Effectiveness of Instructional Design

to Contextualize Pharmacology

for Nursing Students

By

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Abstract

Learning pharmacology can be overwhelming for undergraduate nursing students and often occurs in specific pharmacology courses or through an integrated curriculum approach. This study examined the effects of using the Review *and Competency Evaluation (RACE)* approach to lower cognitive load and improve pharmacology knowledge for undergraduate nursing students in a Bachelor of Science in Nursing (BSN) accelerated program. The research used a quasi-experimental design and repeated measures, ANOVA to determine if there was a difference in cognitive load and pharmacology knowledge in two groups, one that used a conventional approach and another that used the *RACE* approach. Data analysis suggested that using the *RACE* approach lowered cognitive load more than a conventional approach, and results indicated a statistically significant difference between cognitive load measured after a conventional approach in pharmacology (M=7.25, SD =1.216) and after using the *RACE* approach (M=6.00, SD =.847), t (23) = 6.191, p < .0001 (two-tailed). Using a one-way analysis of variance between groups, data analysis also indicated a statistically significant difference in pharmacology knowledge (Wilks' Lambda = .594, F (1, 43) = 29.40, p < .0005, η^2 = .406). The intervention group of students had access to the *RACE* online to review and answer questions, and the amount of practice answering questions with the *RACE* online was positively correlated with pharmacology knowledge although data analysis did not yield significant results. There was a moderate relationship between the the amount of online practice and pharmacology test scores, r_s (22) =. 363, p=.081 (two-tailed). A post-intervention survey suggested that the *RACE* approach helped to organize and support learning. Implications of this study would support further online development of the *RACE* approach and future research as a modality for teaching pharmacology.

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Chapter 1: Introduction to Study

Learning pharmacology has become a growing emphasis in nursing education as more patients are taking multiple medications at any given time. The emphasis to learn pharmacology is also reflected by increased pharmacology content on the NCLEX-RN licensure exam, which is based on a practice analysis survey that is conducted every three years by The National Council for State Boards of Nursing (NCSBN). Findings from the recent survey indicate that knowledge of pharmacological therapies is rated as one of the top five considerations for safe and effective practice (National Council of State Boards of Nursing, 2012).

Pharmacology is generally taught in the first semester of a nursing program that includes other coursework such as pathophysiology, health assessment, nursing fundamentals, simulation labs, and varied practicum experiences. Nursing students often feel overwhelmed with learning new concepts and large amounts of information in the time constraints of a course and first semester that includes pharmacology (Pardee, 2007; Vana, Silva, Muzyka, & Hirani, 2011). Pharmacology can be overwhelming since nursing students have to memorize all kinds of medication information, including generic and trade names, common and adverse effects, significant lab values and pertinent teaching points. Nursing students are expected to apply this information in clinical settings, which may occur within the same or future semesters. A survey of third-year nursing students (n = 140) examined attitudes towards learning biological sciences, and students indicated that pharmacology and microbiology were the two sciences that students found most difficult to learn (Bullock & Manias, 2002).

Learning pharmacology in a discrete course can be difficult since students may not appreciate the relevance of what they are learning and how it applies to clinical practice (Batscha, 2002). Difficulty often relates to the amount of information to be learned (Achike & Ogle, 2000; Davis & Stahl, 2009; Rodriguez-Carranza & Campos-Sepulveda, 2008) and the expectation to know facts such as adverse effects, trade and generic names, and important nursing implications (Bullock & Manias, 2002). Even newly graduated nurses have tremendous difficulties understanding principles of pharmacology (Bullock & Manias, 2002).

When material seems overwhelming or difficult to understand, students may learn just enough information to pass an exam without assimilating knowledge for practical application (Lymn & Mostyn, 2010). Pardee (2007) found that nursing students desire a method to organize pharmacology content and support learning, which is especially important since information must be learned in order to retrieve it for meaningful use in other contexts, whether for classroom assessment, clinical performance, or future coursework. Just as beginning students need assistance to manage complex material, Feldon (2007) indicated that novice educators can also benefit from instructional methods to manage the complexity of course material and support teaching due to cognitive demands imposed by teaching and presenting new information. Simultaneous activities of trying to remember and facilitate classroom instruction contributes to cognitive load, which has been described as the amount of load imposed on working memory by information being presented or performance of a particular task (Miller, 1956; Sweller, 2005).

Common instructional methods for teaching pharmacology include case studies, problem-based learning and web-based activities to supplement and enhance learning. However, the interaction of complex pharmacology information and lack of prior experiences can result in high or excessive cognitive load and limit the ability to process and organize information so that it can be readily retrieved when needed. Due to the interaction and complexity of information, it's reasonable to expect that nursing students find it difficult to learn pharmacology without prior knowledge or experiences to benefit learning.

Pharmacology education for nursing students generally occurs in specific pharmacology courses or through an integrated approach, where pharmacology content is blended with other content (Lim & Honey, 2006). Manias and Bullock (2002) identify that comprehensive pharmacology knowledge involves understanding scientific principles underlying medications and contextualizing information to the complex and changing needs of patients. Integrating pharmacology across the curriculum can provide a focus on basic pharmacology principles in the first semesters and contextualize pharmacology in subsequent semesters. Building upon pharmacology through the context of relevant courses and experiences emphasizes knowledge as an inherent aspect of practice rather than viewing medication management as an isolated aspect of nursing practice (Meechan, Mason, & Catling, 2011). Further, integrating pharmacology in coursework can assist students to understand the relevance of what they are learning and how it applies to clinical practice. Studies identify that a structured approach to teaching pharmacology has improved awareness of factors such as side effects, drug actions and association with patient conditions (Meechan et al., 2011).

Problem Statement

Learning pharmacology presents a challenge for nursing students who must learn many new concepts and large amounts of information in the duration of a semester that includes other courses such as pathophysiology, health assessment, and nursing fundamentals. The amount of pharmacology information that needs to be learned can be overwhelming, and at least one study identifies that nursing students express the need for instructional methods and tools that organize information and support learning. Efforts to teach pharmacology often include instructional methods such as case studies and problem-based learning that may depend on prior knowledge, yet beginning nursing students lack prior knowledge or experiences to support effective learning.

Purpose of Study

Considering the complexity of pharmacology information and limited knowledge of beginning nursing students, the purpose of this study was to examine the effects on cognitive load and retention of knowledge when using the RACE© (Tankel & Wissmann, 1999; Wissmann & Tankel, 2001), an instructional tool for learning and teaching psychopharmacology to undergraduate nursing students. This tool was designed to facilitate formative instruction in a pharmacology course and then summative evaluation of knowledge and readiness for clinical at the beginning of the mental health course.

In this study, the RACE© was used only in the mental health course and referred to as the *Review and Competency Evaluation* approach. Instructional materials from the RACE© were used throughout the mental health course, and students were able to formatively practice answering pharmacology questions and prepare for the summative evaluation. The relationship between online practice and improved pharmacology knowledge was examined, and the following research questions and hypotheses were addressed:

Q1. Will instruction with the *Review and Competency Evaluation* approach lower cognitive load and improve retention of psychopharmacology knowledge?

> H_A: Instruction with the *Review and Competency Evaluation* approach in mental health will lower cognitive load more than instruction with a conventional approach in pharmacology.
>
> H_A: Students who receive instruction with the *Review and Competency Evaluation* will score higher on a test of pharmacology knowledge, as compared to students who do not receive this approach to pharmacology instruction.

Q2. Will the amount of online practice with the *Review and Competency Evaluation* make a difference in retention of psychopharmacology knowledge?

> H_A: The amount of practice with the *Review and Competency Evaluation* online be positively correlated with pharmacology knowledge.

A post-intervention survey was also administered to obtain students' perceptions of using the *Review and Competency Evaluation* as an engaging, instructional tool for learning pharmacology. Variables and key terms in this study have been defined and listed:

Cognitive Load. The load imposed on working memory by information being presented or by performance of a particular task (Miller, 1956; Sweller, 2005).

Multimedia. Presentation of material in two or more forms, including words (such as printed text or spoken text) and pictures (such as illustrations, photos, animation). The presentation of multimedia can include a broad range of materials such as online educational games, multimedia encyclopedias, or textbooks, for example (Mayer, 2005).

Self-explanation. Constructive activity that engages students in active learning and insures that learners attend to material in meaningful way while effectively monitoring their evolving understanding (Roy & Chi, 2005). Key cognitive process of self-explanation include generating inferences to fill in missing information, integrating information within study materials and integrating new information with prior knowledge.

Psychopharmacology. Study of pharmacological agents, including anxiolytics, mood stabilizers, antidepressants, antipsychotics and drugs of abuse, that affect emotional and mental functioning.

Psychopharmacology includes the study of scientific principles such as mechanism of action, distribution and metabolism, as well as nursing principles that include administration, important practice implications and patient education (Lehne, 2012).

Multimedia learning. The process of constructing knowledge and building mental representations from words (such as spoken text or printed text) and pictures (such as illustrations, animation or video) in presentations (Mayer, 2009).

Practice. Activities that are purposely designed to improve performance. Practice activities typically require effort and may not seem enjoyable, and most students are incapable of working on practice activities for long periods of time (Chi, De Leeuw, Chiu, & LaVancher, 1994; Gobert & Campitelli, 2007).

The Review and Competency Evaluation (RACE). The *Review and Competency Evaluation* approach to learning includes a multipurpose, instructional tool that can be used for teaching and learning psychopharmacology. The instructional tool includes a study guide of open-ended questions for five medication classifications and a digital, online format designed with Scratch open-source software for designing interactive projects (Lifelong Kindergarten Group at MIT Media Lab, 2003). The format resembles a race track with color-coded groupings of medication classifications. Questions are randomly generated for each medication classification and can be practiced by an individual or administered to a group of students for competency evaluation.

Significance of Study

Determining if the *Review and Competency Evaluation* would make a difference in learning or overall effort to acquire and reinforce psychopharmacology is significant to nurse educators who design instructional materials for pharmacology and complex learning. Access to an effective instructional tool would be relevant for educators who lack the experience or conceptual framework that enables them to successfully manage their classroom and facilitate complex learning (Feldon, 2007). Developing a learning environment that presents material in more than one format could engage beginning nursing students in learning processes that select, organize and integrate complex information.

Moreover, this study signified how pharmacology can be structured and integrated in courses to facilitate understanding about the relevance to patient conditions and clinical practice. This would be especially useful for beginning nursing students who have reported feeling overwhelmed due to little or no prior experience from which to process information, a factor that impacts cognitive processing and learning new information.

Summary of Introduction

Chapter one introduced the background and problem statement, identified as the complexity and amount of pharmacology information that beginning nursing students must learn. Definitions of key terms outlined concepts and variables that were used in the study and provided a guiding framework for the literature review. And finally, research questions and respective hypotheses were developed to examine whether the *Review and Competency Evaluation* approach could make a difference in cognitive load and retention of pharmacology knowledge.

Chapter II: Review of Literature

The literature review is organized by relevant topics, including discussion of information processing, presentation formats and multimedia learning tools relevant to health professionals and pharmacology. A conceptual framework is introduced and includes relevant concepts from the model of information processing and Mayer's theory of multimedia learning. The framework includes underpinnings of the four-component instructional design model (4C/ID), a cognitive load approach to complex learning. The following discussion of the conceptual framework begins with a review of human cognitive architecture, which provides a basis for information processing and how students encode, store and use information.

Information Processing

Human cognitive architecture. The basis of information processing includes the structure of human cognitive architecture and how learners encode, store and use information. Information processes are differentiated by working and long-term working memory (Miller, 1956). Working memory refers to structures and processes used for temporary storage and manipulation of memory. While working memory is often used interchangeably with short-term memory, short-term memory does not involve manipulation of information and is only one aspect of working memory.

Sensory memory is the shortest and first element of memory that reflects the ability to maintain impressions of information after the stimuli has ended (Ormrod, 2004). When the environment stimulates visual or auditory systems, information is processed by attention to certain parts of the stimuli. Information in sensory memory must be quickly processed to select parts of the stimulus and recognize features that can be encoded in short-term memory. Encoding allows the learner to receive and modify information so that it relates to previously stored concepts. It is considered an essential step for short-term memory. Sensory, short- and long-term memory differs in the amount, duration and type of information that is processed.

According to Miller (1956), short-term memory is operationalized as the capacity to maintain small amounts of information in memory, between 5 and 9 (7 ± 2) elements of information at a time. Due to limited capacity of short-term memory, Miller proposed chunking elements of information into meaningful groups to make them more manageable and to categorize them as a single element for storage in long-term memory. Miller identified that without rehearsal of information, all contents are lost within 20 seconds. Rehearsal is the process in memory that facilitates the repetition of information to keep it active. It can maintain information in short-term memory while enhancing transfer to long-term memory and improving storage of information. Interactions between elements of information reduce the capacity of short-term memory, a necessary step for retaining information in long-term memory.

Long-term memory stores knowledge in the form of schemas, which categorize, store and organize multiple elements of information. Cognitive schemas have no limits on informational complexity (Miller, 1956), and they can be automated to free working memory by circumventing and bypassing limitations of memory during mental processing (Paas, Tuovinen, Tabbes, & Van Gerven, 2003). Efficient use of working memory capacity requires less training and mental effort to attain the same or better learning outcomes for long-term memory (Paas, Renkl, & Sweller, 2003).
Learning outcomes can be adversely affected when students lack prior knowledge and schemas to activate for working memory. Since relevant information has not been stored in long-term memory, new information must be gathered through reading, asking questions and forming meaningful patterns that can be applied to multiple settings and future courses. Due to the complexity and interaction of pharmacology information, for example, learning new information can be overwhelming and limit the ability to process and remember information at the same time. Trying to remember information can increase demands on short-term memory and cognitive load, which impacts the ease and ability to process information by working memory. The amount of information retained in and processed by working memory has been termed cognitive load (Miller, 1956; Sweller, 2005).

Cognitive load. Cognitive load represents the load that performing a particular task imposes on the learner's cognitive system (Paas, Van Merriënboer, & Jeroen, 1994). Sweller, (2010) identified three categories of cognitive load: extraneous, intrinsic and germane load. Extraneous cognitive load is caused by the way that material is presented or by instructional materials that overlook the limits of working memory. The necessity of avoiding high levels of extraneous load is especially relevant when the contents to be learned are complex in relation to a learner's level of prior knowledge (Sweller, Merrienboer, & Paas, 1998). In this case, the representation of the learning contents imposes a considerable amount of intrinsic cognitive load. Intrinsic cognitive load entails the natural complexity of instructional material and considers the effect of element interactivity. Elements are anything that need to be learned, such as a concept or procedure (Sweller, 2010). In pharmacology, for example, learning about a prototype medication entails elements of information such as purpose, actions, drug-drug interactions, and adverse effects, all of which cannot be learned in isolation. These elements interact simultaneously to determine the level of intrinsic cognitive load. Germane load is considered effective and effortful learning that results in schema construction and automaticity. Germane and extraneous cognitive load can be modified by effective instructional design (Sweller, 2005; Sweller et al., 1998). Intrinsic load, however, cannot be modified due to the inherent difficulty and complexity of material.

Two different approaches to measuring cognitive load have included subjective rating scales and objective measures such as learning outcomes, behavioral data or time-on-task (Brunken, Seufert, & Paas, 2010). The most common method seems to be self-reported rating scales to measure perceived mental effort, often combined with a measure of perceived task difficulty. Self-reported rating scales are based on the assumption that learners can make a reliable and valid estimation of cognitive load. Most rating scales used a 7- to 9-point Likert scale that asked learners to rate perceived cognitive load on a semantically differential scale, varying from "very, very low" to "very, very high" (Paas, Van Merrienboer, & Adam, 1994). This unidimensional scale can be combined with subjective ratings of variables indirectly related to cognitive load, such as difficulty or fatigue. Paas, Van Merriënboer, et al. (1994) identified that different assessments are highly correlated so that a unidimensional scale is also able to assess cognitive load in valid and reliable ways.

Cognitive load theory. Cognitive load theory has been one of the theories used to integrate knowledge of human cognitive structures and instructional design principles (Sweller, 2005). The problem identified by cognitive load theory is that learning is impaired when the amount of processing requirements exceeds the limited capacity of working memory. Cognitive load theory is based on assumptions of information processing and understanding of how much information can be maintained in working memory. One assumption maintained that working memory is limited and performance is enhanced by automated schemas that are maintained in long-term memory (Sweller, 2005). Changes in long-term memory occur as cognitive structures, or schemas, are developed and allow multiple elements of information to be categorized as a single element. Instructional formats that include construction and automation of schemas would make the most efficient use of working memory (Paas, Renkl, et al., 2003). Automaticity, which can be achieved through rehearsal and repetition, can free cognitive resources in working memory to handle new information and improve learning. According to Sweller's theory, an aim of instruction should be the acquisition of automated schemas and constant monitoring of working memory limitations. In essence, the interaction of long-term memory and working memory should be a central consideration.

Based on characteristics of learning within a cognitive load framework, it's possible to formulate general instructional principles that would support processes of schema acquisition and enable learning (Kalyuga, 2010). According to Kalyuga (2010), developing schematic knowledge structures by grouping and categorizing information would provide a mechanism for acquiring knowledge and storing it in long-term memory. Knowledge can be held in a schematic form in long-term memory whether it is pictorial or verbal, written, or spoken (Sweller, 2005).

A way to reduce working memory-processing limitations is to practice skills provided by schemas until they can operate under automatic rather than controlled processing. Once acquired, schema can be practiced over long periods of time and processed automatically without conscious control. Instruction of complex material can be designed so that "subschemas" are taught in isolation, and instructional strategies bring material back together to describe it as a combined whole (Clark, Nguyen, Sweller, & Baddeley, 2006). In pharmacology, instruction about subclassifications of medications can enable students to develop "subschemas" that can be grouped into a schema, or a single medication classification. Acquiring a schema for a medication classification could reduce cognitive load and the number of interacting elements so that working memory is free to practice knowledge of all classifications as a combined whole.

4C/ID model. The 4C/ID model is based on cognitive load theory and emphasized instructional control of high cognitive load imposed by learning complex tasks (Paas, Van Gog, & Sweller, 2010; Van Merrienboer, 1997; Van Merrienboer & Kischner, 2007). The term 'complex' as it relates to complex cognitive skills is used in the sense that the skills comprise integrated sets of knowledge (Van Merrienboer, 1997). According to Paas et al. (2010), complex tasks could overwhelm learners by interactive information that needs to be processed simultaneously before meaningful learning occurs. Working memory should handle limited amounts of novel interacting information – possibly no more than two or three (Paas, Renkl, et al., 2003). An aim of the 4C/ID model was to ensure that working memory is not overloaded by the information presented (Paas et al., 2010).

As a cognitive load approach for design of complex learning, the 4C/ID model is comprised of task classes that can be described in terms of four components: learning tasks, supportive information, procedural information and part-task practice (Kirschner & Van Merrienboer, 2008). *Learning tasks* include design of case studies, projects, or problems that are whole-task experiences to integrate skills, knowledge and attitudes, commonly known as competencies. Design of learning tasks also included sequencing task classes and identifying performance objectives. *Supportive information* helps students learn to perform aspects of learning tasks, such as problem solving and reasoning, and provides a bridge between what learners already know and what they need to know to work on the learning tasks. *Procedural information* is organized in small information units and best used just-in-time, when students need it as a prerequisite to learning for task performance. Procedural information promotes schema automation through encoding of information. *Part-task practice* pertains to practice that develops a very high level of automaticity; it typically provides huge amounts of repetition after being introduced in the context of a whole, meaningful learning task.

Several studies have outlined how these components are used to support leaning (Pittenger & Olson-Kellogg, 2012a; Sarfo & Elen, 2007). Application of the 4C/ID model in a study by Sarfo and

Elen (2007) used a sample of 129 students and treatments that consisted of a control group and two experimental groups in a 4C/ID leaning environment. The study was designed to explore the effectiveness of a 4C/ID learning environment that contributed to development of technical expertise in secondary technical students. One experimental group included a 4C/ID environment *with* information and communication technology, and another experimental group included a 4C/ID environment *without* communication and information technology. Regardless of whether students used an environment with information and communication technology, students in the 4C/ID learning environments experienced greater leaning gains (M = 10.06 and M = 8.84) than students in the control group (M =5.44). Sarfo and Eleno reasoned that greater learning gains resulted from essential components of 4C/ID learning that were absent in the regular method of teaching. These essential components included learning tasks, instructional strategies, and gradual withdrawal of support for learning.

Other projects have also demonstrated how the 4C/ID model can be integrated into the framework of a course to support student learning (Pittenger & Olson-Kellogg, 2012b; Susilo, van Merriënboer, van Dalen, Claramita, & Scherpbier, 2013; Verheyden et al., 2011). Susilo et al. (2013) described use of the 4C/ID model to plan a continuing education course on communication skills for health professionals. Lecture, role play and small group discussions exemplified components of the 4C/ID model. The course objective was to acquire communication skills on patient advocacy in terms of informed consent. One group focused on learning communication skills, and the other group had previously received training in communication skills and focused on strengthening their teaching skills. Susilo et al. (2013) concluded that the course provided participants with the opportunity to master skills in an integrated fashion. Since integration of skills was started at the beginning of the learning process, learning would be more likely transferred to real settings.

Pittenger and Olson-Kellogg (2012b) integrated whole-task and competency-based learning in a pharmacotherapy course for doctoral-level physical therapy students. The purpose of the capstone competency was to use collaborative tools such as PBworks and Google Sites to apply pharmacotherapy knowledge in a physical therapy case scenario. The 4C/ID model was represented by the whole-task of a very complicated patient case, with scaffolding through an outline of steps and online lectures, practice opportunities with smaller cases, and procedural information through feedback and use of the faculty instructional team. Data was collected through a 10-question survey, 32-question course evaluation, student final project scores and focus groups with instructors and students (*N* =50). Results of the data reflected that implementation of the capstone assessment was a feasible and effective educational strategy. Instructors and designers were able to create learning experiences that were complex and authentic because of the supportive design features of the 4C/ID model.

The aforementioned studies and projects identified how the 4C/ID model can be used to plan educational interventions for teaching complex tasks. The competency to be learned should be introduced as early as possible though different learning tasks (Kirchner & Van Merrienboer, 2008). While the 4C/ID model supports a cognitive load approach to complex learning, cognitive theory of multimedia learning has also identified design principles to support complex learning environments.

Cognitive Theory of Multimedia Learning

Multimedia learning theory (MML) borrowed concepts from cognitive processing, dual coding theory, and constructivist learning (Mayer, 2005). Mayer (2005) identified instructional design principles that support assumptions of cognitive load theory and recognized the relation between factors influencing cognitive load and learning outcomes. Mayer's multimedia learning theory maintained three assumptions: limited capacity for working memory, dual channels to process information, and active processing to create knowledge and mental representations. Cognitive processes in a multimedia learning environment included selecting relevant information, organizing information in working memory, and attempting to integrate it with previously learned knowledge in long-term memory.

Multimedia learning theory supported the premise that learning environments have the potential to improve learning facts and concepts, provided that multimedia presentations are well-designed. According to Mayer (2005), a multimedia learning environment provided material in more than one format and engaged the learner in cognitive processes that select, organize and integrate information. Mayer's theory provided design principles that are based on information processing and how people learn. Design guidelines based on cognitive load theory are relevant to teaching in complex domains like health professions because learning tasks impose a high load on the learner's cognitive system (Van Merriënboer & Sweller, 2010).

Based on Mayer's research, Clark and Mayer (2011) provided guidelines of multimedia learning principles that support learning and effective design of instructional materials. Three design principles and the principle of self-explanation as a constructive learning activity are relevant to this study.

The multimedia principle. The multimedia principle of instructional design maintained that learners learn better from words and imagery than words alone. Learners retain more information and transfer knowledge when information is processed through printed words and imagery that is integrated from both sensory channels (Mayer, 2009). This principle established connections between words and models to illustrate structural relations between units of material. One condition under which the multimedia principle has worked is through application of the coherence principle, constructing a coherent representation of information without extraneous material. The learner must construct a conceptual knowledge representation that integrates different kinds of information into a coherent structure (Schnotz & Bannert, 2003).

The coherence principle. The coherence principle was useful for managing extraneous processing. Use of this principle reduced information that does not support learning or may compete for cognitive resources in working memory, which disrupts the process of organizing and maintaining attention (Mayer, 2005). Excluding irrelevant information would facilitate active processing and allows the learner to pay attention, integrate and mentally organize information in order to create a useful knowledge structure. A concise representation would allow the learner to focus on key elements and organize them in a way that makes sense of the whole concept. Assistance with coherence could occur by highlighting corresponding elements of information or by clearly identifying relationships of given information (Seufert & Brünken, 2006).

The segmenting principle. The segmenting principle was useful for managing and trying to make sense of essential material (Plass, Moreno, & Brünken, 2010). It most likely applies when content is complex and the learner is inexperienced with content. Segments should present a coherent conceptual unit of material, such as a step in a process or classification (or groupings) of material. Segments could be user-paced and manage essential processing so that key concepts are selected for learning, transferred to working memory and encoded in long-term memory. Two key features of segmenting include (a) breaking a unit into parts that are learner-paced, and (b) allowing the learner to control pacing from one part to another. Mayer (2005) contended that people learn better when material is presented in learner-paced segments rather than a continuous unit. User-paced segments established self-paced learning that is effective for adult learning.

Self-explanation principle. Self-explanation was another relevant principle that was used in this study. According to Roy and Chi (2005), self-explanation was a self-directed, constructive activity that engaged the learner in active learning and ensured that the learner attended to material in a meaningful way while monitoring understanding. In essence, people would learn better when they were encouraged to generate self-explanations during learning (Roy & Chi, 2005). Cognitive processes associated with self-explanation include generating inferences to fill in for missing information, integrating information within study materials, and monitoring or correcting inaccurate knowledge (Roy & Chi, 2005). These cognitive processes would require demanding, yet constructive and active processing (Mayer, 2011). Mayer explained, “Actively engaging in cognitive processing is one way to construct a coherent mental representation and model (or knowledge structure) that represents key parts of presented material and their relations” (p. 36).

Formats for Presentation and Learning

In addition to review of information processing and cognitive load that contributes to effective instructional design (Clark & Mayer, 2011), literature about effective presentation formats is also reviewed. Presentation formats should activate multisensory learning and focus attention on relevant aspects of information that can be placed in short-term memory and transferred to long-term memory. Salamonson, Dip, Everett, and Koch (n.d.) identified that whenever new material is presented in a format that allows students to see relationships, students can generate greater connections between information and achieve more successful patterns for long-term memory storage and retrieval.

Effects of color-coding information. Studies about color and information processing are reviewed since presentation formats are relevant to guide learning. Lamberski and Dwyer (1983) explain how factors related to color and information processing seem to be of value when color emphasizes relevant cues or is a coding device. Pett and Wilson (1996) reviewed color research and application to instructional design and found only slight measurable effects of color on learning and information processing. Suggested uses of color that are relevant to this study include the use of color to link related units of information and focus attention on groupings of medication classifications.

Several studies have examined the effects of presenting information and guiding students' attention by color coding (Moore & Dwyer, 1994; Ozcelik, Karakus, Kursun, & Cagiltay, 2009). A study by Moore and Dwyer (1994) investigated the effects of color-coding instructional materials to help undergraduate college students (n =183) process content that emphasized anatomy and functions of the heart. After presentation of content, students received four verbal and visual criterion-based tests to measure achievement on drawing, identification, terminology and comprehension; scores of these four tests were combined into an 80-item total test score. When all criterion tests were combined into a total test score, analysis of variance indicated significant differences on color coding ($F_{1,171} = 5.37$, $p < .05$) in favor of color rather than black and white coding. Moore and Dwyer (1994) discussed that color coding instructional materials helps learners organize or categorize information into useful patterns.

Another study of 52 undergraduate students investigated the effects of color-coded material about neurotransmitters in the nervous system (Ozcelik et al., 2009). Ozcelik et al. (2009) studied how color coding affects multimedia learning and reported results indicating that color coding increased retention and enhanced learning by prompting students to locate corresponding information between illustrations and text. Ozcelik et al. indicated that color coding attracted attention of learners to salient information, similar to how information is processed by attention to certain aspects of sensory stimuli.

Web usability guidelines have also suggested how colors and grouping can facilitate the ease of information processing (U.S. Dept of Health and Human Services, 2006). These guidelines were developed to assist design of information-oriented Web sites, and use of the guidelines is supported by a rating for 'Strength of Evidence.' Ratings included criteria within five categories: strong research support, moderate research support, weak research support, strong expert opinion support, and weak expert opinion support. There was high level of agreement among usability professionals for these evidence ratings (Cronbach's $\alpha = 0.92$).

Relevant to this study, two usability guidelines identified strong research support for grouping related elements by color, which permits users to quickly perceive patterns and relationships. The ability to distinguish patterns and relationships would help organize information into knowledge structures, or schemas. According to usability guidelines (U.S. Dept of Health and Human Services, 2006), people could distinguish up to ten different colors that are assigned to different categories, but it may be safer to use no more than five different colors for category coding. Christ (1975) identified four "focal colors" (red/blue/yellow/green) that are easily discriminated and used to encode information that needs to be remembered. Using no more than five colors to distinguish categories was similar to proposed limitations of working memory and short-term memory capacity, which maintains small amounts of information at a time.

Keller, Gerjets, Scheiter, and Garsoffky (2006) identified several reasons why information visualizations might be appropriate to facilitate acquisition of complex data structures that consist of highly interrelated information units. First, distributing different attributes of information units across different memory and processing systems might free additional processing resources that can be used to increase germane cognitive load (Mayer, 2009). Second, providing learners with a spatial representation of information units might reduce extraneous cognitive load by reducing search processes, as well as by making it easier to draw inferences on how different information units are related to each other.

Information processing and levels of knowledge. Kalyuga, Chandler, and Sweller (1998) studied cognitive load and levels of knowledge associated with different instructional formats and found that structured learning to reduce cognitive load is necessary for low-knowledge learners. The amount of prior knowledge made a difference in how learners process information and link it to what they already know (Kalyuga, 2005). Kalyuga et al. (1998) identified that information presented to learners and activities required of them should be structured to eliminate avoidable load on working memory and maximize acquisition of automated schemas held in long-term memory. Since novice learners such as beginning nursing students often lack the knowledge and framework of schemas that make cognitive processing efficient, structured learning would organize information in a way that reduces cognitive load.

Rehearsal of information and practice. Mayer (2005) contended that it doesn't matter what subject you teach because differences in students' performance are affected by how much they practice. Brabeck and Jeffrey (2012) identified that practice increases automaticity, which frees cognitive resources to handle more challenging tasks, and practice greatly increases the likelihood that students will permanently remember new information by transferring it into their knowledge base. The relationship between the amount of practice and performance has mixed reviews, however, and some studies implied that the duration of rehearsal, or practice, is unrelated to long-term retention and memory performance (Kalyuga, 2005).

Rehearsal involves the process whereby the learner repeats information long enough to keep it active in working memory and move it into long-term memory (Ormad, 2004). Elaborative rehearsal is an active process that involved deeper processing and transfer of information from short- to long-term memory for storage and later retrieval; it involves associations or recoding information in some way such as taking notes, or creating a mnemonic device that helps understanding and memory of the information. Rehearsal and practice have been terms that are sometimes used interchangeably, and Brabeck and Jeffrey (2012) discussed that effective practice involves attention, rehearsal, and repetition that leads to new knowledge and the development of more complex knowledge and skills.

Practice that requires self-explanation, or open-ended answers, is one strategy that has been shown to enhance learning because it involves constructing knowledge that can be encoded and retrieved from long-term memory (American Psychological Association Task Force, 2010; Brabeck & Jeffrey, 2012; Ozuru et al., 2009). Self-explanation has been beneficial to students who have low levels of prior knowledge (Woloshyn & Gallagher, 2009). It was described an active learning process that differs from elaboration as described by the APA Task Force (2010):

> Self-explanations are generated in the context of learning something new, whereas elaborations generally refer to the use of existing knowledge to imbed or embellish a piece of information in a larger context so that is it more memorable [sic]. The issue in self-explanation is how the explanation is generated, whereas the issue in elaboration is the appropriateness or facilitativeness of a particular context or elaboration (p. 71)

Several studies supported that self-explanation is an effective learning strategy for actively processing new material and enabling low-knowledge learners to develop study processes that maximize working memory capacity (American Psychological Association Task Force, 2010; Brabeck & Jeffrey, 2012; Ozuru et al., 2009). Self-explanation seemed to be more appropriate than elaboration for learning scientific factual information (O'Reilly, Symons, & MacLatchy-Gaudet, 1998)

O'Reilly et al. (1998) examined the effects of self-explanation and retention of facts about the circulatory system and found that undergraduate students (*N*=55) who used principles of self-explanation significantly outperformed those who engaged in elaboration and repetition as measured by recall and recognition. In the study by O'Reilly et al., students were randomly assigned to one of three conditions: repetition, self-explanation and elaborative interrogation that required students to answer "why" questions about information. Students in the self-explanation group were required to explain what the facts meant to them and how they related to prior knowledge. Despite the group with significant learning gains due to self-explanation, students had minimal prior knowledge of the circulatory system, and the groups did not differ in their perceived prior knowledge.

Another study also reported significant pre- to post-test learning gains and greater understanding of the circulatory system as a result of self-explanation (Chi et al., 1994). Chi et al. (1994) conducted a study of eight-grade students (*n* =14) who were asked to self-explain after reading a passage about the circulatory system. Students in the control group (*n* = 10) read the same passage twice, but were not prompted to self-explain the passage. Gains in understanding were assessed by answering very complex questions, and three processing characteristics were considered as reasons for these gains. Selfexplaining as a constructive activity was the first characteristic that Chi et al. (1994) contributed to deeper understanding. Second, self-explanation encouraged integration of newly learned materials with existing knowledge. And third, self-explanation occurred in a continuous, ongoing and piecemeal fashion, often resulting in partial and incomplete self-explanations that provided the opportunity to identify conflicting information between the student's knowledge and text description.

Brabeck and Jeffrey (2011) reported that use of self-explanation, or open-ended questions, can provide practice in retrieving information. Roediger and Butler (2011) identified that retrieval practice produces gains in long-term retention, even without feedback, because it promoted the acquisition of knowledge that can be retrieved and transferred to different contexts. Distributing practice over time rather than "cramming" practice into a short amount of time has been found to be more effective for learning (Bahrick & Hall, 2005). Shorter, more frequent learning activities would increase the likelihood that students recall information over longer periods of time and transfer information into long-term memory. Practice on shorter units of information before practice with the combined "whole task" activity could lessen cognitive demands on working memories of novice learners (Paas, 1992).

Multimedia Learning Tools

Multimedia learning tools for health professionals. Many multimedia learning tools (MMLTs) have been designed to educate health professionals, but Grunwald and Corsbie-Massay (2006) contended that there's a lack of evidence to support their cognitive efficiency and educational value. Grunwald and Crosbie-Massay performed a search of PubMed and identified 300 articles regarding medical education software and cognitive load. Articles were sorted and reviewed for design techniques, and a list of common features was developed. These features were cross-referenced with theories of cognitive load to create a list of methods that improved learning. Grunwald and Crosbie-Massay cited less than 40 articles that accounted for the importance of design or cognitively efficient multimedia learning tools. They discussed that features common to multimedia learning tools such as highly interactive screen designs may be too busy and serve no function to the learning task. In turn, these features could overload working memory and cause learning problems.

Huang (2005) designed interactive modules for a Virtual Labs Project, which incorporated practices in education, instructional technology, and human computer interaction. The Project was designed to augment undergraduate biology courses at Sanford University and deliver interactive multimedia about difficult concepts in physiologic systems, including systems such as cardiovascular, gastrointestinal, renal, or respiratory. At the time of publication, Huang identified a lack of standardized design methods for multimedia learning modules and proposed guidelines for best practices in multimedia design. Despite the emphasis on high-quality and interactive multimedia, Huang's proposed best practice guidelines did not acknowledge how design of these modules would control high cognitive load for complex learning.

According to the Association of American Medical Colleges (2007), the Colloquium on Educational Technology accepted Mayer's design principles for instructional design and addressed that certain elements of design might induce cognitive overload and detract from learning by how information is presented. Several studies have examined the effects of a multimedia learning environment on cognitive load in medical education. For example, Pastore (2010) presented participants (N=216) with cardiovascular instruction that included audio instruction, visual instruction and time-compressed learning. Participants were not allowed to set the pace of their instruction, and findings indicated that an increased pace of instruction (50% compression) increased cognitive load to undesirable levels. In another study, Issa et al. (2011) used a pre- and post-test control group design for medical students who received a lecture on shock. Students who received slides that incorporated principles of effective multimedia design showed statistically significant improvements in retention (F=10.2, p=0.0016) and total scores (F=7.13, p=0.0081) as compared with those who received traditional slides.

Multimedia learning tools for nursing education. Multimedia tools for nursing education generally have included materials to supplement learning and understanding. For example, a study of nursing students by Kaveevivitchai et al. (2009) examined the effects of learning vital signs with a multimedia tool that used animation and audio features. The study included measures of factual knowledge with criterion-based tests and performance on vital signs that was enhanced by supplementing lecture with a multimedia learning tool. Kaveevivitchai et al. (2009) found that performance on vital signs was the only significant result. While the conceptual framework for this study was based on cognitive learning theory, the study did not measure mental effort or the effect of cognitive load on learning.

Another study of undergraduate nursing students (*N*=96) used cognitive learning theory as a guiding framework to study the effectiveness of multimedia on medication dosage calculation (Maag, 2004). Maag's (2004) study used four treatment groups to compare principles of multimedia design: text only, text and image, multimedia, and interactive multimedia as a method to learn medication dosage calculation. Rather than measure cognitive load that was experienced while performing dosage calculations, Maag used criterion-based tests for measures of cognitive outcomes, which did not yield significant results. Other studies have used multimedia learning theory to conceptualize web-based interventions and support learning, yet these studies did not examine the relationship between multimedia learning and cognitive load (Gerdprasert, Pruksacheva, Panijpan, & Ruenwongsa, 2010; Koch, Andrew, Salamonson, Everett, & Davidson, 2010).

Hessler and Henderson (2013) utilized cognitive load theory as a theoretical framework to examine the effectiveness of a self-paced computerized case study compared to a traditional hand-written paper case study for undergraduate nursing students. They examined outcomes related to knowledge, attitude, and retention of content and found no significant results between groups for knowledge retention in semesters 1 and 3; however, students in the interactive case study group scored higher on the post-test quiz in the third semester. Based on these results, Hessler and Henderson supported the use of cognitive load theory to improve retention of information across the nursing curriculum.

Another study used cognitive load principles in the design of on-line self-learning packets to teach acid-base balance and respiratory-metabolic basis for arterial blood gas interpretation (Henderson, 2013). One hundred eighty-eight undergraduate students enrolled in prerequisite nursing courses were assigned to a control group and experimental group, and total test gain scores for combined groups from pretest (*n*=177, *M*=6.96, *SD* = 3.97) to posttest (*n*=177, *M*=12.74, *SD*=6.54) showed a significant difference and large effect size (Cohen's *d* = 0.80). Henderson identified relevance to nursing educators and proposed the use of on-line instructional design to support knowledge acquisition and develop self-learning packets for the delivery of complex tasks.

Multimedia learning tools for pharmacology. Pharmacology courses have supplemented learning with multimedia materials that illustrate scientific principles and include web-enhanced learning modules (Quinn, 2003; Tse, Pun, & Chan, 2007). Educators have also described games, use of case studies, and problem-based learning to help undergraduate nursing students comprehend pharmacology (Batscha, 2002; Croteau, Howe, Timmons, Nilson, & Parker, 2011; Manias & Bennett, 2000; Quinn, 2003; Vana et al., 2011). While authors describe how they can engage students in learning pharmacology, they do not acknowledge the effects of cognitive processing and efforts to learn complex material such as pharmacology.

A literature search of multimedia learning tools for pharmacology displayed few relevant results, and only one study described the use of multimedia for teaching pharmacology to undergraduate nursing students. A study by (Pardee, 2007) used original songs as a multimedia, mnemonic device for teaching concepts of pharmacology. Measures of cognitive outcomes included criterion-based tests that included application and analysis level questions. Pardee (2007) reviewed that although the study results did not yield significant variance in test scores between the experimental and control group, the study demonstrated the need for further research of instructional methods designed to teach pharmacology to undergraduate nursing students.

Another study of pharmacology knowledge addressed concepts of information processing and examined the impact of short message systems (SMS) and mobile alerts about medications (Chuang & Tsao, 2013). Chuang and Tsao (2013) evaluated the effectiveness of using SMS to enhance knowledge of medications among a convenience sample of nursing students (*N*=111). A quasi-experimental design was used, and the intervention group (*n* =54) received learning materials about cardiovascular medications twice per day for 10 days. Data was collected from the intervention and comparison group at baseline, one week, two weeks and four weeks post-intervention. A medication knowledge questionnaire was used to measure knowledge and contained 20 multiple-choice questions. Results were significant for increased medication knowledge for the intervention group. After the SMS intervention, the average score on the medication knowledge questionnaire in the experimental group increased from 8.92 points at baseline (out of a possible 20) to 13.46, 13.33, and 12.4 points at one week, two weeks and four weeks, respectively. In the comparison group, the average score on the medication knowledge questionnaire was 7.76 points at baseline and 9.31, 8.93, and 8.67 points at post-test. Chuang & Tsa (2013) discussed how this finding supports information processing concepts about "organization" and "repeating" information that assists students to transfer important information into short-term or even long-term memory.

While some studies have been informed by principles of multimedia learning or concepts of information processing, studies that examine the effects of multimedia learning and cognitive load seem less evident. Multimedia learning tools in nursing education have been designed to enhance recall of information through innovative teaching strategies such as an integrated curriculum (Meechan et al., 2011) or gaming, simulations and self-study review modules (Barkhouse-Maceen & Murphy, 2013; Cowen & Tesh, 2002; Glendon & Ulrich, 2005; Huang, 2005; Lynch-Sauer et al., 2011; Pardee, 2007). However, few of these instructional tools address the impact of multimedia on cognitive processing and learning complex material such as pharmacology. More often, pharmacology-related studies have focused on perceived knowledge of pharmacology, instructional methods to engage students, or strategies for self-directed learning (Manias & Bullock, 2002; Ndosi & Newell, 2009; Tse et al., 2007).

Summary of Literature Review

The literature review introduced a conceptual framework by discussing aspects of information processing, Mayer's theory of multimedia learning, and the 4C/ID model as a cognitive approach to complex learning. The literature also provided an overview of relevant topics and studies related to information processing, multimedia learning tools and instructional tools for pharmacology. While studies have examined the use of multimedia learning tools for health professionals and pharmacology, few of these studies addressed the demands of learning complex material or cited significant results for measures of cognitive outcomes. Only two studies acknowledged cognitive load and the impact of multimedia instruction for teaching pharmacology to undergraduate nursing students. The primary purpose of the literature review was to describe multimedia learning principles and a guiding framework that would support a multimedia learning environment for complex learning.

Chapter III: Methodology

Methodology for this study included implementation of a learning approach to distribute cognitive load and improve pharmacology knowledge. In order to discuss how this approach was implemented, format of the *Review and Competency Evaluation* approach as an instructional variable will be described and application of multimedia learning principles and information processing will be reviewed. The *Review and Competency Evaluation* approach was used as the independent variable and implemented within a mental health course. Design and implementation of this approach reflected principles of multimedia learning, information processing and underpinnings of the 4C/ID model to guide complex learning and pharmacology instruction.

Format of *Review and Competency Evaluation* as an Instructional Variable

Format. The *Review and Competency Evaluation (RACE©)* was originally a 24x36 board game, configured like a racetrack with matchbox cars and a large dice that was rolled in order to determine how many spaces to move the cars. The purpose was to educate and evaluate nursing students' knowledge of psychopharmacology in a game-like format (Tankel & Wissmann, 1999; Wissmann & Tankel, 2001; Tankel, 2001). It was initially used as a formative assessment in pharmacology and then a summative assessment in mental health to determine clinical readiness at the beginning of the mental health course.

Illustrated in Figure 1, a model of the instructional tool resembled a racetrack with five color-coded classifications of medications and 2-4 subclassifications. Each subclassification had relevant questions to practice answering. The cars represented playing pieces that move around the racetrack after roll of the dice. Originally, students participated in a group-like setting or classroom setting, depending on whether the game was used for clinical purposes or class instruction. In a group-like setting, students interacted with each other to provide feedback and support learning. In the clinical setting, clients seemed to enjoy watching students play the game, so questions were adapted so students could use it to instruct clients about medications.

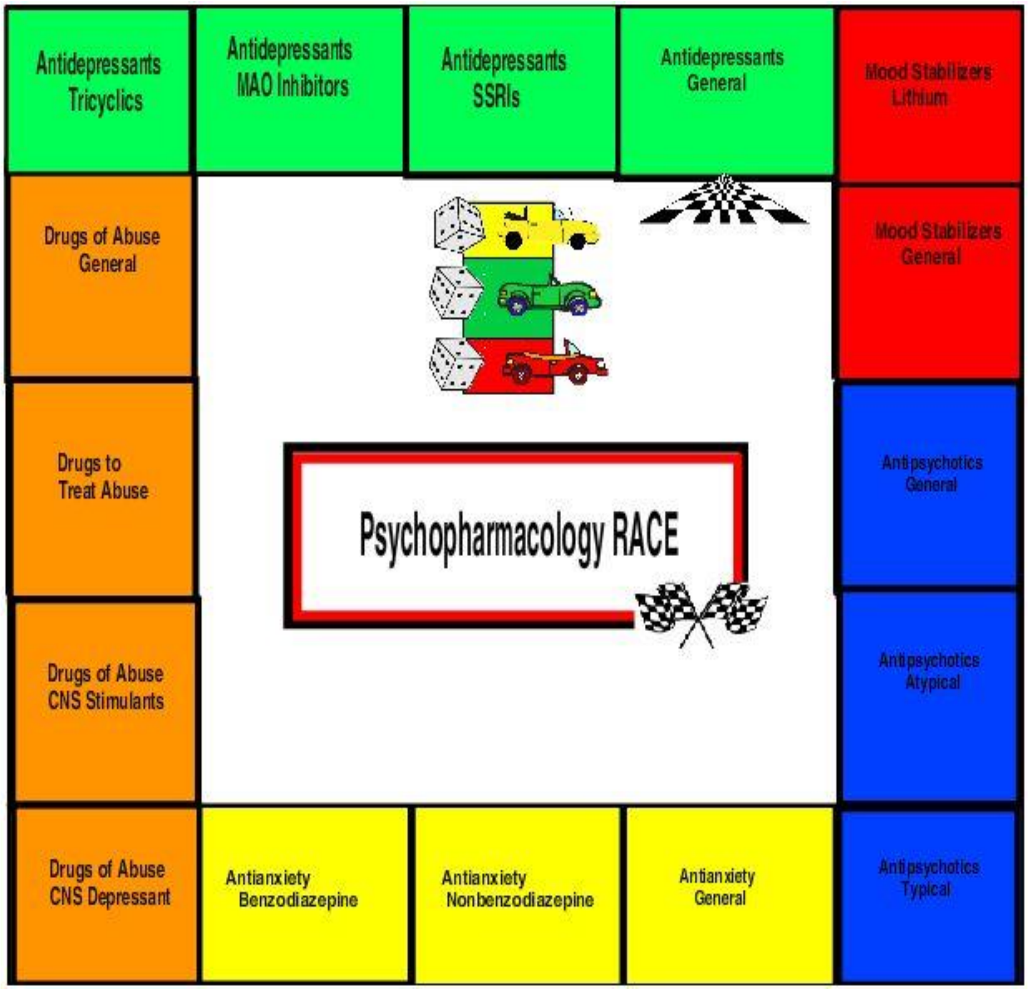

Figure 1. Format of the *Review and Competency Evaluation (RACE)*. This figure illustrates the model (or knowledge structure) of classifications and how medication classifications are color-coded.

Instructional materials for students included color-coded worksheets for each of the five medication classifications. Color-coded worksheets included numbered questions, corresponding with questions that were randomly displayed when the dice is rolled. The *Review and Competency Evaluation* (RACE) had a total of 136 open-ended questions. Depending on use of the tool, students were given multiple attempts to move around the racetrack and answer questions. Students received a one-page list of classifications, medications and highlighted prototypes as identified in Figure 2. Prototype medications had properties that were similar to other medications and assisted students to begin making associations with others in the classification.

Classifications and Example Medications (Brand Names)

Antianxiety	*Antipsychotic*	*Antidepressant*	*Mood Stabilizers*	*Drugs of Abuse*
Benzodiazepines	**Traditional**	**Tricyclics**	**Lithium**	**CNS Stimulants -**
Ativan	Haldol	Anafranil		Amphetamines
Centrax	Loxitane	Ascendin	**Anticonvulsants**	Cocaine Concerta
Klonopin	Mellaril	Elavil	Depakote	Cylert Dexedrine
Librium	Moban	Ludiomil	Lamictal	Nicotine Ritalin
Serax	Navane	Norpramin	Neurontin	Adderall Daytreme
Tranxene	Orap	Pamelor	Tegretol	Focalin Caffeine
Valium	Prolixin	Sinequan	Topomax	
Xanax	Serentil	Surmontil		**Nonstimulant SNRI**
	Stelazine	Tofranil	**Anxiolytics**	Strattera (ADHD)
Nonbenzodiazepines	Thorazine	Vivactil	Ativan	Intuniv
Buspar	Trilafon		Klonopin	
	Haldol Decanoate	**SSRIs**		**CNS Depressants**
(Sedative-Hypnotics)	Prolixin Decanoate	Celexa	**Atypical**	Alcohol
Ambien		Luvox	**Antipsychotics**	Barbiturates
Sonata	**Atypical**	Paxil		Benzodiazepines
Rozerem	**C**lozaril	Prozac		
Prosom	Fanapt	Zoloft		**Opiates**
	Geodon	Lexapro		Codeine Demerol
	Latuda			Heroin Methadone
	Risperdal	**SSNRI**		Morphine
	Saphris	Cymbalta		
	Seroquel	Pristiq		**Medications for**
	Abilify			**Abstinence**
	Zyprexa	**MAO Inhibitors**		Antabuse
		Marplan		LAAM
	Invega	Nardil		Methadone
	Risperdal Consta	Parnate		ReVia
		Emsam Patch		Nicotine Products
	EPS Medications			Vivitrol
	Artane	**Atypical**		
	Ativan	Desyrel		**Medications for**
	Benadryl	Effexor		**Withdrawal**
	Cogentin	Remeron		Ativan Parlodel
	In**D**eral	Serzone		Clonidine Symmetrel
	Klonopin	Wellbutrin		Desipramine Librium
	Symmetrel			Methadone
	Valium			
	Vitamin E			

Figure 2. List of medication classifications. This figure depicts the five medication classifications and highlights prototypes for anxiolytics, which have similar properties to other medications in the subclassification.

Using materials from the RACE©, the mental health course was designed to determine if another approach would lower cognitive load and improve knowledge of pharmacology. Instructional materials from the RACE© were used throughout the mental health course so students could formatively practice answering questions and prepare for the summative evaluation at the end of the course.

Illustrated in Figure 1, an online format of the RACE© was developed with Scratch, open-source software for designing interactive projects (Lifelong Kindergarten Group at MIT Media Lab, n.d.). The project was initially developed by formatting the background with objects, also called sprites, for each medication classification. Each object for the medication classification was color-coded, labeled and then collectively arranged to resemble the race track. Other image objects of race cars and dice were imported to the background since the dice would be clicked to move the car around the track to a medication classification. Each object had at least one script, which was a stacked block of instructions for how the object should respond.

Scripts were added to each object so that the sequence of instructions was to roll the dice, move the car, and broadcast a relevant question. One object was developed to have all 136 pharmacology questions, and this object had different scripts of questions for each classification. A script for drugs of abuse had as many as 35 stacked blocks of questions, for example. Scripts provided instructions to present a question at random when the dice was clicked and the car moved to a classification. In this project, there were a total of 25 objects and 60 scripts.

For the purposes of this study, one car object was used to move around the race track and broadcast questions for the pharmacology test. The comparison group received the first pre-test of pharmacology questions. After this test was done, a new script with the same pre-test questions was developed and used for pre-test administration to the intervention group and for post-test administration to both groups.

Students could use the RACE online to practice answering questions, and the instructor could use the tool within class as a means to evaluate pharmacology knowledge. Each broadcast question was numbered like the study guide questions that were distributed in class. The intent was for students to practice answering questions and then match questions with study guide answers.

Application of multimedia learning principles. As an instructional tool for psychopharmacology, the *Review and Competency Evaluation* approach incorporated principles of multimedia learning that were relevant to this study. Multimedia learning theory (MML) has borrowed concepts from cognitive processing, dual coding theory, and constructivist learning (Mayer, 2005). Considering principles of multimedia learning, the instructional tool provided a *multimedia* format with visual and written materials, supporting that learning tools need to balance between all kinds of cognitive load (Grunwald & Corsbie-Massay, 2006). The online format illustrated a *coherent* model of five, medication classifications that are grouped by color coding. *Segments*, or subclassifications of medications, were arranged within each corresponding classification, and students could self-direct learning and practice answering questions in each *segment* of information. The repetition of answering questions could strengthen cognitive processes in working memory and facilitate automaticity (Sarfo & Elen, 2007). Automaticity can be achieved through rehearsal and repetition and free cognitive resources to handle new information and improve learning (Sweller, 2005). Questions within medication classifications required *self-explanation* about scientific principles (mechanisms of actions, distribution and metabolism by the liver or kidney, for example) and nursing principles (administration, patient education and contraindications). Self-explanation is considered a constructive activity that engages the learner in active processing of information.

Application of information processing. From an information processing perspective, the conceptual structure and mental model of the *RACE* (see Figure 1) organized schemas of information about medication classifications: antidepressants, anxiolytics, drugs of abuse, mood stabilizers, and antipsychotics. Information was grouped by medication classifications and corresponding subclassifications. Instruction about subclassifications of medications enabled students to develop "subschemas" that could be grouped into a schema, or representation of a medication classification. This conceptual structure provided a framework to structure learning and organize pharmacology information for beginning nursing students who often lack the knowledge and framework of schemas to make cognitive processing efficient.

Since factors related to information processing and colors seem to be of value when color represents relevant cues (Lamberski & Dwyer, 1983), the instructional tool illustrated five color-coded medication classifications and groups of medications that go together. Color-coding depicted key medication classifications and corresponding subclassifications. Grouping information by color represented patterns and classifications for encoding in long-term memory. In addition, grouping information regarded the limitations of working memory, or 7 ± 2 pieces of information (Miller, 1956).

Instructional formats that present information in cognitively manageable chunks and focus the learner's attention on key elements of instruction have proven most successful for learning (Grunwald & Corsbie-Massay, 2006). In this study, developing schemas for medication classifications enabled efficient use of cognitive load and reduced the number of interacting elements so that working memory was free to practice learning information from all classifications as a combined whole. Using the whole instructional tool to practice or demonstrate competency for the final evaluation could bring learning together for all medication classifications.

Underpinnings of 4C/ID model. By introducing the competency to be learned as early as possible through different learning tasks, the 4C/ID model has been used to plan educational interventions for complex learning (Kirschner & van Merrienboer, 2008). Use of the *Review and Competency Evaluation* approach within classes of the mental health course reflected underpinnings of this model, meaning that aspects of this approach included supportive information, learning tasks and practice opportunities for the competency evaluation. After introducing and reviewing information in a class, students could use the online tool to practice answering questions and develop high levels of automaticity for improved learning. Part-task practice was based on repetition and strengthening of knowledge within context of the whole task (Kirschner & van Merrienboer, 2008). It enabled students to recognize how practice can contribute to whole-task performance through the final competency evaluation.

Other benefits of answering practice questions with the online tool included simulation of whole-task performance for the competency evaluation. It provided a mental model and conceptual framework that organized information and facilitated encoding of information that could be retrieved as working knowledge, rather than simply reviewing and learning from the study guide of written questions. Visually encoding information through color-coded groupings of medication subclassifications links units of information that can be chunked together for a single classification and enhance recall of information.

Learning tasks in the study were based on instructional materials from the *Review and Competency Evaluation* approach and assigned to different classes related to mood disorders, thought disorders, anxiety disorders and substance use. Each task was implemented within context of a class that corresponded with a relevant medication classification. The class identified a learning task and supportive information, including text resources and a study guide of open-ended questions about a specific medication classification. Procedural information in the 4C/ID model represented students' ability to answer questions and application of information in the respective class, for just-in-time learning. In addition to components of the 4C/ID model illustrated in Table 1, the aforementioned principles of multimedia learning and information processing provided a guiding framework from which to examine whether the *Review and Competency Evaluation* approach could make a difference in cognitive load and learning pharmacology.

Table 1. Example Class Blueprint for Learning Tasks Related to Anxiolytic Medications

Component of 4C/ID Model	Class Activity
Task	Learners are challenged with integrating and strengthening knowledge of anxiolytic medications, including benzodiazepines, nonbenzodiazepines and general characteristics.
Mental model	Classification and subclassifications of anxiolytic medication in the *Review and Competency Evaluation* (Figure 1)
Context	Class about anxiety disorders
Supportive information	
Worksheets	Study guide of questions for benzodiazepines, nonbenzodiazepines and general information (Appendix A)
Text resources	Mental health and pharmacology texts Table that highlights prototype anxiolytic medications
Cognitive feedback	After task completion, provide verbal feedback/answers to study guide questions in order to encourage students to reflect on the quality of their answers and understanding of information.
Learning task 1.1	Review completed worksheets of medication questions in class
Learning task 1.2	Practice answering questions about anxiolytics with online tool

It follows that the purpose of this research was to examine the effects on cognitive load and knowledge when using the *Review and Competency Evaluation* approach for teaching pharmacology to undergraduate nursing students. The relationship between practice and test performance was also examined. The following discussion of methodology explains the research design, research questions and hypothesis, sampling procedures, measures for data collection and procedures for data analysis.

Research Design

This research used a quasi-experimental design and repeated measures, ANOVA to determine if there was a difference in cognitive load and pharmacology knowledge when using the *Review and Competency Evaluation* approach for teaching and learning pharmacology. Exploring how this approach was effective to impact learning provided useful information for further development as an online, instructional tool. An intervention and comparison group was used to examine whether the instructional tool would make a difference in cognitive load and knowledge of pharmacology. The intervention group included nursing students in a mental health course that received the intervention, and the comparison group included students in a mental health course that received conventional instruction with PowerPoint, readings and case studies.

This quasi-experimental research design involved implementation of the independent variable (*Review and Competency Evaluation* approach) without random assignment of participants to the intervention and comparison group. The dependent variables were measures of cognitive load from the Subjective Cognitive Load (SCL) scale and measures of pharmacology knowledge from the *Review and Competency Evaluation* test. The following research questions and hypotheses were addressed:

Q1. Will instruction with the *Review and Competency Evaluation* approach lower cognitive load and improve retention of psychopharmacology knowledge?

H_A: Instruction with the *Review and Competency Evaluation* approach in mental health will lower cognitive load more than instruction with a conventional approach in pharmacology.

H_A: Students who receive instruction with the *Review and Competency Evaluation* will score higher on a test of pharmacology knowledge, as compared to students who do not receive this approach to pharmacology instruction.

Q2. Will the amount of online practice with the *Review and Competency Evaluation* make a difference in retention of psychopharmacology knowledge?

H_A: The amount of practice with the *Review and Competency Evaluation* online will be positively correlated with pharmacology knowledge.

Sample

The convenience sample for this study represented the population of nursing students who planned to receive a Bachelor of Science in Nursing (BSN) degree and qualify for the National Council Licensure Examination. The convenience sample included two groups of undergraduate nursing students enrolled in BSN accelerated programs of two private universities in the Midwestern United States. These accelerated programs condensed a two-year, pre-licensure program into five semesters. Admission criterion for both accelerated programs included a Bachelor of Arts or Bachelor of Science degree from an accredited college or university. The program for the comparison group required a minimum GPA of 2.7, and the program for the intervention group required a minimum GPA of 3.0. Expected enrollment for each program was generally 24 - 30 students.

The convenience sample was selected due to availability of a comparison and intervention group with similar sequencing of pharmacology prior to the mental health course. The comparison group included beginning, accelerated nursing students who took a 3-credit pharmacology course during a summer session; these students were enrolled in a 14-week mental health course that was web-enhanced and received in-class instruction 2.5 hours per week, August to November 2014. The intervention group included students who took a 3-credit pharmacology course in a 7-week fall session prior to the mental health course; students in the intervention group enrolled in a 7-week mental health course that was also web-enhanced but received in-class instruction 4 hours per week, October to December 2014.

At the beginning of the mental health course for the comparison group, the instructor provided an overview of previously-learned basic principles that were reviewed in the pharmacology course. The pharmacology course provided learning about classifications such as antidepressants, anti-anxiety medications, antipsychotics, mood stabilizers and drugs of abuse, as well as sedative/hypnotics and medications to treat substance withdrawal. Information relative to these classifications was presented more in-depth throughout the mental health course. As each mental health disorder was introduced in class, there was further instruction about specific medication classifications relevant to the disorder or medications to treat side effects. The method of instruction included Power Point and case studies, and the textbook was *Essentials of Psychiatric Mental Health Nursing* (Townsend, 2014).

Instruction in the intervention group was similar to instruction for the comparison group; however, the intervention group did not have an overview of basic pharmacology principles. Basic pharmacology principles were included in instruction about medication classifications within each respective class. As part of the intervention, instruction also included review of study guide questions that were distributed the first class day. While Power Point was used to introduce the medication classification and provide an overview of concepts, the study guides had more directed questions and information for learning. Students in the intervention group also used a different textbook, *Essentials of Psychiatric Mental Health Nursing* (Varcarolis, 2014).

Although each group used a different syllabus, text and method of instruction, the common aim was to teach students more in-depth information about pharmacology in the mental health course. The comparison and intervention groups had different course instructors, which was invariably a consideration for design and limitation of the study. Different instructor teaching styles would be one example of an extraneous variable that could impact study results (Cohen, Manion, & Morrison, 2011). An alternative design would have been to use the same instructor in both the intervention and comparison groups and minimize this extraneous variable. However, if the *Review and Competency Evaluation* approach lowered cognitive load and improved pharmacology knowledge, then any instructor could use this approach in an effective manner, regardless of teaching style.

Sampling Procedures

Students in the comparison and intervention groups were eligible to participate in the study if they had completed the pharmacology course prior to mental health. On the first day of the mental health course, students in the comparison and intervention groups were provided with information about the study. Informed consent was distributed and reviewed, and students were given the opportunity to ask questions.

In the intervention group, use of the *Review and Competency Evaluation* approach was explained as part of the customary course design, and students were reassured that pre- and post-test scores would not impact their course grade. One student questioned if the pre- and post-test would occur within or outside class time. It was explained that tests would occur within class time for convenience of study participation, and a pseudonym would be used to assure confidentiality and anonymity of test scores. It was reiterated that instructional materials would be used even if students declined participation. Course enrollment for the selected intervention group was 24 students, and 24 students agreed to participate.

For the comparison group, information about the study was presented in a similar manner, and informed consent was distributed and reviewed. The study was explained by presenting the *Review and Competency Evaluation* on an overhead projector and highlighting the purpose and process for administering the test to measure pharmacology knowledge. Students were given the opportunity to clarify information after informed consent was distributed and reviewed. Students did not have any questions or concerns, and twenty-two students agreed to participate. Once written consent was received, students were given instructions for developing a pseudonym that could be used to assure confidentiality and anonymity of test scores.

Protection of Human Subjects

Prior to data collection, Institutional Review Board (IRB) approval was obtained from the Human Subjects Committee of the researcher's university (Appendix B), as well as each university (Appendix C and D) for the intervention and comparison groups respectively. Informed and written consent emphasized that participation in the study was voluntary, and students could withdrawal participation at any time without impacting course performance or course grade. Informed consent explicitly stated that scores on the pre- and post-tests would not impact their course grade, and a pseudonym would be used to protect anonymity and confidentiality of test scores.

Benefits and risks of participating in the study were described in the consent and also discussed with students. Risks were minimal and similar to those experienced when taking a test, such as anxiety, test-taking fatigue, embarrassment about performance, or feeling discouraged if unable to remember previously-learned information. Additional benefits included the ability to recall concepts about previously learned in pharmacology or understanding what might be learned in the mental health course.

Data Collection Instruments

Test of pharmacology knowledge. Pharmacology knowledge was measured with open-ended questions from each classification in the *Review and Competency Evaluation* (RACE) instructional tool. Questions were open-ended to promote self-explanation and assist students to attend to material in a meaningful way. Used as a test, the instructional tool had 136 possible questions, but the number of questions within each medication subclassification varied from 4-16 questions. For the purpose of this study, 30 questions (Appendix E) were administered to participants at the beginning and end of the mental health course. In this manner, pretesting was used instead of explicit goal formation to alert the learner of certain information to be learned, and post-testing served as a codifying agent after instruction (Grunwald & Corsbie-Massay, 2006).

Test performance was expressed as a percentage, the number of correct answers divided by the total possible. Since questions were open-ended, answers were scored with a recall protocol to evaluate the meaning of the answer rather than exact wording. Mayer (2009) cited studies that used a recall protocol to measure knowledge retention by examining learner's written explanations to questions and focusing on the meaning of the answer rather than the exact wording (Mayer, 2009). Open-ended and short-answer questions were found to assess recall of information rather than recognition, selecting or guessing from options provided in multiple-choice questions (Ndosi & Newell, 2009; Roy & Chi, 2005). Ndosi and Newell (2009) found that this is important to nursing professionals who by the nature of their job require recall of information more than recognition.

Reliability. Reliability was addressed by application of a scoring protocol for the pharmacology test, which included 5 questions about drugs of abuse, 5 questions about antidepressants, 6 questions about mood stabilizers, 6 questions about anxiolytics, and 8 questions about antipsychotics. The scoring protocol was devised by two educators, one who teaches pharmacology and another who teaches and practices mental health nursing. Answers were based on information from pharmacology and mental health nursing texts (Lehne, 2012; Varcarolis, 2014). While answers were established by mutual agreement, a percent-agreement was not calculated for inter-rater reliability. To ensure objectivity, the protocol was applied to scoring and if answers varied from established answers, additional review of the pharmacology and mental health texts validated whether an answer was acceptable and agreed-upon.

After administering the final pharmacology test to the comparison and intervention groups, all pre- and post-tests were scored. To avoid bias and influence on scoring, the tests had a cover sheet with directions for development of a pseudonym that was the same for both groups. Each cover sheet was stapled to several blank sheets of notebook paper which was used to write the question number and answers. The cover page was turned to the back of the test so scoring could begin with the first page of answers, and there was no identifiable difference between answer sheets for each group.

After reviewing the test, the educator of the comparison group identified that content of 26 questions was presented through Powerpoint, which also included four case studies. Content of four questions was presented through assigned textbook readings. The researcher reviewed the final tests with the scoring protocol, and notes were written within answers and margins when answers varied or meaning was questionable. These notes and answers were compared with text resources and shared between the researcher and educator for discussion, agreement for meaning of the answer, and scoring. All available answer information was used for scoring, and answers were reviewed multiple times to ensure that participants could receive the benefit of all possible points. A percent-agreement for scoring the tests was not calculated, and this would be considered a limitation for an estimate of inter-rater reliability.

The pre- and post-test included 30 questions for a total of 63 points. Questions represented open-ended questions from each medication classification, and answers were scored with partial credit. Partial credit provided the opportunity to receive possible points for an answer and demonstrate emerging mastery of course material. The motive for partial credit scoring was to obtain a more accurate estimate of the student's ability rather than a simple pass/fail score (Masters, 1982).

Estimation of internal consistency reliability was based Cronbach's alpha, a commonly-used practice in education research (Cohen, Manion, & Morrison, 2011). Cronbach's coefficient alpha was used to measure test reliability of partial-credit scoring since Kuder-Richardson formula 20 (KR-20) requires items that are dichotomously coded. Since Cronbach's alpha is based on a single test administration to a group of individuals, a measure of reliability with Cronbach's alpha was computed on the final test, yielding an alpha coefficient of 0.86. While acceptable values of coefficient alpha range from 0.70 to 0.95, values 0.70 – 0.79 are considered reliable and values 0.80 – 0.90 are considered highly reliable (Cohen, Manion, & Morrison, 2011).

Validity. Content validity of the *Review and Competency Evaluation* was also established by expert review of two educators, one who teaches pharmacology and another who teaches and practices mental health nursing to maintain knowledge of practice trends and medication administration. Questions represented concepts about psychotropic medications that are emphasized in mental health texts, mental health practice and pharmacology textbooks (Lehne, 2012; Stuart, 2013). Answers to questions represented factual data from which to assess recall of information. Since questions were open-ended, answers could be reviewed and supplemented as clinical knowledge changed or new developments occurred. Also important, new questions could be added as practice trends changed.

Test questions were designed to validate psychopharmacology knowledge, the underlying construct relative to mental health nursing. Questions represented dimensions of pharmacology, including mechanism of action, therapeutic uses, adverse effects, and drug interactions. Since many questions tested knowledge of closely related concepts, validity evidence was supported by the pattern of associations with other questions, one means of validity evidence (Fowler, 1995).

Measure of practice with the *Review and Competency Evaluation* online. The amount of practice with the *Review and Competency Evaluation* online was measured by user activity reports in Blackboard Learn™, a learning management system that supported use of the activity for research purposes and statistics tracking. This was the only activity posted on Blackboard, and activity reports included the frequency and time of student access. Time-on-task was not tracked since students could have been performing other activities or declined to immediately log out when finished. To assure anonymity of practice, each student was enrolled in Blackboard with their pseudonym and used this pseudonym for the login.

Perceptions of using the *Review and Competency Evaluation*. A post-intervention survey about using the *Review and Competency Evaluation* approach was administered. The survey was adapted from three subscales of the Intrinsic Motivation Inventory (IMI; Appendix F) (Ryan, 1982) because they related to interest/enjoyment (7 items, $\alpha = 0.80$), perceived competence (6 items, $\alpha = 0.87$), and effort/importance (5 items, $\alpha = 0.84$). Statements for each subscale were answered with a 7-point Likert scale, from 1 (not at all true) to 7 (very true).

The original IMI consisted of 27 items assessing dimensions of intrinsic motivation, defined as engaging in an activity for satisfaction gained while attempting to achieve a new skill, performance level or new task (Ryan, 1982). According to McAuley et al. (1989), the overall inventory appeared to be internally consistent ($\alpha = 0.85$), and items on the subscales were stable across a variety of tasks, conditions and settings. The IMI items were generically worded, allowing the researcher to substitute the activity/task of interest into the item structure. In this study, for example, an item such as "I tried very hard to do well at this activity" was changed to "I tried very hard to do well on these learning materials". In addition to questions adapted from the Intrinsic Motivation Inventory, the survey included additional open-ended questions: What was most helpful in using the *Review and Competency Evaluation* approach? What was least useful? and What aspects of this approach helped to organize and support learning?

Subjective Cognitive Load scale. In this study, the Subjective Cognitive Load (SCL) scale allowed participants to rate the amount of effort to learn pharmacology on a 9-point Likert type scale with categories that range from 1 (very, very low mental effort) to 9 (very, very high mental effort). Defined as the amount of overall effort to learn, cognitive load was measured twice in the intervention group. The first measure of cognitive load occurred within a week of completing the pharmacology course. The second measure occurred after using the *Review and Competency Evaluation* approach in the mental health course.

The Subjective Cognitive Load (SCL; Appendix G) scale originated from a scale designed to assess perceived item difficulty in cognitive tests (Bratfisch, Borg, & Dornic, 1972). Paas (1992) developed a unidimensional, 9-point Likert scale and later refined it (Paas, Tuovinen, et al., 2003; Paas, Van Merriënboer, et al., 1994). Paas et al. (2003) found that self-reports on rating scales were reliable and frequently used measures of cognitive load.

Reliability of Subjective Cognitive Load scale. Previous studies that adapted the SCL to a 7-point Likert scale indicated that reliable measures of cognitive load could be obtained from unidimensional scales that are valid, reliable and unintrusive (Paas, Tuovinen, et al., 2003; Paas, Van Merriënboer, et al., 1994; Wiebe, Roberts, & Behrend, 2010). Experiments related to training in statistics (Paas, 1992) and geometrical problem solving (Paas, Van Merriënboer, et al., 1994) used a modified version of the rating scale and found that reliability measures of the SCL scale remained high, with Cronbach's alpha measures of 0.90 and 0.82 respectively.

Validity of Subjective Cognitive Load scale. Subjective ratings of mental effort have been considered valid measures of cognitive load as reported in former studies (Paas, 1992; Paas et al., 1994). Validity of the SCL is based on assumptions that participants are able to introspect on their cognitive processes and report the amount of mental effort (Paas, Van Merriënboer, et al., 1994). Pass et al. (1994) reported other researchers who found that participants can introspect on cognitive processes and have no difficulty in assigning numerical values to the invested mental effort. As compared to other self-report measures, Wiebe et al. (2010) identified that the SCL scale reported validity and sensitivity to a wide range of treatment conditions and learning outcomes.

Demographic survey. A demographic survey (Appendix H and I) was developed to identify characteristics of the comparison and intervention group, including healthcare experience and methods used to learn, review and study pharmacology. The intervention group had three additional survey questions about using the *Review and Competency Evaluation* approach to support learning: What was most helpful in using this approach? What was least useful? and What aspects of this approach helped to organize and support learning?

Data Collection Methods

Data collection for comparison group. Since data collection for the comparison group included a pre-test of pharmacology knowledge, test questions from the *Review and Competency Evaluation* were administered after informed consent was received on the first class day. Students were first given directions for developing a pseudonym that was documented on a blank piece of paper used to record test answers. The *Review and Competency Evaluation* test was projected on a screen, and each time the dice was clicked, the car moved to a different medication subclassification for a question to appear. Each question was read aloud and presented on screen for one minute. Students recorded the question number and their answer on the blank piece of paper. Thirty questions were administered, and it required approximately 40-45 minutes to administer since some students needed additional time to write their answers. The post-test was administered in the same manner at the end of the semester; students received the same 30 questions, and the test was administered on the last class day before the course final and immediately followed another end-of-semester competency that was required for the course. In addition, students received a demographic survey that identified personal characteristics, including prior degree and methods used to learn, review and study pharmacology.

Data collection for intervention group. Data collection for the intervention group included administration of the Subjective Cognitive Load Scale on the first class day of the mental health course, which was one week after completing pharmacology. Participants rated perceived mental effort to learn pharmacology on a 9-point Likert type scale with categories that range from 1 (very, very low mental effort) to 9 (very, very high mental effort). The second measure of cognitive load occurred at the end of the mental health course and immediately before administering the *Review and Competency Evaluation* post- test.

After completion of the SCL scale, the pre-test was administered. The *Review and Competency Evaluation* test was projected on a screen, and each time the dice was clicked, the car moved to a different medication subclassification for a question to appear. Each question was read aloud and presented on screen for one minute. Students were given a blank piece of paper to write the question number and their answer. Students in the intervention group received the same thirty questions as the comparison group, and it required the same amount of time to administer.

After taking the pre-test, students in the intervention group were given a packet of color-coded questions for each classification of medications from the *Review and Competency Evaluation* instructional tool. The researcher explained that each classification of medications would be reviewed and discussed in a relevant class, which provided the context for learning. In subsequent weeks, students were advised of the classification that would be reviewed in class so they could attempt to answer questions on the worksheets and be prepared for class discussion. Students also received a one-page table of relevant classifications and common medications so they could study for quizzes about names of prototype medications that were given at the beginning of each class. The medication table represented a model of five classifications, and the quizzes simply required listing select medications for a specific classification in order to recall medication prototypes and acquire schemas from which to make connections and apply new information.

In addition to distribution of study guide questions, students in the intervention group were introduced to the RACE online during the first class day. They were given instructions for how to access the site with their pseudonym password and provided with a demonstration of how to use the RACE online for practice of one classification or all classifications. Since study guide questions were first used in the class about thought disorders, students were reminded of how to access the site during this class and four additional classes. Students were given the opportunity to ask questions or identify difficulties accessing the site. The RACE online was available for students to use during the entire semester. Some students used the RACE online to practice, and others did not. Due to the pace of accelerated instruction, the RACE online was used one additional time for class practice and then deferred until the post-test.

The post-test was administered in the same manner at the end of the course; students received the same 30 questions, and the test was administered on the last class day before the course final and immediately followed another end-of-semester competency that was required for the course. In addition, students received a demographic survey that identified personal characteristics, including healthcare experience and methods used to learn, review and study pharmacology. They also answered open-ended questions about using this approach for learning pharmacology.

Limitations of Methodology

Students from two accelerated nursing programs were selected to participate in the study due to sampling convenience and sequencing of pharmacology prior to mental health. Although the convenience sample represented the population of nursing students who receive a Bachelor of Science in Nursing (BSN) degree and qualify for the National Council Licensure Examination, students in the accelerated programs differed from students in a traditional program in terms of program duration. The pace of learning in an accelerated program was quite fast, as evidenced by earning a degree in five semesters rather than two years, for example. The ability to process information and assimilate new knowledge was not underestimated, and the overall amount of effort to learn new information could increase cognitive load and impact learning. However, this also suggested the need for more structured and systematic learning to distribute cognitive load so that students would feel less overwhelmed.

Also relevant to limitations of the methodology, measures of cognitive load for the intervention group were not administered within a single course. Instead, cognitive load was measured after completion of the pharmacology course and at the end of the mental health course. Since the natural complexity of information in a pharmacology course could increase demands on cognitive load due to learning and trying to process information at the same time, differences in cognitive load would need to be cautiously interpreted. While the intervention distributed cognitive load over five classes for each related medication classification, instruction in the pharmacology course included an introductory class about basic pharmacology principles and another three-hour class specific to central nervous system drugs, which included classifications that were similar to the intervention.

Differences in teaching styles for each class of students could have also impacted study results, although the instructor of the comparison group reviewed each question on the pharmacology post-test and identified use of PowerPoint, a case study or text readings as it pertained to each question. The instructor for the intervention group did not change the customary approach to teaching pharmacology, which included using aspects of the *Review and Competency Evaluation (RACE)* approach. Since the instructor for the intervention group was also the researcher, students' initiative and performance could have been altered when they realized their role to participate in the study.

Another potential limitation would be reliability of the pharmacology measure since the alpha coefficient should be measured each time the test is administered. Reliability is concerned with the ability of an instrument to measure consistently, so additional study should not rely on published alpha estimates and alpha should be measured each time the instrument is administered (Tavak and Dennick, 2011). It's equally important to consider that each time the test is administered, current and correct information is available for scoring a test that measures nursing-related knowledge.

Summary of Methodology

The first measure of cognitive load for the intervention group occurred on the first class day of mental health, which was one week after completing pharmacology. Cognitive load was measured with the unidimensional, Subjective Cognitive Load scale. The second measure of cognitive load occurred at the end of the mental health course and immediately before administering the *Review and Competency Evaluation* post- test.

Pharmacology knowledge for the intervention and comparison groups occurred in the beginning of the mental health course since students had already received some instruction in pharmacology. The second measure of pharmacology knowledge occurred at the end of the mental health course and after intervention with the *Review and Competency Evaluation* approach. The intervention for the intervention group included study guide questions and instructor support to assist students in answering questions. This form of guidance and instructional support was process-oriented and meant to guide the student through the process of answering questions on the study guides. Students were asked to bring completed worksheets to class, and instructor feedback encouraged them to critically compare their answers. Students could use what they already knew about pharmacology to help them structure and begin to understand new information. Once students received correct feedback to questions, the intent of rehearsing answers with the *RACE* online was to drill and practice in order to strengthen response to answers, an aspect of constructing cognitive schemas that can be automated for complex learning (Van Merrienboer & Kester, 2005). The model for data collection is depicted in Figure 3.

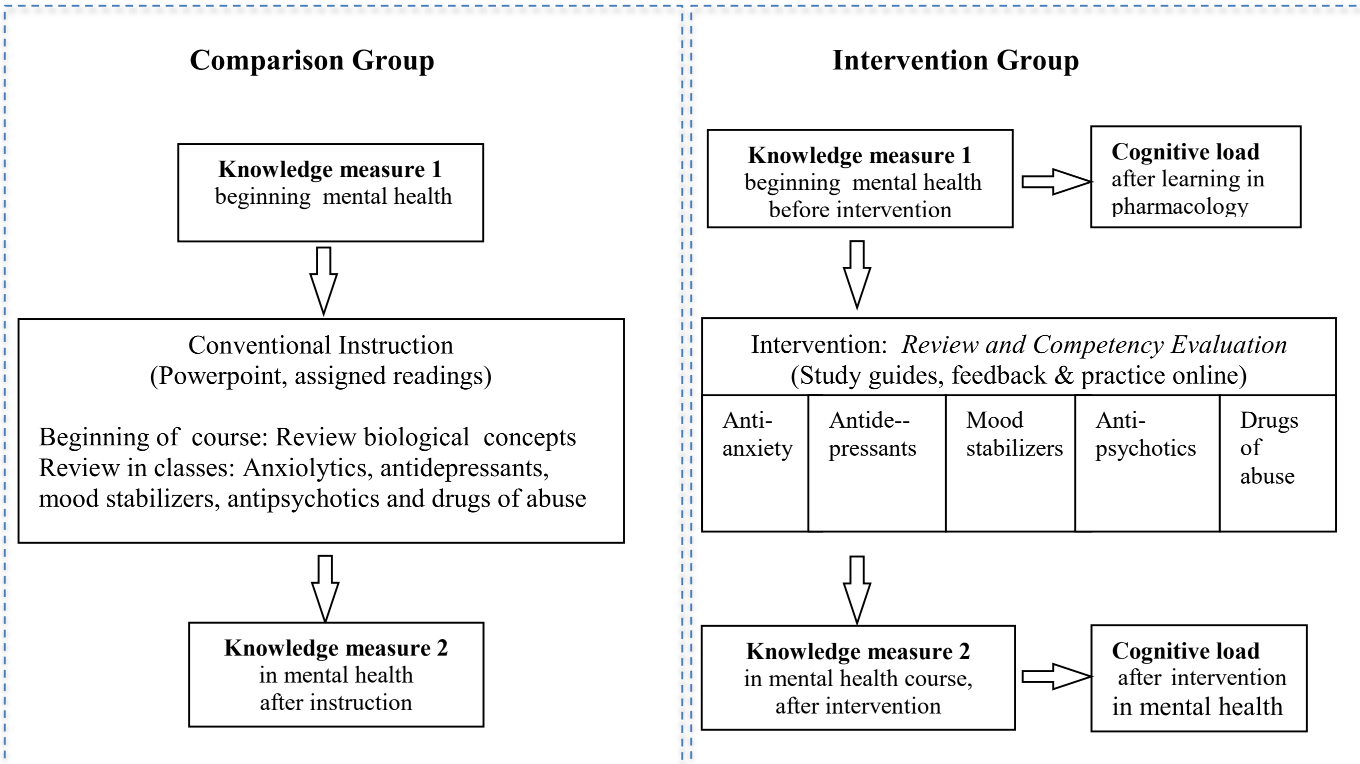

Figure 3. Model of data collection. For the comparison group pharmacology knowledge was measured at the beginning and end of the mental health course. For the intervention group, cognitive load and pharmacology knowledge was measured before (beginning of mental health) and after the intervention (end of mental health).

Chapter IV: Research Findings

This quasi-experimental study was designed to investigate the differences of cognitive load and pharmacology knowledge in two groups, one that used a conventional approach (PowerPoint, case studies) and another group that used the *Review and Competency Evaluation (RACE)* approach. In addition to analysis of data for the hypotheses, this chapter includes descriptive statistics for each group in terms of age, healthcare experience and use of time for reading or studying pharmacology. Results of a post-intervention survey for the intervention group included perceptions of using the *Review and Competency Evaluation* approach for learning.

Description of the Sample

The convenience sample for this study included two groups of undergraduate nursing students enrolled in baccalaureate accelerated programs of two private universities in the Midwestern United States. These accelerated programs condensed a two-year, pre-licensure program into five semesters. Admission criterion for both accelerated programs included a Bachelor of Arts or Bachelor of Science degree from an accredited college or university. In addition, the accelerated program for the comparison group required a minimum GPA of 2.7, and the accelerated program for the intervention group required a minimum GPA of 3.0.

The convenience sample was selected due to availability of a comparison and intervention group with similar sequencing of pharmacology prior to the mental health course. The intervention group included students who took a 3-credit pharmacology course in a 7-week fall session prior to the mental health course; students in the intervention group were enrolled in a 7-week mental health course that was also web-enhanced but received in-class instruction 4 hours per week, October to December 2014.

The comparison group included beginning, accelerated nursing students who took a 3-credit pharmacology course during a summer session; these students were enrolled in a 14-week mental health course that was web-enhanced and received in-class instruction 2.5 hours per week, August to November 2014. One student in the comparison group did not complete the post-test for the study and was excluded from data analysis. The final sample size was 21 students for the comparison group and 24 students for the intervention group.

Demographic data collected for the comparison group (Appendix H) was similar to data collected for the intervention group (Appendix I). Age demographics of each sample is presented in Table 2. There was no significant difference in age as determined by a *t*–test, t (41) = -2.025, *p* = .051 (2-tailed).

Table 2. Age Demographics of Comparison and Intervention Group.

Group	*N*	*M*	*SD*
Comparison	21	26.22	4.87
Intervention	24	30.15	7.4

Additional data was collected about previous healthcare experience and amount of weekly time spent reading the text and studying class notes as presented in Table 3. More students in the comparison group had previous healthcare experience (*n*=8, 38%), as compared to students in the intervention group (*n*= 5, 21%). Two students in the comparison group did not read about pharmacology in the text, as compared to one student in the intervention group; one student in the comparison group did not study pharmacology notes.

More students in the intervention group reported at least one hour of reading (*n*=14, 58%) and studying class notes (*n*=21, 87%), as compared to students in the comparison group who spent at least one hour of reading (*n*=7, 33%) and studying notes (*n*=10, 48%). Since students in the comparison group did not have access to instructional materials from the *Review and Competency Evaluation (RACE)* approach, they were asked to report additional resources used to learn pharmacology. Students reported using these resources: epocrates, flashcards, websites, drug handbook, Pinterest and Google.

Table 3. Summary of Characteristics for Comparison and Intervention Group.

	Comparison (*N*=21)		Intervention (*N*=24)	
Characteristic	*f*	(%)	*f*	(%)
Previous healthcare experience	8	(38)	5	(21)
Weekly time reading about pharmacology in text				
Did not read text	2	(9)	1	(4)
<1 hour	12	(57)	9	(37)
1-3 hours	7	(33)	10	(47)
4-5 hours			3	(12)
>5 hours			1	(4)
Weekly time studying pharmacology notes				
Did not study notes	1	(5)		
<1 hour	10	(48)	3	(12)
1-3 hours	9	(43)	16	(66)
4-5 hours	1	(4)	3	(12)
>5 hours			2	(8)
Weekly time using other resources to review pharmacology				
Did not use resources	1	(5)	**	
< 1 hour	13	(62)		
1-3 hours	7	(33)		
4-5 hours				
>5 hours				
Other use of resources	Epocrates Flashcards Websites Handbook Pinterest Google			
Weekly time completing and reviewing *RACE* study guide questions				
< 1 hour	**		5	(21)
1-3 hours			18	(75)
4-5 hours				
>5 hours			1	(4)

***Columns are blank because students were not required to answer these questions on demographic survey.*

Because students in the intervention group (*N*=24) used instructional materials from the *RACE,* they were asked to identify the amount of weekly time spent completing study guide questions that represented each of the five medication classifications. Most students (*n* = 18, 75%) reported at least 1-3 hours weekly using the study guide questions and few (*n* = 5, 21%) reported less than one hour. One student spent at least five hours weekly completing questions. More students in the intervention group reported reading or studying class notes at least one hour weekly, although students in the comparison group also acknowledged time spent reading and studying notes. One explanation for this finding might be that the *Review and Competency Evaluation* approach provided a means for organizing information in a way that could be easily retrieved for concentrated study. This explanation is similar to another finding that nursing students desired a method to organize pharmacology content and support learning (Pardee, 2007).

In review of demographic data, both groups included undergraduate nursing students in accelerated programs, and students had prior degrees with a mean age of 26 (comparison group) and 30 years (intervention group). Students in each group had completed a 3-credit pharmacology course that included review of basic principles and medication classifications, so they had some baseline knowledge of pharmacology.

Data Analysis of Hypotheses

Data was analyzed using the Statistical Package for Social Sciences (SPSS; Version 22) for this quasi-experimental study. The study was designed to investigate the differences of cognitive load and pharmacology knowledge in two groups, one that used a conventional approach (PowerPoint, case studies) and another group that used the *Review and Competency Evaluation (RACE)* approach. The independent treatment variable was the *Review and Competency Evaluation* approach, and the dependent variables were scores on cognitive load and scores on a test of pharmacology knowledge. An alpha level of .05 was set for three hypotheses:

1. Instruction with the *Review and Competency Evaluation* approach in mental health will lower cognitive load more than instruction with a conventional approach in pharmacology.

2. Students who receive instruction with the *Review and Competency Evaluation* will score higher on a test of pharmacology knowledge, as compared to students who do not receive this approach to pharmacology instruction.

3. The amount of practice with the *Review and Competency Evaluation* online will be positively correlated with pharmacology knowledge.

Hypothesis one. For the first hypothesis, a paired–samples t-test was used to analyze data and determine if instruction with the *Review and Competency Evaluation (RACE)* approach in mental health lowered cognitive load more than instruction with a conventional approach in pharmacology. Review of a scatterplot indicated no significant outliers in the data. To test for normality, a variable was created for the difference scores, and this variable was checked for skewness, kurtosis, and outliers (Cohen, Manion, and Morrison, 2011). The paired samples t-test indicated a statistically significant difference between cognitive load measured after a conventional approach in pharmacology (M=7.25, SD =1.216) and after using the *RACE* approach (M=6.00, SD =.847), t (23) = 6.191, p < .0001 (two-tailed). The mean difference in cognitive load lowered by 1.25 with a 95% confidence interval ranging from .83 to 1.67. Cohen's d was computed in order to identify effectiveness of the *RACE* approach, relative to comparison with the conventional approach. Effectiveness was calculated and interpreted according to proposed guidelines: ≤ .20 = small effect, 0.50 = moderate effect, ≥ 0.80 = large effect (Cohen, 1992). In this study, Cohen's d (1.26) indicated a large effect size and difference of 1.26 standard deviations between mean cognitive load scores. Results of the data analysis suggested that using the *Review and Competency Evaluation* approach lowered cognitive load more than a conventional approach in pharmacology.

Hypothesis two. For the second hypothesis, a repeated measures ANOVA with two groups was used to analyze data and determine if students who used the *RACE* approach scored higher on a pharmacology test, as compared to students who did not receive this approach. The first pharmacology test was administered at the beginning of the mental health course of each group, and the second test was administered after intervention for the intervention group and after conventional instruction for the comparison group. Both groups received the second pharmacology test before they were scheduled to take another standardized test to measure content mastery for mental health, so students had presumably studied a broad range of course materials.

Levene's test across groups indicated significance level of .006, so equality of variances could not be assumed. Since the optimal choice of whether to use Levene' test or another test for equality of means can rely on the underlying distribution (Cohen, Manion, and Morrison, 2011), a test for normality was analyzed with the Shapiro-Wilk test. Results of the Shapiro-Wilk test was .074, suggesting normal distributions. A one-way analysis of variance between groups indicated a statistically significant difference in knowledge (Wilks' Lambda = .594, F (1, 43) = 29.40, $p < .0005$, $\eta^2 = .406$). The group of students who used the *RACE* approach scored higher on the pharmacology test, as compared to students who did not receive this approach. The effect size was indicated by eta-squared and suggested that 40% of variance in test scores was attributed to the intervention. Effect size of .40 would be a large effect according to Cohen's (1992) classification: .01 is a small effect, .06 = medium effect and .14 = large effect. Mean scores and standard deviations for the pharmacology test are presented in Table 4.

Table 4. Descriptive statistics of pharmacology test.

	Comparison (*N*=21)		Intervention (*N*=24)	
Pharmacology Test	*M*	*SD*	*M*	*SD*
Baseline	19	5.095	23	4.615
Final	24	6.012	43	10.935

A line graph with error bars (see Figure 4) was used to inspect mean differences of scores across groups and represent the standard error of the mean for each level of measurement. The line graph included the group mean at baseline (beginning of mental health course) and after instruction (end of mental health course). Error bars of the means on the post-test also suggested that there was a true difference in mean scores between groups. According to Cumming, Fidler, and Vaux (2007), the larger the gap between bars, the smaller the P value and stronger evidence for a true difference in means.

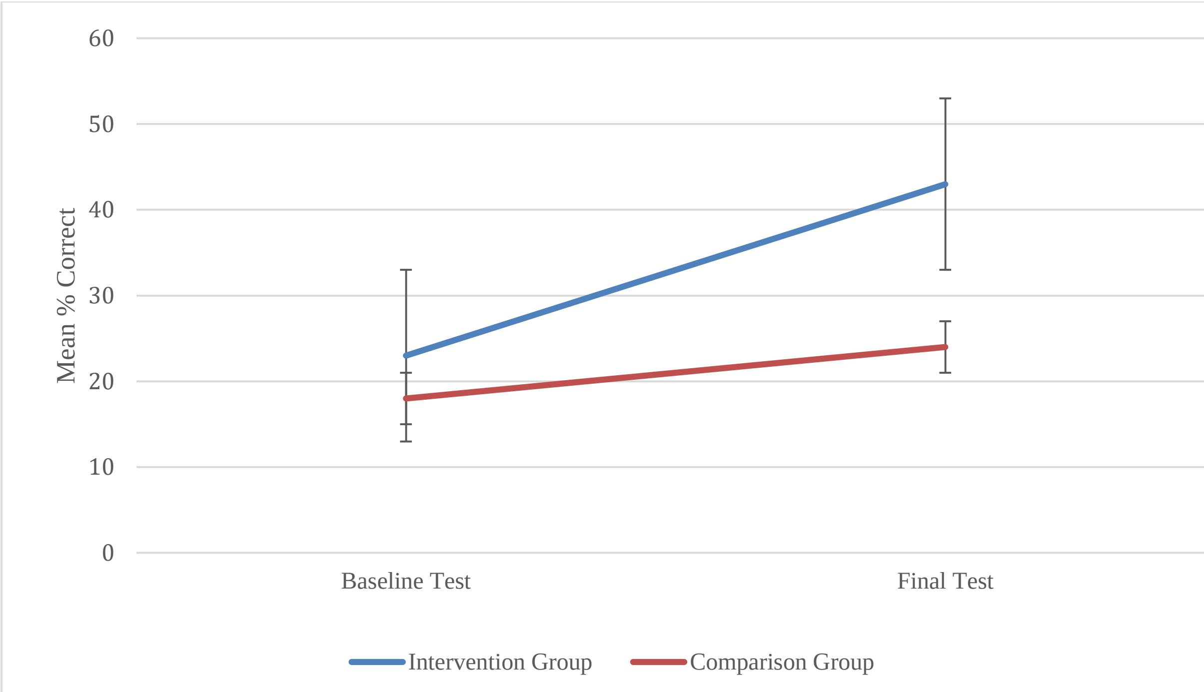

Figure 4. Line graph of mean test scores for comparison and intervention group. This line graph represents mean percent correct for the baseline and final test. Error bars represent standard error of the mean.

Hypothesis three. For the third hypothesis, correlation analysis was done to determine if there was a relationship between two variables, the frequency of online practice and final test score. A scatterplot was used to detect outliers, inspect the relationship and determine if the relationship was linear. First, a bivariate scatterplot of final test scores and frequency of online practice was generated to visually assess whether the relationship was linear and determine if assumptions would be met for a Pearson's product-moment correlation. The scatterplot had 24 data points; inspection of these data points indicated a column of 15 data points that was distant from the other grouping (see Figure 5) and represented students who did not choose to use the RACE online.

Since the scatterplot suggested a nonlinear relationship between the two variables, bivariate normality was confirmed with the Shapiro-Wilk test of normality. Using 24 cases, the Shapiro-Wilk test indicated normality of test scores with significance .486 and non-normality of practice time with significance .0005. Since bivariate normality was not met and the relationship appeared nonlinear, assumptions for using a Pearson's product-moment correlation were not met.

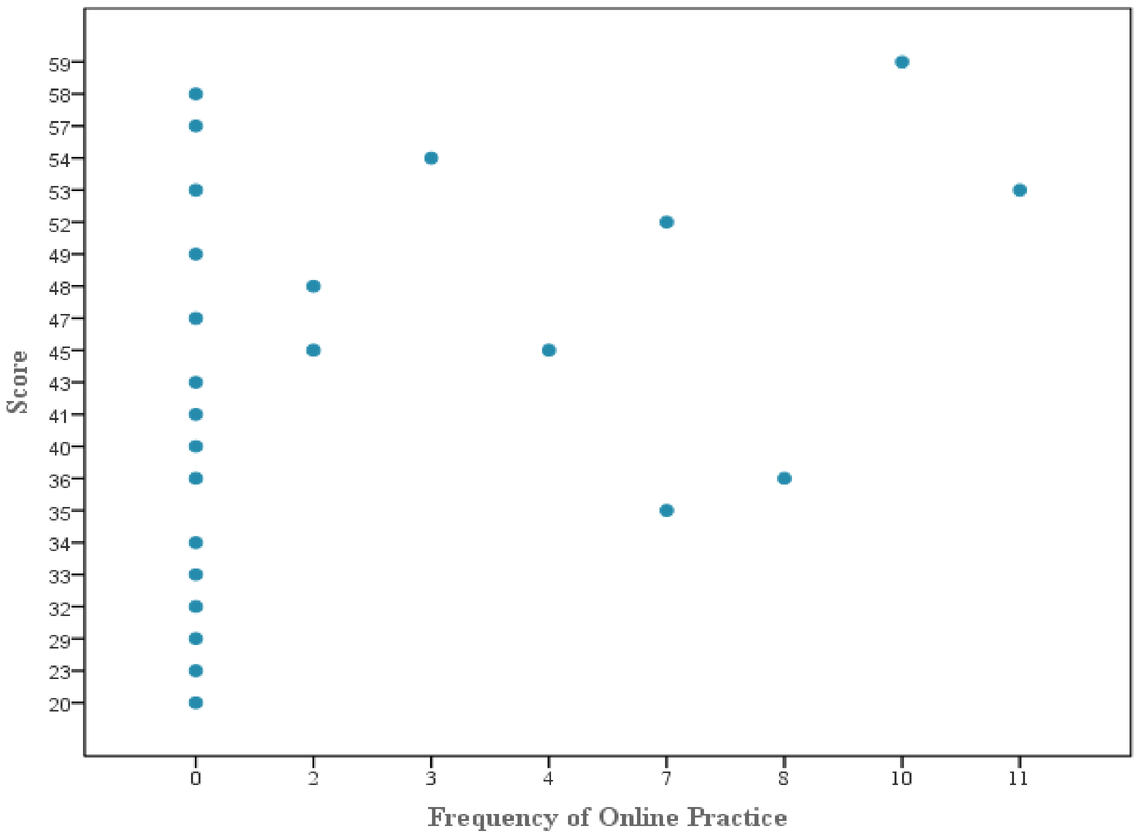

Figure 5. Bivariate scatterplot of final test scores and frequency of online practice.

Instead, a Spearman's rank-order correlation was generated to determine if there was a correlation between students' final test scores and frequency of online practice. There was a moderate relationship between the variables, r_s (22) =. 363, p=.081 (two-tailed). A one-tailed test would reach the .05 level of significance between the two variables r_s (22) =. 363, p=.04 (one-tailed), with online practice positively correlated with higher test scores. One explanation for marginal significance between frequency of online practice and final test scores could be that all students had access to the same questions and information without using the RACE online. Whether using the RACE online or not, students' amount of study time and use of learning materials would impact final test scores. Results of the post-intervention survey indicated that some students didn't put a lot of energy or effort into learning activities, and this lack of effort could have impacted their test scores.

Since the scatterplot identified 15 data points that were distant from the main grouping, these data points (or outliers) were removed from the data set for a second correlation analysis. A review of some texts and writings suggested removing extreme outliers from a data set to perform a Pearson's correlation since it can be sensitive to non-normality (Kowalski, 1972). After removing outliers and including only nine cases of online practice, the Shapiro-Wilk test indicated normality of practice with significance .343. A Pearson's correlation was calculated (r = .165, n = 9, p = .674); there was a small relationship between frequency of online practice and final test scores, and the relationship was not significant. According to Cohen, Manion and Morrison (2011), a smaller sample size would need a greater correlation coefficient in order to be statistically significant. The correlation in this analysis could have been influenced by the sample size (n=9) since correlations for a small sample may not reach statistical significance at the traditional $p<.05$ level (Cohen, Manion, and Morrison, 2011).

In review, one hypothesis was statistically significant for improved pharmacology knowledge, and another hypothesis was significant for lowered cognitive load. Despite the possibility of a Type I error, which would imply that there really wasn't a difference in knowledge and cognitive load, a large effect size indicated educational significance of the intervention. Cohen, Manion, and Morrison, (2011) explained that effect size can be susceptible to many influences, including sample size, range of scores, and reliability of measures. Despite a normal distribution, for example, a smaller range of test scores could lead to a higher effect size. In this study, results of hypotheses testing indicated that using the *Review and Competency Evaluation (RACE)* approach improved knowledge and lowered cognitive load more than a conventional approach in pharmacology. The effect of lowering cognitive load may have been greater than learning outcomes on the test due to how content was distributed across mental health classes so that students had more cognitive resources free to focus on a single medication classification in each class. While cognitive load was lowered to improve learning, learning outcomes could have been adversely affected if knowledge was not stored in long-term memory for retrieval when needed. Students who were unable to retrieve and apply knowledge on the pharmacology test likely scored lower, in comparison to peers. The intent of using the RACE online was to strengthen knowledge through practice and repetition of questions and answers. One comment in the post-intervention survey suggested that students could not effectively use the RACE approach because they had too many other assignments, an important consideration for accelerated learning. To gain perceptions about using the *RACE* approach, a post-intervention survey was administered only to the intervention group.

Post-intervention Survey

The post-intervention survey was adapted from three subscales of the Intrinsic Motivation Inventory (Appendix F). The Intrinsic Motivation Inventory assessed dimensions of intrinsic motivation, defined as engaging in an activity for satisfaction gained while attempting to achieve a new skill, performance level or new task (Ryan, 1982). Three subscales were used to survey students' attitudes about interest/enjoyment, perceived competence, and effort/importance as related to using the *RACE* approach. Statements for each subscale were answered with a 7-point Likert scale, from 1 (not at all true) to 7 (very true).

Bar graphs were created to depict mean scores of items for each subscale, beginning with interest/enjoyment in Figure 6. Mean scores of this subscale ranged from 2.29 - 4.54, and one item about boring activities was negatively worded so the mean score was 2.29 (indicating untrue that activities were boring).

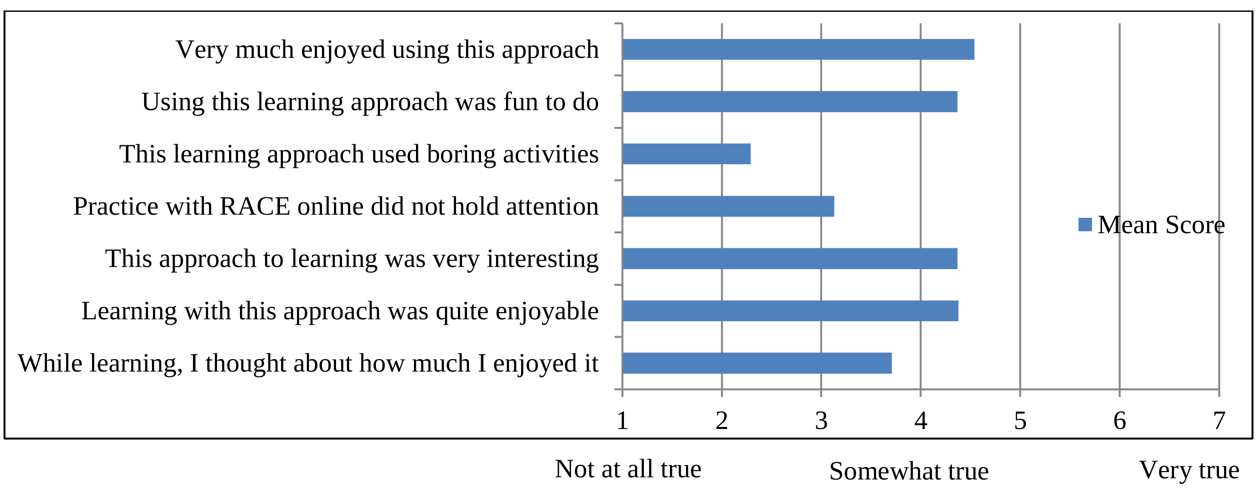

Figure 6. Bar graph of mean scores for subscale Interest/Enjoyment. Mean ratings for items on this subscale ranged from 2.29 – 4.54 on a 7-point Likert scale.

The subscale of interest/enjoyment suggested that students (*N* = 24) somewhat enjoyed using the approach and found it interesting and enjoyable. On average, it was somewhat true (mean = 3.13) that practice online did not sustain attention, and this might account for 15 students who declined to practice. online. At the beginning of the study, several students asked if answers to questions could be available online, but this feature wasn't yet developed for the online instructional tool. Without immediate feedback, students seemed to prefer studying with worksheets that were distributed in class.

The perceived competence subscale in Figure 7 included questions that were adapted to obtain information about using the *RACE* online. While all students (*N*=24) answered survey questions about practicing online, only nine students actually used the online resource. For this reason, descriptives included the subsample of nine students. Mean scores for items ranged from 3.44 – 4.33 on a 7-point Likert scale. Students (*n* = 9) felt somewhat competent (mean = 4.33) after practicing with the *RACE* online although the mean for the perceived competence subscale was 3.8, lower than the other subscales.

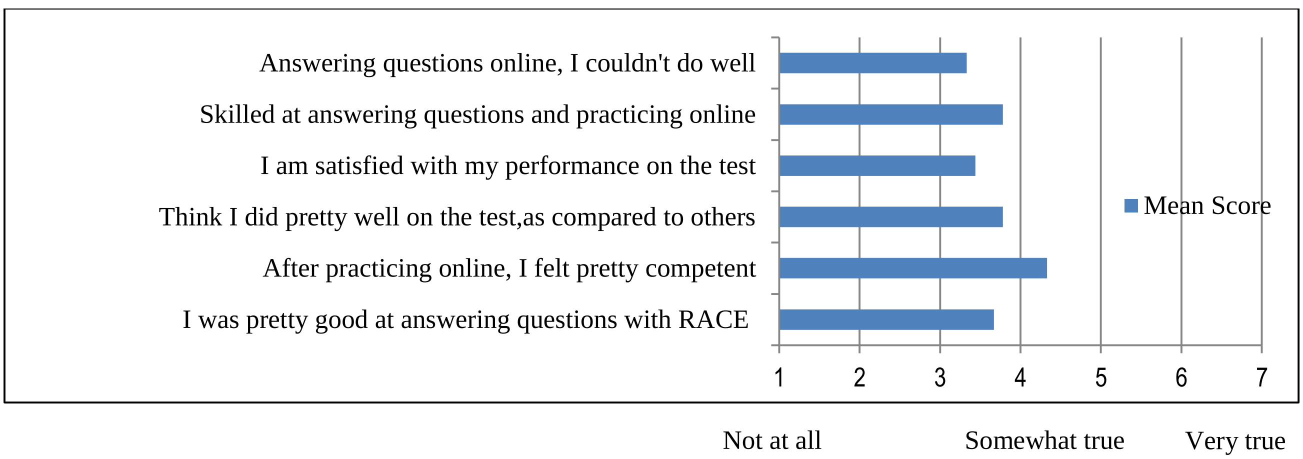

Figure 7. Bar graph of mean scores for subscale: Perceived competence. Mean ratings of items on this subscale ranged from 3.44 – 4.33 on a 7-point Likert scale.

The final subscale of the post-intervention survey pertained to effort or importance of doing well on the learning activities. Mean ratings for the subscale in Figure 8 ranged from 3.38 – 4.21. It was somewhat important for students to do well on the learning activities (mean = 4.21), yet mean scores for amount of energy (3.38) and effort for learning (3.42) were lower. The mean score was 3.6 for two questions, I tried very hard and I didn't try very hard to do the leaning activities. These were two questions from the original subscale and modified in this study to specify *learning* activities. The question, I didn't try very hard, was reverse-scored on the original instrument and for this study. When responses for this item were reversed for data analysis, both items had the same mean score and supported validity of responses and validity of the original instrument.

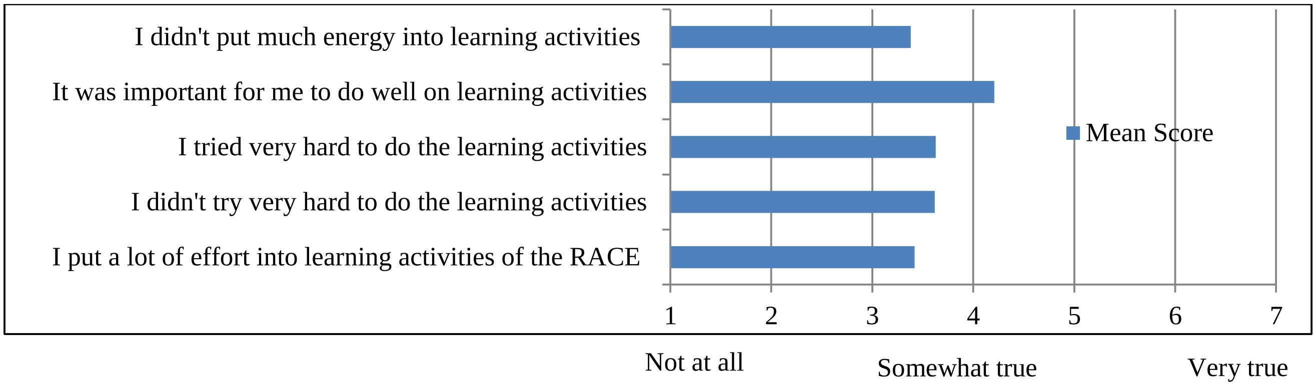

Figure 8. Bar graph of mean scores for subscale: Effort/Importance. Mean rating of items on this subscale ranged from 3.38 – 4.21 on a 7-point Likert scale.

Mean scores for each subscale of the post-intervention survey are summarized in Table 4. The mean score was highest for the subscale, Interest/Enjoyment (mean=4.50), suggesting that students enjoyed the approach and found it interesting. The mean score was lower for the subscale, Effort/Importance (mean=4.05), which identified that students didn't try very hard despite feeling that it was important for them to do well, the highest scoring item on this subscale. Overall, students felt somewhat unconfident and dissatisfied with performance as indicated by the subscale Perceived Competence (mean 3.80).

Table 4. Mean Score for Each Subscale of Post-Intervention Survey.

	Intervention Group (*N*=24)
Subscale	Mean Score
Perceived Competence	3.80
Effort/Importance	4.05
Interest/Enjoyment	4.50

In addition to questions adapted from the Intrinsic Motivation Inventory, the post-intervention survey included three open-ended questions: What was most helpful in using the *Review and Competency Evaluation* approach? What was least useful? and What aspects of this approach helped to organize and support learning? Students provided useful, written feedback about using the approach to structure and organize learning. They also identified that an overview of medications for each classification facilitated and focused learning. The study guide questions allowed them to generate their own answers and practice answers until content was understood. Comments were reviewed for each question, and data was combined into categories to provide clarity of responses for the first question, for example (see Table 5).

Table 5. Post-Intervention Survey Question, What was Most Helpful in RACE Approach to Learning?

Category	Example Comments
Overview of medications	Comprehensive information about drugs Helps highlight most important information List and overview of all important medications
Interactive versus memorization	Made learning pharmacology interactive instead of just pure memorization
Focused studying and made it easier	Made learning the drug/pharmacology easier because it gave me a study guide that allowed me to concentrate on specific aspects of pharmacology
Systematic, alternative learning approach	Very organized Splitting into categories Format new and different Provided alternative method to study Broken up into categories of medications Formatting of categories of different drugs (anxiolytics, antipsychotics, etc.)
Allowed to generate own answers and practice	Question and answer style required me to generate my own answers rather than select what ‘looked best’ It was a way for me to practice until I understood the content
Varied questions, ability to study correct answers	Varied questions Liked questions as a guide to focus studying Being able to have correct answers, knowing that I was actually studying the correct answers

In contrast, least useful activities included the lack of generic and trade names of medications on the study guide questions and table of medications. Another limitation was the inability to receive immediate feedback for answers. The idea of a ‘game’ or ‘game board’ was not appealing although implementation of the intervention was not facilitated in a competitive or fun-spirited manner. Categories and example comments for least useful activities are presented in Table 6.

Table 6. Post-Intervention Survey Question, What was Least Useful in the RACE Approach?

Category	Example Comments
Review of questions and answers	RACE questions were not all discussed in class, would have been easier to study if there was an answer key
	Would have been helpful to have full explanation of answer available earlier in semester
Lack of generic/trade medication names	May be more beneficial to learn generic names, as well as brand names as used by NCLEX
Unable to review answers for feedback	Limited feedback
	Wasn’t set up in a way where you could check answers or track progress as you went
	Did not really correlate with textbook (if missed answer, didn’t understand) couldn’t easily look up answers
	The RACE questions did not display the correct answers after the question. I had no means to verify my answers and therefore did not use this tool as a means for study.
	Answers, reasoning were not available to check yourself online.
Usability of questions	Random questions that were used in RACE Several questions are vague, require further explanation
Online use of RACE	Online “gameboard” was not very user friendly The “game”

The final question of the post-intervention survey pertained to aspects of using this approach that helped support and organize learning. In general, students identified that categories or classifications, as well as color-coding each classification, helped organize key concepts and information. The study guide handouts that were reviewed in class supported learning and organized studying. Although implementation in this study did not necessarily use a game-like approach, at least one student identified that the idea of a game-like approach was useful. Categories and example comments about how this approach organized and supported learning are presented in Table 7.

Table 7. Post-Intervention Survey Question, What Aspects Helped to Organize and Support Learning?

Category	Example Comments
Medication classifications	Color-coding by drug type. Breaking drugs up by class, sections. Organized meds into drug classes, easier to remember Categorized learning without giving overwhelming information Drugs clearly organized by category, indicated drugs to remember Breaking down questions by pharmacological group helped organize concepts and applications
Instructional method	Repetition Game-like approach Different way to learn Detailed and systematic Handouts/ notecards were incredibly helpful in organizing studying. Good approach, but there were too many other assignments to really use it. Going over answers in class, informing students of correct answers for studying

Summary of Research Findings

In review, results and comments of the post-intervention survey indicated that the instructional approach supported learning pharmacology in a way that minimized feeling overwhelmed. It was accurate that students should eventually be able to recognize trade and generic names of medications, although a table with both trade and generic names may have been overwhelming. Learning prototypes enabled students to begin to making associations with other medications in a classification. In a few cases, students commented about the usefulness of repetition and answering questions. The open-ended questions in the *RACE* approach allowed students to generate their own answers, an important consideration as students begin to build their knowledge base. An important limitation of this approach was the inability of students to receive online, corrective feedback about answers. Corrective feedback could have reinforced practice and repetition of answers until it was encoded in their knowledge base.

Chapter V: Discussion, Conclusions and Recommendations

The final chapter concludes with an overview of the study, limitations relevant to the study, and discussion of findings. In addition, further development of the *RACE (Review and Competency Evaluation)* online is reviewed within the section of recommendations for further study. A conclusion is supported by practical implications for curriculum, educators and students in regards to teaching and learning complex information such as pharmacology.

Overview of Study

The purpose of this quasi-experimental study was to examine the effects of an instructional approach to lower cognitive load and improve pharmacology knowledge, in comparison to a group that did not receive this approach. A comparison and intervention group of undergraduate nursing students in two accelerated nursing programs participated in the study during their mental health course. Both groups had prior instruction in pharmacology and received additional instruction in the mental health course. Baseline knowledge of pharmacology was measured at the beginning of the mental health course and again at the end of the mental health course.

A cognitive load approach was used since pharmacology involves complex learning that tends to overwhelm students. In this study, cognitive load was defined as the overall amount of effort to learn pharmacology relative to mental health nursing. For the intervention group, cognitive load was measured at the end of pharmacology and again after completion of the mental health course. The *Review and Competency Evaluation* approach, or study intervention, was used to distribute cognitive load over five classes to provide a context for learning and allow students the opportunity to make associations with class content. The intent was to lower cognitive load and improve the ability to learn pharmacology or acquire more pharmacology knowledge, as compared to the comparison group.

Limitations of Study

Students in both groups participated in mental health clinical experiences, which could have impacted pharmacology knowledge. Students were responsible for learning about medications for assigned patients, but they did not administer medications. Clinical experiences occurred during the time between pre- and post-test measurements of pharmacology knowledge. These learning experiences could have impacted a difference in knowledge or emphasized some medications, and improved knowledge for the intervention group might not be attributed to the use of the *Review and Competency Evaluation* approach. In addition, the natural occurrence of maturation is anticipated for students since they must demonstrate safety and readiness for the National Council Licensure Examination. Students are expected to acquire and develop a knowledge base from which to make sound clinical decisions.

Especially relevant to the intervention group, the pre-test at the beginning of the study sensitized students to reinforcement of using the study guide questions to practice and prepare for similar questions on the post-test. This testing effect could have sensitized students to possible questions on the post-test and resulted in higher test scores. Required to demonstrate mastery of course content at the end of their respective courses, students in both groups prepared for the same standardized test that included some pharmacology. Students in the treatment group received the additional benefit of using an instructional tool that supported learning.

The potential to generalize findings is recognized yet questionable due to differing nursing programs and program designs. In this study, undergraduate nursing students represented the general population of students who receive a BSN degree and qualify to apply for the National Council Licensure Examination (NCLEX-RN); however, applicants for NCLEX-RN also represent graduates from associate degree programs. Students in associate degree and traditional baccalaureate programs could have inherently different characteristics than students in accelerated programs that require a prior degree, for example. In this study, students' desire to progress through the program at a faster pace required learning greater amounts of information in a shorter duration of time (five semesters). Learning more in a shorter amount of time could be overwhelming and impact knowledge retention and the ability to effectively process information. However, this supported the need for instructional methods that would lower cognitive load for effective learning to occur.

Discussion of Findings

This study proposed to answer two research questions and test associated hypotheses:

Q1. Will instruction with the *Review and Competency Evaluation* approach lower cognitive load and improve retention of psychopharmacology knowledge?

> H_A: Instruction with the *Review and Competency Evaluation* approach in mental health will lower cognitive load more than instruction with a conventional approach in pharmacology.
>
> H_A: Students who receive instruction with the *Review and Competency Evaluation* will score higher on a test of pharmacology knowledge, as compared to students who do not receive this approach to pharmacology instruction.

Q2. Will the amount of online practice with the *Review and Competency Evaluation* make a difference in retention of psychopharmacology knowledge?

> H_A: The amount of practice with the *Review and Competency Evaluation* online will improve students' performance on a test of pharmacology knowledge.

Hypothesis one. Results of the first hypothesis yielded significant results and indicated that instruction with the *RACE* approach lowered cognitive load more than instruction with a conventional approach in pharmacology. The change between the first and final measure of cognitive load could have been impacted by prior understanding of basic pharmacology principles, resulting in a knowledge base from which to apply specific knowledge in mental health. Considering that cognitive load can be impacted by prior knowledge and how leaners process information, Kalyuga et al. (1998) described that information presented to learners should be structured to eliminate avoidable load on working memory and maximize acquisition of automated schemas held in long-term memory.

Since beginning nursing students in this study had minimal knowledge or schemas to make cognitive processing efficient, the *Review and Competency Evaluation* approach attempted to structure and organize information in a way that reduced cognitive load. The post-intervention survey asked students to identify how this approach helped to organize and support learning, and students identified some of the following examples: organized medications into classifications, color-coded medications by drug type, categorized learning to prevent feeling overwhelmed, and organized questions by pharmacological group. The use of color-coding linked related units of information and focused attention on groupings of medication classifications. By focusing on one relevant classification in a class, working memory could handle information without being overloaded. Other studies have cited that working memory should handle limited amounts of novel interacting information – possibly no more than two or three (Paas, Renkl et al., 2003). In this study each medication classification included only 2-3 related groupings, and each class focused on one classification. Keller, Gerjets, Scheiter, and Garsoffky (2006) identified several reasons why information visualizations, one example being the *RACE* model (see Figure 1), might be appropriate to facilitate acquisition of complex knowledge structures that consist of highly interrelated informational units. First, distributing different attributes of information across different memory and processing systems might free processing resources that can be used to increase germane cognitive load (Mayer, 2009), necessary for effective and efficient learning. Second, providing learners with a spatial representation of information might reduce extraneous cognitive load by making it easier to draw inferences on how different information is related. In this study, the *Review and Competency Evaluation* approach used different multimedia modalities, both visual and written presentation of materials, to illustrate how informational units were related in order to minimize cognitive overload and support learning.

Lowering cognitive load with the *RACE* instructional approach was useful to improve learning based on principles of cognitive theory and multimedia learning (Clark and Mayer, 2011), which maintains that more knowledge can be retained when information is processed to establish connections between words and models. In this study, the *RACE* represented a model of five classifications and corresponding elements by color-coded relationships. A segment or conceptual grouping of color-coded information assisted the student to categorize learning. One student commented that organizing medications into drug classifications made it easier to remember information. Using no more than five colors to distinguish categories acknowledged limitations of working and short-term memory capacity (Miller, 1956). Cognitive load was lowered by a concise representation of all medication classifications to be learned, so they could be organized in a way that made sense of the whole concept, psychopharmacology knowledge.

Hypothesis two. The second hypothesis yielded results that were significant for higher scores on a pharmacology test after instruction with the *RACE* approach, as compared to students who did not receive this approach. Despite group differences in level of prior knowledge at the beginning of the study, the difference of mean scores between groups was statistically significant at the end of the study. While students in the intervention group were sensitized to test questions through use of the same study guide questions, study and practice may have provided the opportunity to encode information and more efficiently learn for the post-test. In this manner, post-testing served as a codifying agent after instruction (Grunwald & Corsbie-Massay, 2006) and could allowed for the transfer of information from short-term to long-term memory for retrieval in necessary learning contexts, whether classroom, clinical or simply preparing for the licensure examination.

In regards to improved pharmacology knowledge, understanding and answering open-ended questions was important for several students. As several students commented in the post-intervention survey, the “question and answer style required me to generate my own answers rather than select what ‘looked best,’ and it was a way for me to practice until I understood the content.” Questions that required self-explanation enhanced learning because they involve constructing knowledge that could be encoded and transferred to long-term memory (American Psychological Association Task Force, 2010; Brabeck & Jeffrey, 2012; Ozuru et al., 2009). Similar to other findings (Woloshyn & Gallaghe, 2009), self-explanation in this study was useful for students with beginning levels of prior knowledge. Open-ended and short-answer questions have shown to assess recall of information more than recognition, selecting or guessing from options provided in multiple-choice questions (Ndosi & Newell, 2009; Roy & Chi, 2005). Ndosi and Newell (2009) found that this is important to nursing professionals who by the nature of their job require recall of information more than recognition.

In contrast, one student commented in the survey that it was not useful to answer random questions, presumably through the *RACE* online. Since survey results were reviewed after completion of the study, it was not possible to clarify meaning of this student’s response. Nevertheless, Sweller (2005) proposed that a random component of problem-solving novel material may cause a heavy working memory load. If students were unable to answer questions because the information was new or unfamiliar, then searching for the answer could place more demands on learning, leading to frustration and overload. Until there's a common knowledge base from which to make connections and associate new knowledge, it's reasonable that questions would seem random. Sweller described how the concept of a "random component is quite unavoidable when dealing with novel material that necessitates problem-solving" (p. 76). In this study, students could use what they already know about pharmacology to structure and learn new information. The practice of answering questions online was purposely designed to improve test performance, although it required effort and was less enjoyable.

Hypothesis three. The third hypothesis related to the amount of practice with the *Review and Competency Evaluation (RACE)* online and students' performance on a test of pharmacology knowledge. The amount of practice online was positively correlated with pharmacology knowledge although results of this data analysis was marginally significant. Students expressed at the beginning of the study and through the post-intervention survey that they wanted corrective feedback about their answers. Although one student commented, "it was a way for me to practice until I understood the content", practice could have been interpreted as online or through rehearsal of written answers. The lack of immediate feedback may have discouraged online practice in favor of using the study guides that were distributed in class, although different multimedia modalities and presentation formats can distribute cognitive load for effective learning.

According to Mayer (2009) distributing information across different memory and processing systems might facilitate processing and increase germane cognitive load, effective and effortful learning that results in schema construction and automaticity (Sweller, 2005). In this study, the intent of practice was to focus attention, rehearse and facilitate repetition of answers to questions so that responses could become automatic and remembered. Even if students were unable to remember answers, they could practice retrieval of information, especially with open-ended questions. While students in this study wanted online feedback for answers, Roedigier and Butler (2011) identified that retrieval practice can produce gains in long-term retention, even without feedback, because it promotes the acquisition of knowledge that can be retrieved and transferred to different contexts.

Although the relationship between practice and performance has mixed reviews (Kalyuga, 2005), Brabeck and Jeffrey (2012) found that practice increased the likelihood that students would permanently remember new information by transferring it into their knowledge base. Distributing practice over time rather than "cramming" practice into a short amount of time has been found to be more effective for learning (Bahrick & Hall, 2005). A study by Chuang and Tsa (2013) reported findings about information processing concepts that "organized" and "repeated" information so that students could transfer important information into short-term or even long-term memory. Shorter, more frequent learning activities could increase the likelihood that students recall information over longer periods of time and transfer information into long-term memory. In this study, the practice of answering questions from each medication classifications before the combined "whole task" activity was meant to lessen cognitive demands for learning through shorter, focused learning activities.

A way to reduce working memory limitations has been to practice and develop schemas until they can operate under automatic rather than controlled processing. Once acquired, schemas can be practiced over long periods of time and processed automatically without conscious control. As cited by Clark et al. (2006), instruction of complex material can be designed so that "subschemas" are taught in isolation, and instructional strategies bring material back together to describe it as a combined whole. In this study, instruction about subclassifications of medications enabled students to develop "subschemas" that could be grouped into a single medication classification. This instruction reduced cognitive load and the number of interacting elements so that working memory was free to practice knowledge of all classifications as a combined whole. Online practice of answering questions required rehearsal, a process in memory that facilitates the repetition of information to keep it active and stored in short- and long-term memory.

Overall, subjective reports of cognitive load could have been caused by extraneous load (poor design of the instructional tool), germane load (students' ability to answer questions), or intrinsic load (complexity) of the pharmacology material. A model of five color-coded medication classifications illustrated a beginning knowledge structure to learn. Color-coding focused attention to groupings of medication classifications and linked units of information for students to organize learning. Learning about one medication classification each week provided an instructional format that allowed for changes in long-term memory as structures and schemas developed for new information. However, students needed more instructional support to use the *RACE* online for learning.

Implications and Future Research

Studying effects of the *Review and Competency Evaluation* (*RACE)* approach was useful to validate effectiveness for teaching and learning pharmacology. Results of the post-intervention survey identified students' perceptions and provided useful examples of how the approach helped to organize and support learning. Since instructional design is an iterative process, a secondary purpose of this study was to obtain baseline information about whether the *RACE* improved learning and discern whether it should be further developed as an online instructional approach.

Based on the post-intervention survey, receiving feedback about answers seemed to be a priority for students. Developing online feedback or adding answers to questions might have motivated students to practice until feeling more confident of their answers and knowledge. Even adding hints to answers could be motivating and assist students to search for answers without feeling overwhelmed or the effects of random questions. Questions could be somewhat rewritten so the number of blanks might indicate the number of words required to answer the question, or blanks in different parts of the question would prompt the student to type an answer. Providing students with the opportunity to answer questions online by typing answers, whether full or partial answers, should be further developed for the online format. Constructing short-answer items online would provide similar practice for NCLEX style questions that are administered for licensure examination.

The option to use the *RACE* online, with or without feedback, would give students more flexibility in how they used it. Feedback could encourage persistent use, or drill and practice, and correct feedback could increase perceived competence for answering questions. Students might choose to practice more so they could better understand material that was more demanding or difficult to learn. A follow-up study to compare differences in knowledge between an intervention and comparison group, with and without feedback respectively, could complement existing findings of this study.

An alternative study design would be to measure cognitive load after each unit about a medication classification in order to identify patterns of cognitive load associated with learning. A time series measurement could identify units of information that were more difficult or challenging, especially since students commented that they desired feedback and answers to questions earlier in semester. Developing self-paced learning modules would provide students with the opportunity to use it earlier in the semester.

Since the *RACE* was initially used in a game-like manner to teach pharmacology and evaluate readiness for mental health clinical (Tankel and Wissmann, 1999), the ability to practice online before the competency evaluation could motivate students to practice and prepare for any clinical readiness evaluations. Use of an online timer could assist students to pace learning and answer questions in an allotted amount of time. The ability to learn and compete with peers, whether in the classroom or remotely, could be added since students indicated the lack of usefulness as a game-like activity. A few studies have used mobile devices for teaching and learning pharmacology to nursing students (Chuang & Tsao, 2013), so development of a mobile *RACE* application would be a consideration for design and further study. And finally usability studies could evaluate how students use the *RACE* online and what barriers prevent successful learning. Usability studies with instructors could also prove beneficial since novice instructors can benefit from new instructional tools. While the focus of this study related to how students can learn psychopharmacology, further research is needed to study how the tool can be used to organize and support teaching for novice educators.

Conclusions

As it relates to development opportunities for the *RACE* online, a multimedia learning environment for pharmacology should adapt teaching to different learning styles of students. According to Mayer (2005), a multimedia learning environment provides material in more than one format and engages the learner in cognitive processes that select, organize and integrate information. Since intrinsic cognitive load cannot be modified due to the inherent difficulty and complexity of material, germane and extraneous cognitive load can be modified by effective instructional design (Sweller, 2005; Sweller et al., 1998). As part of the theoretical framework for this study, the Four-Component Instructional Design (4C-ID) model considers design of a multimedia learning environment for complex learning (Van Merrienboer & Kester, 2005). Pharmacology is complex learning, so knowledge and skills shouldbe integrated and transferred to real-life practice settings. The 4C-ID model can also be used as a theory to guide multimedia learning at the level of course and curriculum design (Van Merrienboer & Kester, 2005).

Since comprehensive pharmacology knowledge requires a basic understanding of scientific principles, a curriculum can be designed to present basic pharmacology in the first semester with an overview of general classifications. A beginning pharmacology course can include principles such as pharmacodynamics, or how drugs work in the body, and pharmacokinetics, the absorption, distribution and metabolism of drugs. Subsequent semesters can contextualize pharmacology in a relevant course and review specific classifications, therapeutic uses, contraindications, drug-drug interactions and adverse effects, for example. This would also assist students to appreciate the relevance of what they are learning and how it applies to clinical practice that is often associated with the course. Initially, the *Review and Competency Evaluation (RACE)* approach was implemented as a formative assessment in pharmacology and then as a summative assessment in mental health (Tankel & Wissmann, 1999). Since the 4C-ID model maintains that authentic learning based on real-life tasks is the driving force for learning, questions in the *RACE* approach could be modified to include authentic case scenarios in order to facilitate the transfer of learning to practice settings.

Integrating pharmacology across the curriculum and within courses has many practical implications for learning. Providing a context for just-in-time learning makes it meaningful and promotes acquisition of information that becomes knowledge. Considering the proliferation of accelerated nursing programs that shorten the program duration of a baccalaureate nursing degree, identifying instructional approaches that lower cognitive load and minimize feeling overwhelmed is important for nursing students. Accelerated nursing programs place higher demands on learning due to the nature and pace of accelerated learning.

If using instructional approaches such as the *RACE* can make learning pharmacology more pleasant, then perhaps students will report feeling less overwhelmed. Although the focus of this study pertained to psychotropic medications relative to mental health, the instructional tool can be adapted to other focus areas by redesigning the format to include relevant classifications and questions. A feature of the *RACE* includes open-ended questions that can be supplemented with answers as clinical knowledge changes or new developments occur. New questions can also be added as practice trends change. Using this form of question in lieu of a graded, multiple-choice test challenges students to recall and use information at an application level or higher in preparation for the NCLEX licensure exam. Nevertheless, well-designed instructional approaches not only prepare nursing students for licensure and practice but also account for information processing and multimedia principles to ensure that students learn in a manner that is effective and efficient.

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Appendix A: Study Guide of Questions for Antianxiety Medications

Nonbenzodiazepines

NB1. What are two nonbenzodiazepine antianxiety medications?

NB2. The mechanism of action for the nonbenzodiazepines is a high affinity for serotonin receptors. How does this lead to effectiveness in treating anxiety?

NB3. Nonbenzodiazepines have an extensive first pass effect. What's the significance of this and/or nursing implications?

NB4. Do nonbenzodiazepines produce tolerance? Physical addiction? Psychological addiction? Are they controlled substances?

Benzodiazepines

B1. Name two benzodiazepine medications used for anxiety.

B2. Name some benzodiazepine medications used as a sedative-hypnotic for sleep.

B3. Benzodiazepines are lipid soluble. What's the significance of this?

B4. The benzodiazepines mechanism of action is to enhance which inhibitory neurotransmitter?

B5. Do benzodiazepines produce tolerance? Physical addiction? Psychological addiction? Are they controlled substances?

General

G1. Besides anxiety, what are other uses of these medications?

G2. What are common adverse effects of antianxiety meds?

G3. What are important nursing implications true of all the antianxiety medications?

G4. What are common interactions between benzodiazepines and other medications? Are these interactions true for nonbenzodiazepines?

G5. How are benzodiazepines discontinued? Name at least 3 withdrawal symptoms if not discontinued correctly.

G6. Antianxiety meds treat the ______________, not the _________________________.

G7. For what reasons are antianxiety meds used for alcohol detoxification?

G8. What are some benzodiazepine medications used for sedation?

G9. Describe why the barbiturates are less commonly used now to treat anxiety.

Appendix B: IRB Approval from KU Research & Graduate Studies

KU RESEARCH & GRADUATE STUDIES
The University of Kansas

APPROVAL OF PROTOCOL

May 28, 2014

Kimberlee Tankel
tankel@ku.edu

Dear Kimberlee Tankel:

On 5/28/2014, the IRB reviewed the following submission:

Type of Review:	Initial Study
Title of Study:	Effects of the 4C/ID Model on Cognitive Load and Retention of Pharmacology Knowledge for Undergraduate Nursing Students
Investigator:	Kimberlee Tankel
IRB ID:	STUDY00001194
Funding:	None
Grant ID:	None

The IRB approved the study on 5/9/2014.

1. Any significant change to the protocol requires a modification approval prior to altering the project.
2. Notify HSCL about any new investigators not named in original application. Note that new investigators must take the online tutorial at https://rgs.drupal.ku.edu/human_subjects_compliance_training.
3. Any injury to a subject because of the research procedure must be reported immediately.
4. When signed consent documents are required, the primary investigator must retain the signed consent documents for at least three years past completion of the research activity.

Please note university data security and handling requirements for your project:
https://documents.ku.edu/policies/IT/DataClassificationandHandlingProceduresGuide.htm

You must use the final, watermarked version of the consent form, available under the "Documents" tab in eCompliance.

Sincerely,

Stephanie Dyson Elms, MPA
IRB Administrator, KU Lawrence Campus

Human Subjects Committee Lawrence
Youngberg Hall I 2385 Irving Hill Road I Lawrence, KS 66045 I (785) 864-7429 I HSCL@ku.edu I research.ku.edu

Appendix C: IRB Approval of Protocol for Intervention Group

Institutional Review Board

August 20, 2014

Project Number:	2014-006
Project Title:	Effects of the 4C/ID Model on Cognitive Load and Retention of Pharmacology Knowledge for Undergraduate Nursing Students
Sponsor:	None
Protocol Version/Date:	5/07/2014
Primary Investigator:	Kim Tankel, MSN, RN, ARPN
Co-Investigator #1:	Young-Ji Lee, Ph.D.'
Department:	Nursing, USM & Educational Leadership, KU
Meeting Date:	June 1, 2014
IRB Approval Date:	June 1, 2014
IRB Expiration Date:	June 1, 2015
Type of Approval:	Full Committee Review – New Proposal

Dear Ms. Tankel & Dr. Lee

This is to certify that your research proposal, identified above, involving human participants, has been reviewed and ***approved*** by the University of Saint Mary Institutional Review Board. **This approval is based upon the assurance that you will:**

- Protect the rights and welfare of research participants
- Employ approved methods of obtaining informed consent from these participants
- Not create undue risk to the human participants in consideration of, and in comparison to, potential benefits that might be derived from participation and the expected importance of the knowledge that may be expected to result
- Only use the informed consent documents bearing the correct approval and expiration dates when obtaining informed consent from research participants
- To the extent allowed by the protocol, selection of subjects is equitable among the potential populations of participants
- Provide the IRB with your advertisements and recruitment materials/incentives for approval and as these materials change
- Payment to participants occurs as described in the above referenced project
- Report any increase in the number of subjects approved by the IRB before implementation
- Maintain approval from external institutions as appropriate/required and provide such evidence to this IRB upon renewal or completion of the project
- Adhere to all USM IRB Policies and Procedures Relating to Human Subjects, as written in accordance with the Code of Federal Regulations (45 CFR 46).
- Maintain copies of all pertinent information related to the research study including, but not limited to, video and audio tapes and other forms of image capture, instruments, copies of written consent agreements, and any other supportive documents in accordance with USM IRB Policies and Procedures Relating to Human Subjects.

- Report to the USM IRB immediately if any of the following occur:
  - Unanticipated problems
  - Unanticipated deviations from previously approved
  - Any proposed changes from the previously approved research. Changes may not be initiated without prior IRB review and approval, unless a delay in implementation would place subjects at risk.
- If the research is continuing one year from the date of the IRB approval then you must submit in writing a status report of this research. Federal regulations and IRB policies require continuing review at intervals appropriate to the degree of risk, but not less than once per year.

If you have any questions regarding the protection of human participants, or the IRB process for human subjects research, please do not hesitate to contact the Chair of the USM Institutional Review Board (913-758-6127) or don.kellogg@stmary.edu.

Very truly yours,

Donald W. Kellogg

Donald W. Kellogg, PhD, RHIA, CPEHR, FAHIMA
Chair, USM IRB

Appendix D: IRB Approval of Protocol for Comparison Group

From: IRB [irb@william.jewell.edu]
Sent: Friday, May 09, 2014 3:13 PM
To: Timmons, Melissa Joy
Cc: Tankel, Kimberlee J
Subject: RE: IRB SP 14-18: contingent approval

Many thanks for closing the loop, Melissa and Kim. You are good to go. Joy, pat

Patricia Schoenrade, Ph.D.
Professor| Psychology Department
816-415-7583 (office)
Office: Curry Library I-18

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"Wonder is the basis of worship."
Thomas Carlyle

Appendix E: Pharmacology Test Questions from the RACE

G8. What is an important baseline test for Depakote. Name two common side effects of Depakote.

M1. What are two treatment interventions for lithium toxicity?

AT2. Who are candidates for atypical antipsychotics vs. typical antipsychotics?

AT5. What are four atypical antipsychotics?

AT3. Atypical antipsychotics have a low incidence of EPS; however, one has significant potential side effects. Which antipsychotic is it and what are the nursing implications?

G7. For what reasons are antianxiety meds used for alcohol detoxification?

G1. Besides anxiety, what are three uses of these medications?

G5. How are benzodiazepines discontinued? Name 3 withdrawal symptoms if discontinued incorrectly.

S4. What is one common CNS stimulant cardiovascular adverse effects?

G6. Do antidepressants produce physical dependence? Psychological dependence? Tolerance?

MAO1. What are two MAO Inhibitor antidepressants?

MAO3. When are MAOIs clinically indicated?

T3. What are two clinical indications for the tricyclic antidepressants?

M6. What is the maintenance lithium level? When should blood levels be drawn?

M5. What three body systems need to be checked prior to starting lithium?

AT7. What baseline & regular metabolic monitoring is important for atypical antipsychotics? Give 3 examples.

T2. Antipsychotics block neurotransmitters within & outside the CNS. Name two neurotransmitters.

T5. Antipsychotics block alpha 1 receptors. As a result, what is the potential adverse effect?

B4. The benzodiazepines mechanism of action is to enhance which inhibitory neurotransmitter?

B3. Benzodiazepines are lipid soluble. What's the significance of this?

S2. What are two therapeutic uses of CNS stimulants such as Ritalin and other amphetamines?

SA5. What medication would you anticipate to be given for opioid detoxification?

SA10. What are two medications that can be given for abstinence from nicotine?

T1. What are two tricyclic antidepressants?

G5. Until therapeutic level of a mood stabilizer is achieved, what other type of medications can manage mania?

G11. If EPS occurs, what are three general strategies for reduction of symptoms?

G1. Do antipsychotics produce physical or psychological dependence? Do they produce tolerance?

AT1. What was the 1st atypical antipsychotic? Why is this considered atypical?

B1. Name three benzodiazepine medications used for anxiety.

G6. Antianxiety meds treat the _____________, not the ________________________.

Appendix F: Post-Intervention Survey Questions for Intervention Group

The *Review and Competency Evaluation* (RACE) provided learning activities that included study guides for each medication classification, instructor feedback in class, and the RACE online to practice answering questions.

Considering use of this approach to learn and review pharmacology, please read each of the following items carefully and indicate how true it is for you. Use the following scale to respond:

1	2	3	4	5	6	7
not at all true			somewhat true			very true

Interest/Enjoyment

1. I very much enjoyed using this approach to learn pharmacology.
2. Using this approach to learn pharmacology was fun to do.
3. I thought this learning approach used boring activities. (R)
4. Using the RACE online to practice answering questions did not hold my attention at all. (R)
5. I would describe using this approach to learn pharmacology as very interesting.
6. I thought learning pharmacology with this approach was quite enjoyable.
7. While learning pharmacology with this approach, I was thinking about how much I enjoyed it.

Perceived Competence

8. I was pretty good at answering practice questions with the RACE online.
9. After practicing with the RACE online for a while, I felt pretty competent.
10. I think I did pretty well on the test of pharmacology knowledge, as compared to other students.
11. I am satisfied with my performance on the test of pharmacology knowledge.
12. I was pretty skilled at answering study guide questions and practicing them with the RACE online.
13. Answering practice questions with the RACE online was an activity that I couldn't do very well.(R)

Effort/Importance

14. I put a lot of effort into learning activities of the *Review and Competency Evaluation (RACE).*
15. I didn't try very hard to do the learning activities (R)
16. I tried very hard to do the learning activities.
17. It was important for me to do well on the learning activities.
18. I didn't put much energy into the learning activities (R)

What was most helpful in the *Review and Competency Evaluation* (RACE) approach to learning?

What was least useful?

What aspects of this approach helped to organize and support learning?

Appendix G: Subjective Cognitive Load (SCL) Scale

Indicate the amount of overall effort that it took to learn pharmacology.

Subjective Cognitive Load (SCL) Scale

1	2	3	4	5	6	7	8	9
Very, very low mental effort	Very low	Low	Rather low	Neither low nor high	Rather high	High	Very high	Very, very high mental effort

Source: Adapted from Subjective Cognitive Load Scale by Paas, 1992.

Appendix H: Demographic Questionnaire for Comparison Group

Please circle the correct response or write in a response to each question.

Previous experience:
Healthcare field
Non-healthcare field

Previous degree: ________________________________
Age in years: ___________________________________

The following questions relate to reviewing and learning about pharmacology in mental health nursing.

How much time did you spend each week reading about pharmacology in your textbook?

<1 hour
1-3 hours
4-5 hours
> 5 hours
I did not read the book

How much time did you spend each week studying pharmacology class notes?

<1 hour
1-3 hours
4-5 hours
> 5 hours
I did not study class notes.

How much time did you spend each week utilizing other available resources to review pharmacology?

< 1 hour
1-3 hours
4-5 hours
> 5 hours
I did not use other resources.

If other resources were used, what kind of resources did you use? ____________________

Appendix I: Demographic Questionnaire for Intervention Group

Please circle the correct response or write in a response to each question.

Previous experience:
Healthcare field
Non-healthcare field

Previous degree: ________________________________
Age in years: ___________________________________

The following questions relate to reviewing and learning about pharmacology in mental health nursing.

How much time did you spend each week reading about pharmacology in your textbook?

<1 hour
1-3 hours
4-5 hours
> 5 hours
I did not read the book

How much time did you spend each week studying pharmacology class notes?

<1 hour
1-3 hours
4-5 hours
> 5 hours
I did not study class notes.

How much time did you spend completing each study guide of questions?

	< 1 hour	1-3 hours	hours	>5 hours	Did not complete
Anxiolytics					
Antidepressants					
Antipsychotics					
Mood stabilizers					
Drugs of abuse					