the sample. The dependent variables were post- and follow-up treatment math test scores, post- and follow-up treatment math SE1 scores, and student satisfaction scores collected at the end of the study. The students' baseline math knowledge and math self-efficacy were used as covariate data.

The three research questions were: (a) Does interactive multimedia to present content result in greater mean mathematics scores when compared with text only, text and image, text, image, and animated self-study modules at the retention level posttest and at the two-week follow-up measurement? (b) Does interactive multimedia to present content result in higher math self-efficacy mean scores when compared with text only, text and image, text, image, and animated self-study module posttest and at the two-week follow-up measurement? (c) Does interactive multimedia to present content result in greater student satisfaction scores when compared with text only, text and image, text, image, and animated self-study module at the two-week follow-up measurement?

Summary of Findings

There were three instruments used in the study and the reliability of each instrument was determined. The three math tests were analyzed for coefficient stability and the reliability coefficient between the pre-treatment math test and the post- and follow-up math tests were .82 and .77 respectively, indicating a moderately strong reliability between the tests. The participants' mean pre-treatment math test score was 16.56 (*SD* = 4.04, out of 24 questions) and these results are similar to results from previous studies presented in the literature (Bindler & Bayne, 1984; Blais & Bath, 1992; Chenger et al., 1988; Hodge, 1999; Pozehl, 1996; Segatore et al., 1993). Less than 75% of the sample obtained a pre-treatment math test score of 80% or better. Therefore, the study confirmed that baccalaureate-nursing students continue to demonstrate a lack of mathematical proficiency in order to safely administer medications to patients. The post- and follow-up treatment math test scores did not improve significantly during the study. However, 40% of the sample scored 80% or better on the follow-up treatment math test indicating a movement toward improved proficiency.

The MSES developed by Betz and Hackett (1993) has a median alpha coefficient of .94 (n = 262) indicating a strong reliability. The participants in the current study at both universities (n = 96) entered the study with a "moderate" level (M = 6.27, SD =1.37) of math self-efficacy. Correlation coefficients were computed among the three math tests and three math self-efficacy scale results. The findings computed from the correlational analyses showed that 4 out of 9 correlations were statistically significant ($p < .05$) and were greater than or equal to .31.

The results from the computed ANCOVA indicated that the data collected from the pre-treatment math test (covariate) was significant for student scores on the post- and follow-up treatment math tests. However, the treatment did not have a significant influence on the outcomes of the post- and follow-up treatment math tests. The data collected from the pre-treatment SE1 covariate interacted positively with the data gathered from the follow-up SE1 results; but the treatment did not have an effect on the post- and follow-up SE1 results.

The information obtained from the satisfaction survey indicated that the students in the TIAI group rated the interactive-multimedia program the highest.

Limitations

The major limitation to this study was the short length of the treatment. The one-hour treatment time was restricting and did not allow for substantial learning to occur. Nursing students' poor mathematical skills will not be substantially improved during a one-hour learning experience. An increased period of time (e.g. 6 to 8 hours) using the different learning modules may possibly lead to different outcomes. A determination of an adequate treatment length may be difficult to obtain and longer treatment periods may be challenging to implement in most educational settings during a research study. Historically, nurse educators have stated they have minimal amount of time to provide remedial math review and medication dosage calculation instruction for students. The instruction of this important skill falls to the wayside while other curricular activities take higher priority. In order for students to learn medication dosage calculation skills independently, the learning material needs to be provided in an interesting manner and educators have to determine when to teach and evaluate this important skill during the nursing curriculum. If an educator provides a learning tool that intrinsically motivates students to learn these skills independently then an increased time-on-learning may occur.

Another limitation to this study was the students' lack of motivation to participate during the research study. Motivation is a broad term that relates to many individual self-perceptions and affects, such as a person's expectations, goal directed behaviors, interest, and expenditure of effort (Boekaerts, 2001). These perceptions and affects could have influenced the students' participation in this study. Since the students' contribution to this study was of their own volition and they did not receive a substantial token for their efforts, it is likely that their interest and personal expectations were low. The students' motivation would have been increased if their goal-directed behavior had important personal meaning. Allen and Papas (1999) recommended that medication dosage calculation competency be connected to the capability of administering medications in the clinical setting. This ability serves as a powerful incentive for nursing students.

The interpretation of the results from the present research is limited by the use of a moderate convenience sample at two universities in northern California. Participants from different locations in the United States or worldwide would possibly lend different results. Another limitation to the study may be gender bias because there were only 12 males in the sample of 96. Past research findings indicated that male students have exhibited higher math self-efficacy (Betz & Hackett, 1993) and higher math-test scores (Ethington & Wolfle, 1986). In this current study there was no significant difference, between males and females, in pre-math SE1 scores ($t = .76, p = .45$). In addition the study did not focus on students' math test anxiety and attitudes toward computers. Since the multimedia presentation did not offer audio, there may have been an imbalance in dual coding in the participants' working memory and this could have influenced the integration of verbal and pictorial models (Mayer, 2001). These factors could be considered confounding variables and limitations.

Furthermore, the lack of qualitative data collected during the study posed a limitation. Qualitative data, such as the information provided in a focus group or an open-ended survey, would provide information about the students' experiences while going through the different learning methods provided during the study. The analysis of qualitative data would possibly give the researcher some idea as to how much additional time is really needed in order to improve the students' mathematical abilities and about the nature of students' satisfaction with the different treatments.

Discussion and Conclusions

The discussion of the findings from the study is presented within the perspective of the four theoretical frameworks and the review of the literature. The four theoretical frameworks supporting this study were Paivio's (1986) dual coding theory, Mayer's (2001) cognitive theory of multimedia learning, Sweller's (1988) cognitive load theory, and Bandura's (1977) social cognitive theory. The first three theories were used as guiding frameworks for the development of the four treatments, and the last theory was the underlying concept of the MSES used in the study.

Paivio (1986) explained that verbal and nonverbal cognitive processes code stimuli received by the human senses and furthermore he believed that the use of imagery significantly assists with enhancing cognitive functions. The combination of text and images improves simple recall when compared with the use of text only. However, Paivio also stated that pictures presented alone have a stronger impact on memory then when words are used alone. The students assigned to the TI group (*n* = 26) scored a little higher (*M* = 17.31, *SD* = 4.61) than the T group (*n* = 24) on the post-treatment math test (*M* = 17.25, *SD* = 3.50), but not significantly different. These results could be due to the small convenience sample, or the images used in the modules were not extremely significant to the learning of the presented material.

Mayer's (2001) theory of multimedia learning dovetailed the concepts presented by Paivio, however he included "animation" when pictures were involved and "narration" when the idea of text was presented. In addition, Mayer's theory included three assumptions: dual channels, limited capacity, and active processing. The "dual channel" assumption was based upon the idea that animation or on-screen text is processed in the visual/pictorial channel, and the spoken word or a non-verbal sound (e.g. non-lyrical music) is passed on by the auditory/verbal channel. Second, the idea of limited capacity surrounded the idea that the human working memory does not have endless ability to process information processed by the auditory or visual channels of working memory. Third, Mayer explained the concept of active processing and this part of his theory alludes to the idea that learners attempt to make sense of multimedia explanations by paying attention, organizing information, and combining new information with previous knowledge stored in the long-term memory. In the current study, the TIA group had the highest mean post-treatment math-test score (*M* = 18.00, *SD* = 3.63). The computer-based learning methods used in this study might have contained too much text within the learning modules. More animation and audio (less text) could be used in future multimedia presentations. These presentations might lend more effective learning outcomes.

Sweller (1988) explained the mental processes of learning, problem solving, and human memory in his cognitive load theory. Learning material is first processed in the working memory, however humans have a limited capacity to store information in the working memory and possess a larger capacity to store more information in the long-term memory. Based upon Sweller's premise, instructional design should not place too heavy of a load on the working memory because of its limited capacity to store information. Moreover this theory explicated that too much sensory overload on the working memory hinders a learner's ability to organize information and mentally retrieve previously learned material stored in the long-term memory. These ideas are instrumental when educators are considering how to present learning content to students in a constructive manner. The four learning methods contained exactly the same learning material, enhanced by images, images and animation, or image, animation and interactivity respectively. As all four groups of students scored similarly in the outcome assessment (follow-up treatment math and math SE1 scores), it is unlikely that the multimedia modules conferred an overload of the students' working memory.

Lastly, Bandura's (1977) social cognitive theory pertained to an individual's self-efficacy in social learning environments. This theory stated that an individual's belief in their ability to be successful at any given task or behavior influences their aptitude. If a nursing student has had a bad experience with learning math concepts in the past, or has been told that they "can't do math," then their self-efficacy plummets and this in turn affects their ability to do math in the future. In addition, the calculation of medications for patients involves a certain amount of anxiety because the student understands the ramifications of miscalculations. This anxiety could act as a "co-effect," but if a student is verbally persuaded, shown how to calculate the medication dosage, and ultimately demonstrates mastery, the student's anxiety should decrease and the self-efficacy increase. More specifically, this theory supported the development of Betz and Hackett's (1993) MSES, and the concept of math self-efficacy was explored by implementing the MSES in this study. Interestingly, the MSES scores did not change significantly for any group during this study, indicating that the different treatments had no effect on the students' math self-efficacy.

In regards to the first research question concerning an increase in cognitive outcomes following a short interactive multimedia (TIAI) presentation of remedial math concepts and medication dosage calculation instruction, this study did not render statistically significant increases in mean math scores at the post- and follow-up treatment periods. These results were most likely the result of the short treatment time imposed upon the study and the lack of student motivation. The results indicated that a one-hour intervention is not sufficient to correct the deep-seated math problem that has been documented by educators for many years. However, this study showed that the computer-based learning modules did not impede the students' learning. Therefore, further research is needed to determine if increased learning can be achieved by providing multimodal (verbal and pictorial) online learning modules that nursing students can use at their convenience for longer periods of time.

Aberson and colleagues (2000) developed the WISE project and implemented an Internet-based interactive tutorial as a learning supplement for an introductory and intermediate Statistics course. These researchers conducted a small descriptive study (n = 111) that compared students' (participating in a lectured-based environment) Statistic's test results with an interactive Web-based tutorial group's test results. Unfortunately, the time spent on learning the material during the study was not published. The results showed that both groups had an improvement in their post-test scores when compared with their pre-test scores. However, there were no significant outcomes for the interaction effects. The study's results indicated that the tutorial could be used to introduce material that is generally discussed in the classroom environment with similar cognitive outcomes.

The present study did not compare the achievement outcomes associated with the interactive multimedia-learning tool, launched by a Web browser, with learning outcomes achieved from face-to-face instruction. However, the learning outcomes associated with the interactive multimedia tool were compared with outcomes associated with three other learning methods. All of the learning methods rendered similar mean math-test and math self-efficacy scores. The undergraduate students involved in Aberson's et al., (2000) study indicated that the tutorial was easy to use and they would like to see more tutorials offered in the future. These qualitative statements are congruent with satisfaction results obtained from the present study.

The second research question concerning the interaction effect of the learning method on students' math self-efficacy mean scores was not significant. The students' ($n = 96$) scores did not significantly increase over the course of the study, and overall the students demonstrated a "moderate amount" of math self-efficacy at the beginning, as well as at the end of the study ($M = 6.27$, $SD = 1.37$; $M = 6.57$, $SD = 1.37$). Several researchers have looked at the concept of math self-efficacy and its correlation with mathematical achievement (Betz & Hackett, 1983; Hodge, 1997; Junge & Dretzke, 1995; Lussier (1996); Pajares, 1996; Malpass et al., 1999). Hodge (1997) reported that math self-efficacy was not correlated with nursing students' mathematical achievement. However, the results garnered from the present study indicated a moderate correlation; specifically, the correlation among post-treatment math-test scores and post-treatment math SE1 results ($r = .28$, $p = .01$) indicated a significant finding. Madorin and Iwasiw (1999) reported a significant increase in nursing students' ($n = 23$) self-efficacy scores directly following a 30-minute CAI program regarding the post-surgical care of a patient with lung cancer. Although, at the end of the students' eight-week clinical rotation there were no significant differences in the mean self-efficacy scores of the two groups studied. Therefore indicating that the CAI did not have a long-lasting effect on improving self-efficacy.

The focus of this study was not to determine differences in male and female math self-efficacy scores, but future studies could look at these differences in order to interpret current findings in light of the existing literature. Junge and Dretzke (1995) had research findings that were significant for mean differences between males and females taking the MSES (Betz & Hackett, 1993). Betz and Hackett (1993) reported that math self-efficacy scores are strong predictors of overall math performance. These researchers determined that a group of female students ($n = 153$), studying for male-dominated professions, scored significantly lower on the math SE 2 (belief in ability to receive an "A" or "B" in college math courses) when compared with a group of male students ($n = 109$) $t = -3.5$, $p < .001$. Since the majority of the students in this study were female and studying a primarily female dominated profession, the results gathered from this present study may be consistent with the findings reported by Betz and Hackett (1993) when looking at overall math self-efficacy results. Lussier (1996) indicated from research findings that women with strong mathematical backgrounds had similar math self-efficacy scores when compared to their male colleagues.

The last research question asked about the students' satisfaction with the different treatments used in the study. The group with the highest satisfaction score was the TIAI group ($M = 3.82$, $SD = 0.89$, $\eta^2 = .03$); although, these results were not significantly different from those of the other groups. This group looked most favorably on this method of learning remedial math concepts and medication dosage calculations. The literature indicates that online interactive learning experiences, as reported by some students, are more satisfying and meaningful then traditional learning methods (Brown, 2001; Sery-Ble et al., 2001; Thiele et al., 1999; Ryan et al., 1999). Wegner, Halloway and Garton (1999) reported positive comments from an Internet-based test group. Thirty-six percent of the experimental group (n = 14) stated they liked using technology in their Internet-based instruction and 21% reported satisfaction with the convenience of their online learning experience. These innovative learning methods are: widely accessible, self-paced and intuitive, enhance cognitive outcomes, and promote the learning of computer skills (Mayer, 2001).

Implications for Future Research

The following two sections provide recommendations for future research in the area of nursing education and implications for clinical nursing practice. Technological advances have an effect on almost all teachers and learners in institutes of higher learning around the globe (Samoa Launches Online Medical School, 2003; Schwartz, 2003). These technological advances are pervasive and over the past few years' educators from different disciplines have focused their energies on the analyses of the effectiveness of learning through the use of various technologies (Phipps & Merisotis, 1999). However, research on the effectiveness of interactive multimedia leaning tools used in nursing education is lacking.

A major implication of the "no significant difference" finding in the current study is that technology did not hinder learning, and nurse educators can reflect upon traditional instructional design and technological advances available to them in order to make informed decisions about future education and the enhancement of the delivery of instruction. Further research that addresses some of the limitations of this study is necessary in order to determine if interactive multimedia tools are effective in increasing student understanding and application of knowledge regarding the proper calculation of medication dosages.

The results from the present study are limited because of the short treatment time, student motivation and the use of a small convenience sample. Despite the lack of significant findings for increased math scores and math self-efficacy results, students' satisfaction with the interactive multimedia learning method suggests that this method might motivate students to review remedial math concepts needed to calculate medication dosages. The motivational concept, as it is related to the learning and instruction of medication dosage calculations, could be further investigated in future studies.
Clearly the treatment period has to be significantly altered and it is not clear as to how long the treatment should be in order to significantly boost student learning. The identification of the appropriate time-on-task may require descriptive research in order to collect data to answer specific questions regarding students' experiences from the different learning methods provided in the experimental research. Capturing "time-on-

task" data in an electronic database may be a possible method of correlating the frequencies of using the multimedia tool and students' test score results.

One suggestion for future descriptive research would be the creation of student focus groups, open-ended questionnaires, or interviews in order to identify students' attitudes and feelings when attempting to relearn basic math concepts under the various treatment methods. Various extraneous variables not studied in the present study could be identified, such as motivation constructs, math-test anxiety, attitudes toward computer-centered learning, fatigue associated with the rigorous nursing program, and negative affects toward math.

In general the assessment of the effectiveness of multimedia learning launched via an Internet browser is an educational challenge. Researchers have attempted to compare Internet-based learning with face-to-face learning and have reported similar learning outcomes (Aberson et al., 2000; Wegner et al., 1999). Researchers committed to nursing education could determine the effectiveness of multimedia-learning tools versus the traditional lecture-based delivery of remedial math concepts and medication calculations during a one-unit seminar offered at the freshman level. Math test results, math self-efficacy outcomes, and students' perceptions of both methods of instruction could determine the best approach in learning remedial math concepts at the university level. Nurse researchers would be able to determine best practices and influence the nursing curriculum.

Instructional designers are available to nurse educators at many universities and they can suggest methods of delivering information via technological platforms that are based on theoretical frameworks. Phipps and Merisotis (1999) argued that educators do not use theory as a guiding framework when developing multimedia educational tools, and the instructor does not take into consideration the different learning styles of the students. The gathering of qualitative data regarding students' preferred learning methods would provide more information about the various technologies that might be superior for different educational objectives and styles of learners. Education provided via technological advances emphasizes an educational paradigm shift and encourages the student to take on the role of "active" learner versus a "passive" student sitting in a classroom. Not all students or teachers in higher education welcome this constructivist approach because they are not accustomed to this type of learning or teaching.

Today's college students are "heavy users" of technology and the use of informal learning activities, related to their studies, offered on the Internet might bring "new life" to traditional subject matter (The Pew Internet and American Life Project, 2002). Future research could look at the development of animated/narrated multimedia tools that are geared toward specific medication dosage calculation problems, as well as conceptual and mathematical problems. Many students struggle with specific types of problems posed in the clinical setting, such as fluid replacement calculations. The use of such technological software as Flash and LiveSlideShow could enable the nurse educator to produce fairly simple multimedia tools and use them when conducting a remedial math review in a didactic or clinical setting. Future studies could include extrinsic motivators, such as gift certificates for the highest and the most improved test score during a study.

Currently, personal digital assistants (PDA) are becoming popular information tools and educators could look at research opportunities surrounding the development and use of animated medication-calculation programs provided by the PDA. The students who grew up in the Information Age are enamored with technology and the lure of its attractive qualities (animated images with audio) because they find it entertaining. These qualities of educational technology might motivate students to learn remedial math and retain the information over a longer period of time. Nurse educators are in a position conduct research in multimedia design and instruction, and ask for support in the development of meaningful learning tools that will enhance student learning. Authentic quantitative and descriptive research is still needed in multimedia and online learning in order to determine student satisfaction, cognitive outcomes, and pedagogical best practices.

Implications for Clinical Practice

A current report informed the American public that over 8 million families have reported at least one family member succumbing to a serious injury due to a medication or medical error (Commonwealth Fund, 2002). Moreover, human fatalities as a result of medication errors in hospital settings increased 237% between 1983 and 1993 (Low & Belcher, 2002). These statistics are unfathomable and as a result of these facts, legislation is before Congress in an attempt to prevent or reduce the number of medical errors. Future research is needed in order to determine the effectiveness of different clinical systems that can promote patient safety by identifying human errors in healthcare settings. The Medication Error Prevention Act of 2002 (H.R. 4673.IH), proposed by Congresswoman Constance A. Morella of Maryland, is a bill that is ready for Congressional approval (The Library of Congress, 2002). This bill was drafted in response to the IOM's (2000) report that 44,000 to 98,000 people die each year in this country due to medical errors. Congresswoman Morella proposed the use of clinical systems, such as the MedMARx, in order for health care professionals to "anonymously and voluntarily" report medication and/or other medical errors via the Internet-based program without the threat of litigation. Nurses are reluctant to report medication errors because they fear negative repercussions, such as loss of employment or being deemed incompetent.

The use of this type of system would assist with the identification of specific medical errors and then hospital personnel can identify solutions to prevent future mistakes. Nurse managers are in a position to review medical errors made by the nursing staff and future descriptive research surrounding the use of a clinical system by nurses would offer important information regarding the exact types of errors. This research would further identify the types of medication errors (e.g. dosage miscalculations) and set up a forum for discussion regarding effective educational solutions in the clinical setting. Interactive multimedia learning tools, launched via the Internet, may be introduced to nurses and the program's effectiveness could be analyzed in future research studies. Nurses' satisfaction and motivation to use educational tools in the workplace would provide information about how they learn most effectively. Ultimately the results of such research would have a positive outcome on the reduction of medication errors in the hospital setting, thereby promoting safe and effective patient care. Nurse educators are in a position to be actively involved in evaluating modern technologies that enhance educational opportunities in the classroom and clinical setting

New graduates of nursing programs are expected to pass a medication dosage calculation test upon employment at most hospital agencies in this country. This assessment of nurses' knowledge is one step in the right direction in preventing medical errors. Nurse educators working in hospital settings would be able to refer new graduates that failed the required test to use convenient interactive multimedia-learning tools or other methods of instruction deemed effective. The results from the research conducted by these nurse educators in the clinical setting could be communicated back to faculty in schools of nursing and the Board of Registered Nurses (BRN) in an attempt to document the need for further education and evaluation of nursing students math calculation proficiency before graduation.

Summary

In summary, making safe medication administration a priority in our schools of nursing will decrease the alarming number of medication errors in our nation's healthcare settings and thus prevent untoward injury to patients. This present study was important for three reasons:

1. Nursing education research pertaining to the effectiveness of interactive multimedia tools on nursing students math proficiency, math self-efficacy, and student satisfaction is lacking.
2. The results from the study did not offer significant positive findings; however, the delivery of an interactive multimedia tool via the Internet did not have a negative effect on student achievement, math self-efficacy or student satisfaction.
3. The study's results confirmed that undergraduate nursing students continue to show inadequate math calculation proficiency and it is necessary to explore instructional design that will motivate students to learn and retain this important nursing skill.

The present experimental study provided discussion of four conceptual frameworks that other researchers can use to base their development of other multimedia learning tools and guide their replication of the study. The participants in the study were randomly assigned to the experimental groups, thereby reducing the risk of spurious variables affecting math achievement or student satisfaction. The reliability of the instruments used in the study was determined to be high, along with significant validity. Future nursing education research could look at qualitative data gathered from the students in an attempt to consider the students' attitudes toward remedial math, opinions about adequate treatment time, attitudes toward computer-based learning, and test anxiety. This information would not focus only on instructional technology, but it would reveal information about the prior experiences of these low-proficiency students.

Three research questions were posed at the beginning of the present study in an attempt to ascertain the effectiveness of the use of multimedia technology in raising students' math test scores, math self-efficacy results, and student satisfaction. No significant findings were discovered in the study, however during the study the researcher learned that application of the American Association of Higher Education's (Chickering & Ehrmann, 1996) recommended principles of good practice in undergraduate education could be applied to the development and use of educational technology. These seven principles include emphasis on: time-on-task, giving prompt feedback in learning environments, use of active learning techniques, communication of high expectations, respect for various methods of learning, creation of collaboration among learners, and increased communication between students and faculty members regarding learning outcomes. These guiding principles can influence informed decisions about future nursing education.

What is the optimal method of learning for low-proficient nursing students attempting to achieve math proficiency in order to perform accurate medication dosage calculations? The answer to this question remains unknown, however it is our responsibility as educators to conduct further research in an attempt to solve this fundamental nursing education problem.

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Appendixes

Appendix A

Medication Dosage Calculation Module 1: Text Version

Common Fractions:

A common fraction consists of a "numerator" (top number) and a "denominator" (bottom or 'down' number). A fraction is an expression of a "part" of a "whole" unit.

Example:

The common fractions, 1/3 and 1/4, share the number "1" as a numerator, and the numbers "3 and 4" are the denominators.

Reminder! When the numerators of fractions are equal, the lowest denominator has the "greater" value!

Let's look at an example: 1/3 versus 1/4 tablet of acetaminophen. Which tablet has a greater value?

Appendix B

Medication Dosage Calculation Module 1: Text and Image Version

Common Fractions:

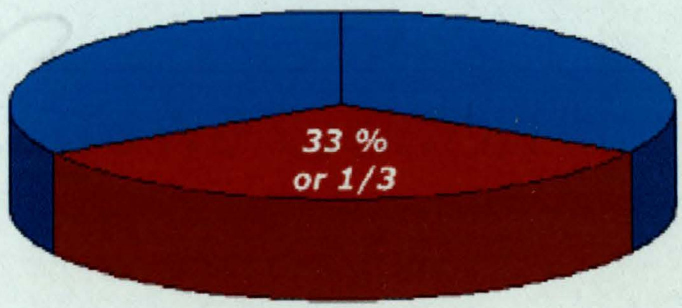
A common fraction consists of a “numerator” (top number) and a “denominator” (bottom or ‘down’ number). A fraction is an expression of a “part” of a “whole” unit.

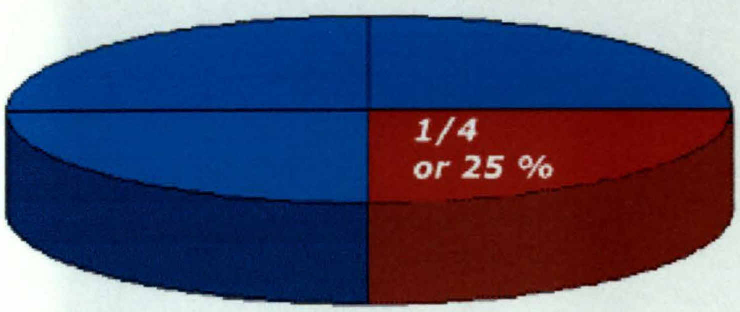
Example:

The common fractions, **1/3** and **1/4**, share the number **“1”** as a **numerator,** and the numbers **“3 and 4”** are the **denominators.**

Reminder! When the numerators of fractions are equal, the lowest denominator has the “greater” value!

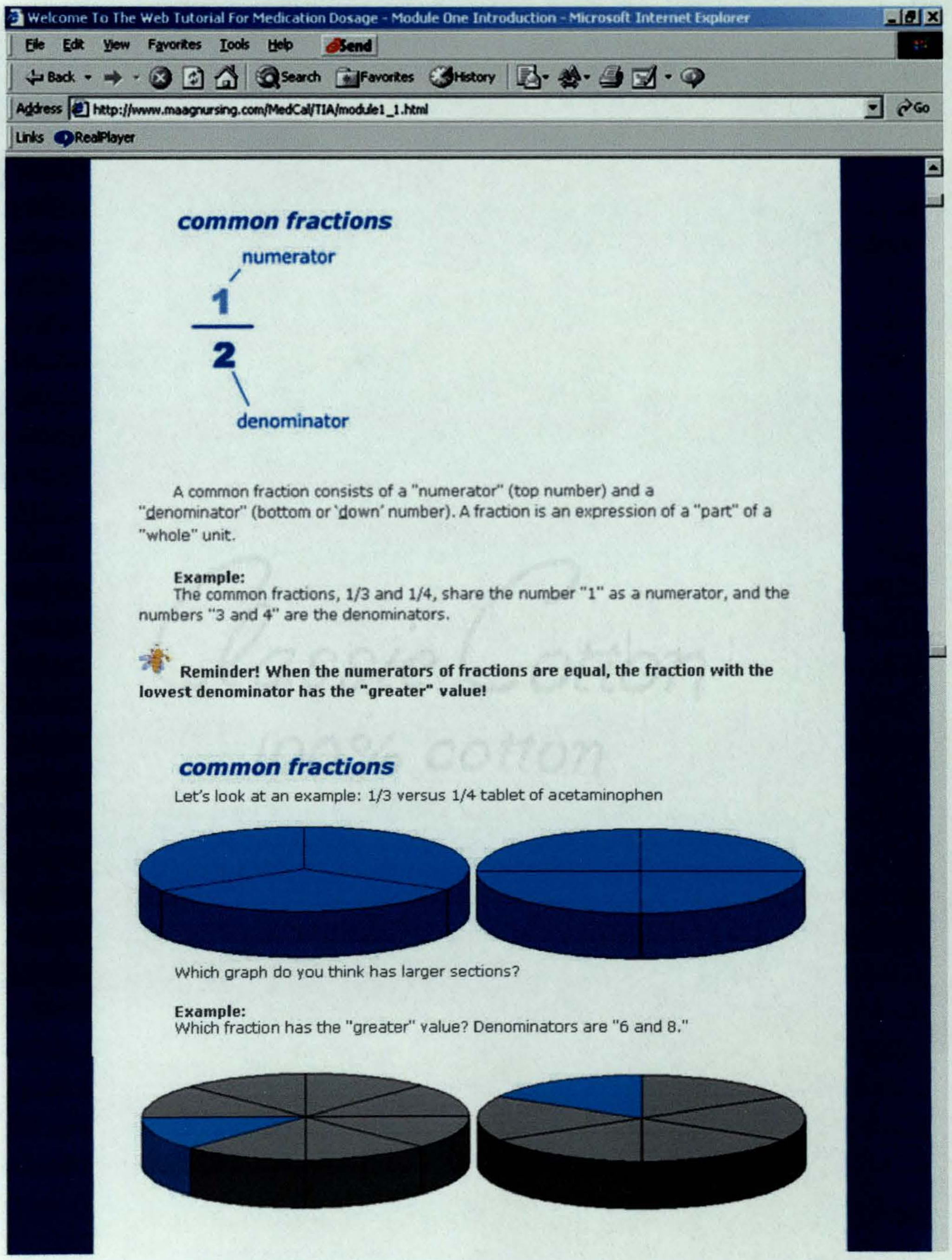
Let’s look at an example: **1/3** versus **1/4** tablet of acetaminophen. Which tablet has a greater value?





Appendix C

Medication Dosage Calculation Module 1: Text, Image, and Animation Version



Appendix D

Medication Dosage Calculation Module 1: Text, Image, Animation, and Interactivity Version

Web Tutorial For Medication Dosage Calculation

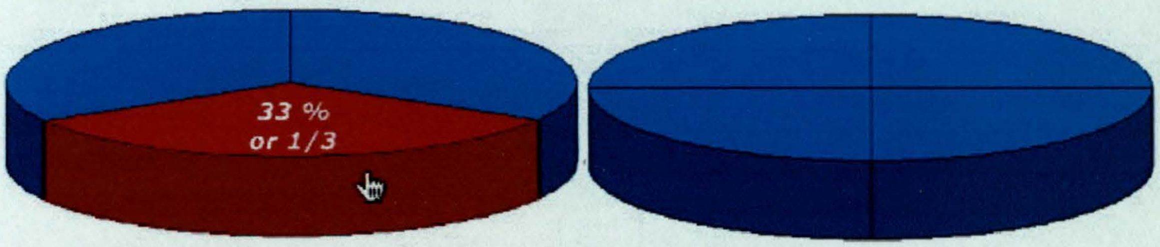
Margaret Maag MSN, RN

module 1 >> module 2 >> module 3 << back home >>

common fractions decimals ratios proportions percentages

common fractions

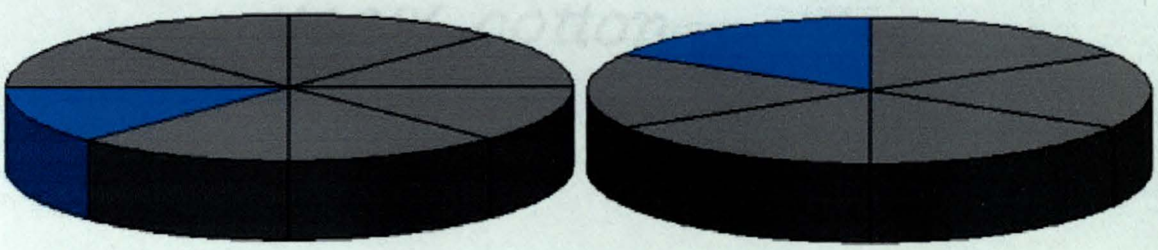
Let's look at an example: 1/3 versus 1/4 tablet of acetaminophen



Point your cursor to the "greater" value illustrated above.

Example:

Which fraction has the "greater" value? Denominators are "6 and 8." Click on the correct answer!



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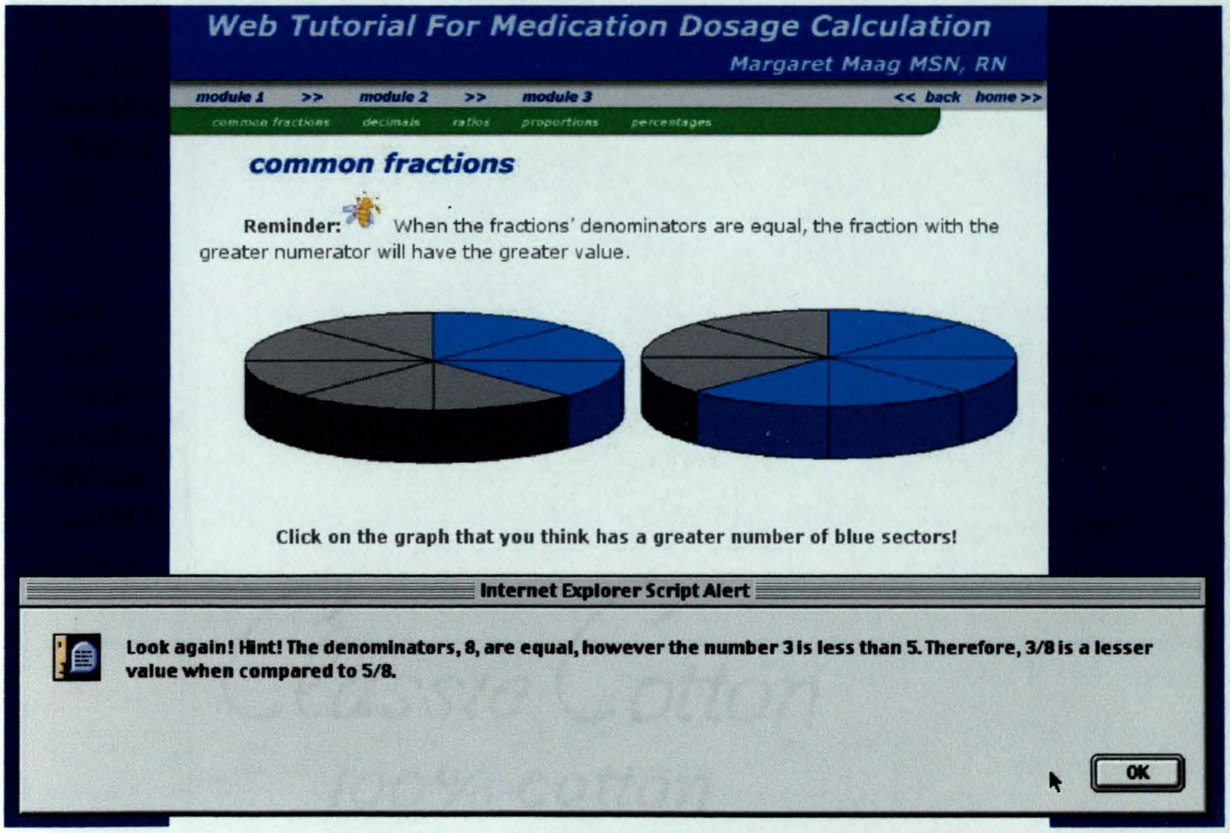
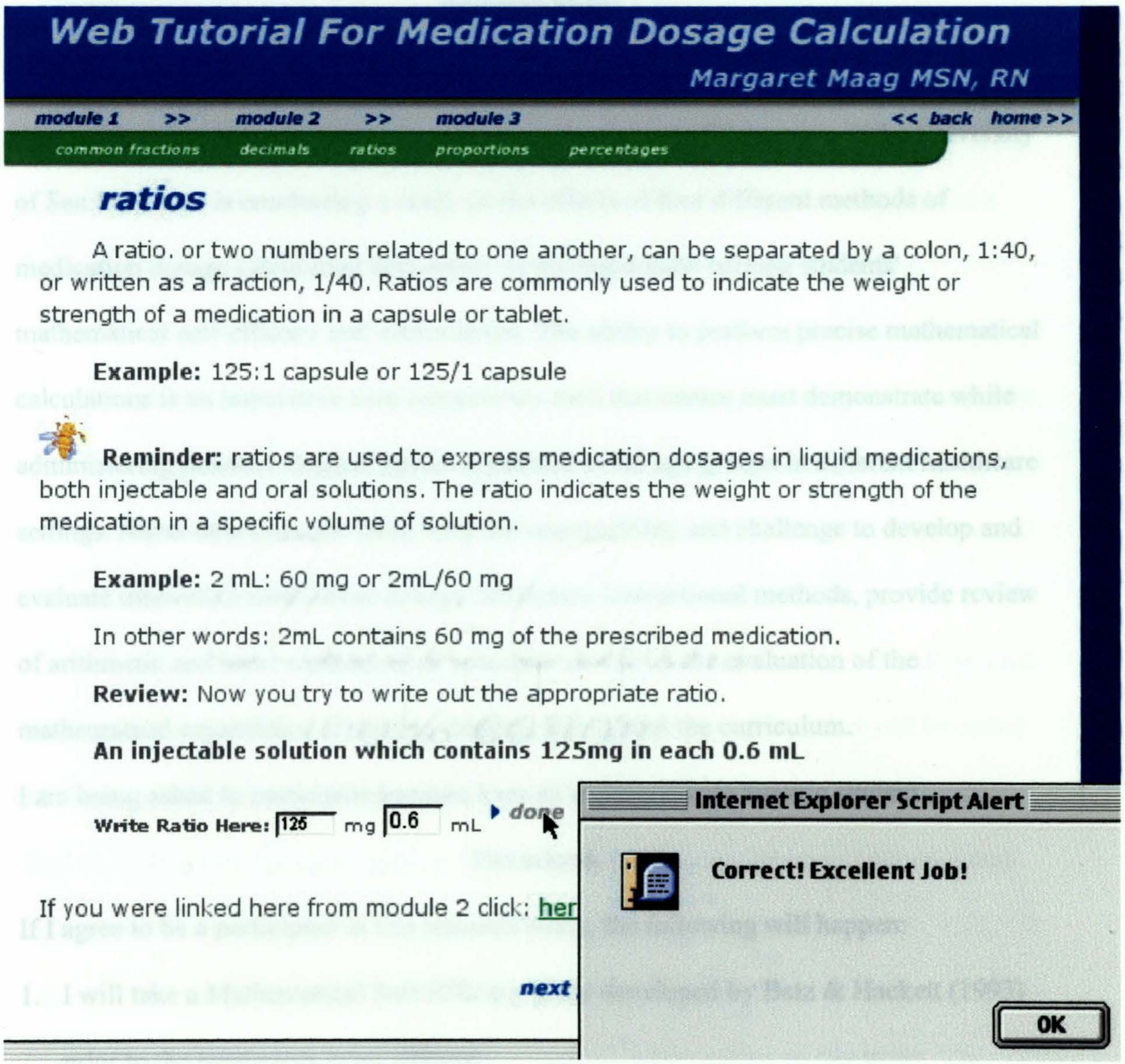
Appendix E

Medication Dosage Calculation Module 1: Text, Image, Animation, and Interactivity Version



Appendix F

Medication Dosage Calculation Module 1: Text, Image, Animation, and Interactivity Version



Appendix G

Consent to be a Research Subject

Research Study

Purpose and Background

Margaret Maag, a doctoral candidate in the School of Education at the University of San Francisco is conducting a study on the effects of four different methods of medication dosage calculation instruction on undergraduate nursing students' mathematical self-efficacy and achievement. The ability to perform precise mathematical calculations is an imperative core competency skill that nurses must demonstrate while administering pharmacological agents to patients of all age groups in different healthcare settings. Nurse educators are faced with the responsibility and challenge to develop and evaluate innovative medication dosage calculation instructional methods, provide review of arithmetic and basic mathematical concepts, as well as the evaluation of the mathematical capabilities of nursing students throughout the curriculum.

I am being asked to participate because I am an undergraduate nursing student.

Procedures

If I agree to be a participant in this research study, the following will happen:

1. I will take a Mathematical Self-Efficacy Scale developed by Betz & Hackett (1993) prior to the treatments being offered.
2. I will take a 25-item medication dosage calculation pretest (Test A) that the researcher has developed prior to the treatments being offered.
3. I will be randomly assigned to an A, B, C, or D learning group.

4. I will take the Mathematical Self-Efficacy Scale and a 25-item medication dosage calculation posttest (Test B) that the researcher has developed directly following the treatment.
5. Two weeks following the treatment, I will take the Mathematical Self-Efficacy Scale and a 25-item follow-up medication dosage calculation posttest (Test C).

If I am assigned to the C or D teaching group I will be escorted by the researcher or a research assistant to a lab located on the University of San Francisco's campus.

Risks and/or Discomforts

1. It is possible that eyestrain may result from looking at a computer monitor for approximately one hour. Otherwise, there are no inherent risks and/or discomfort to participating in this study. I am free to decline to answer any of the review math questions included in the online tutorial or stop participation at any time.

2. Test results will be kept confidential and no individual identities will be used in any reports or publications resulting from the study. Study information will be coded and kept in locked files at all times. Only study personnel will have access to the files.

3. Because the time required for my participation may be up to 2 hours, I may become bored or tired.

Benefits

There may be a cognitive benefit to me from participating in this study. The anticipated benefit of this study is to receive information regarding the effectiveness of four different approaches to teaching medication dosage calculations to undergraduate nursing students.

Costs/Financial Considerations

There will be no financial costs to me as a result of taking part in this study.

Questions

I have talked with Margaret Maag about this research study and have had my questions answered. If I have further questions about the study, I may call her at (415) 422-2017.

If I have any questions or comments about participation in this study, I should first talk with the researcher. If for some reason I do not wish to do this, I may contact the IRBPHS, which is concerned with protection of volunteers in research projects. I may reach the IRBPHS, which is concerned with protection of volunteers in research projects. I may reach the IRBPHS office by calling (415) 422-6091 and leaving a voicemail message, by emailing IRBPHS@usfca.edu, or by writing to the IRBPHS, Department of Psychology, University of San Francisco, 2130 Fulton Street, San Francisco, CA 94117-1080.

Consent

I have been given a copy of the "Research Subject's Bill of Rights" and I have been given a copy of this consent form to keep. PARTICIPATION IN RESEARCH IS VOLUNTARY, I am free to decline to be in this study, or to withdraw for it at any point. My decision as to whether or not to participate in this study will have no influence on my present or future status as a student or employee at USF.

My signature below indicates that I agree to participate in this study.

______________________________ ________________

Subject's Signature Date of Signature

______________________________ ________________

Signature of Person Obtaining Consent Date of Signature

Appendix H

University of San Francisco IRBPHS Approval

Institutional Review Board for the Protection of Human Subjects
Education Building-Room 023
Counseling Psychology Department
2130 Fulton Street
San Francisco, CA 94117-1070

May 24, 2002

Margaret Maag
745 Stanford Ave
Menlo Park, CA 94025

Dear Margaret Maag:

The Institutional Review Board for the Protection of Human Subjects (IRBPHS) at the University of San Francisco (USF), which operates under the rules and regulations set forth by the Federal Office for Protection from Research Risks (OPRR) and the Department of Health and Human Services (DHHS) has
reviewed your initial application for human subjects approval regarding your study, "THE EFFECTIVENESS OF AN INTERACTIVE MULTIMEDIA LEARNING EXPLANATION ON BACCALAUREATE NURSING STUDENTS' MATHEMATICAL ACHIEVEMENT AND SELF-EFFICACY".

Your Initial Application has been approved by the committee (IRBPHS #02-016)
Please note the following:

1. Approval expires twelve (12) months from the dated noted above. At that time, if you are still collecting data from human subjects, you must file a Renewal Application.
2. Any modifications to the research protocol or changes in instrumentation (e.g., changes in subject sample, wording of items, consent procedures, tasks required of subjects) must be proposed in a Modification Application, which must be approved prior to implementation of any changes.
3. Any adverse reactions or complications on the part of Human Subject must be reported (in writing) to the IRBPHS within ten (10) working days in the form of a Human Subjects Incident Report.

If you have any questions, please contact Steven Del Chiaro, IRBPHS Coordinator, at (415) 422-6091.

On behalf of the IRBPHS committee, I wish you much success in your research.

Sincerely,

Terence Patterson

Terence Patterson, Ed. D, ABPP
Chair, IRBPHS

Appendix I

San Jose State University IRBPHS Exempt Letter

San José State
UNIVERSITY

Office of the Academic Vice President
Associate Vice President Graduate Studies and Research
One Washington Square
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Voice: 408-283-7500
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To: Margaret M. Maag
School of Nursing
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2130 Fulton Street
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From: Nabil Ibrahim
AVP, Graduate ~~Studies & Research~~

Date: September 1, 2002

The Human Subjects-Institutional Review Board has granted a request to change the title for an approved research study. The protocol was originally reviewed under the title, "A Comparison of Two Approaches to Teaching Medication Dosage Calculations to Undergraduate Nursing Students," and was approved on October 4, 2001. The study is now entitled:

> "The Effectiveness of an Interactive Multimedia Learning Explanation on Baccalaureate Nursing Students' Mathematical Achievement and Self-Efficacy."

In addition, since there are no major changes to the protocol, the Human Subjects-Institutional Review Board has granted this project a one-year extension effective from the expiration date of the original approval. Data collection beyond October 4, 2003 requires an extension request.

If you have any questions, please do not hesitate to contact me at (408) 924-2480.

Appendix J

Pre-Treatment Math Test Key

Identification Number_________________(Last 4 digits of Social Security Number)

Instructions: Please complete all of the following questions and circle the correct answer for each problem. There is one correct answer for each problem. You may write on this test to solve the following problems. Please remember to reduce numbers to the lowest terms and round to the nearest tenth. The use of a calculator is prohibited. You have 40 minutes to complete this test. Good Luck!

1. Multiply **1/4** by **4/5**

   a) 0.2*
   b) 0.3
   c) 0.4
   d) 0.5

2. Divide 1/150 by 1/100

   a) 0.6
   b) 0.7*
   c) 0.8
   d) 0.9

3. Multiply **12.5** by **3.5**

   a) 42.5
   b) 43.5
   c) 43.8*
   d) 45.8

4. Divide **70** by **4.5**

   a) 15.0
   b) 15.6*
   c) 16.2
   d) 17.4

5. Convert **0.3%** to a fraction

   a) 3/1000*
   b) .30/100
   c) 3/100
   d) 0.3/1000

6. Convert **15%** to a decimal number

    a) 0.015
    b) 0.15*
    c) 1.5
    d) 15.0

7. Convert **0.45%** to a ratio

    a) 0.045 : 100
    b) 0.45 : 100*
    c) 45 : 1,000
    d) 45 : 100

8. Convert **11** grains into milligrams (1grain = 60mg)

    a) 650 mg
    b) 655 mg
    c) 660 mg*
    d) 665 mg

9. A **110**-pound (lb.) child would weigh how many kilograms (kg)? (1kg = 2.2 lb)

    a) 48 kg
    b) 49kg
    c) 50 kg*
    d) 51 kg

10. If a medication dose is **6 mg** per lb. of body weight, how much should be administered per kg of body weight? (1kg = 2.2 lb)

    a) 1.3 mg
    b) 13.2 mg*
    c) 13.6 mg
    d) 14.2 mg

11. A physician asks you to weigh an infant who weighs **5000** grams, but the scale only weighs in pounds. How much will the infant weigh in pounds? (1000 g = 2.2 lb)

    a) 10 lb.
    b) 10.5 lb.
    c) 11.0 lb.*
    d) 11.5 lb.

12. A physician's order is to administer **0.2** oz. of liquid Tylenol every 4-6 hrs. for a temperature greater than 101.5 F. The nurse has a measuring cup in mL calibrations. How many milliliters will the nurse administer to the client? (1 oz = 30 mL)

    a) 3 mL
    b) 4 mL
    c) 5 mL
    d) 6 mL*

13. A nurse is to infuse a **1.75-liter** (L) of intravenous (IV) solution for a dehydrated client. Approximately how many ounces will the nurse be infusing?

    a) 46 oz
    b) 48 oz
    c) 56 oz*
    d) 58 oz

14. Convert **57** mL to drams (1 dram = 4 mL)

    a) 1.4 drams
    b) 1.5 drams
    c) 13.2 drams
    d) 14.3 drams*

15. Convert **3.5 Tablespoons** (T) into milliliters (mL) (1 Tbsp. = 15 mL)

    a) 5.25 mL
    b) 52.5 mL*
    c) 53.5 mL
    d) 62.0 mL

16. A physician's order is to administer Tylenol **1-g** liquid, po, q 4-hr prn headache. Medication available: Tylenol **500 mg/15 mL**. How many teaspoons (t) will you administer to the client?
    (1 tsp. = 5 mL)

    a) 5.5 t
    b) 6.0 t*
    c) 6.5 t
    d) 7.0 t

17. A physician's order is to administer **0.6 mL** Polytrim Ophthalmic Solution to the client's right eye (OD) once-a-day (qd). How many drops (gtts) will you instill into the client's right eye each day? (15 gtts = 1mL)

a) 3 gtts
b) 6 gtts
c) 7 gtts
d) 9 gtts*

18. A physician's order is to administer Demerol **80-mg** IM q 4h prn pain. Medication available: Demerol **100 mg/mL**. How much medication will you administer for one dose?

a) 0.7 mL
b) 0.8mL*
c) 0.9 mL
d) 1.0 mL

19. A physician's order is to administer Noroxin **0.85-gram** po now. Medication available: **400 mg/tablet.** How many tablet(s) will you administer to the client?

a) 0.5 tab
b) 1.0 tab
c) 1.5 tabs
d) 2.0 tabs*

20. A physician's order is to administer Amoxycillin **0.2 grams** po every (q) 6 hrs for 4 days. Medication available: **125-mg/ 5 mL**. How much will you administer to the client for one dose?

a) 4 mL
b) 8mL*
c) 40 mL
d) 80mL

21. A physician's order is to administer Lanoxin **0.25-mg** po every day. Medication available: **1 tab = 1/240 grain.** How much medication will you give to the client?

a) 0.2 tab
b) 0.5 tab
c) 1.0 tab*
d) 1.2 tabs

22. A physician's order is to administer Rifadin **10 mg/kg, po, every (q) day**. The client weighs **132 pounds (lbs.)**. Medication available: **150 mg/tab**. How many tablets (tabs) will you administer to the client?

    a) 2.0 tabs
    b) 2.5 tabs
    c) 3.5 tabs
    d) 4.0 tabs*

23. A nurse practitioner's order is to administer Dynapen **125 mg**, po, q 6 hrs. Medication available: Dynapen **62.5 mg/5 mL**. How much will you administer to the client per dose?

    a) 7 mL
    b) 8 mL
    c) 9 mL
    d) 10 mL*

24. A client is to receive an intravenous (IV) of **300-mL** normal saline over a period of 1 hour. The IV drop factor is **15 drops per 1 mL**. How many drops per minute would you calculate?

    a) 75 gtts*
    b) 80 gtts
    c) 85 gtts
    d) 90 gtts

25. A physician's order is to administer Morphine Sulfate **7.5 mg**, IV q 3 h, prn pain. Medication available: Morphine Sulfate **10mg/mL**. Direct IV infusion is not to exceed **10mg/4 minutes**. Over what period of time will you administer this medication to the client?

    a) 2.0 min
    b) 3.0 min*
    c) 3.5 min
    d) 4.0 min

The End!

Appendix K

Post-Treatment Math Test Key

Identification Number__________________(Last 4 digits of Social Security Number)

Instructions: Please complete all of the following questions and circle the correct answer for each problem. There is one correct answer for each problem. You may write on this test to solve the following problems. Please remember to reduce numbers to the lowest terms and round to the nearest tenth. The use of a calculator is prohibited. You have 40 minutes to complete this test. Good Luck!

1. Multiply **1/3** by **3/5**

a) 0.2*
b) 0.3
c) 0.4
d) 0.5

2. Divide **1/175** by **1/125**

a) 0.5
b) 0.6
c) 0.7*
d) 0.8

3. Multiply **15.5** by **9.4**

a) 145.0
b) 145.7*
c) 146.5
d) 144.9

4. Divide **100** by **5.5**

a) 0.18
b) 1.8
c) 18.1
d) 18.2*

5. Convert **0.9%** to a fraction

a) 0.9/1000
b) 9/100
c) 9/1000*
d) 90/100

6. Convert **22%** to a decimal number

a) 0.022
b) 0.22*
c) 2.2
d) 22.0

7. Convert **0.93%** to a ratio

a) 0.93 : 100*
b) 0.0493 : 100
c) 93 : 100
d) 93 : 1,000

8. Convert **13** grains into milligrams (1 grain = 60 mg)

a) 7.8 mg
b) 48 mg
c) 488 mg
d) 780 mg*

9. A **123-pound** (lb.) adult would weigh how many kilograms (kg)? (1 kg = 2.2 lb)

a) 54 kg
b) 56 kg*
c) 60 kg
d) 61 kg

10. If a medication dose is **8** mg per lb., how much should be administered per kg of body weight? (1 kg = 2.2 lb)

a) 1.7 mg
b) 17 mg
c) 17.6 mg*
d) 176 mg

11. A physician asks you to weigh an infant who weighs **3750** grams, but the scale only weighs in pounds. How much will the infant weigh in pounds? (1000 g = 2.2 lb)

a) 7.5 lb.
b) 7.8 lb.
c) 8.3 lb.*
d) 8.5 lb.

12. A physician's order is to administer **0.8** oz. of liquid Colace every day for constipation. The nurse has a measuring cup in mL calibrations. How many milliliters will the nurse administer to the client? (1 oz = 30 mL)

a) 12 mL
b) 24 mL*
c) 25 mL
d) 30 mL

13. A nurse is to infuse a **1.5**-liter (L) of intravenous (IV) solution for a dehydrated client. Approximately how many ounces will the nurse be infusing?

a) 24 oz
b) 32 oz
c) 44 oz
d) 48 oz*

14. Convert **45** mL to drams. (1 dram = 4 mL)

a) 11.3 drams*
b) 12.0 drams
c) 13.1 drams
d) 13.3 drams

15. Convert **4. 5** Tablespoons (T) to milliliters (mL) (1 Tbsp = 15 ml)

a) 6.6 mL
b) 6.8 mL
c) 66.0 mL
d) 67.5 mL*

16. A physician's order is to administer Kaopectate **1.3 g**, po, prn loose stools. Medication available: Kaopectate **750 mg/15 mL**. How many **teaspoons (t)** will you administer to the client? (1 tsp = 5 mL)

a) 4.5 t
b) 5.1 t
c) 5.2 t*
d) 5.5 t

17. A physician's order is to administer **0.2 mL** Polytrim Ophthalmic Solution to the client's right eye (OD) once-a-day (qd). How many drops (gtts) will you instill into the client's right eye each day? (15 gtts = 1mL)

a) 3.0 gtts*
b) 3.5 gtts
c) 4.5 gtts
d) 5.0 gtts

18. A physician's order is to administer Vistaril **60-mg** IM q 4-6h prn anxiety. Medication available: Vistaril **50 mg/mL**. How much medication will you administer for one dose?

a) 1.0 mL
b) 1.1 mL
c) 1.2 mL*
d) 1.4 mL

19. A physician's order is to administer Ciprofloxacin **0.75 grams,** po, every (q) 12hrs for 4 days. Medication available: **250 mg/tablet.** How many tablet(s) will you administer to the client?

a) 2.5 tabs
b) 3.0 tabs*
c) 3.5 tabs
d) 4.0 tabs

20. A physician's order is to administer **Cephalexin 0.1 gram**, po, every (q) 6hrs. for 5 days. Medication available: **250 mg/mL**. How much will you administer to the client for one dose?

a) 0.2 mL
b) 0.3 mL
c) 0.4 mL*
d) 0.5 mL

21. A physician's order is to administer Lanoxin **0.125-mg** po every day. Medication available: **1 tab = 1/240 grain.** How much medication will you give to the client?

a) 0.1 tab
b) 0.2 tab
c) 0.5 tab*
d) 1.0 tab

22. A physician's order is to administer **Cefadroxil 15 mg/kg/ po every (q) 12 hrs**. The client weighs **110 pounds (lbs.)**. Medication available: **500 mg/tab**. How many tablet(s) (tabs) will you administer to the client?

a) 0.25 tab
b) 0.5 tab
c) 1.0 tab
d) 1.5 tabs*

23. A nurse practitioner's order is to administer Dynapen **600 mg**, po, q 12 hrs. Medication available: Dynapen **125 mg/5 mL**. How much will you administer to the client per dose?

a) 10 mL
b) 15 mL
c) 20 mL
d) 24 mL*

24. A client is to receive an intravenous (IV) of **750-mL** normal saline over a period of **1.5** hour. The IV drop factor is **10 drops per 1 mL**. How many drops per minute would you calculate?

a) 80 gtts
b) 82 gtts
c) 83 gtts*
d) 85 gtts

25. A physician's order is to administer Ativan **3.5 mg**, IV now. Medication available: Ativan **4mg/mL**. Direct IV infusion is not to exceed **2mg/1 minute**. Over what period of time will you administer this medication to the client?

a) 2.0 minutes*
b) 2.5 minutes
c) 2.8 minutes
d) 3.5 minutes

The End!

Appendix L

Follow-Up Treatment Math Test Key

Identification Number_________________(Last 4 digits of Social Security Number)

Instructions: Please complete all of the following questions and circle the correct answer for each problem. There is one correct answer for each problem. You may write on this test to solve the following problems. Please remember to reduce numbers to the lowest terms and round to the nearest tenth. The use of a calculator is prohibited. You have 40 minutes to complete this test. Good Luck!

1. Multiply **1/2** by **4/5**

a) 0.2
b) 0.3
c) 0.4*
d) 0.5

2. Divide **1/150** by **1/125**

a) 0.5
b) 0.6
c) 0.7
d) 0.8*

3. Multiply **25.5** by **10.3**

a) 262.7*
b) 267.0
c) 268.1
d) 268.8

4. Divide **200** by **2.5**

a) 8.0
b) 8.5
c) 80.0*
d) 80.5

5. Convert **0.8%** to a fraction

a) 0.8/1000
b) 8/100
c) 8/1000*
d) 80/100

6. Convert **33%** to a decimal number

a) 0.033
b) 0.330
c) 0.33*
d) 33.0

7. Convert **0.44%** to a ratio

a) 0.044 : 100
b) 0.44 : 100*
c) 4.4 : 100
d) 44 : 1,000

8. Convert **12** grains into milligrams (1 grain = 60 mg)

a) 7.20 mg
b) 72 mg
c) 680 mg
d) 720 mg*

9. A **135-pound** (lb.) adult would weigh how many kilograms (kg)? (1 kg = 2.2 lb)

a) 61.0 kg
b) 61.4 kg*
c) 62.4
d) 63.0 kg

10. If a medication dose is **4** mg per lb., how much should be administered per kg of body weight? (1 kg = 2.2 lb)

a) 7.8 mg
b) 8.0 mg
c) 8.8 mg*
d) 9.4 mg

11. A physician asks you to weigh an infant who weighs **3000** grams, but the scale only weighs in pounds. How much will the infant weigh in pounds? (1000 g = 2.2 lb)

a) 5.0 lb.
b) 5.8 lb.
c) 6.0 lb.
d) 6.6 lb.*

12. A physician's order is to administer **0.4** oz. of liquid Colace every day for constipation. The nurse has a measuring cup in mL calibrations. How many milliliters will the nurse administer to the client? (1 oz = 30 mL)

a) 10.0 mL
b) 11.0 mL
c) 12.0 mL*
d) 12.5mL

13. A nurse is to infuse a **1.25**-liter (L) of intravenous (IV) solution for a dehydrated client. Approximately how many ounces will the nurse be infusing?

a) 38 oz
b) 40 oz
c) 42oz*
d) 44 oz

14. Convert **37** mL to drams (1 dram = 4 mL)

a) 6.4 drams
b) 7.1 drams
c) 8.2 drams
d) 9.3 drams*

15. Convert **5.5** Tablespoons (T) to milliliters (mL) (1 Tbsp = 15 ml)

a) 37.5 mL
b) 38.0 mL
c) 82.5 mL*
d) 90.5 mL

16. A physician's order is to administer Kaopectate **1.2 g**, po, prn loose stools. Medication available: Kaopectate **600 mg/ 15 mL**. How many **teaspoons (t)** will you administer to the client? (1 tsp = 5mL)

a) 4.0 t
b) 4.5 t
c) 5.5 t
d) 6.0 t*

17. A physician's order is to administer **0.4 mL** Polytrim Ophthalmic Solution to the client's right eye (OD) once-a-day (qd). How many drops (gtts) will you instill into the client's right eye each day? (15 gtts = 1 mL)

a) 5 gtts
b) 6 gtts*
c) 7 gtts
d) 8 gtts

18. A physician's order is to administer Vistaril **80-mg** IM q 4-6h prn anxiety. Medication available: Vistaril **50 mg/mL**. How much medication will you administer for one dose?

a) 0.7 mL
b) 0.8 mL
c) 1.4 mL
d) 1.6 mL*

19. A physician's order is to administer Ciprofloxacin **0.35 grams,** po, every (q) 12hrs for 4 days. Medication available: **250 mg/tablet.** How many tablet(s) will you administer to the client?

a) 1.4 tabs*
b) 1.5 tabs
c) 1.6 tabs
d) 1.7 tabs

20. A physician's order is to administer **Cephalexin 0.8 grams**, po, every (q) 6hrs. for 5 days. Medication available: **250 mg/5 mL**. How much will you administer to the client for one dose?

a) 10 mL
b) 12 mL
c) 14 mL
d) 16 mL*

21. A physician's order is to administer Lanoxin **0.250-mg** po every day. Medication available: **1 tab = 1/240 grain.** How much medication will you give to the client?

a) 1.0 tab*
b) 1.5 tab
c) 2.0 tab
d) 3.0 tab

22. A physician's order is to administer **Cefadroxil 20 mg/kg/ po every (q) 24 hrs**. The client weighs **165 pounds (lbs.)**. Medication available: **500 mg/tab**. How many tablet(s) (tabs) will you administer to the client?

a) 1.0 tab
b) 1.5 tabs
c) 2.0 tabs
d) 3.0 tabs*

23. A nurse practitioner's order is to administer Dynapen **175 mg**, po, q 12 hrs. Medication available: Dynapen **62.5 mg/5 mL**. How much will you administer to the client per dose?

a) 12 mL
b) 13 mL
c) 14 mL*
d) 15 mL

24. A client is to receive an intravenous (IV) of **900-mL** normal saline over a period of **1.5** hour. The IV drop factor is **15 gtts per 1 mL**. How many drops per minute would you calculate?

a) 75 gtts
b) 80 gtts
c) 85 gtts
d) 90 gtts* **(invalid)**

25. A physician's order is to administer Ativan **1.5 mg**, IV now. Medication available: Ativan **2 mg/mL**. Direct IV infusion is not to exceed **2mg/1 min**. Over what period of time will you administer this medication to the client?

a) 0.4 min
b) 0.5 min
c) 0.7 min*
d) 1. 0 min

The End!

Optional:

Your SAT 1 Math Score:______________

Appendix M

Mathematics Self-Efficacy Scale

Permission Agreement for Five Sample Items

A ten-point Likert type scale is made available (0 = no confidence at all to 8-9 = complete confidence) to the participant while answering the following types of questions from Part One of the MSES. The participants are instructed to circle a number on the scale that is appropriate.

"How much confidence do you have that you could successfully:"

1. "Determine how much interest you will end up paying on a $675 loan over 2 years at 14 3/4% interest"
2. "Figure out how much material to buy in order to make curtains"
3. "Compute your income taxes for the year"

The following two sample questions taken from Part Two of the MSES asks the participant to "rate the following college courses according to how much <u>confidence</u> you have that you could complete the course with a final grade of "A" or "B." Once again, a ten-point Likert type scale (0 = no confidence at all to 8-9 = complete confidence) is made available to the participant. The participants are instructed to circle a number on the scale that is appropriate.

1. "Algebra II"
2. "Biochemistry"

Appendix N

Student Satisfaction Survey

ID Number:______________

Research Group: Circle One!

A B C D

Instructions

Please circle your response to the following items. Rate the aspects of the learning modules on a 1 to 5 scale (1 equals "strongly disagree" and 5 equals "strongly agree"). A "1" represents the lowest and most negative impression on the scale, "3" represents an adequate impression, and "5" represents the highest and most positive impression.

Your feedback is sincerely appreciated. Thank you.

1=Strongly disagree 2=Disagree 3=Neither agree/nor disagree 4=Agree 5=Strongly agree

1. The modules stimulated my learning	1	2	3	4	5
2. I will be able to use what I learned in the learning modules	1	2	3	4	5
3.The modules were an efficient way to learn medication dosage calculations	1	2	3	4	5
4.The activities in these learning modules gave me sufficient practice and feedback	1	2	3	4	5
5.The difficulty level of the learning modules is appropriate	1	2	3	4	5
6.The length of the learning modules is appropriate	1	2	3	4	5
7.I really enjoyed learning the material in this way	1	2	3	4	5
8.This was a fun way to learn medication calculations	1	2	3	4	5

Thank you for your participation in this research study!

Appendix O

Letter of Support from Dr. M. Solomon

UNIVERSITY *of* SAN FRANCISCO

School of Nursing
2130 Fulton Street
San Francisco, CA 94117-1080
TEL 415 422-6681
FAX 415 422-6877

March 18, 2002

Dear Margaret,

In light of the literature, which consistently points to the difficulty nursing students all over the country are having in applying math to patient care problems, I am most enthusiastic about the study you have planned. Your innovation is not only significant, I believe it has great promise to be quite effective in addressing the problem.

The reliability study you conducted last year was well received by students, who readily volunteered to participate. There is definitely the flexibilty in the N340 class schedule to accommodate your study plan in the fall and I am quite honored to help in any way that I can.

Best regards,

Margot

Margot R. Solomon, PhD, RN
Assistant Professor of Nursing

Appendix P

Letter of Support from Dr. P. M. Connolly

San José State
UNIVERSITY

School of Nursing
One Washington Square
San Jose, CA 95192-0057
Voice: 408-924-3131
Fax: 408-924-3135
E-mail: www.sjsu.edu/depts/casa

Director:
Dr. Jayne Cohen

April 23, 2002

Margaret M. Maag, RN, MS
745 Stanford Ave.
Menlo Park, CA 94025

Dear Margaret:

The Program Evaluation and Research Committee in the School of Nursing has reviewed your request to have access to nursing students in the undergraduate program as part of your research project, The Effectiveness of an Interactive Multimedia Learning Explanation on Baccalaureate Nursing Students' Mathematical Achievement and Self-Efficacy," as part of your doctoral degree requirements in the School of Education at the University of San Francisco. I understand that you have discussed the details of the data collection and implementation of the intervention with Dr. Hooper and that she will work collaboratively with you in terms of access to the students.

The Committee has approved your request with the following conditions:

1. Approval by the San Jose State University Human Subjects-Institutional Review Board,

2. Approval and collaboration with the faculty of record for the courses in which the students are enrolled,

3. That there is no negative impact on the students' grade(s) in the involved courses,

4. That students are participating in a completely voluntary capacity,

5. That course activities will not be interrupted by the research, and

6. That a summary of the project and its results is provided to the Program Evaluation and Research Committee.

Congratulations in reaching this stage of your doctoral program. If you have any questions, please feel free to contact me at 408-924-3144.

Sincerely yours,

Phyllis M. Connolly

Phyllis M. Connolly, PhD, RN, CS
Chair, Program Evaluation & Research Committee

CC: J. Cohen
C. Hooper

THE UNIVERSITY OF SAN FRANCISCO
Dissertation Abstract

The Effectiveness of an Interactive Multimedia Learning Explanation on Baccalaureate Nursing Students' Mathematical Achievement and Self-Efficacy

Over 8 million families in the United States have reported that at least one member has sustained a severe health problem as a result of a medication or medical error. Researchers have discovered the most common type of error is the administration of an improper dose of medication. The ability to perform mathematical calculations is a competency skill that is essential while administering pharmacological agents to patients. Unfortunately, nursing students' lack of mathematical proficiency and self-efficacy continues to be shown in today's nursing programs. The focus of this study was to look at the effectiveness of an interactive multimedia-learning tool on 96-undergraduate nursing students' math test and self-efficacy scores and student satisfaction at two northern California universities.

An experimental factorial design involving two independent variables, treatment level and school, and five dependent variables: post- and follow-up treatment math achievement and self-efficacy scores, as well as satisfaction outcomes. Covariate data included pre-treatment math and self-efficacy scores. There were four randomly assigned treatment groups in the study: text only, text and image, multimedia, and interactive multimedia. The Math Self-Efficacy Scale (MSES) and a pre-math exam were administered to students consenting to participate in the study. Directly following the treatment the students completed the MSES and a post-treatment math exam. Two weeks later the students completed the MSES and a follow-up treatment math exam. A short student satisfaction survey was administered at the end of the study.

The outcomes derived from the study indicated no significant changes in math test or math self-efficacy scores between the treatment groups at both universities. However, the student satisfaction scores indicated that the interactive multimedia group rated their learning method higher than the other groups (though not statistically significantly). The limitations to the study were the treatment time, small sample size, and lack of qualitative data. This study's results are consistent with other interactive multimedia learning outcomes. The interactive multimedia tool had no negative effect on student learning and provided a convenient and accommodating method of instruction for nursing students.

Margaret Hansen Maag
Margaret Hansen Maag, Author

Mathew Mitchell
Chairperson, Dissertation Committee