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The Effects of Using Multimedia Presentations and Modular Worked-out Examples as Instructional Methodologies to Manage the Cognitive Processing Associated with Information Literacy Instruction at the Graduate and Undergraduate Levels of Nursing Education

Shawn P. Calhoun
University of San Francisco, calhouns@usfca.edu

The University of San Francisco

THE EFFECTS OF USING MULTIMEDIA PRESENTATIONS AND MODULAR WORKED-OUT EXAMPLES AS INSTRUCTIONAL METHODOLOGIES TO MANAGE THE COGNITIVE PROCESSING ASSOCIATED WITH INFORMATION LITERACY INSTRUCTION AT THE GRADUATE AND UNDERGRADUATE LEVELS OF NURSING EDUCATION

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THE UNIVERSITY OF SAN FRANCISCO
Dissertation Abstract

The Effects of Using Multimedia Presentations and Modular Worked-out Examples as Instructional Methodologies to Manage the Cognitive Processing Associated with Information Literacy Instruction at the Graduate and Undergraduate Levels of Nursing Education

Information literacy is a complex knowledge domain. Cognitive processing theory describes the effects an instructional subject and the learning environment have on working memory. Essential processing is one component of cognitive processing theory that explains the inherent complexity of knowledge domains such as information literacy. Prior research involving cognitive processing relied heavily on instructional subjects from the areas of math, science and technology. For this study, the instructional subject of information literacy was situated within the literature describing ill-defined problems using modular worked-out examples instructional design techniques. The purpose of this study was to build on the limited research into cognitive processing, ill-defined problems and modular worked-out examples by examining the use of a multimedia audiobook as an instructional technique to manage the cognitive processing occurring during information literacy instruction.

Two experiments were conducted using convenience samples of doctoral nursing students (Experiment 1, n = 38) and undergraduate nursing students (Experiment 2, n = 80). Students in Experiment 1 completed a pretest, were exposed to a brief eight-minute and sixteen-second (8:16) multimedia audiobook instructional session, and then completed a posttest. The pretest and posttest consisted of one ill-defined problem presented as an essay-style question, and eleven multiple-choice questions. Experiment 2

built upon Experiment 1 through the addition of three questions measuring extraneous processing, generative processing and essential processing.

Experiment 1 results indicated a large Cohen's effect size for the multiple-choice set of questions ($d = 1.08$) and a medium effect size for the essay-style, ill-defined problem ($d = 0.73$). Experiment 2, results indicated a medium effect size for the multiple-choice set of questions ($d = 0.55$) and a medium effect size for the essay-style, ill-defined problem ($d = 0.67$). With respect to Experiment 2, there were statistically significant differences between generative processing and extraneous processing, $t(79) = 6.84$, $p < .001$ and between essential processing and extraneous processing was $t(79) = 4.37$, $p < .001$. There was no statistically significant difference between essential processing and generative processing was $t(79) = 1.69$, $p = .09$.

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

Shawn P. Calhoun ____________ December 9, 2011
Candidate

Dissertation Committee

Mathew Mitchell ____________ December 9, 2011
Chairperson

Xornam Apedoe ____________ December 9, 2011

Susan Prion ____________ December 9, 2011

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Dedication

This dissertation is dedicated to my wife Nazanin and my sons Christopher and Matthew.

TABLE OF CONTENTS

Tables

Figures

I. STATEMENT OF THE PROBLEM

The acquisition of information literacy skills is an important component of an effective educational process. At the college level, proficiency in these skills translates into students' ability to engage in rigorous curricula as well as produce academically sound work. Information literacy skills include the ability to determine the extent of information needed, access the needed information effectively and efficiently, evaluate information and its sources critically, incorporate selected information into one's knowledge base, and use information effectively to accomplish a specific purpose (ACRL, 2000; Farmer & Henri, 2008). Information literacy instruction includes teaching students the skills necessary to manage the complexity of research, the process of collecting and integrating information from different sources, and using technology in the research process (Cox & Lindsay, 2008; Eisenberg, Lowe, & Spitzer, 2004; Farmer & Henri, 2008).

The teaching and development of these skills, however, is not optimal at many U.S. colleges and universities. A 2003 survey of academic libraries revealed that only 47% of over 1,400 surveyed colleges and universities had integrated information literacy into the curriculum of one or more programs. Furthermore, less than 15% had gathered evidence that students are information literate when they graduate (ACRL, 2004b). Data also indicate that doctorate granting institutions had a slightly higher integration rate (49%) but a lower post-graduate literacy rate (13%) (ACRL, 2004a). While academic libraries often have instruction programs designed to teach information literacy skills (Eisenberg, et al., 2004; Neely, 2006b), the integration of this expertise into the college curriculum occurs at only small number of universities and colleges (ACRL, 2004a, 2004b). Furthermore, information literacy can be difficult for many students to master (Eisenberg, et al., 2004; Jacobson & Xu, 2004). A practical gap in higher education is that although information literacy is an important skill set for students, effective information literacy skills instruction is not consistently integrated into the curricula for many students.

One way to address the information literacy skills gap might be through the use of multimedia learning. Mayer (2005) defines multimedia as a way of presenting words such as spoken text or printed text combined with pictures such as illustrations, photos, animation or video. We can further describe multimedia as a computer-based presentation of content that blends text in written or verbal forms, sound and graphics into a discrete learning package. In the context of this study, learning refers to the construction of knowledge.

Multimedia instruction provides a number of possible advantages over other instructional formats and can offer instructional designers unique opportunities not necessarily found in traditional instruction (Clark & Mayer, 2003). For example, multimedia instructional modules can be reused as needed by both the instructor and the learner. Assuming the necessary equipment is available (e.g., a computer or smartphone) the learning module can be reused at a time and place convenient to the learner, or can be inserted into a course as needed by the instructor. A second possibility afforded to the instructional designer is the ability to standardize instruction. In this scenario, the instructor creates one standardized instructional module that can be delivered with exactly the same content, formatting, and sequencing for all learners.

This study hypothesizes that certain instructional design methods that employ multimedia have an advantageous effect on learning when complex problems such as developing information literacy skills are being taught. One potentially effective multimedia instructional design method relies upon the use of examples to build instructional units (Gerjets, Scheiter, & Catrambone, 2004; Rourke & Sweller, 2009).

Information literacy skill building is a complex learning task for many students, (Eisenberg, et al., 2004; Jacobson & Xu, 2004) and instructional design techniques such as the use of examples can assist with managing this complexity (Gerjets, et al., 2004; Rourke & Sweller, 2009). Cognitive processing represents the limited capacity of the human mind to make sense of new information and is limited in nature; therefore, it can be especially challenged by complex learning problems. The terms ‘cognitive load’ and ‘cognitive processing’ are used interchangeably in the research literature to discuss the limited capacity of human cognitive ability (Mayer, 2005; Plass, Moreno, & Brünken, 2010; Sweller, 2010). In this study, the term *cognitive processing* is used wherever possible.

Plass, Moreno, and Mayer (2010) suggest that guided activities such as the use of examples coupled with multimedia can increase essential processing - the cognitive processing necessary to achieve the desired instructional outcomes (Mayer, 2009; Plass, et al., 2010). The research literature suggests that when learners interact with complex learning tasks in multimedia environments and receive structured guidance during learning using examples, non-essential cognitive processing can be reduced (e.g., extraneous cognitive processing) and generative processing increased (Plass, et al., 2010). This line of research illustrates that example-based multimedia instruction, when designed using the principals of the cognitive theory of multimedia learning, can have a positive effect on achieving complex instructional outcomes.

The literature outlining the acquisition of information literacy skills as complex and difficult for students to master, coupled with research suggesting that multimedia and example-based instruction are potentially effective instructional design techniques, suggest that there are possible advantages to the use of multimedia learning to deliver information literacy instruction. Moreover, students can use computer-based multimedia instruction whenever and wherever the necessary technology is present, meaning it can be delivered either inside or outside the traditional constraints of a physical library and can be integrated into on-line or in-person courses. The effectiveness and convenience of multimedia instruction will be themes explored further in this study.

Information literacy instruction involves "teaching students the tools, resources, and strategies for using a specific library's information resources to the best advantage for particular assignments given by faculty" (Cox & Lindsay, 2008, p. 12). These complex learning objectives lend themselves to the use of multimedia because it meets one of the central tenets of effective multimedia instruction: high element interactivity. Element interactivity describes the cognitive processing that occurs in working memory during learning and represents the *complexity* of the information presented to the learner during instruction (Kalyuga, 2007). For the purposes of the present study, the term 'complexity' is used in place of the phrase 'element interactivity'. Tasks with lower levels of complexity generally describe situations where there is little interaction among the items being processed, such as when a student is learning individual words while studying a foreign language. In this example of learning a language, the words being studied do not necessarily interact with each other and the student is not being asked to put the learned vocabulary to use (Sweller, van Merriënboer, & Paas, 1998b). Information literacy, on the other hand, is characterized by many complex components: it typically requires the student to use tools such as computers to access resources and databases using search strategies like Boolean or keyword terminology while simultaneously keeping assignment goals and objectives in working memory. An article by van Merriënboer, Kircsher, and Kester (2003) use an example of constructing a literature searches to illustrate the complexity of the information literacy, suggesting that this instructional domain offers high levels of complexity.

Although van Merriënboer, Kircsher and Kester (2003) describe information literacy instruction as comparable to other instructional programs with high levels of complexity and discuss information literacy from the perspective of cognitive processing, they only point to the need for additional research. They did not conduct a study investigating their suggestions about information literacy. A review of the information literacy instruction literature did not reveal a single study that attempted to assess the learning complexity of information literacy. The complexity of learning tasks involving information literacy can have a deleterious effect on student learning and multimedia interventions have been shown to reduce extraneous processing (Gins, 2005; Mayer, 2008). The cognitive theory of multimedia learning appears to provide avenues for addressing the complexity of information literacy instruction and multimedia-based instruction using examples also show promise as effective and convenient instructional design techniques.

Purpose of the Study

The intent of the present study is to investigate the development of information literacy instruction using the principles of cognitive processing theory, and specifically to assess the efficacy of an audiobook instructional module using modular worked-out examples during instruction. The present study will employ the principles of multimedia learning (Mayer, 2009), which are derived from the cognitive theory of multimedia learning (Mayer, 2001) in the design of an audiobook that will deliver information literacy skills instruction.

Information literacy skills include students' ability to retrieve, evaluate, manage and use information effectively and efficiently. Whereas there are multiple areas of information literacy, this study will focus specifically on determining the extent of information needed, the first step in information literacy skill development (ACRL, 2000). The first step in information literacy skill building was chosen because the remaining skills build upon this foundation. Studies employing the cognitive theory of multimedia learning and example-based instructional design as the foundations for information literacy instruction are apparently nonexistent. The present study seeks to begin the process of developing research in these areas.

Cognitive processing theory is based on research regarding the ways the human mind processes information between long-term memory and working memory. Cognitive processing theory breaks down the processing that occurs in working memory into three components: generative processing, extraneous processing and essential processing. Essential processing represents the cognitive processing imposed by the inherent difficulty of intergrading learning material into schemas (Plass, et al., 2010). Extraneous cognitive processing can be caused by poorly designed instruction or the placement of non-essential materials in the instructional module. Extraneous processing does not contribute to learning and is often described as information added to instruction such as unrelated or repetitive content (R. Mayer & Moreno, 2003). Generative processing represents the cognitive process of organizing and integrating new information into schemas that contribute to learning (Plass, et al., 2010).

The present study is particularly interested in developing a multimedia-based audiobook instructional module that manages essential processing using modular worked-out examples. Modular worked-out examples appear from the literature to have particular advantages with respect to reducing non-essential cognitive processing during learning and effectively manage essential processing, particularly for low prior-knowledge learners (Gerjets, et al., 2004). The research on managing essential processing using modular worked-out examples is limited and the present study seeks to add to this emerging research area.

Whereas much of the research supporting cognitive processing theory was developed using research into science, mathematics, and technology instruction, there is a limited body of research in the domain of ill-defined problems, such as information literacy. Prior studies involving science, mathematics, and technology were based upon content wherein problems had well-defined givens, goals, and problem solving operators. A typical ill-defined problem does not provide the learner with the givens, goals, or operators such as formulas for calculating probabilities one might encounter in a statistical problem (Rourke & Sweller, 2009).

For students in college, a typical ill-defined problem is how to *determine the extent of information needed* (a specific information literacy skill) when faced with a research problem such as writing a paper on an unfamiliar topic. Whereas past studies suggest that interventions using worked-out examples with science, mathematics, and technology were particularly effective, in the domain of ill-defined problems, there are few comparable studies (Rourke & Sweller, 2009). It appears that building effective information literacy skills, a real-world ill-defined problem, through worked-examples is a potentially fruitful research area. The present study seeks to address these apparent gaps in the literature.

We do not know the extent to which modular worked-out examples might be effective in the domain of information literacy, or more specifically, how effective modular worked-out examples might be in this ill-defined problem domain. Therefore, it is important in the case of information literacy instruction that an explicit process for developing modular worked-out examples is studied. The current study seeks to address these needs.

Significance of the Study

This study is potentially important for three reasons. First, information literacy has been identified as an important set of skills for higher education students' to master (ACRL, 2000). Prior efforts to teach information literacy at the college level and integrate various instructional methods into the college curriculum have shown mixed results (ACRL, 2004a, 2004b). There are few studies that use the cognitive theory of multimedia learning as the theoretical rationale for developing information literacy instruction, suggesting that the present study will fill a gap in the literature.

Second, instructional methods focused on ill-defined problems are an emerging area of research. Whereas the majority of prior studies that used the cognitive theory of multimedia learning have focused on experiments involving well-defined areas of study such as science, mathematics, and technology, there has been little research linking the cognitive theory of multimedia learning and ill-defined problems (Rourke & Sweller, 2009). Research on ill-defined problems such as information literacy from the theoretical perspective of the cognitive theory of multimedia learning appears to be an area that would benefit from additional study.

Third, modular worked-out examples have rarely been employed outside the domains of science, mathematics, and technology. Whereas this instructional method has shown promising results in well-defined areas (Catrambone, 1994; Gerjets, et al., 2004; Rikers, Van Gerven, & Schmidt, 2004; Scheiter, Gerjets, Vollman, & Catrambone, 2009), the application of this method to ill-defined problems such as information literacy are limited. The present study examines the development of an instructional intervention that will synthesize these three important areas of research.

Theoretical Rationale

The following section provides additional background on the major components of cognitive theory of multimedia learning (CTML): active engagement, dual coding, and working memory, as well as the CTML processes of: extraneous processing, essential processing, and generative processing. The following CTML model (Figure 1) provides a visual representation of conceptual and theoretical framework guiding this study.

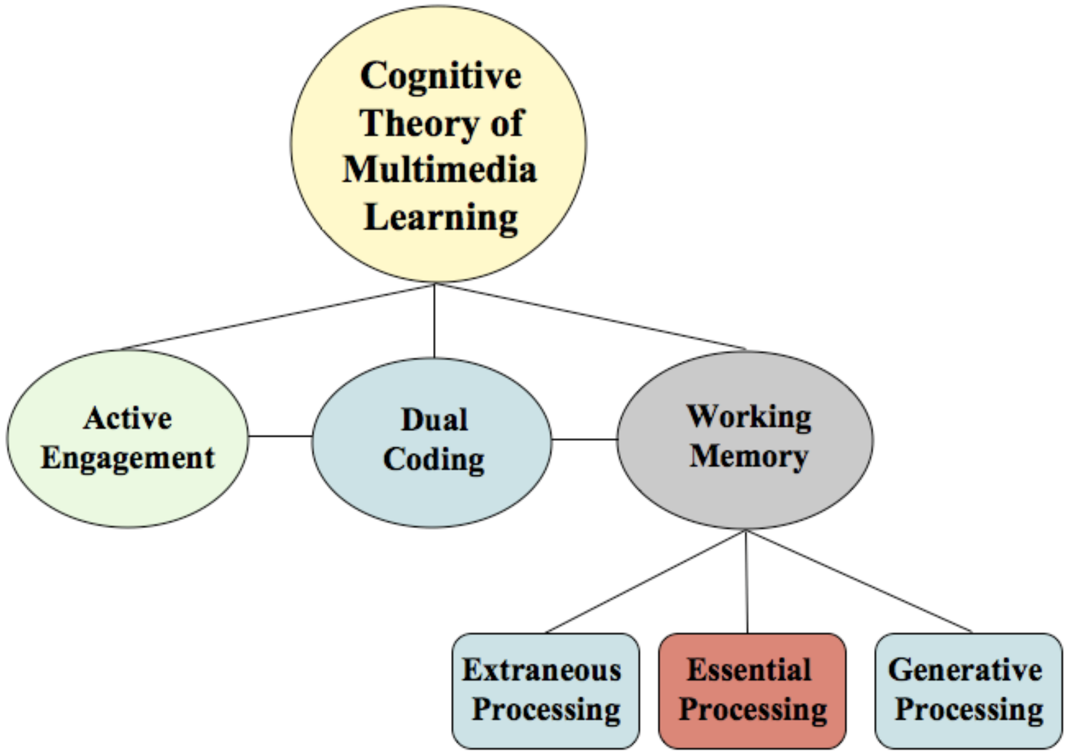

Figure 1. Cognitive Theory of Multimedia Learning (CTML) and working memory model (Mayer, 2009; Paivio, 1986).

Multimedia is defined as the presentation of material in the form of pictures and words (Mayer, 2001). Pictures can include photographs, maps, screen shots, and other visual forms. Examples of how words can be expressed include text on a page, text on a computer screen or in spoken form, pictures, and photographs, PowerPoint slides, and similar visual objects. Pictures and words in various combinations such as computer-based combinations of recorded voice and images typically comprise multimedia. Words and pictures can be combined in multiple forms, each of which meet Mayer's (2001) definition of multimedia.

The cognitive theory of multimedia learning suggests that there are three characteristics of how the human mind works that, when combined, dictate the effectiveness of learning: 1) humans beings have an audio and a visual channel for processing information, 2) the human mind is limited in its capacity to effectively process new information via working memory, and 3) learners must be actively engaged in processing new information if it is to be used to create new knowledge or augment existing schemas (Baddeley, 1986; Chandler & Sweller, 1991; Paivio, 1986). The cognitive theory of multimedia learning suggests that people learn better from words and pictures than from words alone, and that learning is deeper when appropriate pictures are added to text (Mayer, 2001, 2008). The cognitive theory of multimedia learning provides the theoretical rationale upon which many of the principles of multimedia learning were developed.

In the present study, the cognitive theory of multimedia learning will be used to discuss what instructional designers can do to build effective multimedia for student learning. Multimedia for instructional purposes is contextualized for this study within the cognitive theory of multimedia learning. The cognitive theory of multimedia learning, the principles of multimedia and related research agendas have been studied extensively and the evidence pointing to beneficial learning have been well documented (Mayer, 2005; Plass, et al., 2010; Sweller, van Merriënboer, & Paas, 1998a). However, there appears to be a paucity of research that extends cognitive processing theory and the principles of multimedia design to the delivery of information literacy instruction using multimedia audiobooks. This study will contribute to the literature though its investigation of a novel information literacy instruction method using the principles of multimedia learning and the cognitive theory of multimedia learning.

Active Engagement and Limited Capacity

Learning does not happen simply by the act of listening to or watching instructional material. Active engagement is an essential element in the cognitive theory of multimedia learning model. Active engagement, also discussed in the literature as active processing, captures the motivational dimension of learning, and “implies that the learner is actively engaged in processing information and makes an effort to construct coherent mental models” (Westelinck, Valcke, De Craene, & Kirschner, 2005, p. 557). The active processing assumption proposes that when constructing a coherent mental representation of experiences from learning, the brain is appropriately engaged in the learning activity. Further, the learner’s willingness to invest significant effort in learning implies motivation and a willingness on the part of the learner to consider success or sub-optimal performance in relationship to effort (Wittrock, 1990). Examples of active processing include attending to incoming information and organizing new information with other prior knowledge (Mayer, 2005).

The limited capacity assumption, a sub-component of active engagement within the cognitive theory of multimedia learning, suggests that there are constraints on cognitive capacity. These constraints are often discussed in terms of the dual channel assumption, wherein the research suggests that there are two independent complementary systems for processing images and verbal information that have an additive effect (Mayer, 2005; Paivio, 1986). The constraints on the amount of pictorial and verbal information that can be processed are articulated in cognitive processing theory as a limitation of an individual's working memory. Whereas working memory is extremely limited and is able to only process about seven new elements of new information simultaneously, long term memory is theoretically unlimited in its capacity to store knowledge (Kalyuga, 2009a). While instructional designers can optimize information receipt using dual channels, working memory represents the fixed limit of individuals' capacity to process new information and store knowledge.

Active Engagement and Dual Coding

The dual coding assumption, also referred to in the literature as dual-channel processing, states that human beings have two separate but complementary systems for processing pictures and words and these systems are identified as the visual and auditory channels (Paivio, 1986). Within the context of multimedia learning, this assumption of dual coding assigns objects such as pictures with the visual channel and spoken words with the auditory channel. Researchers note that the dual coding "assumption is incorporated into the cognitive theory of multimedia learning by proposing that the human information-processing system contains an auditory/verbal channel and a visual/pictorial channel" (Mayer, 2005, p. 33). Further, it is important to note that these systems are additive, meaning that the amount of information being processed has the potential to overload cognitive capacity.

Dual coding affords the learner the opportunity to process two streams of information simultaneously and more effectively than if the two streams had to be processed in a serial manner. For example, the instructional designer who builds learning modules with multimedia where one piece of information is delivered in an auditory format while a second, complementary but independent piece of information is delivered in the visual channel, is taking advantage of the dual processing assumption. The optimization of learning potential via dual channel processing of multimedia is tempered, however, by the limited capacity of the brain to make sense of new information.

Working Memory and Cognitive Processing

Working memory has a unique role when helping achieve educational goals as well as significant limitations. The center of cognition where all active thinking takes place is in working memory (Mayer, 2009). The cognitive theory of multimedia learning relies upon assumptions regarding the way in which working memory functions during instruction, and is built upon three related assumptions. The first assumption is that of the human brain as a dual-channel processor, where verbal and pictorial information is taken in and processed separately using independent channels. The second assumption is that the brain has limited capacity to process information in the dual-channel architecture. The third assumption is that the human mind has the capacity to engage in active processing. During this engaged, active learning state, individuals have the greatest opportunity to successfully organize and integrate new information into their preexisting knowledge (Mayer, 2005).

For learning to be successful, active processing must take place in working memory and individuals must earnestly engage in the tasks related to learning. According to Mayer in *Across the Century: The Centennial Volume* (Corono, 2001, p. 42), "knowledge is not a commodity that can be placed neatly in a learner's head, but rather it is the result of a learner's active sense-making," [where sense-making is] "processing new information using schemata in working memory." The integration of new knowledge into long-term memory occurs when a learner actively processes it in working memory using the process of encoding. The capacity for the brain to encode is limited by its ability to process a limited amount of information in working memory (Moreno & Mayer, 2000). The cognitive theory of multimedia learning further divides working memory into three cognitive processing tasks.

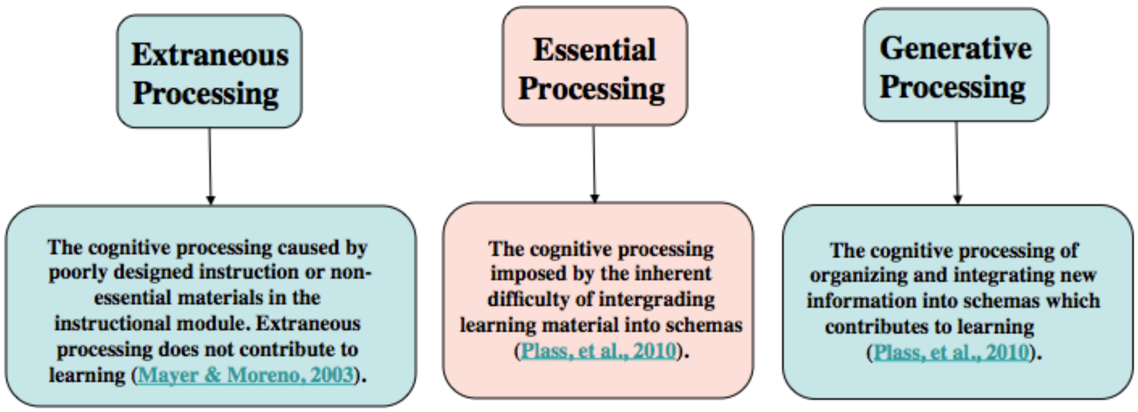

Figure 2. Three types of cognitive processing.

Extraneous processing represents the cognitive processing that occurs when multimedia-learning materials contain information or other content that is not germane to the immediate learning goals (see Figure 2). An example of extraneous material might be the use of musical accompaniment that has no instructional benefit in a multimedia instructional module. In this example, the music can act as a distraction, reducing available cognitive resources necessary for essential and generative processing. *Essential processing* (see Figure 2), also discussed in the literature as intrinsic processing, represents the cognitive processing needed to mentally represent the incoming material and is generally attributable to the complexity of the material (Mayer, 2008). Citing the work of Mayer (2005) and Sweller (1999), Mayer describes the third component of working memory as *generative processing* (see Figure 2); wherein cognitive processing capacity is used to “make sense of the incoming material, including organizing it and integrating it with prior knowledge” (2008, p. 762).

There are a number of principles supporting the cognitive theory of multimedia learning, and specifically generative processing. For example, the modality principle suggests that people learn better from graphics and narration than graphics and printed text (Mayer & Moreno, 2003). Additionally, the redundancy principle suggests that people learn better when the same information is not presented in more than one format (Mayer, 2001, 2005).

Before moving on to discuss the essential, generative and extraneous processing components of working memory in more detail, it is important to note that these processes are additive, insofar as each contributes to total cognitive processing. The additive nature of these three components was originally introduced by Sweller (1994), and later discussed by Mayer (2003), who noted that if extraneous and generative processing are high, there is no room in working memory for generative processing, the process that instructors are generally most concerned with achieving. Given that there are limits on working memory, it is conceivable that if the cognitive processing associated with extraneous processing load were high, there would be insufficient additional resources available for generative and essential processing. The next section will first address extraneous processing, generative processing and essential processing in more detail. Second, principles for managing cognitive processing will be introduced. Finally, the additive nature of extraneous processing, generative processing and essential processing will be discussed.

Extraneous processing

The human mind is limited in its capacity to effectively process new information. One of the factors that can reduce a learner's ability to create new knowledge is extraneous processing. Extraneous processing (see Figure 2) was first referred to in the literature using the synonymous term of extraneous load (Sweller, et al., 1998b). Extraneous processing occurs when learners "attend to and process material that is not essential to building a mental model of the to-be-learned system" (Mayer, 2008, p. 763). Examples where extraneous processing could be introduced into learning materials such as multimedia instructional modules include the use of music, video or other multimedia not directly related to the instructional goals.

The five evidence-based principles for reducing extraneous processing are coherence (reduce extraneous material), signaling (highlight essential material), redundancy (do not add on-screen text to narrated animation), spatial contiguity (place printed words next to corresponding graphics) and temporal contiguity (present corresponding narration and animation at the same time) (Mayer, 2005, 2008). Excessive extraneous processing in working memory can reduce or eliminate a student's capacity for generative and essential processing (Plass, et al., 2010).

Generative processing

Generative processing (see Figure 2) is the cognitive activity that occurs when the learner is constructing new knowledge. The concept of generative processing was first introduced in a slightly different form as germane load (Sweller, et al., 1998b). The current definition of generative processing states that the learner is actively making sense of new information, is engaged in a process of mentally organizing new information into a coherent knowledge structure, and is integrating the new information with prior knowledge (Mayer, 2009; Mayer & Moreno, 2007). Therefore, one goal of managing the additive effects of working memory (extraneous processing, essential processing, and generative processing) is optimizing instruction so that the majority of the limited capacity of working memory is available for generative processing.

Essential processing

Essential processing (see Figure 2) was first described in the literature as intrinsic load (Ayres, 2006; Kirschner, 2009). The current definition of essential processing states that cognitive processing is "aimed at mentally representing the essential material in working memory [where] essential material is the core information from the lesson that is needed to achieve the instructional goal" (Mayer, 2009, p. 171). However, the complexity of learning tasks determined by the number of interacting elements and the relationships between them can overwhelm the limited amount of working memory available to the learner (Mayer, 2008).

There are three evidence-based principles suggested by Mayer (2008, 2009) that assist with the effective management of essential processing: 1) segmenting (presentation of lessons in learner-paced segments), 2) pre-training (providing pre-training in the name, location, and characteristics of key components of the instruction) and 3) modality (presenting instruction using pictures and spoken words). The research on pre-training further divides this instructional approach into part task and whole-task instruction with the expressed aim of more effectively managing essential processing (Mayer, 2005; Musallam, 2010). Whereas early CTML research suggested that essential processing could not be manipulated by instruction (Sweller, 1994), researchers are increasingly arguing that there are effective instructional design techniques that can increase essential processing (Gerjets, Scheiter, & Catrambone, 2006).

Extraneous, essential, and generative processing are additive, and when combined represent the total overhead placed on working memory induced during instruction. The reduction of extraneous load and the effective management of essential load can therefore create a more optimal amount of working memory available to the learner for the construction of new schemas using generative processing. It follows, then, that application of the principles of the cognitive theory of multimedia learning have the potential to not only reduce the load imposed on working memory but also to afford instructional designers the ability to carefully manage and optimize instruction in light of the limits of working memory (van Merriënboer & Sweller, 2005). This management of generative and extraneous cognitive processing has the potential to increase essential processing, thereby possibly increasing student learning.

The present study is focused on reducing essential processing demands for students when learning complex material such as information literacy skills. The following section provides additional background regarding information literacy and the opportunities to optimize learning during instruction involving this complex problem. Additionally, the following section describes the need for information literacy skill development in the area of nursing instruction at the graduate and undergraduate levels.

Background and Need

The development of methods to manage essential processing are relatively recent (Mayer, 2009; van Merriënboer, Schuurman, De Croock, & Paas, 2002). Before new methods for managing essential processing developed, it was widely assumed that essential processing was outside the control of instructional designers (Sweller, 1994). However, a new line of research suggests that the essential processing that occurs within working memory can be managed, thereby offering the potential to increase instructional effectiveness. While the research is extensive on managing extraneous processing and generative processing, the research on managing essential processing is an emerging line of educational research. This new line of research shares a common thread suggesting that reducing the complexity of learning tasks can increase essential processing.

Essential Processing, Complexity and Information Literacy

Information literacy is considered a set of skills that include students' ability to retrieve, evaluate, manage, and use information effectively and efficiently. These skills are further defined as determining the extent of information needed; access the needed information effectively and efficiently; evaluating information and its sources critically; incorporating selected information into one's knowledge base; using information effectively to accomplish a specific purpose and; understanding the economic, legal, and social issues surrounding the use of information, and access and use information ethically and legally (ACRL, 2000; Neely, 2006b).

Because there are multiple levels related to overall information literacy skills and no practical way to test for all levels in the present study, this investigation of information literacy will be limited to research on 'determining the extent of information needed' by students within the cognitive theory of multimedia learning (CTML) model of managing essential processing.

Information literacy standards (ACRL, 2000) include seven related skills (Figure 3). One rich example of how CTML can help to explain a learning opportunity is through an examination of the first goal of information literacy, which is defined by the Association of College and Research Libraries as helping students 'determine the extent of information needed' (ACRL, 2000).

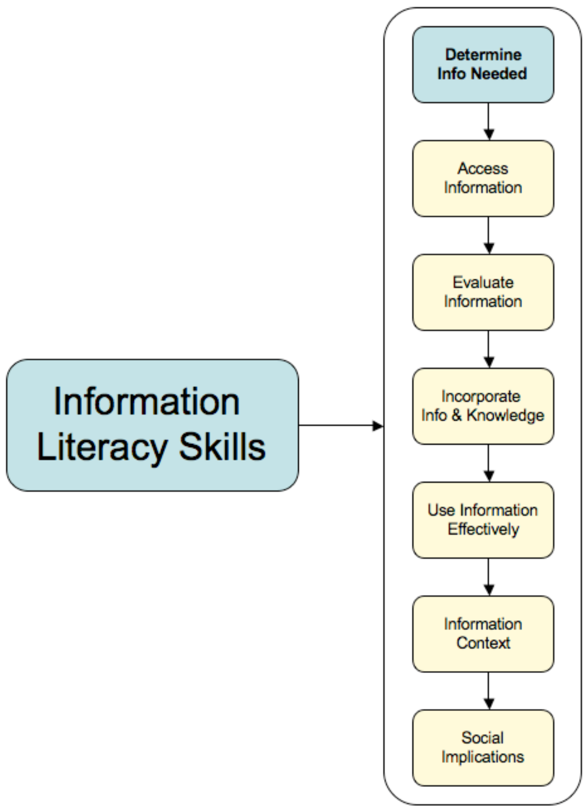

Figure 3. Hierarchical model of the seven information literacy skills (ACRL, 2000).

The first information literacy skill, 'determining the extent of information needed', and the focus of the present study, provides the foundation for each of the seven information literacy skills (ACRL, 2008). By example, in 'determining the extent of information needed', the student demonstrates a capacity to move along a path from an initial problem, such as an in-class discussion about a class project, to evaluating resources and looking critically at the process they went though in assessing if they adequately assessed the extent of information needed. Information literacy skills have a logical hierarchy. Although there is overlap between each of the skills, instruction and assessment of students learning can be completed as if they were independent because individual competencies and performance indicators can be associated with each skill (Cox & Lindsay, 2008; Meyer et al., 2008).

Supporting each information literacy skill are performance indicators developed by ACRL, and these performance indicators were designed to align with Bloom's Taxonomy (ACRL, 2000; Bloom, 1956). There are four performance indicators associated with 'determining the extent of information needed' (see Figure 4).

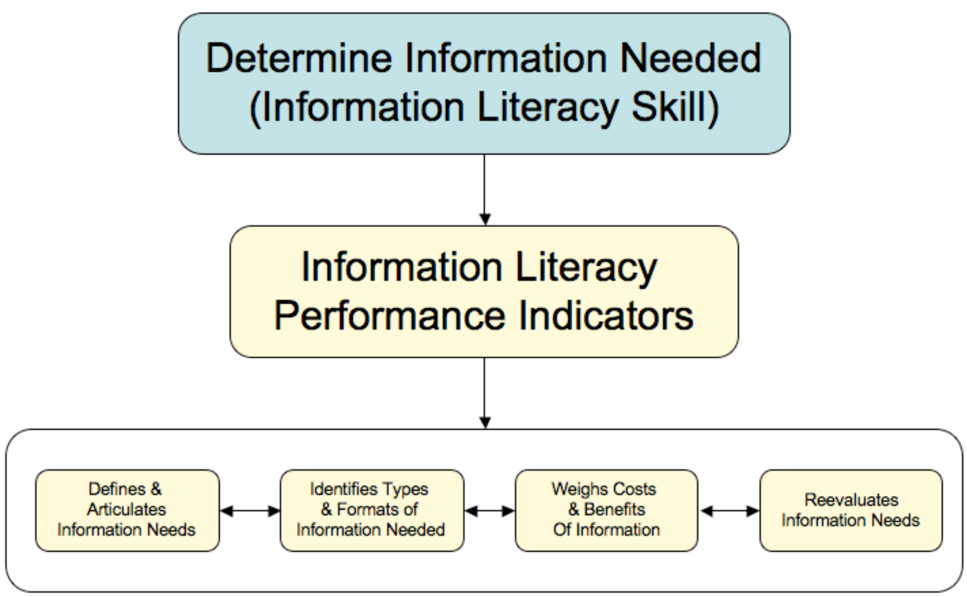

Figure 4. Determining the extent of information needed skills and performance indicators.

The first performance indicator states that the information literate student defines and articulates the need for information and has the ability to identify key concepts and terms that describe the information need. Second, the student has the capacity to identify a variety of types and formats of potential sources of information as well as can identify the value and differences of potential resources in formats such as multimedia, databases, websites, data sets, audio/visual materials, and books. Third, the information literate student considers the costs and benefits of acquiring the needed information and can define a realistic overall plan and timeline to acquire the needed information. Fourth, the information literate student has the skills necessary to reevaluate the nature and extent of the information needed as a project progresses and can describe the criteria used to make decisions and choices about their selection process (ACRL, 2000). Each of these performance standards represent a students' proficiency at determining the extent of information needed, are interdependent ,and require learning information literacy skills that overlap with each other.

When reviewing the content and objectives of ACRL's first information literacy standard, the overview information literacy performance indicators outlined above suggests that there are a number of related but different learning outcomes and that these relationships between learning outcomes are complex. The application of information literacy skills is a complex process requiring students to evaluate information and their sources, apply critical thinking and reasoning skills, revise based on they types of information found and culminates with the overall integration of what was learned into a research assignment (Scharf, Elliot, Huey, Briller, & Joshi, 2007). This type of complexity is discussed in the CTML literature as element interactivity. The present study uses the term complexity to describe this phenomenon. The complexity new ideas, when they interact in such a way to generate excessive extraneous cognitive processing and degrade generative and essential processing, can impede effective learning (Mayer, 2005). When instruction is not optimally designed, the learner's effort toward mastering these skills can cause essential processing overload, thereby decreasing the effectiveness of instruction. This complex interaction of skills and learning outcomes is an important factor for instructional designers.

Numerous studies have linked essential processing to the complexity of learning material (Plass, et al., 2010). Determining that an item is neither too complex or too easy is important in the context of the present study (Plass, et al., 2010). Research suggests that complexity interacts with prior knowledge (Sweller, 2010). Whereas some learning material might constitute a simple problem for more advanced students, those with low prior-knowledge might find the material to be learned complex. Therefore, low prior-knowledge learners who are challenged with complex learning tasks often encounter situations where the imposed cognitive processing outstrips their capacity to convert new information into effective schemas. As was demonstrated by the pilot study, the sample of DNP students' appears to have exhibited low prior-knowledge with respect to 'determining the extent of information needed'. It is anticipated that results from the present study will illustrate a difference in complexity between the open-ended questions (ill-defined problems) which are likely to be more difficult for students and the multiple choice questions which should be easier for students to solve. However, it is important to provide evidence that the intervention material is appropriately complex.

Typically, researchers concerned with cognitive processing and the cognitive theory of multimedia learning have measured complexity by estimating the number of elements that constitutes a learning problem as it is processed in working memory. This measure is generally expressed as complexity (Sweller, 2010; Sweller & Chandler, 1994). Measures to determine complexity have typically been applied in the instructional areas of well-defined problems such as science and mathematics. By example, the individual steps necessary to solve mathematical formulas generally lend themselves to the quantification of steps in the problem solving process. However, in the area of ill-defined problems, the cognitive processing research appears to provide few corollary measures that quantify the complexity of learning problems.

The cognitive theory of multimedia learning suggests that the complexity of learning tasks can inhibit essential processing which is necessary for optimal learning to occur. Therefore, it appears reasonable to suggest that the difficulty students have with determining the extent of information needed (Cox & Lindsay, 2008) can be explained by the complexity inherent in developing appropriate information literacy schemas. Therefore, the cognitive theory of multimedia learning appears to offer insights into ways instructional designers can reduce essential processing demands for students when engaged in this first step of information literacy.

Essential Processing and Instructional Methods

The research on instructional models that attempt to manage essential processing is recent and generally involves instructional interventions in the sciences, technology, and mathematics. The instructional methods studied to manage essential processing include segmenting (Mayer, 2009; Stark, Mandl, Gruber, & Renkl, 2002), pre-training

(Musallam, 2010; Stark, et al., 2002), part and whole-task (Salden, Paas, & Van Merriënboer, 2006a), and worked examples (Van Gerven, Paas, Van Merriënboer, & Schmidt, 2002). Each of these instructional methods has a number of unique features that will be discussed in the review of literature. The following section focuses specifically on instructional design methods involving examples and their applicability to this study.

Instructional Examples

Schemas, stores of information in long-term memory, are considered an essential component in developing expertise in knowledge-rich domains as they afford the learner the ability to efficiently process complex learning problems (Gerjets, et al., 2004). When a learner does not have appropriate problem solving schemas, one effective way to build them is though the use of examples (Atkinson, Derry, Renkl, & Wortham, 2000; Gerjets, et al., 2004, 2006). Examples are instances of problems with fixed boundaries that focus the learner on a formulaic representation of a learning problem. A number of studies have investigated the use of examples to build problem solving schemas (Gerjets, et al., 2004). One typical element of early research into the use of examples was that many of these studies relied on rote-practice instructional methods, wherein students were asked to repeatedly solve practice problems without regard to the optimization of cognitive processing.

Instructional examples are widely used as ways to explain a variety of learning situations. However, not all examples offer learners reasonable ways to build problem-solving skills, which are important when building schemas. Early research involving general examples involved measuring students' ability to "identify a member of a target concept after viewing numerous instances and noninstances of it, to learn whether students could successfully derive the underlying concept common to the examples" (Atkinson, et al., 2000, p. 182). General examples are not a focus of the current study. The focus of this study is using examples in the more complex process of helping learners to problem solve. The current study refers to examples that apply to problem solving situations, wherein they are used to illustrate a principle or pattern necessary to develop learners' schema (Atkinson, et al., 2000). One problem-solving task might be for a student engaged in an academic research assignment to identify the extent of information needed within the context of developing information literacy skills. In this case, the goal would be to help the student; 1) define and articulate their information needs; 2) identify types of information needed; 3) weigh the costs and benefits of available information sources and; 4) reevaluate information needs.

Within problem-based learning, there are three types of approaches to developing schemas. Three methodological approaches to problem-based example learning are, conventional examples, molar worked-out examples and modular worked-out examples (see Figure 5).

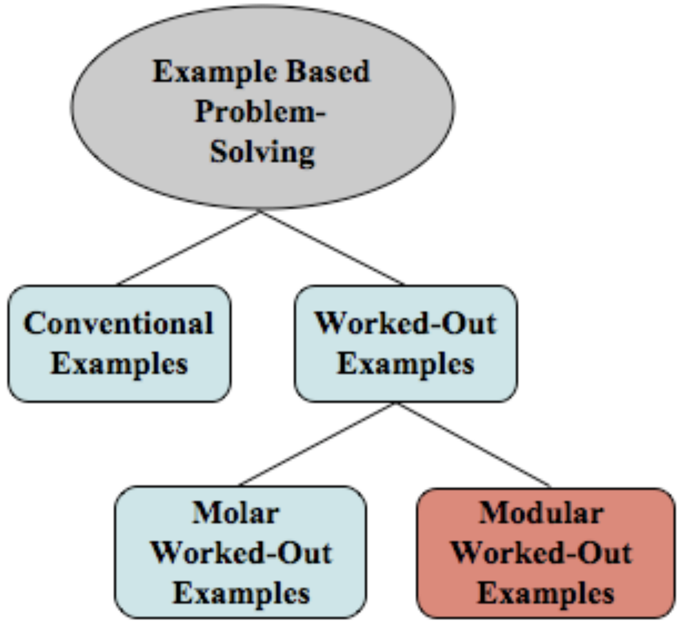

Figure 5. Example-based instructional problem-solving methodologies.

Figure 6 illustrates how these three example based instructional methods can be differentiated, using an instructional problem from the domain of mathematics. The three examples (Figure 6) share the same objective of teaching students permutation without replacement, a method of calculating complex event probabilities. The molar and modular worked-out examples below were used in a prior study (Scheiter, et al., 2009) and provided the baseline for development of the conventional example, which was built by the current author with reliance upon the work of Atkinson et al. (2000).

Conventional Example	Molar Worked-Out Example	Modular Worked-Out Example
Calculating probability: Permutations without replacement.	*100m-sprint example: permutations without replacement.*	*100m-sprint example.*
Formula: For this type of problem, the following formula is applied: $A = \frac{1}{\frac{n!}{(n-k)!}}$ with *A* being the solution, *n* being the number subjects and *k* being the number of variables that have to be correctly guessed.	**Introductory Text:** *At the Olympics 7 sprinters participate in the 100m-sprint. What is the probability of correctly guessing the winner of the gold, the silver, and the bronze medals?*	**Introductory Text:** *At the Olympics 7 sprinters participate in the 100m-sprint. What is the probability of correctly guessing the winner of the gold, the silver, and the bronze medals?*
Example*: At the Olympics 7 sprinters participate in the 100m-sprint. What is the probability of correctly guessing the winner of the gold, the silver, and the bronze medals?*	**Identify task features:** The given problem is a permutation-without-replacement problem. Problems of this type have two important features. First, the order of the selection is important, and second, there is no replacement of selected entrants.	**Find 1st event probability:** In order to find the first event probability you have to consider the number of acceptable choices. The number of acceptable choices is 1 because only 1 sprinter can win the gold medal. The pool of possible choices is 7 because 7 sprinters participate in the 100m-sprint. Thus, the probability of correctly guessing the winner of the gold medal is 1/7.
Solution: $A = \frac{1}{\frac{7!}{(7-3)!}}$ $A = \frac{1}{7*6*5}$ $A = \frac{1}{120}$	**Apply formula:** For this type of problem, the following formula should be applied: $A = \frac{1}{\frac{n!}{(n-k)!}}$ with *A* being the solution, *n* being the number of all participants in the 100m-sprint and *k* being the number of sprinters that have to be correctly guessed.	**Find 2nd event probability:** In order to find the second event probability you again have to consider the number of acceptable choices. The number of acceptable choices is still 1 because only 1 sprinter can win the silver medal. The pool of acceptable choices is reduced to 6 because only the remaining 6 sprinters participating in the 100m-sprint are eligible to receive the silver medal. Thus, the probability of correctly guessing the winner of the silver medal is 1/6.
	Insert values: In the given example there are 7 sprinters to choose from. This is the set of elements for selection (n=7). As we want to find out the probability of correctly guessing the winner of the gold, silver and bronze medals, 3 sprinters out of the group of 7 sprinters have to be selected. Therefore, the number of selected sprinters equals k=3. Inserting these values into the formula for permutations.	**Find the 3rd event probability:** In order to find the third event probability you again have to consider the number of acceptable choices. The number of acceptable choices is still 1 because only 1 sprinter can win the bronze medal. The pool of possible choices is reduced to 5 because only the remaining 5 sprinters participating in the 100m-sprint are eligible to receive the bronze medal. Thus, the probability of correctly guessing the winner of the bronze medal is 1/5.
	Calculate probability: In order to calculate the probability of correctly guessing the winner of each of the three medals, divide 1 (the particular permutation we are interested in) by the number of possible permutations. Thus, the probability of getting this permutation (the winner of each of the three medals) equals 1/210.	**Calculate the overall probability:** The overall probability is calculated by multiplying all individual event probabilities. Thus, the overall probability of correctly guessing the winner of each of the three medals is 1/7 * 1/6 * 1/5 = 1/210.

Figure 6. Complex event probability instruction using conventional, molar, and modular worked-out examples.

The conventional example (Figure 6) leads with an explanation that the learner will be performing a calculation of probability, specifically using permutations without replacement. This conventional example leads with a mathematical formula, corresponding to the formulaic approach previously discussed. It is important to note that the conventional example leads with a general, abstract formula followed by an example and the learner is not led through a step-by-step solution. The conventional example simply applies the formula to the given problem and the learner has to infer that the formula matches the given problem.

The molar worked-out example starts with a statement of the problem. While the molar worked-out example has a similar formulaic approach to the conventional example, it offers the learner more explanations of how permutation without replacement works and specifies how values are placed into the formula. By example, the step titled *Identify Task Features* (Figure 6) under the *molar worked-out example*, asks the learner to notice that the order of selection is important and that there is no replacement of entrants in the race. Conceptually this step in the molar worked-out example can be viewed as requiring the reader to engage in an analysis of the surface features of the problem category (permutation without replacement) in a way that is abstract and might overly distance the learner from the problem at hand. This additional processing by the learner requires cognitive effort, and therefore can reduce available working memory capacity and reduce essential processing.

Comparing molar and modular approaches (Figure 6), the molar approach challenges the learner to solve problems as one complete unit while the modular worked-out example solution breaks down complex problems into a logical progression of more easily solved sub-problems. An additional important difference between modular worked-out examples and molar worked-out examples is that the modular approach does not begin with a focus on the mathematical formula. Instead, the modular worked-out example guides the learner through a step-by-step approach to solving the problem identified at the beginning of the given example. The modular worked-out example includes a step-by-step series of explanations for the learner that connects the values needed to reach a correct solution with a rationale for each step. Therein lies the modular approach to problem solving. Whereas molar approaches ask the learner to solve problems as one complete unit, modular solutions break down the big problem into a series of more easily solved sub-problems.

While the same instructional problem is applied in each of the three example formats, the order, top to bottom, of each example followed illustrates significant differentiation between conventional and worked-examples. Research suggests that modular worked-out examples are particularly effective for low prior-knowledge learners whereas the molar approach may be more advantageous for learners with high prior-knowledge (Gerjets, et al., 2004, 2006). Finally, the solution is given in a simplified format as the last step in the modular worked-out example, which research suggests allows for optimal essential processing.

Ill-Defined Problems

An important development in the research on worked-out examples was a study by Rourke and Sweller (2009), who sought to apply worked-out examples using ill-defined problems. The authors state that “a well defined problem has well-defined givens, goals and problem solving operators while an ill-defined problem does not have givens, goals or operators” (Rourke & Sweller, 2009, p. 185) and worked examples have predominantly been investigated using well-defined problems found in science, mathematics, and technology (Rourke & Sweller, 2009). Looking back at the earlier examples of conventional examples, molar worked-out examples and modular worked-out examples (Figure 6), one can see how the permutation without replacement molar worked-out example had clearly defined givens and goals the process necessary to solve the problem was unclear. Rourke and Sweller (2009) discusses this process more abstractly as a the operators within an with ill-defined problem. In the domains of science and mathematics the givens, goals and operators are often explicitly clear. By example, in a hypothetical formula of X+1=Y, 1 is a given, the operator + is clearly understood by most students and the goal of solving for Y is clear. Rourke and Sweller (2009) made a unique contribution by examining worked-out examples using ill-defined problems wherein the paths (operators) to achieve an acceptable outcome could be viewed as unclear. Rourke and Sweller (2009) used an example from arts education, wherein students were asked to identify an artist based on a visual representation of a piece of their artistic work. In this example of ill-defined problem solving the goal of identifying the artist is clear, but the paths and operators needed to solve the problem were not as clear as would be found in a mathematical formula.

The focus of the Rourke and Sweller study (2009) was to evaluate, in the context of cognitive processing theory, the extent to which worked-out examples could improve the problem solving skills of novice, college-age students in the domain of visual literacy. Specifically, the study involved providing students with methods for identifying art objects by visual analysis of the styles of different designers and in turn asked the students to use appropriate language to describe works of art. This combination of identification and description defines visual literacy. The authors go on to identify visual literacy as the skills needed to visually identify a particular designer and express the attributes of the designer using the vocabulary of visual artists (Rourke & Sweller, 2009). Rourke and Sweller note that this identification exercise is an ill-defined problem, in that "the style of a designer is determined by several factors and identifying a designer could be carried out by using several different combinations of factors" (2009 p. 187).

The Rourke and Sweller (2009) study participants were 102 first-year university design students. The experiment divided the subjects into either a worked-out example group or a problem solving group, and all participants received the same introductory design history lecture. After the lecture, the problem-solving group were provided with an image of a design object and asked to match the object using the visual design language from the introductory lecture. The worked-out example group was provided with the similar images as the problem-solving group, augmented with brief samples of language from the visual design lecture. The researchers conducted a 2 (instructional method) x 5 (designers) ANOVA, and the results indicated a significant main effect of the worked-out example instructional method when compared to the problem solving method (Rourke & Sweller, 2009). The results from the Rourke and Sweller (2009) study suggest that instructional domains that include ill-defined problems might benefit from the application of worked-out examples.

Summarizing the research on worked-out examples, it appears that worked-out examples can be more effective than conventional problems, and that modular worked-out examples have the potential to be more powerful than molar worked-out examples. Additionally, recent studies have extended the use of worked-out examples into the domain of ill-defined problems as reflected in the work by Rourke and Sweller (2009).

For students in college, a typical ill-defined problem is how to determine the extent of information needed when faced with a research problem for a course. This problem has been well identified within the research on information literacy (Donaldson, 2000; Jacobson & Mark, 2000; Meyer, et al., 2008) and has been identified as the first step toward developing information literacy skills (ACRL, 2000). Thus, it appears that the problem of determining the extent of information literacy within the context of information literacy would be an excellent candidate to extend the work of Rourke and Sweller (2009) by applying worked-examples to a real-world ill-defined problem in information literacy skill development.

In addition to investigating ill-defined problems, prior research appears to indicate that for low prior-knowledge learners, the use of modular worked-out examples may be the most successful. However, Rourke and Sweller (2009) did not explicitly develop their models in terms of a modular worked-out example approach. This study argues that determining the extent of information needed is comparable in terms of complexity to visual literacy instruction problems (Rourke & Sweller, 2009), and therefore constitutes an ill-defined problem. We do not know the extent to which worked-out examples might be effective in the domain of information literacy, or, more specifically, how effective modular worked-out examples might be in this ill-defined problem domain. Therefore, it is important in the case of ‘determining the extent of information needed’ that an explicit process for developing modular worked-out examples is studied. The current study seeks to address these needs.

Nursing Informatics and Information Literacy Skill Development

Nursing informatics, a sub-set of healthcare informatics, is a combination of computer science, information science and nursing science designed to assist in the management and processing of nursing data, information and knowledge to support the practice of nursing and the delivery of nursing care (Graves & Corcoran, 1989). Within the context of nursing informatics, nurse educators describe information literacy as providing a foundation for nursing practice as these skills insure practitioners the ability to be intelligent information consumers (Thede & Sewell, 2010). Nursing informatics and information literacy are particularly important when discussing evidence-based nursing practice (Guenther, 2006; Prion, 2011b).

Evidence-based nursing practice relies upon nurses making the best possible patient care decisions through the use of evidence in the form of research conducted by nurses and other healthcare professionals (Polit & Beck, 2008). The skills necessary to access quality evidence such as what can be located in journal articles is often developed through information literacy instruction. Information literacy is an important, but often neglected, foundation for evidence-based nursing practice (Jacobs, Rosenfeld, & Haber, 2003; Ross, 2010; Shorten, Wallace, & Crookes, 2001). Although many of the skills developed in nursing informatics instruction suggest that the convergence of the information found in nursing journals and the attendant technology available to search these resources could reduce the importance of information literacy instruction, the literature does not fully support this assumption (Guenther, 2006; Ku, Sheu, & Kuo, 2007; S. Prion, personal communication, December 10, 2011; Saba & McCormick, 2011). For example, Ku et al. (2007) note that most nursing informatics programs maintain an excessive instructional focus on basic computer skills without sufficient attention to the development of information literacy skills such as searching journals, screening the information found and integrating the evidence found into practice. Evidence-based nursing demands an underlying understanding of how information is organized and accessed (Jacobs, et al., 2003), and therefore relies upon the skills information literacy instruction seeks to build.

Although it is widely accepted that nursing informatics, and therefore information literacy, are an important component of nursing education (Saba & McCormick, 2011; Thede & Sewell, 2010), there is room for improvement with respect to the delivery and efficacy of information literacy education. In one of the few national surveys of information literacy and nursing education, scholars note that fewer than one-third of the nursing schools included nursing informatics in their curricula and that only a small number of nursing schools offer a separate course in nursing informatics (Carty & Rosenfeld, 1998). In addition, the definitions used in the nursing literature for information literacy vary, and a small number of studies have investigated the efficacy of information literacy instruction with nurses (Ku, et al., 2007). For example, studies have found positive results using web-based instructional modules for delivering information literacy instruction to nursing students (Grant & Brettle, 2006) as well as information literacy instruction using more traditional classroom-instruction (Ku, et al., 2007).

Many professional nursing and healthcare organizations have recognized the need to address information literacy within nursing education. Examples of the organization identifying this need include the American Nursing Association, the National League for Nursing, the American Association of Colleges of Nursing and the International Medical

Informatics Association (Englebardt & Nelson, 2002). For example, the American Association of Colleges of Nursing (2012) notes that information literacy skills are essential for baccalaureate, masters and doctor of nursing practice (DNP) students.

There is a limited body of research into methods of delivering information literacy instruction at the graduate and undergraduate levels of nursing education. However, a small number of studies have shown promising results using instructional designs such as one-day intensive in-class instruction (Courey, Benson-Soros, Deemer, & Zeller, 2006; Grant & Brettle, 2006; Ku, et al., 2007). The present study will build upon this prior research by introducing instructional design methodologies coupled with cognitive processing theory to deliver a brief, multimedia instructional session designed for both undergraduate and graduate nursing students. Additionally, the present study argues that information literacy, as a component of nursing informatics, will benefit from research into the information literacy instruction delivered within the emerging research into ill-defined problems.

Research Questions

1. What is the level of change in nursing students' ability to determine the extent of information needed after a multimedia presentation using modular worked-out examples addressing information literacy (instructional treatment)?
2. What is the level of extraneous processing for students during the instructional treatment?
3. What is the level of generative processing for students during the instructional treatment?
4. What is the level of essential processing for students during the instructional treatment?

Summary

Despite the important role information literacy skills play in college students' education, many previous attempts at integrating information literacy instruction into higher education have been sub-optimal (ACRL, 2004a, 2004b). The complexity of information literacy is one important factor that has contributed to the difficulties of delivering information literacy instruction (Cox & Lindsay, 2008). The cognitive theory of multimedia learning (Mayer, 2005) coupled with modular worked-out examples (Gerjets, et al., 2004, 2006) provide insights as to the ways complexity can be effectively managed during cognitive processing. Although limited, the research literature suggests that instruction involving ill-defined problems such as information literacy instruction can be effective when presented using worked-out examples (Rourke & Sweller, 2009). Whereas recent studies did not assess the cognitive processing associated with ill-defined problems presented in a multimedia format using modular worked-out examples (Rourke

& Sweller, 2009), this study will examine the efficacy of this combination of instructional design techniques, with information literacy as the instructional content.

Definition of Terms

Audiobooks – Files containing images and pre-recorded audio accessible using Apple iTunes (Macintosh and PC operating systems). Audiobooks (using an .m4b file type) can also contain metadata such as chapter markers and hyperlinks and can be used as complete mobile learning packages (Prion & Mitchell, 2008).

Cognitive Processing (Cognitive Load) – Describes the total load imposed upon working memory during learning caused by the additive nature of *Essential Processing, Extraneous Processing* and *Generative Processing* (Sweller, et al., 1998b).

Cognitive Processing (Load) Theory – A learning and instructional design theory that takes into consideration the limited capacity of human cognitive architecture (Plass, et al., 2010).

Cognitive Theory of Multimedia Learning (CTML) - Assumes that the visual/pictorial and auditory/verbal channels in working memory are extremely limited so that only a few items can be held or manipulated in each channel at any one time. CTML suggests that people learn better from words and pictures than from words alone, and that learning is deeper when appropriate pictures are added to text (Mayer, 2001, 2008).

Essential Processing – The cognitive processing imposed by the inherent difficulty of integrating learning material into schemas (Plass, et al., 2010). Essential processing is measured using a scale of 1-9 developed by Knaus, Murphy, & Holme (2009) and modified by Musallam (2010).

Extraneous Processing – Is the cognitive processing caused by poorly designed instruction or non-essential materials in the instructional module. Extraneous processing does not contribute to learning (Mayer & Moreno, 2003). Extraneous processing is measured using a scale of 1-9 developed by Knaus, Murphy, & Holme (2009) and modified by Musallam (Musallam, 2010).

Generative Processing – Is the cognitive processing of organizing and integrating new information into schemas which contributes to learning (Plass, et al., 2010). Generative processing is measured using a scale of 1-9 developed by Knaus, Murphy, & Holme (2009) and modified by Musallam (Musallam, 2010).

Ill-defined Problems - Whereas a well defined problem has well-defined givens, goals and problem solving operators, an ill-defined problem does not have givens, goals or operators (Rourke & Sweller, 2009). Ill-defined problems lack a definitive answer, answers are heavily dependent upon the problem's conception and require the learner to use working memory to retrieve relevant concepts and map them to the task at hand (Ashley, Chi, Pinkus, & Moore, 2000).

Information Literacy - Information literacy includes the ability to determine the extent of information needed, access the needed information effectively and efficiently, evaluate information and its sources critically, incorporate selected information into one's knowledge base, and use information effectively to accomplish a specific purpose (ACRL, 2000; Farmer & Henri, 2008). Information literacy is assessed using instruments developed by Beile-O'Neil (2005) and others (SAILS, 2001). An information literacy assessment rubric was developed by the present researcher.

Information Literacy, *Determining the Extent of Information Needed* - Determining the extent of information needed is the first step in developing information literacy skills. Determining the extent of information needed requires the student to articulate the need for information and describe the information needed, identify a variety of types and formats of potential sources of information, consider the costs and benefits of acquiring the needed information, and possess the skills necessary to reevaluate the nature and extent of the information needed (ACRL, 2000). Information literacy is assessed using instruments developed by Beile-O'Neil (2005) and others (SAILS, 2001). An information literacy assessment rubric was developed by the present researcher.

Mental Effort - Mental effort is the term used on the essential processing scale item for study participants to quatitify their effort. Mental effort is synonomus with essential processing.

Modular Worked-out Examples – Modular worked-out examples break down complex problems into a logical progression of sub-problems (Sheiter, Gerjets, Vollman, & Catrambone, 2009).

II. REVIEW OF THE LITERATURE

The purpose of this study is to assess the effect of information literacy instruction within the domain of ill-defined problem solving using modular worked-out examples. The theoretical rationale for the present study is cognitive processing theory, and more specifically, the cognitive theory of multimedia learning and modular worked-out examples. Information literacy instruction appears from the literature to be a particularly complex instructional problem and might benefit from the present instructional design. The first section of this review of the literature provides an overview if information literacy and outlines methods for the assessment these skills. The second section of this review provides background on working memory and cognitive processing theory. The third and fourth sections of this review provide background on worked-out examples and ill-defined problems.

Information Literacy

Information literacy education in American libraries dates back to the mid-1800s and has remained a core competency of librarians throughout the history of the American Library Association (ALA). Information literacy skills include the ability to determine the extent of information needed, access the needed information effectively and efficiently, evaluate information and its sources critically, incorporate selected information into one's knowledge base and use information effectively to accomplish a specific purpose (ACRL, 2000; 2008). The development of information literacy in higher education parallels the creation and development of both public and private colleges and universities in the United States and can be specifically tied to the Morrill Federal Land Grant Act of 1862 under which many undergraduate institutions were chartered

(Bramley, 1969). In 1876, the establishment of Johns Hopkins University, the first institution chartered expressly for graduate education continued the parallel development of information literacy instruction and higher education (Tucker, 1980). Johns Hopkins was one of the first academic institutions where teaching and research, the fundamental building blocks of information literacy, were part of the founding principles of the university.

Between 1870 and 1912, librarians began to become recognized as educators, and student education programs that focused on library research skills, the precursors to information literacy instruction, became a more recognized component of student education (Tucker, 1980). In a 1913 survey of New York libraries, 49 percent of the respondents stated that they had an organized library instruction program or service, and a national survey conducted shortly thereafter found that 20.5 percent of academic libraries had a library instruction component to their charter (Tucker, 1980). As early as the 1950's scholars began suggesting that library instruction should be a central component of a college student's experience (Rockman, 2004). This symbiotic relationship between higher education and academic libraries continues and information literacy skills instruction has matured ever since. Whereas information literacy instruction and research spans the K-12 and higher education, the primary focus of the current study is its application and research investigating its use in higher education.

The 1960s and 1970s were a time of social upheaval in the United States, and, according to Farber (1999), educational reform was a key component of the changes ushered in during that era. Farber (1999) notes that the Carnegie Commission on Higher Education, whose tenure lasted from 1967 to 1973, conducted the most comprehensive studies ever of American higher education. One recommendation from the Carnegie Commission study was that libraries should engage more aggressively in on-campus instruction. In the 1970s there was a shift from global views of academic library instruction being an institutional objective to an increasingly library-centric view of how information literacy skills should be taught to college students. One outcome of this shift was a transition from instructional objectives as overarching information literacy goals to decentralized, classroom-centric instruction. Academic librarians and university faculty increasingly partnered in giving information literacy instruction, and according to Rockman (2004), these faculty-librarian partnerships remained prevalent up until the late 1980s.

In 1989, the American Library Association (ALA) formed its Presidential Committee on Information Literacy. The committee report notes that "information literacy is a survival skill in the Information Age and that information literate people know how to find, evaluate, and use information effectively" (ALA, 1989). In response to the report, the ALA formed the National Forum on Information Literacy (NFIL). NIFL took on the charge of helping to bridge what the committee identified as gaps among the K-12, higher education and business comminutes with respect to information literacy advocacy and education. The Association of College and Research Libraries (ACRL), a division of the ALA, also responded, publishing their Information Literacy Competency Standards for Higher Education (ACRL, 2000). The ACRL standards "provide a structured and logical way for academic librarians and university faculty to work together to integrate information literacy skills" (Eisenberg, et al., 2004, p. 27) into the academic lives of college students both domestically and internationally (Rockman, 2004). These findings by ACRL (2000) and the subsequent development of ACRL's information literacy standards have been endorsed by the American Association for Higher Education (October 1999) and the Council of Independent Colleges (February 2004), two organizations that include in their charters the assessment of college and university educational programs.

ACRL's Information Literacy Standards not only set forth specific definitions of information literacy, they also identify these skills as an important part of an individuals' foundation for lifelong learning. Additionally, the need for information literacy skill development is common to all academic disciplines and facilities a learner's mastery of content and ability to control their learning. ACRL's information literacy standards describe the increasing interconnectedness between information literacy as it has evolved from the mid-1800s to today, and how technology has become a key component of information literacy instruction and students' approach to educational research problems.

Information Literacy Standards for Higher Education

The Association of College and Research Libraries (ACRL) defines information literacy as a set of skills whereby students recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information. Information literacy is evolving as a key component of students' skills as they relate to the prevalence of technology in the higher education arena (ACRL, 2000). Students not only need information literacy skills to evaluate information resources, an increasing number of these resources require students to possess skills related to technology. For example, navigating a library website and the information databases provided therein requires a combination of information literacy and technology skills. Individuals' information literacy skills should be developed so that they can meet or exceed the requirements of college learning, and theses skills can be seen in students ability to access learning resources effectively though libraries, online resources, via the Internet and a host of other methods.

Not surprisingly, some of the resources students find reaches them without any known filters or verifiable sources, which, as the ACRL points out raises questions about authority, validity, and reliability. Examples of authoritative sources include peer reviewed journals and databases; information sources that might lack authority or be considered biased include popular magazines. Validity and reliability, in the context of information literacy, address whether claims made in the source are creditable. The uncertain authority, validity and reliability of information sources are a challenge for students, and the best response to this challenge is to instruct students in information literacy.

The Association of College and Research Libraries notes (ACRL, 2000) that information literacy:

> Forms the basis for lifelong learning. It is common to all disciplines, to all learning environments, and to all levels of education. It enables learners to master content and extend their investigations, become more self-directed, and assume greater control over their own learning" (p. 2).

From the ARCL information literacy standards, the following high-level skills provide the basis of information literacy instruction: 1) determine the extent of information needed; 2) access the needed information effectively and efficiently; 3) evaluate information and its sources critically; 4) incorporate selected information into one's knowledge base; 5) use information effectively to accomplish a specific purpose, and; 6) understand the economic, legal, and social issues surrounding the use of information, and; 7) access and use information ethically and legally. The instruction and assessment of information literacy in higher education settings has generally incorporated or addressed some or all of these skills. The present study will focus specifically on the first standard, determining the extent of information needed.

The teaching and assessment of information literacy skills has been a core competency of academic librarians for nearly a century (DeFranco & Bleiler, 2003). While early library instruction of information literacy focused primarily on instructional methods and specific library resources, today's information literacy instruction is more nuanced. According to Tucker (1980), the early years of library instruction focused on using resources available in libraries to teach student how best to use reference sources and these efforts were generally ad-hoc efforts to support an institutions general educational goals. Modern information literacy instruction often not only addresses resources and instructional methods, but also might include the technology skills necessary for students to become information literate. Universities and colleges today often have dedicated instruction librarians and assessment has become a component of many library assessment programs. A 2003 survey of large academic libraries reported that 54 percent of respondents had "library instruction that included tours, class sessions, online tutorials and other types of presentations" (DeFranco & Bleiler, 2003, p. 11). These findings show that many academic libraries have information literacy programs in place. However, many of the assessment activities supporting these programs are at best localized to specific university programs, and the generalization of results to broader academic communities is problematic.

This study traces Burkhardt's (2007) method for separating information literacy assessment literature into two broad categories. Burkhardt notes that only a small number of assessments have been developed at the national level, while the majority discussed in the literature are local case studies (2007). The use of general case studies designed to meet individual library needs as sources for information for the present is problematic. Therefore, the next section of this study provides an overview of two large-scale information literacy assessments that were developed using well-established instrument design protocols, thus providing the basis for assessing information literacy in the present study.

Information Literacy Assessments

Information literacy assessments in higher education settings are tasks typically undertaken by librarians. Results from a survey of academic and research libraries (DeFranco & Bleiler, 2003) notes that 88 percent of the respondents (n = 38) used instruments for assessing information literacy that were developed by librarians and the remaining were developed institutionally by libraries (n = 67). Only five cases were reported where the instrument was developed outside the library (DeFranco & Bleiler, 2003). Although the DeFranco (2003) survey provides an overview of the ways in which a sample of academic libraries assess information literacy, the research does not discuss the reliability or validity of the instruments used. However, the study states that while many library instruction efforts have been assessed, nearly sixty percent of the respondents from a survey of instructional efforts in libraries "indicated that the current assessment tool was not able to provide adequate information about the success of the instruction program" (DeFranco & Bleiler, 2003, p. 15). While there are an increasing number of studies that investigate the impacts of information literacy instruction in higher education, the findings are often localized. A localized assessment of information literacy addresses the unique needs of an individual institution or academic program. Additionally, the methodology and populations chosen for the studies limit the generalizability of the findings.

In summarizing the information literacy assessment landscape Neeley (2006b) notes that the research is "fractured, with no clear trends or generalizable findings for comparative purposes across institutions" (p. 2). While the academic community clearly recognizes the importance of information literacy, and academic libraries are striving to meet the needs of students and faculty, many of the information literacy programs and assessments have been developed locally and offer limited empirical data supporting study findings. However, there are a number of instruments that have been developed using traditional measures of validity and reliability, thereby suggesting that their results are more generalizable than the majority of information literacy studies.

Standardized Assessment of Information Literacy Skills (SAILS)

One early review of the library literature suggested that there was little agreement in the academic library community as to the best method to assess information literacy (O'Connor, Radcliff, & Gedeon, 2002). One of the first efforts to assess information literacy skills was the Standardized Assessment of Information Literacy Skills (SAILS) instrument. O'Connor, Radcliff, and Gedeon note that the purpose of SAILS was to "develop an instrument for programmatic-level assessment of information literacy skills that is valid, and thus credible, to university administrators and other academic personnel" (2002, p. 528). The intent of SAILS was to introduce information literacy assessment uniformity across different academic institutions, provide effective longitudinal assessment, and ensure validity across academic disciplines and content areas. The development of SAILS would help address the criticisms common to many local information literacy instruction and assessment studies (Beile-O'Neil, 2005; Eisenberg, et al., 2004).

The developers of the SAILS utilized a learning systems approach to instructional design (Dick, Carey, & Carey, 2009), noting that integrating the development of instructional goals in conjunction with assessment criteria is well suited to information literacy programs (O'Connor, et al., 2002). The five phases of the learning systems approach to instructional design (ID) approach are: (1) determine instructional goals; (2) describe the desired learning behaviors of those who have achieved the instructional goals; (3) study the attributes of learners and the learning environments; (4) write performance objectives that describe the skills the learner should achieve, the learning conditions and specific measurable performance criteria; and (5) develop the instrument including the writing of test items (Dick, Carey, & Carey, 2005; O'Connor, et al., 2002). Additionally, the use of an ID approach to test development provides a theory-based, systematic and reflective structure for the development of educational programs (Smith & Ragan, 2005). The ID processes, as applied during the development of the SAILS instrument, not only facilitated a systematic instrument design, it also provided the developers with a model that allowed for the coupling of information literacy skills instructional goals with an assessment of the desired educational outcomes. The use of established ID practices will be discussed later in this literature review, as ID is a central tenet of using cognitive processing theory and the principles of multimedia to address cognitive processing during learning.

Validation of the SAILS instrument questions was completed using a three-stage process. In stage one of the validation, the researchers used a small pool of six learners to gauge initial item accuracy and validity. Stage two involved small group trials with a class of twenty students in a simulated testing environment. Stage three was a field trial where the researchers attempted to design a testing environment that closely resembled a live teaching situation. Stage three was conducted in the spring of 2001 with 554 students at Kent State University. Of the 554 students who participated in the SAILS instrument validation, 537 completed the survey and 337 provided valid student identification numbers that were used to secure student academic and demographic data. Descriptive data regarding student demographics and pretest results were not reported (O'Connor, et al., 2002).

Item response theory (IRT) consists of a family of models that have been demonstrated to be useful in the design, construction, and evaluation of educational and psychological tests (Hambleton, Swaminathan, & Rogers, 1991). The developers of SAILS used IRT, specifically, a one-parameter Rasch rating scale model, that affords researchers the ability to develop models that measure traits such as ability and aptitude that can be difficult to assess using other measures (O'Connor, et al., 2002). Additionally, IRT demonstrates that student test performance is predictable by factors, traits or latent traits and, that as the level of a trait increases so does the probability of a correct response to a test item (Hambleton, et al., 1991).

In the SAILS instrument design process, the latent traits the researchers were attempting to measure were information literacy ability as described by ACRL. Item difficulty was assessed through a review process that involved experienced reference and instruction librarians. The type or years of reviewer experience was not discussed in the article (Hambleton, et al., 1991).

Analysis of field trial results were conducted using WINSTEPS, a Rasch modeling program and test construction guidelines created by Wright and Stone (1979). According to the Wright and Stone model there are six measurable criteria for determining a subject's latent ability with respect to a construct. O'Connor et al. (2002) assert that if instructional designers have applied the six criteria successfully, they can conclude that the instrument accurately measures the latent traits associated with information literacy.

Using the six test construction criteria outlined by Wright and Stone (1979), the first research question investigated by the SAILS team was, "Is a discernable line of increasing intensity defined by the data?". To assess this construct, the authors graphed individuals and items along a line representing the information literacy construct. Item calibrations were evenly distributed between -3.29 and + 2.86 along the information literacy trait. Question two was, "is test item placement along the line reasonable?" The authors concluded that "the individual items and comparison of their placement along the variable with their own intent, the content experts input and the previous phases of data collection … for the most part the ordering of items from easy to difficult makes sense" (O'Connor, et al., 2002, p. 538). The third question was, "Do the items work together to define a single variable?" This question was addressed using item infit and outfit. Rasch model analysis of infit measures the degree to which the item “works for persons close to it in ability [and] outfit, which indicates how well an item works for persons far from it in ability” (O'Connor, et al., 2002, p. 538). The authors conclude that for the second measure of test validity, their pilot instrument had a small number of misfitting items (9%), and they adjusted these items as necessary to increase item fit. Where the first three criteria discussed above focused primarily on item development, the final three test construction criteria focused on differentiating individuals’ responses to SAILS test items.

The fourth question was whether respondents were adequately separated along the information literacy line as defined by the test items. The authors reported a Cronbach’s alpha of .64, indicating a moderate level of separation among individuals. The fifth question was whether individual placements along the variable corresponded to past student academic achievement. The authors focused their responses to this question using ACT and GPA scores from 398 students, a subset of the 537 who completed the assessment and provided access to their academic records. The ACT is an assessment taken by high school students and is a general assessment of college readiness. Results indicated that there was a small correlation (.263) between the Rasch measure and GPA and a moderate correlation (.482) between the Rasch measure and participants ACT scores. No additional analyses were provided breaking down the ACT or GPA results by gender, age or other demographic variables. The authors concluded that the moderate ACT correlation suggests that the SAILS information literacy assessment measures students accurately at different ability levels.

The sixth question was, “How valid was each person’s measure?” The researchers used the concept of consistency to assess validity. The research data gathered suggested that if there are wide discrepancies in the order of item difficulty, the validity of individuals’ results is suspect. Looking at the order of item difficulty for each respondent, as measured by infit and outfit, the researchers concluded that there were 44 (8.2%) individuals who were misfit. Response analysis of the misfits indicated that there were no apparent response patterns and therefore no need to adjust item difficulty.

The Project SAILS instrument is designed to report the performance of cohort groups rather than individual study participants. Furthermore, the analysis of SAILS results are generally completed by comparing sets of aggregate student scores across multiple participating institutions (Rumble & Noe, 2009). One recent example of a SAILS implementation was conducted by Rumble and Noe (2009) at a large, comprehensive research university with a student population (undergraduate, graduate and doctoral) of approximately 24,500 students.

Results from the Rumble and Noe (2009) study indicated that students scored on average at similar levels across each of the three participating institutions. No statistically significant differences between students at different participating institutions were found as part of the study. While the SAILS report provided the researchers with assessment data that included external benchmarking, they noted that key questions remained unanswered. The national benchmarks associated with the SAILS standards and skill sets did not indicate ‘‘mastery’’ of information literacy but rather average student performance (Rumble & Noe, 2009). Although SAILS is one of the few instruments that provides an information literacy assessment instrument inclusive of all five ACLR standards, important limitations were found. For example, analyzing results at the individual student level appears to be unsupported in SAILS, thereby potentially limiting the present researchers ability to employ the SAILS instrument. The company that owns and implements the SAILS instrument for colleges and universities does not provide the ability to easily and inexpensively conduct pretest posttest implementations. For example, no published results allow for analysis at the level of control group compared to treatment group results analysis, nor are there known SAILS studies that evaluate different instructional treatment types.

A major limitation of the Rumble and Noe (2009) study was the lack of specific SAILS results such as mean scores, difference scores or cohort-level results. However, after an extensive review of the literature, there appear to be a few studies that report detailed results. A recent study (Detlor, Julien, Willson, Serenko, & Lavallee, 2011) used the SAILS instrument to compare information literacy skills at Canadian business schools located in three separate universities. The three business schools were quite different from each other in that they were from dispersed geographical regions of Canada, the student populations were different sizes, each school had different information literacy program components, and each location placed different emphases on information literacy instruction (Detlor, et al., 2011). Results across the three institutions with respect to information literacy skills were not strong. Between the three locations, only two statistically significant differences were found between levels of information literacy skill. The researchers attributed the differences to the number of first-year students in one location who completed the study and the small amount of information literacy instruction provided to students at another institution (Detlor, et al., 2011).

For the purposes of the present study, the Detlor, et al. (2011) findings support the overall effectiveness of SAILS, while confirming a number of its shortcomings. For example, the researchers note that SAILS is a rigorously tested instrument and there were no apparent shortcomings with respect to the instruments ability to assess multiple information literacy constructs (Detlor, et al., 2011). However, the design of the SAILS instrument does not allow for participant level analysis. As an instrument designed to report at the institutional level, SAILS may not be the optimal assessment tools for individual academic programs such as graduate or undergraduate nursing. Although SAILS provides a key milestone in the development of information literacy assessments and the individual information literacy items appear to be particularly effective (Cannon, 2007; Detlor, et al., 2011; Rumble & Noe, 2009), it does not appear to be an appropriate fit as a stand-alone assessment instrument for the present study.

In conclusion, the researchers stated, “the analysis showed that most items developed to date were reliable and valid and that the items worked together to measure at least some portion of the trait of information literacy” (O'Connor, et al., 2002, p. 540). As previously discussed, a general criticism of information literacy assessments is that they lack rigorous reporting of their validity and are therefore not generalizable to larger populations of students. The SAILS authors suggest that the results from their study, and the instructional design processes they chose to employ, demonstrates that the construct of information literacy was rigorously evaluated. The SAILS validation efforts suggest that the instrument is capable of longitudinal use across multiple academic disciplines and can afford institutions the ability to compare student information literacy skill acquisition across different academic institutions. While the development and validation work O’Connor et al. (O'Connor, et al.) completed with respect to SAILS was important, others have noted that relatively little has been written abut the results of applying the SAILS instrument beyond the pilot study (Burkhardt, 2007). However, one example of a rigorous evaluation and implementation of the SAILS instrument can be seen in the work by Beile-O’Neil (2005) to modify the SAILS instrument to assess the information literacy skills of graduate education students.

Beile Test of Information Literacy for Education (B-TILED)

The Beile Test of Information Literacy for Education (Beile-O'Neil, 2005) was developed in conjunction with the Institute for Library and Information Literacy Education (ILIE) and the Institute of Museum and Library Services (IMLS). IMLS provides federal support in the form of grants to approximately123,000 libraries and 17,500 museums in the United States, primarily through the Library Services and Technology Act. ILIE promotes information literacy in the K-16 classroom and is partially funded by IMLS and the U.S. Department of Education.

The Beile Test of Information Literacy for Education (B-TILED) was developed as a response to the Project for the Standardized Assessment of Information Literacy Skills (SAILS) assessment (SAILS, 2001). The B-TILED instrument was developed using information literacy standards published by the International Society for Technology in Education and the Association of College and Research Libraries (Beile-O'Neil, 2005).

Beile-O’Neil (2005) notes that the development of the SAILS instrument modeled the ACRL Information Literacy Standards to all types of educational programs and all types of higher education institutions. SAILS did not directly address the needs of information literacy skills instruction for any one specific academic discipline. The B-TILED was developed as an information literacy skills assessment for graduate education students. Further, the delayed production and lack of large-scale use of the SAILS instrument and its lack of domain-specific (e.g. education) design, and the probable costs of SAILS use all led to the development of the B-TILED (Beile-O'Neil, 2005). The B-TILED information literacy assessment differs from SAILS in that it is “relatively inexpensive to administer and score, and can be used to evaluate instructional efforts at the local level” (Beile-O'Neil, 2005, p. 11). SAILS did not meet its goal of being an assessment that could reasonably span disparate educational needs and objectives. Beile-O’Neil addresses the gap between assessments that are overly broad such as SAILS and other assessments explicitly localized to the specific needs of individual institutions, which severely limited their use in the broader academic community.

The content of the B-TILED was based upon the five standards and twenty-two performance indicators contained in the Information Literacy Competency Standards for Higher Education (ACRL, 2000) and, incorporated instructional standards specific to the education domain from National Council for Accreditation of Teacher Education (NCATE). “Overall, these standards [ACRL and NCATE] encompass identifying, accessing, locating and using research and technology resources, evaluating resources, and modeling and teaching ethical practices related to technology use” (Beile-O'Neil, 2005, p. 55).

B-TILED test item construction was built upon a multiple-choice format consistent with the item construction process used in the SAILS instrument development process. The researcher began item construction using a test-bed of items developed for

SAILS. After review of the test-bed of items, the researcher noted that a majority of the SAILS items would be rewritten by for the B-TILED and resulted in the development of 62 new test items (Beile-O'Neil, 2005). Content analysis was performed by Beile-O’Neil and by a panel of information literacy assessment experts from the Project SAILS team.

An assessment of B-TILED content validity sought to examine to what extent items measured constructs from ACRL’s information literacy skills standards. The developers of the B-TILED chose to base content validity “on the opinion of experts regarding the extent to which a test covers a particular subject area” (Fishman & Galguera, 2003, p. 19), in this case information literacy instruction for education students. Specifically, the researchers sought to determine the degree of match between the items and the information literacy objectives. A panel of experts in the field rated the items on the strength of accuracy, clarity and instructional objectivity using a scale where 0 represented no match, 1 was a low match and 3 represented a high match with ACRL and NCATE information literacy objectives (Beile-O'Neil, 2005). The experts were full-time library faculty who were actively engaged in information literacy instruction. The expert review found that 3 items (4.8 %) received average scores below 2.0 while over 95 percent of the items received scores of 2.0 or greater from the experts (Beile-O'Neil, 2005), suggesting a number of items were not as effective as the design team anticipated. Test items that received a low score were sent to the SAILS team for further review and revision. Additional item validation was conducted using individual students and groups of students.

B-TILED development continued with the implementation of an item reduction technique. The researcher chose to use an item sampling technique that would provide systematic steps for choosing instrument survey questions that would span the four ACRL information literacy domains. Furthermore, researchers relied on item analysis scores, feedback from content experts and, item difficulty statistics in determining which items would remain in the test battery. The final instrument contained 22 questions spread across the four ACRL information literacy knowledge domains and 13 demographic questions that were unrelated to information literacy. Having concluded their item analysis and revisions, the researchers turned their focus to selection of the population and test implementation considerations.

The final version of the instrument was sent out in electronic form to 172 education students at a large urban university, resulting in 92 completed surveys. The researcher followed up with a print version of the instrument, sent to a convenience sample of students from the same university that resulted in an additional 80 completed surveys. The final count for useable surveys was 172. The resultant sample was deemed by the researchers to be demographically representative of the population of education students enrolled in the institution and the distribution of test scores was found to approximate a normal distribution (Beile-O'Neil, 2005).

Content validity of the B-TILED was measured using objective feedback from information literacy instruction subject experts. Reviewers rated each of the 62 test items on a 0 to 3 scale (zero being low) and reported their opinions on test item accuracy, clarity and institutional objectivity. The mean score for all information literacy items as rated by the experts was 2.47, leading the researchers to the conclusion that the overall content validity measure was excellent. The researcher performed factor analysis of the items. Conducting a Bartlett's test of sphericity yielded a value of 365.20 and a significance level of .01. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, which tests the strength of test item strength in a correlation matrix, yielded a value of .69. While the researcher notes that the KMO value exceeded the .50 generally considered adequate for factor analysis, others note that a value of .70 is the minimum value (Beile-O'Neil, 2005; Vogt, 2005). Minimum Eigen values were set at 1.0 and factors were extracted using generalized least squares method.

Internal consistency was measured and reported as a K-R 20 coefficient. The value reported was .67, which is generally considered low; however, the researcher points to literature noting that internal consistency standards of high and low are not necessarily found when using this measure (Beile-O'Neil, 2005; L. A. Clark & Watson, 1995). The researcher discussed a number of possible reasons for the low K-R 20 value, including test length, homogeneity of population and the nature of the information literacy construct.

Cannon (2007) completed two surveys using the B-TILED (Beile-O'Neil, 2005) with graduate students in separate general and special education teacher education programs. The study investigated the information literacy knowledge of students in "graduate-level teacher preparation programs and their readiness to integrate their knowledge of information literacy into their classroom teaching" (Cannon, 2007, p. 85). The researcher used the complete set of 22 B-TILED items covering all five major areas of the ACRL (2000) information literacy standards. A score on the B-TILED of 57%, or 13 of the 22 multiple-choice questions answered correctly, indicated minimum competence in information literacy knowledge (Beile-O'Neil, 2005; Cannon, 2007).

The first research question in the Cannon (2007) study relevant to the present study investigated to what extent do graduate general education and special education students differ in their knowledge of information literacy. Results indicated that graduate special education students (n= 45) (M = 60.36, SD = 16.77) did not differ from general education students (M= 57.19, SD = 14.71) in their knowledge of information literacy. Participants' B-TILED scores indicated that they met the minimum acceptable score with respect to information literacy competence.

The second research question relevant to the present study asked to what extent do graduate teacher education students who have training in the knowledge of information literacy differ in their knowledge of information literacy from those without training? Results indicated that graduate teacher education students who had received training in any setting in the knowledge of information literacy did not score significantly higher in information literacy knowledge (M = 59.52, SD = 15.74) than those without training (M = 55.90, SD = 15.74).

Although the present study does not use the full 22-item B-TILED, the Cannon (2007) study provides guidance as to the interpretation of scale scores. Based on Cannon’s (2007) results, a score on the B-TILED of 57% suggests a general comparative guideline for the minimum competence in information literacy knowledge when this scale is used in other studies. Additionally, the Cannon (2007) study shows that there was no significant difference between intact groups with respect to information literacy skill. While the use of intact groups can be seen as a methodological limitation, the present study also employed two different intact groups of study participants.

The B-TILED study appears to demonstrate that the SAILS development efforts were generally valid and, the SAILS model was effective when enhanced for graduate education students. The results from these studies suggest that information literacy instruction and the skills related to the ACRL information literacy standards can be accurately assessed. These findings support the idea that information literacy instruction, while difficult to implement, can be a valuable part of an academic institutional curricula. The present study will attempt to leverage these findings and extend the use of SAILS and B-TILED through the application of cognitive processing theory and modular worked-out examples within the domain of nursing student information literacy skills instruction.

Working Memory

In this section of the literature review, an overview of schemata and the processes of long-term and working memory are discussed as a precursor to a review of cognitive processing theory. The human brain processes new information and either creates new schemas or modifies existing schemata during learning. Schemata are structures in an individual's mind that represent general forms of knowledge as it relates to objects, situations, and events (Paivio, 1986). In turn, these schemata create a construct, such as information literacy, for the storage and organization of information in long-term memory, and this construct can be recalled into working memory when an individual is faced with tasks related to the construct (Mayer, 2005). The schema concept has been used in the analysis of perceptual recognition, memory and motor skills and in understanding written and spoken communication (Paivio, 1986). The formation and enhancement of an information literacy schema can be seen as the overarching goal of information literacy instruction. The importance of schema use and their limitations are discussed in the following sections on long-term and working memory.

Long-term memory represents the cumulative knowledge an individual possesses and can also be thought of as the comprehensive collection of schemata an individual has available for recall and use when faced with a perceptual, memory, motor skill, or discourse problem or situation. Unlike working memory, which will be discussed shortly, "long-term memory can hold large amounts of knowledge of long periods of time, but for a person to actively think about material in long-term memory, it must be brought into working memory" (Mayer, 2001, p. 45). Where long-term memory is practically unlimited and provides the storage for knowledge or schemata, working memory, where the human brain processes schemata when faced with a learning opportunity, is extremely limited in its ability to be effective when processing new information.

Working memory has a unique role when helping achieve educational goals as well as significant limitations. "Working memory is the center of cognition since all active thinking takes place there" (Clark & Mayer, 2003, p. 36). For learning to be successful, an individual must actively engage in the tasks related to learning and the active processing takes place in working memory. According to Mayer in *Across the Century: The Centennial Volume* (Corono, 2001, p. 42), "knowledge is not a commodity that can be placed neatly in a learner's head, but rather it is the result of a learner's active sense-making," [where sense-making is] "processing new information using schemata in working memory." The integration of new knowledge into long-term memory occurs when a learner actively processes it in working memory using the process of encoding.

The capacity for the brain to encode is limited by its ability to process a limited amount of information in working memory (Moreno & Mayer, 2000).

Before discussing the limited processing capacity of working memory, it is important to first investigate Pavio's dual-channel assumption. Pavio asserts that the working memory is divided into two distinct channels that initially process verbal and auditory information separately from visual and pictorial information. These two separate functions are described as a dual-channel model for information processing. The dual-channel theory, used synonymously with dual-coding theory, suggests that there are "two classes of phenomena handled cognitively by separate subsystems, one specialized for the representation and processing for information about nonverbal objects and events, the other specialized for dealing with language" (Paivio, 1986, p. 53). The mind initially processes these inputs via sensory memory. Cognitive processing theory, as it relates to multimedia, posits that the inputs are a combination of words and pictures, processed via auditory or visual senses in the limited space of working memory and transferred to long-term memory. Figure 7 depicts CTML and the roles of long-term and short-term memory visually.

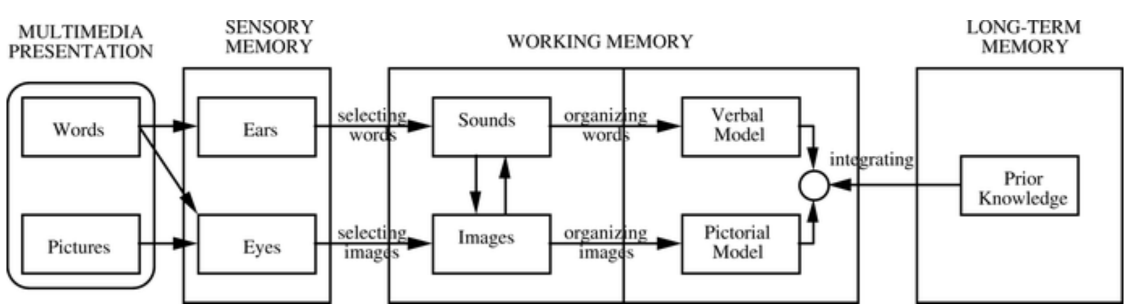

Figure 7. Mayer's (2001) Cognitive Theory of Multimedia Learning (CTML) model depicting the roles of long-term memory and working memory.

The cognitive limits of working memory are specific to the verbal and pictorial channels and are temporal; further, each channel can only process a limited amount of material in a given time. While long-term memory storage has few limits, “the capacity for mentally holding and manipulating words and images in working memory is limited” (Mayer & Moreno, 2003, p. 44). Schemata construction, the roles of long-term and short-term memory and, the dual-channel assumption have important implications for education. Educational instruction designed or implemented without consideration of how long-term and short-term memory operates can reduce the effectiveness of student knowledge building. The following sections will discuss cognitive processing theory as an effective bridge to multimedia instructional design. Cognitive processing theory accounts for the dual-processing schemata construction discussed earlier and can assist the instructional designer in building educational materials that optimize long-term and short-term memory.

Cognitive Processing Theory

Before continuing on to how best to build educational initiatives that optimize knowledge building, it is important to consider the various ways the mind processes new information. The following sections address Mayer’s assumptions about and supporting research on essential processing, generative processing and extraneous load. Understanding essential processing, generative processing and extraneous load, derived from cognitive processing theory, provide tools for researchers and instructional designers to implement effective enhance educational activities.

Cognitive processing theory takes into account how human cognition operates and provides a well-researched model that assists instructional designers in the development of multimedia approaches to effective learning. Cognitive processing theory was originally proposed by Chandler and Sweller (1991). Researchers use the terms 'cognitive load' and 'cognitive processing' interchangeably. This study uses the term cognitive processing wherever possible.

Building upon the research supporting dual channel processing and working memory (Baddeley, 1986, 1992, 2007; Daneman & Carpenter, 1980; Paivio, 1986), cognitive processing theory "suggests that effective instructional material facilitates learning by directing cognitive resources toward activities that are relevant to learning rather than toward preliminaries to learning" (Chandler & Sweller, 1991, p. 293). Meaningful learning, as one of the essential goals of education, is a key problem cognitive processing theory helps to address. Meaningful learning happens when the learner achieves a deep understanding of the educational materials and organizes new knowledge in relevant ways with new or existing schemata (Mayer & Moreno, 2003). In this context, information literacy and multimedia learning focuses first on the limitations of working memory.

The structures of long-term and short-term memory, coupled with the dual channel nature of cognition appear to be an efficient way for researchers to model how the human brain processes new information and creates new schemata or enhances existing knowledge. "Without knowledge of relevant aspects of human cognitive architecture such as the characteristics of and intricate relationships between working memory and long-term memory, the effectiveness of instructional design is likely to be random" (Mayer, 2001, p. 28). Thus, cognitive processing theory is essential in helping instructional designers systematically manage the limited capacity of working memory and assess the educational effectiveness of multimedia instruction.

Working memory assists learners with the cognitive tasks of short-term information storage and processing new information. Working memory is one factor that can help researchers determine the capacity of learners to process and therefore create new knowledge. Learners with more working memory capacity are more efficient and potentially more effective during a learning task.

Citing work by Daneman and Carpenter (1980) on working memory, Baddeley (1992) discusses a reading comprehension interventions using standardized tests which found correlation coefficients of about 0.5 and 0.6 between working memory and reading comprehension. The study included reading span tests, reading comprehension tests and a word span test and examined the theory that working memory capacity influences the "initial encoding of facts and their subsequent retrieval involve working memory and could differentiate good and poor readers" (Daneman & Carpenter, 1980, p. 452). The Daneman and Carpenter (1980) study subjects were undergraduate psychology students ($n = 21$) enrolled in a psychology course at a large academic institution. The span test was correlated with the traditional assessment of comprehension. The researchers used verbal SAT scores as a control, $r(18) = .59$, $p < .01$. Subjects' SATs ranged from 400 to 710 with a mean of 570 ($SD = 79.8$). The reading span test was even more closely related to performance on the two specific tests of comprehension. For the fact-checking questions and the reference questions, the correlations were $r(18) = .72$ and $.90$, $p < .01$ respectively. The reading span for the 20 readers varied from 2 to 5 with a mean of 3.15

(*SD* = .93). Readers with smaller reading and word spans performed substantially less than students with larger spans (Daneman & Carpenter, 1980, p. 455-456). Tests of listening were equally important. Readers with large oral reading spans were better at fact questions and pronoun reference questions, $r(19) = .81$ and .84, $p < .01$, respectively. These correlations are similar to the .72 and .90 found in the prior experiment correlate with oral reading ability. Additionally, readers with large silent reading spans were better at fact questions and pronoun reference questions, $r(19) = .74$ and .86, $p < .01$. Both spans were significantly correlated with verbal SAT scores, $r(19) = .55$, $p < .01$, $r(19) = .49$, $p < .05$. The authors' research demonstrated high correlations between the measures of working memory span and measures of reading comprehension (Daneman & Carpenter, 1980). The capacity for working memory as it relates to learning is an important component of cognitive processing theory and has key role when addressing the optimization of instructional design.

Addressing instructional inefficiencies in educational settings is a primary objective of instructional design. Cognitive processing theory assists educators who chose to address the limitations of long-term and short-term memory. Inefficiently designed instruction results in requiring students to become engaged in cognitive activities far removed from the goals of the instructor (Chandler & Sweller, 1991). Educational tasks that are designed to optimize how the human mind processes and stores information can be more effective than activities that overtax the cognitive limits of learners.

Cognitive processing overload in multimedia learning occurs when one or both of the auditory/verbal or the visual/pictorial channels are taxed beyond the limited capacity of working memory (Mayer & Moreno, 2003; Paivio, 1986). While long-term memory storage of new knowledge is practically unlimited, optimal learning takes place when the dual-channels of working memory are carefully accounted for in the instructional design and teaching of new subjects. The central problems of limited working memory are discussed in the literature as cognitive processing. The three areas when combined together that represent the construct of cognitive processing are essential processing, extraneous processing, and generative processing. The following sections will provide an overview of the essential processing, extraneous processing and generative processing literature.

Extraneous processing occurs when the learner is faced with poorly designed materials or information that is irrelevant to the learning task (Plass, et al., 2010). Extraneous cognitive overload occurs “when essential cognitive load (required to understand the essential material in a multimedia message) and extraneous cognitive load (required to process extraneous material or to overcome confusing layout in a multimedia presentation) exceeded the learner’s cognitive capacity” (Mayer, 2005, p. 184). When cognitive processing overload eclipses the learners’ ability to process essential material, learning is degraded. Extraneous load is determined by the ways in which instructional designers format educational materials for the learner, and each format chosen for the presentation of material will vary in cognitive processing requirements (Carlson, Chandler, & Sweller, 2003).

Generative processing is the cognitive activity that occurs when the learner is constructing new knowledge. The concept of generative processing was first introduced in a slightly different form as germane load (Sweller, et al., 1998b). Recent definitions of generative processing suggest that when the learner is actively making sense of new information, engaged in a process of mentally organizing new information into a coherent knowledge structure, and is integrating the new information with prior knowledge, the learner is engaged in generative processing (Mayer, 2009; Mayer & Moreno, 2007).

Essential processing

Essential processing refers to the cognitive selection of verbal items, such as spoken words and, images or pictures necessary for the learner to make sense of material essential to the construction or augmentation of schemata. Cognitive processing theory suggests that there is limited capacity in working memory to process the essential words of images needed for meaningful learning. Essential processing, also known as intrinsic cognitive processing (Sweller, 1999), addresses the cognitive processing necessary to make sense of the essential material included in educational materials. The term ‘essential material’ suggests that while some of the educational content in an instructional lesson or multimedia package is critical to gaining understanding, instructional design often clutters essential information with content that is not germane to instructional objectives (Mayer, 2005). Cognitive overload, in the context of essential processing, is the excessive amount of mental effort that occurs when learning new material essential to the educational goals of the instructor.

The cognitive processing associated with essential processing stems from the inherent complexity of learning materials. For example, recent studies have investigated chemistry education within the contest of cognitive processing theory and found that for novice learners, chemistry can be an very complex learning challenge (Musallam, 2010). Increases in cognitive processing are associated with increases in the complexity of instruction, and research suggests that the higher the complexity, increases in the adequacy of schema construction and learning transfer can follow (van Merriënboer & Sweller, 2005). The present study will investigate information literacy, a complex learning challenge for learners (Cox & Lindsay, 2008).

Two types of overload can occur when essential processing is not optimized during instructional design or instruction. Mayer's cognitive theory of multimedia learning suggests that the "visual/pictorial and auditory/verbal channels in working memory are extremely limited so that only a few items can be held or manipulated in each channel at any one time" (Mayer, 2001, p. 170). When there is an excess of information in either channel, essential overload occurs, reducing the amount of learning the individual can process and therefore retain. Type 1 essential overload occurs when both the visual and auditory channels in working memory are overtaxed. One method to reduce Type 1 essential overload is referred to as segmenting.

Segmenting is a CTML principle suggesting that when the learner is allowed to pace instruction, rather than receiving it in one block, essential processing is reduced, therefore allowing more meaningful learning to occur. Mayer summarized three related studies where each compared two groups of students; where one group received instruction via a multimedia animation with pictures and narration with the pace controlled by the learner, while a second group received the same multimedia instruction in a single block, with no mechanism for the learner to control the pace of instruction. The median effect size of the application of the segmenting principle for the three studies was 0.98 (Mayer, 2005). Learning was enhanced for the groups that were able to regulate the pace of their learning using multimedia, presented using the segmenting principle.

Of the three studies, the study that used the atmospheric phenomenon of lightning as the multimedia instructional content had a effect size of 1.13 on tests of learning transfer (Mayer & Chandler, 2001). In that study, two related experiments were conducted. The participants were 59 college students from the authors' pool of undergraduate psychology subjects. All participants were determined to lack familiarity with the material to be taught using multimedia, and when divided into test and control groups, had similar mean ages and SAT scores. Cognitive processing was measured using a researcher-developed subjective scale. The use of a subjective self-assessment of cognitive processing was deemed acceptable by the authors based on prior research such as the work by Paas and Van Merriënboer (1994) who state that "the rating-scale technique can be considered a valuable research tool for estimation of cognitive load in instructional research" (p. 131). Cognitive processing self-assessments are operationally simple to implement, have minimal intrusion on the instructional session, and have been used successfully in prior research (Mayer & Chandler, 2001; Paas & Van Merriënboer, 1994). The present study will also employ a subjective cognitive processing assessment scale, as the literature suggests additional research is needed in the area of cognitive processing self-assessments.

In addition to the cognitive processing self-assessment, students participating in the study completed a demographic survey that gathered participant age, gender, SAT scores, and familiarity with subject matter data. Meteorology and knowledge of weather was the content of the multimedia experiment. After completing the test or control experiment, students completed knowledge transfer and retention tests. The materials given to the control and experiment groups were virtually identical. The differences between the control and experiment groups were in the method of multimedia instruction. The control group was instructed using a whole-whole presentation, where the learners received the entire multimedia instructional package in a complete unit, then received the same whole-whole instruction a second time. The experimental group received a part-whole multimedia instructional package. This segmented methodology was designed to test the cognitive processing principle of segmentation that hypothesizes that learner paced instruction makes more effective use of the limited capacity of working memory.

Results from the study reveal that the part-whole group who received multimedia instruction consistent with the segmentation principle performed significantly better than the whole-whole group, $t(28) = 2.877$, $p < .01$. The researcher notes that there was a pattern to these results consistent with cognitive processing theory insofar as the whole-part method placed less load on working memory (Mayer & Chandler, 2001). Therefore, in this study learners who received the whole-part multimedia instruction experienced less cognitive processing than the whole-whole group and were “better able to mentally organize the presented material into a cause-and-effect chain and to mentally relate the material with relevant prior knowledge” (Mayer & Chandler, 2001, p. 395). The segmenting principle of cognitive processing theory suggests to instructional designers that learners can achieve more meaningful learning when this principle is adhered to rather than when it is ignored.

Long-term transfer is a primary goal of instruction. An area of concern when reviewing the whole-whole, whole-part study is that only short-term effects were measured. Considering the content of the present study, information literacy can be viewed as a set of skills that ideally should serve learners’ beyond their time in a formal educational setting. While it is understood that long-term transfer is a difficult and costly attribute to measure, the lack of information regarding the long-term efficacy of the Mayer and Chandler (2001) study is noted as a limitation.

As previously mentioned, there are two types of cognitive processing overload that can occur when essential processing is not optimized during instructional design or instruction. Type 1 cognitive overload occurs in the visual/pictorial and auditory/verbal channels when the limited capacity of working memory is overtaxed, reducing the amount of learning the individual can process and therefore retain. Type 2 essential processing overload is limited to the visual channel and "this overload can occur when a lesson with animation and concurrent onscreen text (or text with static diagrams and printed text) is presented at a fast pace" (Mayer, 2005, p. 170). The CTML modality principle is one approach to reducing Type 2 cognitive overload. This principle suggests that instructional designers can off-load essential processing from the visual channel to the auditory channel by converting text on a screen to narration (Mayer, 2005). The modality principle, as a method to reduce extraneous cognitive processing, has been studied extensively and the research to date appears to provide strong evidence in support of the instructional design principle.

Mayer (2005) summarized nine studies of the modality principle, each addressing Type 2 cognitive processing overload. These nine studies consisted of 21 experiments and significantly different groups were used including high-school students, working adults and college students.. The median effect size across all of the experiments was 0.97 and the range of Cohen's effect sizes was from 0.33 to 1.58. Across these nine studies of particular interested was learning transfer as a dependent variable. The content of the experiments included mathematics problems, meteorology, brake system operation, electrical engineering problems, aircraft and electric motor operations and an environmental science game. The research methodology across the 21 experiments was similar. Transfer tests were used to assess student performance, comparing students who received instruction using graphics and printed text to student who received instruction via graphics and narration. For the purposes of the current study, the first study chosen for review was selected in part because population studied the multimedia content included audio of human speech which is content similar to the current study design that will use an audiobook learning package, an enhanced multimedia podcasting technique.

Type 2 essential overload can be addressed by the modality principle. This principle affords instructional designers techniques to off-load essential processing from the visual channel to the auditory channel and can address cognitive overload caused by split-attention. Ayers and Sweller define split-attention as occurring when “learners are required to split their attention between and mentally integrate several sources of physically or temporally disparate information, where each source of information is essential for understanding the material” (In Mayer, 2005, p. 146). In an early study of Type 2 essential overload, Tindall-Ford, Chandler and Sweller (1997) designed three experiments using multimedia that incorporated audio text and visual diagrams.

When considering essential processing, one of the factors that influences cognitive processing is element interactivity. Citing earlier research (Chandler & Sweller, 1996; Sweller, 1994), Tindall-Ford, et al. note that the factors that influence intrinsic cognitive processing can also include the degree of interaction between learning elements (1997). Element interactivity describes the effect of new ideas which when they interact

act in such a way to generate extraneous cognitive processing and therefore impede effective learning. This interaction is an important factor for instructional designers as they can lead to essential processing overload. Tindall-Ford (1997) conducted a number of experiments that lend support to the importance of managing element interactivity. The present study uses the term complexity to describe element interactivity.

Each of the Tindall-Ford et al. (1997) experiments were conducted at an industrial training facility in Australia. The first Tindall-Ford, et al. experiment involved instruction using engineering materials that were high in element interactivity. The training materials included instructions in the testing of electrical appliances using a voltmeter. The participants were 30 electrician apprentices who were all in their first year of training and had completed at least 10 years of Australian high school. Participants were split into groups and randomly assigned to one of the three groups. Group one received visual-only instruction to test the hypothesis that visual-only learning requires more cognitive processing, consistent with the split-attention principle of multimedia learning. The split-attention principle reflects research suggesting that high element interactivity increases cognitive processing and can degrade an instructional designer's desired learning outcomes. The second group received instruction in an audio-visual format of instruction. The audio-visual group received instructions in a format that required them to integrate both text and diagrams within the limitations of their working memory. This group provided a control to test for the limited nature of working memory.

The third group of learners received an integrated format of instruction. The researchers' hypothesis for integrated format of instruction was that it would "reduce the extensive search and match process and therefore make available relatively more working memory capacity" (Tindall-Ford, et al., 1997, p. 261) in the second group. "Search" and "match" describes the situation when "sources of information that require mental integration for understanding are separated in time or space [and] cross-referencing may substantially increase the burden on working memory" (Kalyuga, 2009b, p. 67), thereby potentially reducing the desired learning outcomes.

Phase one of the experiment involved each group receiving instructions in either a visual-only, audio-visual or integrated format. The duration of instruction for phase one was five minutes for each group. The testing phase directly followed, and each participant was tested individually; there was no time limit for the test. One month after the initial phases, participants were retrained and retested. The duration of the study time was increased from 5 minutes to 10 minutes.

Results from the experiments indicated that there was no significant main effect between the three groups, $F(2,27) = 1.03$, $MSE = 1.20$. Researchers used $p < .05$ for all results. The interaction between the groups and test periods was not significant, $F(2,27) = 0.40$, $MSE = 0.66$, and test scores improved between the first and second phases, $F(1,27) = 40.45$, $MSE = 0.66$. The researchers performed a 3 (group) X 3 (phase) ANOVA for section 2, $F(2,27) = 1.91$, $MSE = 7.77$, that demonstrated no significant differences in test scores between the three groups. The researchers noted that while the results were not statistically significant, the direction of the results favored the integrated and audio-visual groups.

Transfer tests were completed for each group. The researchers performed a 3 X 2 ANOVA and reported a significant difference between groups, $F(2,27) = 3.76$, $MSE = 0.59$, which indicated that the audio-visual group had significantly higher scores than the visual-only group. Additionally, there was a significant difference between the first and second phase, $F(1,27) = 9.37$, $MSE = 0.46$ and the interaction between the two groups was not significant, $F(2,27) = 1.57$, $MSE = 0.46$ which the researches deemed demonstrated a similar pattern between the two testing periods. Finally, transfer test results indicated that there was a significant main effect due to the groups, $F(2,27) = 13.90$, $MSE = 0.66$. The audio-visual and integrated instruction format groups performed significantly better than the visual-only group and there was no significant difference between the audio-visual and integrated groups.

The research experiment results discussed above suggest that there are distinct benefits to the presentation of instruction in either an integrated or audio-visual format (Tindall-Ford, et al., 1997) and strongly suggest that integrated and audio-visual methods of instruction lead to reduced cognitive processing and higher transfer test results. Audio-visual formats were more effective than traditional visual-only formats for delivering instruction, lending support to the cognitive processing theory of essential processing (Tindall-Ford, et al., 1997). Specifically, these tests addressed the issues of split attention, modality and element interactivity demonstrating the advantages of applying cognitive processing theory to instructional design in the instruction of electrical principles. Limitations to the study included the small sizes of the test participant group. For the purposes of the present literature review, the fact that the experiments did not involve students enrolled at a college or university was an additional limitation.

It is important to note that the effects of essential processing extraneous processing and generative processing are additive (Plass, et al., 2010; van Merriënboer & Sweller, 2005). Additionally, the capacity of working memory is limited. For the instructional designer, the additive effects of cognitive processing and the limited capacity of working memory suggest that when any of the three sources of cognitive processing, either independently or when combined, exceeds available working memory, the learner's capacity to create or modify schemas can be degraded. Therefore, one goal of managing the additive effects of cognitive processing is to optimize instruction so that the limited capacity of working memory is available for generative processing. The present study seeks to address this need by investigating the management of the essential processing associated with instruction designed to instruct students in the area of information literacy.

Cognitive Processing Measurement

Regardless of the type of cognitive processing to be measured (essential processing, extraneous processing, generative processing or, all three types combined), there are two dimensions for categorizing assessment methods. The first dimension addresses the subjective relationships of cognitive processing to the phenomenon being measured and the second addresses objective relationships of cognitive processing to the phenomenon being measured. This section will outline the two dimensions of cognitive processing assessment discussed in the literature. Figure 8 provides a visual representation of subjective and objective cognitive processing assessment techniques.

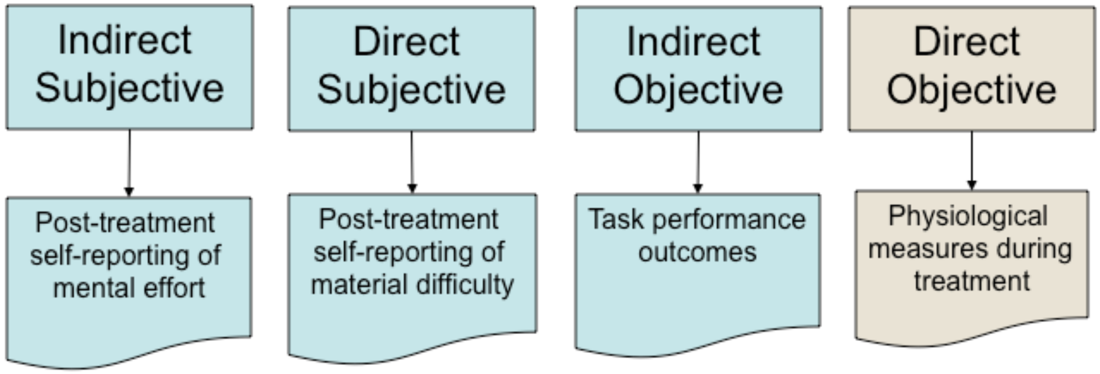

Figure 8. Subjective and objective cognitive processing assessment techniques.

One dimension of cognitive processing assessment is *objectivity (subjective or objective)* and “describes whether the method uses subjective, self-report data or objective observations of behavior, physiological conditions, or [task] performance” (Brunken, Plass, & Leutner, 2003, p. 55). The second dimension of cognitive processing measurement, *causal relationships* (either indirect or direct) classifies assessment “methods based on the type of relation of the phenomenon observed by the measure and the actual attribute of interest” (Brunken, et al., 2003, p. 55).

Measures of cognitive processing are typically differentiated as either direct or indirect assessment techniques (Brunken, et al., 2003). Indirect subjective measures are either multidimensional in that they gather data on multiple correlated variables such as mental effort and learner fatigue (Brunken, et al., 2003; Paas, Tuovinen, Tabbers, & Van Gerven, 2003) or unidirectional scales (Paas & Van Merriënboer, 1994). Direct subjective measures of cognitive processing illicit feedback from students as to their perceived level of difficulty with learning material (Kalyuga, Chandler, Tuovinen, & Sweller, 2001; Sweller, 1999). Indirect subjective measures typically involve ratings of mental effort as an assessment of the learners perceived difficulty with learning materials.

An example of a unidirectional subjective measure can be seen in the research of Paas & Van Merriënboer (1994) who used a 9-point rating scale to assess the participants' perceived difficulty (cognitive processing) with an instructional intervention on machinery programming using geometry.

Pupillary response and heart rate variability are two direct objective measures of cognitive processing discussed in the literature. Although these and other physiological measures of cognitive processing appear promising (Brunken, et al., 2003), a summary of 27 studies showed that only two used physiological objective measures (Paas, Renkl, & Sweller, 2003; Paas & Van Merriënboer, 1994). One possible reason few studies have used physiological measures stems from findings that they provide less than compelling indirect causal links to transfer performance and are difficult to distinguish from other similar patterns of behavior (Brunken, et al., 2003). The most frequently employed objective method of measuring cognitive processing are performance outcome measures (Mayer, 2001). As this study uses *indirect subjective measures* of cognitive processing, the discussion now turns to this category of assessment.

Indirect Subjective Cognitive Processing Assessment

Indirect subjective assessments of cognitive processing generally include posttreatment questionnaires wherein participants are asked to report via a rating scale their mental effort during an intervention (Brunken, et al., 2003). The use of rating scales as a measure of cognitive processing originated with the work of Paas and Van Merriënboer (1994) and was based on earlier research by Borg, Bratfisch and Dorni'c (1971). The advantages of subjective measures appear to be numerous. From a practical point of view, subjective measures "do not interfere with primary task performance; are inexpensive and can detect small variations in workload (i.e. sensitivity)" (Paas, Tuovinen, et al., 2003, p. 68). Additionally, subjective measures appear to have acceptable convergent, construct and discriminate validity (Paas, Tuovinen, et al., 2003). The advantages of scale-based methods for assessing self-reported levels of cognitive processing contained multiple facets. By example, the combination of physiological objective measures such as self-reported stress levels with self-reported questions about perceived levels of success with a learning problem creates a fairly robust method to assess cognitive processing (Paas, Renkl, et al., 2003; Paas & Van Merriënboer, 1994). Pass and Van Merriënboer (1994) extended this line of research by investigating the use of a one-dimensional scale (removing the physiological measures) for assessing cognitive processing, wherein they suggest that a single question asking participants to rate their level of mental effort on a scale of 1 (very low mental effort) to 9 (very high mental effort) was easily and reliably accomplished by learners. The present study uses two 9-point scale questions (DeLeeuw & Mayer, 2008; Musallam, 2010; Swaak & de Jong, 2001) for the assessment of generative processing (indirect subjective measures) and modifiying the 5-point scale question (Knaus, et al., 2009; Musallam, 2010) to a 9-point scale for the assessment of essential processing (direct subjective measure).

One example of a study that included measures of cognitive processing investigated learning differences between molar and modular worked-out examples in the instructional domain of probability calculation during complex events (Gerjets, et al., 2006). Referred to in the study as Experiment 2 (Gerjets, et al., 2006), the researchers hypothesized that cognitive processing would be lower for participants exposed to modular worked-out examples when compared to molar worked-out examples. The dependent measures were learning time, frequency of example retrieval, cognitive processing (direct subjective measures), problem-solving time and problem solving performance (indirect objective measures of cognitive processing). Cognitive processing data were captured by the use of a modified version of the National Aeronautics and Space Administration Task Load Index (NASA-TLX) task load index (Gerjets, et al., 2006; Hart & Staveland, 1988). The modified version of the NASA-TLX assessed cognitive processing via subjective and objective survey questions about learner task demand, effort and feelings of success. With respect to three self-reported measures of cognitive processing, modular examples were favorable to molar examples (task demands: $F(1, 77) = 5.91$, MSE = 437.97, $p = .02$, $f = .28$; effort: $F(1, 77) = 5.55$, MSE = 371.88, $p = .02$, $f = .27$; feeling of success: $F(1, 77) = 5.56$, MSE = 392.91, $p = .02$, $f = .27$). From this limited body of research, it would appear that the direct and indirect measures of cognitive processing used in this study have the potential to provide sufficiently accurate and reliable methods of assessing essential processing, generative processing and extraneous processing.

The cognitive processing assessment literature suggests that assessments can be divided into direct and indirect measures. Furthermore, indirect and direct measures can be further divided into subjective and objective categories. Indirect subjective measurement is most frequently employed method for assessing cognitive processing. Indirect subjective measures such as mental effort are generally combined with task performance measures such as transfer performance, comprehension and measures of time-on-task (Brunken, et al., 2003; Musallam, 2010). Prior studies that have combined subjective measures with task performance measures have shown promising results assessing cognitive processing (Gerjets, et al., 2006) and suggested that measures of mental effort can be reliable (Brunken, et al., 2003; Musallam, 2010). However, there does not appear to be a single study that investigated information literacy from the research perspective of assessing cognitive processing through the use of subjective measures. The present study is designed to provide insight into this promising research area.

Cognitive Processing Management Instructional Techniques

There is a logical progression of instructional techniques researchers have used to manage cognitive processing. This proposed method of using modular worked-out examples in this study will benefit from an overview of the cognitive processing management instructional technique literature. This section will open with a discussion of segmenting and then continue with a review of the pre-training, part/whole and worked-example literature. This section will close with an overview of the modular worked-out example literature.

Segmenting

Segmenting instruction occurs when the instructional designer manages essential processing by breaking a “complex multimedia message into smaller parts that are presented sequentially with pacing under the learner’s control” (Mayer, 2009, p. 176). A 2003 study using interactive multimedia, found evidence in two experiments for the segmenting principle (Mayer, et al., 2003). Both experiments involved the use of a computer-based pedagogical agent to train college-age students in the operation of an electronic motor and a similar paper-based training module covering the same content as the multimedia pedagogical agent. Experiment 2a participants were 37 college students, with 18 in the interactive group and 19 who received the paper-based training. Results from the 2a experiment showed an effect size of 0.70. Experiment 2b participants were 41 college students (different sample than experiment 2a) with 22 receiving interactive training and 19 receiving paper-based training. Experiment 2b results revealed an effect size of 1.03. Mayer discusses the same experiments in a separate article and reports the effect sizes as 0.82 for 2a and .098 for 2b (Mayer, 2009, p. 180). It is unknown why these data were reported differently. Regardless of the apparently different results, Mayer (2009) notes that segmenting is similar to worked examples, an essential processing management instructional method that will be discussed shortly.

Pre-training

Pre-training involves providing direction to learners before they receive instruction related to the intended learning outcomes often measured in terms of transfer. In a 2002 study (Stark, et al.), researchers used an example elaboration instructional technique as a pre-training method to manage generative processing. The Stark et al. (2002) study was a partial replication of an earlier study (Renkl, 1997) that focused on the effectiveness of worked-out examples as an instructional intervention. One hypothesis of the Stark et al. (2002) study was that students given pre-training instruction using an example elaboration technique would demonstrate increased transfer when compared to students who receive an alternative pre-training technique. The researchers argue that pre-trained students generate deeper learning and effective cognitive processing and additionally that the increased generative processing induced by example elaboration leads to increased transfer performance (Stark, et al., 2002).

Stark et al. (2002) identify three characteristics influencing the effects of example elaboration. The first characteristic is prior knowledge, which has been extensively researched as an important component of cognitive processing theory and the cognitive theory of multimedia learning (Mayer, 2005; Stark, et al., 2002). The second component of the study was domain-specific interest on the part of study participants. The researchers note that this motivational, behavior based factor may not have been sufficiently studied within the example-based research. Third, the researchers suggest that a low tolerance for ambiguity on the part of the learner can influence the effectiveness of example-based interventions. The researchers suggest that low-tolerance for ambiguity leads to superficial learning, whereas learners with a higher tolerance are more likely to engage in deep learning. From these components, the researchers suggest four profiles associated with example elaboration (see Figure 9).

Learner Profile	**Above average learning outcomes**	**Below average learning outcomes**
	Learners independently generate solutions before they took notice of the solutions provided by the examples presented	Low elaboration activity; the learners stayed rather passive, only meta-cognitive elaborations were generated
	Deep cognitive elaboration; the explication of goals and operators and of domain-specific principles dominated	Little meta-cognitive work by the learner; uncritical and superficial elaboration behavior

Figure 9. Learner elaboration profiles and their influence on learning outcomes (Renkl, 1997; Stark, et al., 2002).

In addition, the researchers used the construct of ‘mental effort’ to represent cognitive processing. These profiles, coupled with the three characteristics that influence the effects of example elaboration and mental effort, constitute the basis of the Stark et al. (2002) study.

The participants in the Stark et al. study were 54 bank apprentices (demographic data were not provided). The elaboration training was provided to half of the participants and the other half received instruction on how to use a think-aloud process when studying. Elaboration training consisted of a 20-minute session wherein a trainer modeled cognitive elaboration techniques using a worked-out example and engaged in a question-and-answer session. The only instruction given to the think aloud group was that while studying the examples, they should verbalize everything they thought (Stark, et al., 2002). Results from the study indicated that students with a high tolerance for ambiguity critically analyzed their level of knowledge and self-diagnosed discrepancies between their actual knowledge and the knowledge necessary for understanding the example (Stark, et al., 2002).

Part/Whole Task

Whole-task and part-task approaches to managing generative processing in working memory are predicated on research which suggests that instruction should be differentiated based upon the level of element interactivity (van Merriënboer, Kester, & Paas, 2006). Generally, researchers divide element interactivity into high and low. The current study argues that information literacy instruction is high in element interactivity and therefore complex.

Part-task instruction research suggests that this method can be most effective with instruction involving materials with lower levels of complexity (van Merriënboer, et al., 2006). By example, learning to drive a car as a complex task, "where the parts of a task are strongly interrelated which makes it very difficult to define meanigful parts to train" (Salden, Paas, & Van Merriënboer, 2006b, p. 351). However, researches note that "part-task methods are unable to cope with task organization when parts interact highly with eachother" (Salden, et al., 2006a, p. 324). Given the complexity of information literacy (Cox & Lindsay, 2008), the part-task method of instruction will not be discussed further, however, part-task methods provide the theoretical basis for whole-task approaches, which will be covered in the next section of this review of the literature.

The research literature divides whole-task approaches into two categories. The first category is considered static, in that the whole-task training is "characterized by the fact that every learning task includes the skills that the learner should have acquired and be able to apply after the training" (Salden, et al., 2006a, p. 325). The second category of whole-task approaches are considered dynamic, in that they are computer based and "adjustments can be made in the order and complexity of the learning tasks [wherein] the program can respond to the learner's problems during the training, with decisions being made that are typically based on the performance of the trainee" (Salden, et al., 2006a, p. 328). One characteristic that differentiates these two approaches is that static whole-task training is considered advantageous in group training environments and dynamic whole-task training is better suited for individualized training (Salden, et al., 2006a). While the literature on static whole-task does not appear to specifically address the management of generative processing, and is therefore omitted from this study, there is limited research on the use of a dynamic whole-task approach in the management of generative processing.

Salden, Paas and Van Merriënboer (2006b) developed personalized adaptive task selection training (dynamic whole-task) as a way to investigate possible differences between part-task and whole-task methods for managing generative processing. Their hypothesis was that group-based, non-adaptive whole-task methods cannot adequately compensate for learner ability or task complexity. To test their hypotheses, the researchers developed a computer based air traffic control system for novice students (*n*=60, *M*=20.3 years, *SD* = 2.35). Four experimental conditions were developed and students were randomly assigned to one of the four conditions. The two independent measures were performance (number of correct responses to instrument questions) and mental effort (subjective scale to determine cognitive processing). The first test condition was the condition, where the students' performance and mental effort were combined. The second condition was termed yoked efficiency, where students in this group were assigned the same questions in the same order as the personalized efficiency condition. The third group, personalized preference, were asked at the beginning of the training sequence to select a level of training complexity, and based on that choice, received random questions determined by the researchers to be associated with the chosen level of complexity. The fourth group, yoked preference, used the same task assignment principle as the personalized preference condition. Participants in the fourth group selected a level of complexity, but rather than a random presentation of questions, the questions were presented in a fixed sequence. The researchers hypotheses were that; 1) non-adaptive task selection, as seen in the design of the yoked conditions, (static-whole part) would lead to less efficient transfer task performance than the two adaptive, personalized task selection (dynamic whole-part) conditions; and, 2) that adaptive task selection based on personalized efficiency would perform better on transfer tasks than personalized preference.

The study was divided into two phases, the first being a training phase, and the second was a transfer test phase (Salden, et al., 2006b). During both phases, students were assessed on the following dependent variables: number of learning tasks that was completed before reaching the highest complexity level, total number of learning tasks, training time, mean complexity level that was reached during training, and absolute jump size between complexity levels. Two subjective measures, performance and mental effort were used. Results from the *training phase* revealed a significant effect for method of task selection, $F(3, 56 = 3.04$, $MSE = 2.07$, $p > 0.05$, $n2 = 0.14)$, and that the personalized efficiency condition reached a higher mean complexity level t $(56 = 2.19$, $p < 0.05)$ than the personalized preference condition. The first hypothesis was confirmed. However, planned comparisons revealed the opposite effect of what was expected in the second hypothesis. Results from the *transfer test* phase revealed a significant effect for the factor method of task selection, $F(3, 56) = 8.18$, $MSE = 28.18$, $p < 0.0001$, $n\ 2 = 0.31$. The personalized preference condition attained more conflict identifications the personalized efficiency condition. Data from the training efficiency measures revealed a significant effect for method of task selection, $F(3, 56) = 4.45$, $MSE = 0.89$, $p < 0.01$, $n2 = 0.19$. With regard to the first hypothesis, no difference ($t < 1$) was found between the personalized conditions and the yoked conditions. In contrast with the second hypothesis, planned comparisons showed that the personalized efficiency condition was less efficient than the personalized preference condition.

Summarizing the results from the aforementioned study, the researchers conclude that "personalized adaptive task selection leads to more efficient training and better transfer performance than non-adaptive task selection was partially confirmed", however “no support was found for the second hypothesis that task selection based on personalized efficiency would lead to more efficient training and higher transfer than selection based on personalized preference (Salden, et al., 2006b, p. 359-360). The findings suggest that personalized adaptive task selection (whole-task) appears promising with respect to increasing the effectiveness of multimedia instruction through the effective use of learner’s generative processing ability. However, there are significant practical concerns. For example, in relation to the current author’s study, the potential costs related to the development of a computer-based multimedia application are prohibitive.

Conventional examples

Researchers note that learning by example has been major theme in the educational literature for nearly four decades (Atkinson, et al., 2000). This early research into example-based learning was typified in part by the presentation of problems using a step-by-step approach and was often formulaic. This formulaic approach can be seen in Figure 6 wherein the mathematics formula for calculating probability was introduced very early in the conventional example exercise and could be seen as a dominant component of the example. While this early conventional example research was directed at helping students develop schemas through practice, this formulaic approach was not particularly effective, as it focused on the surface features of the problem without necessarily helping students to efficiently develop the schemas necessary for solving novel problems (Atkinson, et al., 2000). These drawbacks to conventional examples led to the development of a new body of literature that focused on more complex method of example based instruction, specifically worked-out examples (Atkinson, et al., 2000).

Worked-out Examples

Developing expertise in knowledge-rich domains require information stores in long-term memory known of as schemas. Schemata afford a learner the ability to efficiently process learning problems with high element interactivity (Gerjets, et al., 2004). When a learner lacks sufficient problem solving schemas, a potential effective way to build them is though the use of instructional examples (Atkinson, et al., 2000; Gerjets, et al., 2004, 2006). The literature suggests that conventional examples (Atkinson, et al., 2000), molar worked-out examples (Atkinson, et al., 2000; Gerjets, et al., 2004) and modular worked-out examples (Gerjets, et al., 2004; Sheiter, et al., 2009) can assist learners in developing more efficient schemas.

Worked-out examples in mathematics and the sciences generally include a formula describing the learning problem, the steps a learner should take to solve the problem, and an optimal solution (Mayer, 2005). Worked-out examples are typically effective when developing learner's problem solving schemas during initial cognitive skill acquisition and research suggests that students who have studied worked-out examples (problems with step-by-step solutions) can be more efficient at building new schemas (Atkinson, et al., 2000; Gerjets, et al., 2004; Sweller, et al., 1998b). Comparing worked-out examples to conventional example problem-solving instructional methodologies, Van Gerven, Pass and Tabbers (2006) note that worked-out examples have repeatedly shown better results with respect to schema development than conventional examples. Relating these findings to cognitive processing theory, researchers note that "conventional problems [examples] elicit both forward (i.e., from main goal to sub-goals) and backward processing, (i.e., form main goal to sub-goals), whereas worked examples only evoke forward processing [and that] backward processing…is associated with extraneous cognitive load" (Van Gerven, Paas, & Tabbers, 2006, p. 146). Additionally, the research suggests that worked-out examples have an instructional advantage over conventional examples in that worked-out examples with "less specified or unspecified goals reduce[d] the load on working memory and led to a more extensive exploration of the problem space which, in turn, leads to improved learning" (Van Gerven, Paas, & Tabbers, 2006, p. 146). Discussed in the cognitive theory of multimedia learning literature as the goal-free effect (Paas, Camp, & Rikers, 2001), research suggests that worked-out examples, while not necessarily following rigid instructional goals of conventional example problems can, nevertheless meet instructional designers' intended learning outcomes.

A study by Van Gerven et al. (2002) compared worked-out examples and conventional example problems. Working with a group of 30 psychology students (18 females, 12 males, median age 19.50 years) and 24 elderly participants (12 females, 12 males, median age 66.00 years), the researchers tested mixed instructional formats (conventional examples and worked-out examples) between age groups, with transfer distance as dependent measure. All subjects were pretested using a standardized intelligence test and a computation-span test. A subjective cognitive processing assessment scale was used during the study. The task domain was a water-jug problem (mathematical problem solving test) where the subjects performed water measurement problems by simulating the allocation of water into different size containers. Prior studies suggested that this type of complex mathematical problem produces substantial burdens on working memory and resulted in reduced learning transfer (Luchins & Luchins, 1991). Summarizing the results from the study, the researchers concluded that worked examples were a more efficient method of instruction than conventional problems for the elderly subjects (Van Gerven, et al., 2002). One limitation of the Van Gerven et al. (2002) study is that the research was primarily focused on the management of generative processing. A key research area for this study is the management of essential processing.

Van Merriënboer, Kester, & Paas (2006) used worked-out examples, water-jug problems (mathematics), and groups of older and younger students in an experiment similar to the Van Gerven et al. (2002) study. Van Merriënboer, Kester, & Paas (2006) added variation to earlier research (Van Gerven, et al., 2002) by changing the modality of the instruction. The two training modalities were low-variability worked-out examples (blocked format of training examples) and high-variability worked-out examples (random format of training examples). Training problems used in the study were presented in either random order or by clustering the questions into blocks of problems in categories, thereby creating the different experimental conditions. The study (van Merriënboer, et al., 2006) had five problem categories each related to solving water-jug problems (summation, subtraction, combinations of summation and subtraction, and categories of combined summation and subtraction). The cluster method grouped similar questions into categories, and the random format consisted of random groupings of questions. The researchers' hypothesis was that high training variability would lead to greater optimization of generative processing within working memory. Prior research suggested that high training variability leads to contextual interference which prevents learners from engaging in superficial processing, thereby increasing capacity for generative processing (Van Gerven, Paas, Van Merriënboer, et al., 2006).

Based on the results from the study, Van Gerven et al. concluded that there was a "tendency for both young and elderly adults to perform better in the random than the blocked condition" (2006, p. 318). Higher variability of training problems using a random format had a positive effect on transfer for the population studied than blocked training problems. However, this study was focused primarily on generative processing, which limits its applicability to the present study. A benefit of these two worked-out example studies (Van Gerven, et al., 2002; Van Gerven, Paas, Van Merriënboer, et al., 2006) is that they provide support for looking more closely at alternative methods for managing cognitive processing through the use of worked-out examples. The present study now turns to a discussion of molar and modular worked-out examples, as these approaches appear to have particular applicability in the instructional domain of information literacy instruction.

Molar Worked-out Examples

One way to conceptualize modular worked-out examples is by comparing them with molar worked-out examples. Molar worked-out examples require the learner to keep multiple steps in working memory when learning to solve a problem, thereby potentially overtaxing working memory. The cognitive demands of molar worked-out examples have been shown to be especially taxing with novice learners (Gerjets, et al., 2004). With molar worked-out examples the learner is essentially attempting to solve the entire problem at once. With complex problems the learner is being asked to keep a large amount of information in working memory, thus making the molar method of problem solving potentially difficult. Modular worked-out examples break up a complex problems into discrete, smaller problems gathered together at the end of the problem solving exercise. Thus, the learner is not necessarily required to process a possibly excessive amount of information in working memory.

Molar worked-out examples are often found in the well-structured domains of science and mathematics. Molar worked-out examples typically present learning problems procedures as ‘recipes’ and demonstrate to the student how to categorize problems by considering multiple structural features of the problem (Rikers, et al., 2004). Multiple researchers (Atkinson, Catrambone, & Merrill, 2003; Mayer, 1981; Reed, 1999) have extensively evaluated the use of molar worked-out examples with instruction in the domain of mathematics (e.g. algebra and statistical probability). These studies concluded that molar worked-out examples often share traits in their construction such as the grouping of question, similar categories and templates often typified by formulas that represent the solution procedure (Gerjets, et al., 2004; Sheiter, et al., 2009). In studies comparing molar and modular worked-out examples, finding suggests that students perform better (e.g. transfer performance) when instructed using modular worked-out examples (Gerjets, et al., 2004, 2006; Sheiter, et al., 2009). The following section of this review of the literature provides background for worked-out examples.

Modular Worked-out Examples

Whereas molar approaches to problem solving challenge the learner to engage with problems as one complete unit, modular worked-out examples break down complex problems into a logical progression of more easily solved sub-problems. Modular worked-out examples differ from molar examples in the following ways. First, modular worked-out examples break down complex problems into smaller solution problems. This method of instructional design appears to reduce cognitive processing when compared to molar worked-out examples, by requiring learners to keep fewer problem solution elements in working memory (Sheiter, et al., 2009). Second, modular worked-out example elements are conveyed to the learner separately, often in a logical sequence. Third, molar and modular worked-out examples appear to manage different types of cognitive processing. Whereas molar worked-out examples are intended to either increase generative processing or decrease extraneous processing, modular worked-out examples focus on the management of essential processing (Gerjets, et al., 2004).

Whereas the use of worked examples is one of the earliest and best known techniques for effectively managing cognitive processing (Paas, Renkl, et al., 2003), early research often assumed that essential processing could not be manipulated using instructional design (Gerjets, et al., 2004). Modular worked-out examples were selected for the present study as the literature suggests that this instructional design strategy might have advantages with respect to the management of essential processing. Furthermore, the literature suggests that within the domain of complex ill-defined problems such as information literacy skills instruction, worked examples are an area that might benefit from this instructional technique (Rourke & Sweller, 2009).

The experimental evidence supporting the advantages of modular worked-out examples was summarized by Gerjets, Scheiter and Catrambone (2004), who evaluated the results from two experiments comparing modular and molar worked-out examples. Experiment 1 (Catrambone, 1994) involved 66 students faced with learning problems in the domain of mathematical probability. When faced with either a molar or a modular worked-out example, the students exposed to modular-examples outperformed the molar-example group on transfer performance (Gerjets, et al., 2004). Experiment 2 (Catrambone, 1994) was a variation on Experiment 1 (Catrambone, 1994) wherein the researcher introduced differentiations between worked-out example formats, i.e. changes in worked-out example wording and limiting the examples to one instructional problem category. The results from Experiment 2 were similar to Experiment 1, demonstrating that modular worked-out examples had a statistically significantly positive effect on transfer performance. An important limitation shared between Experiments 1 and 2 was that there was no assessment of cognitive processing.

Whereas there are no known studies using multimedia audiobooks, modular worked-out examples and information literacy instruction, recent studies using hypermedia provide a multimedia-based instructional parallel to the present study. The management of essential processing using both molar and modular worked-out examples was investigated using a hypermedia instructional format by Scheiter et al. (2009). The primary research question asked by Scheiter et. al (2009) centered on learners preference for control of the learning activity when engaged in a statistical probability learning exercise. Summarizing the findings by Scheiter et al. (2009), learners in certain situations not only prefer modular worked-out examples over molar worked-out examples, they generally prefer a level of control over the learning module.

Scheiter et al. (2009) investigated the interaction of essential processing and modular worked-out examples in a study with 79 university students (34 male, 45 female). The learning domain for the study was probability theory wherein students could select the format of instruction (e.g. modular or molar) and the instructional content in both formats was delivered using a computer-based hypermedia application. Participants were assessed on the following measures; 1) domain-specific prior knowledge, 2) use of cognitive and metacognitive strategies, 3) epistemological beliefs, 4) attitudes toward mathematics, 5) preferences for amount of instruction, 6) metacognitive activity, and 7) example utilization strategies. A cognitive processing assessment and a problem solving performance test were administered at the end of the instructional intervention. These assessments were used to create 5 groups (clusters) of students for statistical analysis. The first research hypotheses of importance to the current study was that learners with a more favorable pattern of learner characteristics (i.e., a higher level of prior knowledge, better self-regulatory skills, a preference for receiving large amounts of instruction, and more complex epistemological beliefs) would show more effective example utilization strategies (i.e., select modular worked-out examples more frequently than molar worked-out examples). The second hypothesis investigated the extent to which students receiving modular worked-out example instruction would experience less cognitive processing overload than those receiving molar worked-out examples. The last hypothesis sought to explore if there would be an increase in problem-solving performance between clusters of participants (Scheiter, et al., 2009).

The researchers performed cluster and discriminate analysis, concluding that division of the population into 5 clusters was optimal for their study. The researchers were satisfied with the size of the clusters and the overall differences across the five clusters were all highly significant. Clusters had a spread from low prior-knowledge (cluster 1) to high prior-knowledge (cluster 5), with the remaining factors (e.g. use of cognitive and metacognitive strategies, epistemological beliefs, attitudes toward mathematics, etc.) distributed between the 5 clusters.

Scheiter et al. (2009) conducted a 5 (cluster) x 2 (modular v. molar worked-out examples) MANOVA. Summarizing the results from the study, cluster 4 students (high prior knowledge) chose modular worked-out examples (p=.02) significantly more often than molar worked-out examples. Cluster 4 also scored the highest on transfer performance (p=.12). In one of the few experiments comparing molar and modular worked-out examples, results from the Scheiter et al. study (2009) found that certain clusters of participants chose modular over molar worked-out examples. Additionally, results from the study suggest that enhanced transfer test performance may be partially attributable to modular worked-out examples in the domain of statistics instruction. Although the findings revealed reduced cognitive processing for certain clusters of learners (cluster 4 who exhibited higher prior knowledge), the measures of cognitive processing used in the study did not allow for the differentiation of essential processing, a key component of the present study, from extraneous and generative processing.

An important difference between hypermedia and the audiobook instructional module is that the hypermedia intervention investigated by Scheiter et al. (2009) allowed the learner to freely navigate the instructional content. Whereas this study will investigate the delivery of an information literacy instructional module with a set order of modular worked-out examples, the hypermedia format allowed learners to navigate the instructional module freely and without a predetermined order to the examples.

Worked-Out Examples Summary

This body of worked-out example research (Gerjets, et al., 2004, 2006; Sheiter, et al., 2009) suggests that worked-out examples can be an effective instructional intervention and that modular worked-out examples have the potential to be more effective than molar worked-out examples. Furthermore, research suggests that one reason modular worked-out examples can be effective is due to their effective management of essential processing (Gerjets, et al., 2004, 2006; Rikers, et al., 2004; Scheiter, et al., 2009). For example Gerjets et al. (2004), working in the domain of mathematics instruction, broke down a complex problem into smaller, more meaningful modular worked-out example elements that the researchers hypothesized could be better understood separately by the learner than molar worked-out examples. Results from the Gerjets et al. (2004) study suggested that because modular worked-out examples reduce task-related essential processing, "modular examples are superior to molar examples with regard to problem-solving performance for isomorphic and novel problems, different measures of learning time, and cognitive load" (Gerjets, et al., 2004, p. 55).

The use of modular worked-out examples during initial skill acquisition appears from the literature to have a number of advantages. First modular worked-out examples reduce task-related cognitive processing associated with essential processing (Gerjets, et al., 2004, 2006; Sheiter, et al., 2009). Second, modular worked-out examples appear to be superior to other forms example-based instruction for both low and high-prior knowledge learners (Gerjets, et al., 2004). With respect to information literacy instruction and ill-defined problems, further investigation into the advantages modular worked-out examples designed to manage the cognitive processing associated with essential processing appear to be appropriate for additional research.

Ill-defined Problems

Cognitive psychology provides a number of perspectives on the broad topic of problem solving. Schraw, Dunkle and Bendixen (1995) note the spectrum of problem solving strategies including analogical, argumentative, conditional, correlation, pragmatic, scientific and statistical. Summarizing the research into these problem-solving strategies, including Paas's (1992) study involving cognitive processing and example-based instruction, there are two common themes in the problem-solving literature. First, the level of expertise, from novice to expert, is an important determinant of problem solving ability. Second, the structure of a learning problem as either well-defined or ill-defined is an important factor separating the problem-solving literature (Schraw, et al., 1995). Whereas cognitive processing and CTML are well situated in cognitive psychology, the majority of the supporting research has focused on well-defined problems (Mayer, 2005; Plass, et al., 2010; Schraw, et al., 1995). This section of the review of literature will focus on ill-defined problems and will conclude with an overview of one of the few studies that combined ill-defined problem solving, low prior-knowledge participants and worked-out examples.

One of the earliest studies which investigated ill-defined problems noted that well-defined problems have solutions that contain knowable solutions and the answers are absolutely correct, as are found in algorithmic problems (Kitchener, 1983). In contrast, ill-defined problems often have multiple solution steps and the procedures to reach solutions can vary (Kitchener, 1983; Schraw, et al., 1995). With respect to this study, a limitation with these early investigations is that they attempted to situate problem solving within an epistemic, or philosophical theoretical context. The theoretical rationales for the present study are cognitive processing theory and example-based instructional methods.

Whereas a well defined problem often has well-defined givens, goals and problem solving operators, ill-defined problems do not have givens, goals or operators (Rourke & Sweller, 2009). By example, a well-defined problem can be seen in the often-used water-jug problem (Luchins & Luchins, 1991; Van Gerven, et al., 2002; Van Gerven, Paas, Van Merriënboer, et al., 2006). In this well-defined problem, individuals are asked to pour a certain amount of water into a computer simulated jug by pouring jugs of different sizes filled with different amounts of water into each other. The rule given during water-jug experiments is that no water can be spilled. The clear rule needed to solve a water-jug problem and the requirement of an algorithmic (mathematical) solution typifies well-defined problems and therefore constitutes an ill-defined problem.

Of particular interest in the present study is the research into modular worked-out example instructional methods. Whereas a majority of prior studies using example-based interventions have used problems such as water-jug problems, the focus of the present study is on instructional techniques suited to ill-defined problems such as information literacy. The present study proposes that information literacy problem solving does not typically share the algorithmic, rule-based solution steps found in well-defined problems.

There is ample evidence suggesting that problem solving can cause a heavy load on working memory and that worked-out examples can reduce the cognitive processing associated with well-defined problems (Paas & van Gog, 2006; Reisslein, Atkinson, Seeling, & Reisslein, 2006; Rourke & Sweller, 2009). However, the research examining example-based instructional strategies that employ ill-defined problems is limited. One of the few studies linking worked example instruction and ill-defined problems suggests that "there is nothing in the theoretical principles [of cognitive processing theory] to suggest that the effect should not be equally obtainable using ill-defined problems in areas that use a less precise language than that of mathematics, science and technology" (Rourke & Sweller, 2009, p. 187).

Outside the domains of science, technology and mathematics, the research on ill-defined problems is limited. One recent study investigated ill-defined problems in computer-mediated collaborative learning using ill-defined problems during military leadership training (Uribe, Klein, & Sullivan, 2003). In the Uribe et al. (2003) study, 59 Reserve Officer Training Corps (ROTC) students were exposed to a web-based instructional program using an Air Force ROTC training program. The text-based training program was designed to assist participants in (a) defining the problem, (b) gathering data, (c) developing and testing possible solutions, and (d) selecting the best possible solution. The intervention used a web-based interactive module with an interactive "agent [that] explains that the learner must identify the individuals involved, the goal, and the obstacle preventing achievement of the goal" (Uribe, et al., 2003, p. 8). Participants were divided into two treatment groups, individual and collaborative dyads and within these groups, analysis was completed on high and low-ability groupings. Results from the study indicated that collaborative dyads performed significantly better than individuals and that there was no significant difference between low and high-ability students (Uribe, et al., 2003). One of the key limitations of this study was the lack of modular worked-out examples. However, both groups responded positively to the computer-based instructional agent, suggesting that the current study will extend the findings from the Uribe, et al. (2003) study.

Another recent study investigated ill-defined problem solving in the domain of military leadership studies (Schunn, McGregor, & Saner, 2005). Using the ill-defined problem-solving domain of platoon leadership in the military, the researchers conducted a study with sixty-six 'experts, twenty-three 'intermediates' and thirty-nine 'novices' in the domain of military leadership using a battery of fifty leadership scenarios. Study participants received no intervention and simply responded to open-ended questions about leadership. Survey responses were required for each of the fifty scenarios and responses were categorized as being expert, intermediate or novice.

While the design of the Schunn et al. (2005) study lacks research design parallels to the present study, results indicated that the ill-defined problem solving strategies employed were not significantly different across expert, intermediate and novice leader groups [$F(2,125) = 1.3$, $p > .25$] (Schunn, et al., 2005). In summary, the Schunn et al. (2005) study suggests that ill-defined problem-solving strategies are an area of research needing additional study. However, important limitations of the study include the lack of an experimental intervention and the absence of a modular worked-out example instructional format.

Recent developments in the research on worked-out examples includes a study by Rourke and Sweller (2009), who made a unique contribution by examining worked-out examples using ill-defined problems in the domain of art instruction, and specifically visual literacy. Visual literacy can be defined as the skills needed to visually identify a particular designer or artist and express the attributes of the work using the vocabulary of visual artists (Rourke & Sweller, 2009). Visual literacy is cross-disciplinary and can be applied to learning situations in the sciences, mathematics, the humanities, social sciences and parallel instructional challenges found in reading, writing and print literacy (Pettersson, 2002, 2009). The present study suggests that visual literacy and information literacy share common instructional challenges as they both can be considered ill-defined problems.

Rourke and Sweller (2009) suggest that within traditional arts education, visual literacy skills are frequently developed using ill-defined problems. The focus of the Rourke and Sweller study (2009) was to evaluate, in the context of cognitive processing theory, the extent to which worked-out examples could improve the problem solving skills of novice, college-age students in the domain of visual literacy. The Rourke and Sweller study (2009) study involved providing students with methods for identifying art objects by visual analysis different designers styles and in turn asked the students to use language appropriate for the domain to describe works of art. This combination of identification and description defines visual literacy. Rourke and Sweller note that this identification exercise as an ill-defined problem, in that "the style of a designer is determined by several factors and identifying a designer could be carried out by using several different combinations of factors" (2009 p. 187).

The Rourke and Sweller (2009) study participants were 102 first-year university design students. The experiment divided the subjects into either a worked-out example group or a problem solving group and all participants received the same introductory design history lecture. After the lecture, the problem-solving group were provided with an image of a design object and asked to match the object using the visual design language from the introductory lecture. The worked-out example group was provided with the similar images as the problem-solving group, augmented with brief samples of language from the visual design lecture. The researchers conducted a 2 (instructional method) x 5 (designers) ANOVA. The results indicated a significant main effect of the worked-out example instructional method when compared to the problem solving method (Rourke & Sweller, 2009). The results from the Rourke and Sweller (2009) study appear to indicate that instructional domains that include ill-defined problems might benefit from the application of worked-out examples. With respect to this study, the lack of a multimedia intervention was a limitation of the Rourke and Sweller (2009) study.

These findings from studies of ill-defined problems (Paas, 1992; Rourke & Sweller, 2009; Schraw, et al., 1995; Schunn, et al., 2005; Uribe, et al., 2003) suggest worked examples as a possibly effective way to manage cognitive processing in the domain of information literacy instruction. This study attempts to build upon this limited body of research through an investigation of information literacy from the research perspectives of ill-defined problems and modular worked-out examples.

Nursing Informatics

A survey of United States nurses evaluated the readiness of this population for evidence-based nursing practice and specifically evaluated their information literacy skills (Pravikoff, Tanner, & Pierce, 2005). The study sample included 760 nurses from across the United States. A majority of the nurses (67%) frequently sought information from a peer rather than from other sources, such as a journal article or other published source. While most survey respondents stated that they were comfortable with Internet searches, when the researchers inquired about their ability to use well-known health care databases, this perceived success diminished (Pravikoff, et al., 2005). For example, results from the Pravikoff, et al. (2005) study indicated that only 19% of the nurses surveyed felt confident in their ability to search the Cumulative Index to Nursing and Allied Health Literature (CINAHL), and 79% of the nurses had never searched this key health sciences database. As a follow-up to this initial survey, Ross (2010) conducted a survey of practicing nurses (n=128) which confirmed earlier findings that there is a need to develop more effective for information literacy instruction. Particularly interesting findings from the Ross (2010) study were that the use of libraries for additional sources of information by this group was limited, with more than 64% reporting they never used their hospital library, and that more than 97% had never used a university library as a practicing nurse.

While surveys that have investigated the importance of information literacy are illuminating (Pravikoff, et al., 2005; Ross, 2010), there are a number of studies that have introduced instructional interventions targeting the same phenomenon. For example, Courey, et al. (2006) developed a semester-long intervention that integrated information literacy instruction into an associate degree nursing program. In the study, faculty developed a one day intensive information literacy session that included lecture, discussion, hands-on activities, and collaborative learning exercises as well as semester-long activities wherein students accessed, evaluated, and utilized professional nursing journal articles (Courey, et al., 2006). The study focused on students' ability to access information and their attitudes about information. The study involved a treatment group (n=18) and a control group (n=39). Pre-treatment, post treatment differences for the treatment group indicated an increase mean score with respect to access of information (Wilks' Lambda F = 122.35; df = 1, 55; p = .000). The access scale pre-test scores were 2.33 (SD = .65) for the control group and 2.34 (SD = .74) for the treatment group. Posttest scores were 3.45 (SD = .39) for the control group and 3.45 (SD = .48) for the treatment group. With respect to access, there was no significant difference between the control and treatment groups. There was a decrease in students' attitude about accessing information (Wilks' Lambda F = 20.14; df = 1,58; p = .000) as well as a significant difference between groups (Wilks' Lambda F = 9.521; df = 1, 58; p = .003). Although there was an increase in students' ability to access information, they were less positive about information literacy skills after the intervention. Limitations to the study included a small sample size and a lack of information regarding the content and construct validity of the 22-item questionnaire developed by the researchers.

Although the Courey, et al. (2006) results were mixed, recent studies involving nursing informatics instruction that focused specifically on information literacy instruction for college nursing students have reported promising results. Ku, Sheu, & Kuo (2007) developed an intervention involving students in a 3-year RN-BSN women's health course. The study took place in Taiwan and the duration of the course was approximately four months. The researcher developed the information literacy skills instruction goals and objectives and integrated them into the semester-long course. Although the researchers noted that educational experts validated the scales used to measure information literacy, specific steps used to validate the instrument were not provided.

The research design included a treatment group (n=32) and a control group (n=43), and the author developed the instrument used to assess information literacy skills. The instrument included 23 items divided into five categories (searching and screening, integrating, analyzing, applying and presenting). The mean age of the study participants was 30 years, and over 87% had more than five years of work experience. Using a 2 x 2 ANOVA the researchers reported that the experimental group performed significantly better than the control group between pre-semester and post-semester testing (Wilks values = .86, $F = 4.78$; $^{**}p < .01$; Pre-Post, Wilks values = .91, $F = 2.80$; $^{*}p < .05$), especially in the dimensions of information integration, analysis, and application (Ku, et al., 2007).

The results from the Ku, Sheu, & Kuo (2007) study suggested that RN-BSN students who received information literacy instruction scored significantly higher with respect to information literacy skill development than the control group. However, limitations of the study include differences in instruction between the two groups. For example, the instructional content was different between the two groups (one group participated in a ‘marriage and family’ course while the other group was in a ‘women’s health course’). There were apparently no steps taken by the researchers to insure that any instructional content differences did not influence the information literacy instruction, yet the researchers noted that the information literacy instruction was tied to course content (Ku, et al., 2007). These course content and instructional differences between the treatment group and the control group might have led to unintended results with respect to the information literacy instructional outcomes. Additionally, the inclusion of only practicing nurses limits the ability to extend the results to undergraduate nursing students.

A recent study evaluated the effects of a library database searching tutorial delivered online to masters and PhD-level nursing students (Grant & Brettle, 2006). The researchers developed a 12-week instructional module that included information literacy lectures and an on-line, web-based tutorial. The researchers described their intervention as having two sessions, the first being a lecture introducing students (n = 21) to information literacy theory (formulating a search question; selecting search terms; building up a search strategy; limiting searches); the second session included an online demonstration. The second session (n=13) sought to consolidate learning through small group work to address areas of confusion or ambiguity. Between the first session and the second, students accessed the online tutorial on their own time outside of class. During the second session, students were also given the opportunity revisit the tutorial.

Grant and Brettle (2006) employed an instrument developed by Rosenberg et al. (1998) that was originally designed to assess first-year medical students ability to formulate research questions and search databases after a three-hour training session. Grant and Brettle (2006) subsequently modified the Rosenberg et al. (1998) instrument for nursing students. The primary outcomes from the Grant and Brettle (2006) assessment were related to searching performance and the quality of evidence retrieved during searching. The scale for scoring items was 1-16. The scoring guide used was not provided in the research article.

The researchers gathered subjective and objective results. Prior to the information literacy instruction sessions, seven students (54%) demonstrated an understanding of one basic library research technique such as subject searching or use of Boolean operators. Two students (16%) had demonstrated proficiency with both of these library search techniques. The researchers note that 16% of the sample demonstrated the ability to develop a systematic approach to database searches, including the use of more advanced search techniques, e.g. text searching and the use of search functions such as limiting built into library databases (Grant & Brettle, 2006). Following the two sessions, the number of students who could use basic search techniques correctly and in a systematic way increased to 46% (n = 6). Following the assessment of the end-of-module assignment, this figure had increased to 54% (n = 7). A one-way ANOVA for was used to compare the mean pre-session, post-session and post-assignment scores. A significant difference amongst the means was reported, $F(2,14) = 11.493$, $p = 0.001$. Subsequent pair-wise comparisons showed that there was a significant difference between pre-training scores and post-training scores, $F(1,10) = 5.106$, $p = 0.040$, and between post-training scores and the post-assessment scores, $F(1,10) = 9.486$, $p = 0.008$ (Grant & Brettle, 2006).

Eight subjective questionnaires were returned. All respondents indicated that the sessions were useful, well structured and interesting. Participants also noted that the information literacy materials were helpful and relevant to their areas of study. While the researchers did not indicate which of the two sessions were evaluated, five students (63%) agreed or strongly agreed that the instruction session had improved their search skills, and four students (50%) indicated that their knowledge of information literacy skills had increased. Seven students (88%) noted that an improvement in their searching skills (Grant & Brettle, 2006).

While the Grant and Brettle (2006) study reports generally positive subjective and objective responses to the treatment, the overall low number of participants is an important limitation. Although the researchers note that they pilot-tested the web-based tutorial and made changes based upon feedback, no information regarding the instructional design strategies used to develop the tutorial were provided in the research article. Additionally, the lack of control with respect to when in the intervention students could access the web-based tutorial, or how many times students could access it, limit the ability to draw conclusions regarding it's effectiveness within the context of the overall 12-week instructional module.

Clearly nursing and healthcare professional associations have recognized the importance of information literacy instruction at all levels of nursing education. This recognition has extended into the classroom, as demonstrated by the growing body of information literacy research within the nursing education literature (Courey, et al., 2006; Grant & Brettle, 2006; Ku, et al., 2007; Ross, 2010). There is a limited body of literature that specifically investigates stand-alone multimedia or web-based information literacy instruction for nurses. The present study builds upon the prior research through the introduction of cognitive processing theory and modeling the instruction using ill-defined problems in the development of a multimedia instructional module designed for both undergraduate and graduate nursing students.

Conclusions

Although the information literacy literature clearly points to the importance of these skills for college students, the integration of information literacy instruction into the higher education curriculum has been less than ideal (ACRL, 2004a, 2004b; Cox &

Lindsay, 2008; Thompson, 2007). One reason for the difficulties encountered in integrating effective information literacy into curricula is that it is a complex topic involving multiple, related concepts (Cox & Lindsay, 2008). The cognitive theory of multimedia learning, coupled with cognitive processing management techniques, suggests reasonable ways to address the inherent complexity of information literacy skills development (Mayer, 2005, 2009).

Instruction involving complex topics can result in high cognitive processing because multiple elements must be simultaneously processed in limited working memory (Paas, Renkl, et al., 2003; Sweller & Chandler, 1994). The use of modular worked-out examples has shown promise in developing long-term memory schema, one of the primary goals of instruction (Gerjets, et al., 2004, 2006; Plass, et al., 2010; Sweller, 2010). The research literature notes that developing schema effectively requires the effective management of essential processing, the cognitive processing imposed by the inherent difficulty of the material being integrated into long-term memory (Plass, et al., 2010). An analysis of the literature clearly points to a need to further investigate cognitive processing management techniques such as modular worked-out examples.

Ill-defined problems presented to the learner using worked examples as a method to manage cognitive processing during instruction is an emerging line of research (Rourke & Sweller, 2009). Although the research exploring ill-defined problems clearly situates the examples used therein as complex (Rourke & Sweller, 2009), these studies did not assess essential processing, generative processing or extraneous processing during instruction. Additionally, whereas the instructional advantages of multimedia as an instructional medium to manage cognitive processing are extensively discussed in the research literature (Mayer, 2005), there are no known studies that combine information literature, cognitive processing management techniques such as modular worked-out examples and ill-defined problems. This study will address these gaps in the literature.

III. METHODOLOGY

This descriptive study explored graduate and undergraduate nursing students' knowledge of 'determining the extent of information needed', generally considered the first step in building an information literate college student (ACRL, 2000). The present study took place at a medium-sized western United States university. There were five dependent variables in the study, two assessed at pretest and posttest and three of measured posttest only (see Figure 10).

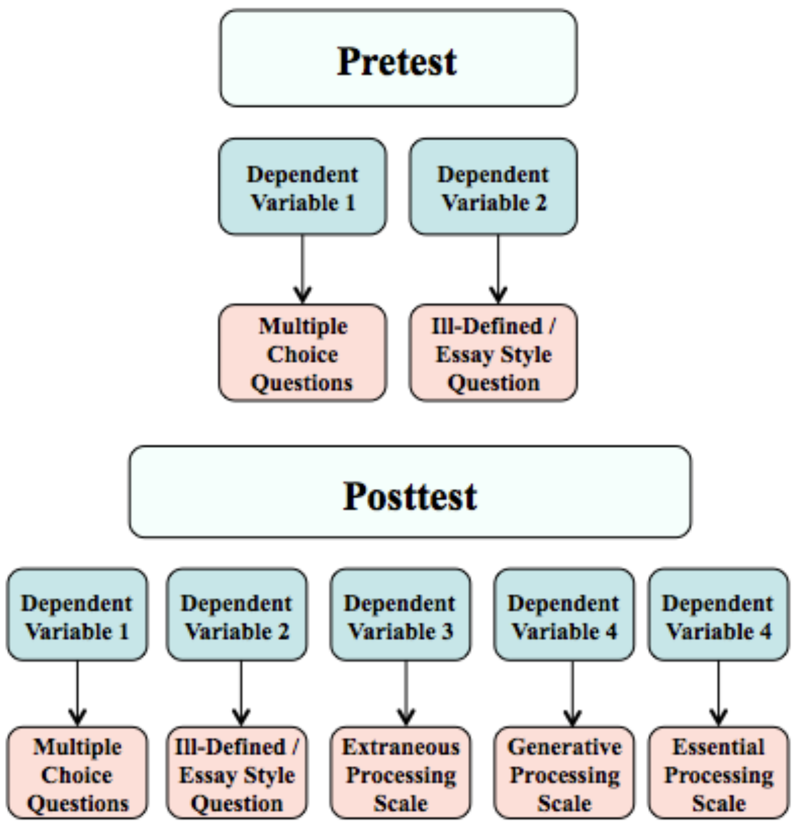

Figure 10. Dependent variables with assessment items for each variable and identified by use on pretest and posttest.

The first two dependents variables were: 1) student difference scores (pretest and posttest) on an multiple choice set of questions related to information literacy assessment,

2) student difference scores (pretest and posttest) on an essay-style set of questions related to information literacy assessment. Dependent variable one and two were measured by modified versions of the *Beile Test of Information Literacy Skills for Education* (Beile-O'Neil, 2005), the *Library and Information Skills Quiz* (SAILS, 2001) and test items developed by the researcher. The third, fourth and fifth dependent variables were self-report measures of extraneous processing, generative processing and essential processing, respectively. The independent variable in this study was test time with two levels: 1) pretest and 2) posttest. The delivery of information literacy instruction was conducted in an audiobook format using a modular worked-out example instructional strategy.

This study builds upon prior research investigating ill-defined problems (Rourke & Sweller, 2009), and seeks to extend earlier studies by explicitly using modular worked-out examples in the instructional domain of information literacy. Rourke and Sweller (2009) state that “a well defined problem has well-defined givens, goals and problem solving operators while an ill-defined problem does not have givens, goals or operators” (Rourke & Sweller, 2009, p. 185).

Whereas prior studies (Mayer, 2005; Plass, et al., 2010) evaluated worked-examples in the domains of science and mathematics wherein the givens, goals and operators were explicitly clear, Rourke and Sweller (2009) made a unique contribution by examining worked-out examples using ill-defined problems wherein the path or paths (operators) to achieve an acceptable outcome could be viewed as unclear. The present study operationalizes an ill-defined problem by posing open-ended information literacy questions during the pretest and posttest. This study argues that information literacy problems fit within the definition of ill-defined problems as they often lack clearly defined givens, goals and operators.

Research Questions

1. What is the level of change in nursing students' ability to determine the extent of information needed after a multimedia presentation using modular worked-out examples addressing information literacy (instructional treatment)?
2. What is the level of extraneous processing for students during the instructional treatment?
3. What is the level of generative processing for students during the instructional treatment?
4. What is the level of essential processing for students during the instructional treatment?

Figure 11 provides a graphic representation of the methods for assessing each research question. Information literacy skills were assessed using a set of 11 pretest and 11 posttest items. Generative, extraneous, and essential processing was assessed using one self-report measure per construct and will be assessed only as part of the posttest. The assessment methods section within the present methodology provides additional details regarding each assessment.

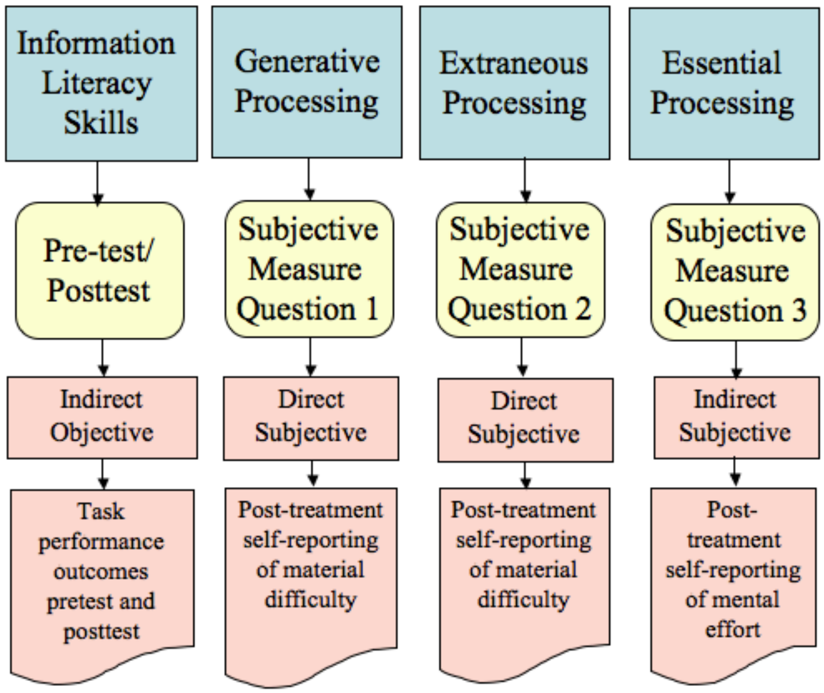

Figure 11. Research questions mapped to intervention assessment strategies.

Research Design

This descriptive study has five dependent variables: 1) student difference scores (pretest and posttest) on an multiple choice set of questions related to information literacy assessment, 2) student difference scores (pretest and posttest) on an essay-style set of questions related to information literacy assessment, 3) a self-report measure of extraneous processing, 4) a self-report measure of generative processing and, 5) a self-report measure of essential processing, respectively. This study has one independent variable, test time with two levels 1) pretest and 2) posttest. The process for developing the intervention is outlined in Figure 12.

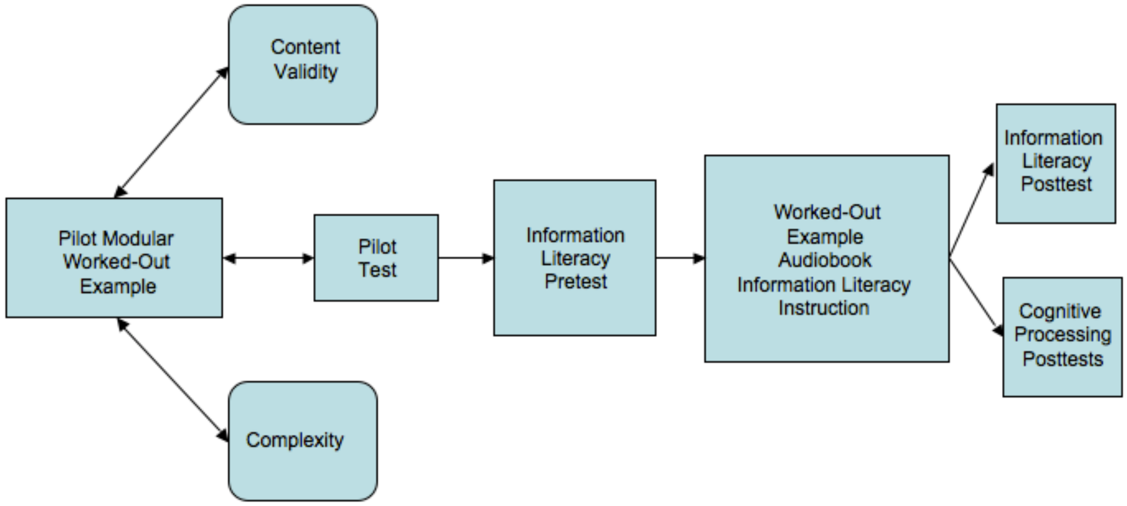

Figure 12. Multimedia audiobook intervention development model.

The study was divided into two experiments. Experiment 1 examined pretest and posttest differences for graduate-level Doctor of Nursing Practice (DNP) students with respect to performance differences on an information literacy assessment. Experiment 2 replicated Experiment 1 used the same 11-question information literacy assessment and multimedia intervention. Experiment 2 extended upon Experiment 1 by adding three questions designed to assess the three types cognitive processing associated with the multimedia intervention; generative processing, essential processing and extraneous processing. Additionally, Experiment 2 sampled undergraduate nursing (BSN) students.

Content Validity and Intervention Complexity

The researcher completed two initial validation steps with respect to the instructional module and test item content. The steps for addressing content validity and item complexity are outlined as follows.

Content validity of assessment

The researcher met with a panel of three information literacy subject experts to review content validity prior to the pilot test. The experts were given copies of the complete methodology, intervention, and the pretest and posttest items. Feedback from the experts revealed no substantive issues with the overall intervention design, the content with respect to information literacy standards or, the appropriateness of the questions to the intended sample of students. As the version of the instrument reviewed by the experts contained a sub-set of the final questions chosen for the pilot (questions 1-7 of the piloted 17-item instrument), the experts re-reviewed the instrument and assessment questions before finalizing the intervention. The expert panel consisted of three librarians with information literacy instruction experience in higher education.

Post-pilot test feedback on the modular worked-out example with respect to complexity and content validity gathered from a panel of information literacy instruction experts. Assessing item complexity is the primary purpose of this second panel review. The panel review also gathered feedback regarding instrument content. The instrument used for this phase of the research is located in Appendix A. The same expert panel used during pilot testing completed this review for complexity. Feedback from the expert panel determined that the instrument questions were appropriately complex given the information literacy concepts assessed. No substantive changes were made to item complexity based on feedback from the expert panel.

The present study used feedback from expert information literacy instruction librarians' to determine the complexity of the intervention. The researcher convened a panel of three information literacy instruction librarians' at a mid-sized private academic library who typically work with both graduate and undergraduate students. The researcher participated with the expert panel in determining the level of complexity. The question posed during the panel discussion was:

> *Within the domain of information literacy instruction and, based on your experience, is "determining the extent of information needed" generally an easy or difficult process for students?*

The intent of this question was to gauge expert insights into the complexity of the learning tasks associated with 'determining the extent of information needed' from librarians experience as information literacy instruction librarians. Additionally, experts were asked to rate each item on a researcher-designed complexity scale. Experts rated, on a scale of one to ten:

> *Within the domain of information literacy instruction and, based on your experience, please rate the proposed question on a scale from easy (1) to extremely difficult (10)?*

This measure of individual item complexity provided an indication of the extent to which item design and content are appropriate measures of information literacy. Additionally, this measure afforded the researcher an opportunity to compare expert assessments of item complexity with individual student scores on each of the pretest and posttest questions. The mean score for the ill-defined problem with respect to complexity was 3.33 (SD=3.0). The range of scores on this item was high. The researcher met with the experts and discussed their scoring. The score differences were related to how the experts interpreted the question on the assessment designed to measure complexity, not the instrument question designed for the present study. The researcher interpreted this score as being acceptable and no changes were made to the ill-defined problem question based on these results. Given that the scale was 0-10, it was assumed that a score on this question near the mean indicated that the item was neither to easy or to complex. For the remaining multiple-choice questions, the scores on the complexity question ranged from a low of 3.0 a high of 6.5. The researcher met with the experts and discussed their scoring. The score differences were primarily related to how the experts interpreted the question on the assessment designed to measure complexity, not the instrument question designed for the present study. The researcher interpreted this range of scores as acceptable and that they met the requirements of the instrument.

Based on this expert feedback the researcher determined the extent to which there were reasonable indications that the material being covered in the intervention was suitably complex for the intended sample population. Results from expert feedback regarding complexity was reviewed by the researcher, and appropriate adjustments to the intervention was made as warranted. A copy of the form used to gather feedback is located in Appendix A. The original assessment designed to gather expert feedback regarding intervention design (S. Prion, personal communication, December 10, 2011) was also used in a recent assessment of nursing education (Ruggenberg, 2008) and, was modified by the researcher to meet the needs of the present study (Appendix A).

Audiobook Content Validity

Content validity of the worked-out example information literacy instructional module audiobook was assessed using a panel of two expert information literacy instruction librarians. The assessment of content validity assisted with determining the extent to which the information literacy audiobook instruction module measured the intended learning outcome constructs (Creswell, 2003) as specified by the *Information Literacy Competency Standards for Higher Education* (ACRL, 2000). The experts were recruited from a mid-sized university library that provides both graduate-level and undergraduate information literacy instruction. The panel was asked to review the instructional module script and provide detailed feedback as to the appropriateness of content for graduate-level and undergraduate instruction, the accuracy of mapping to ACRL information literacy standards to pretest and posttest questions as well as the level of complexity of the intervention.

The process for gathering audiobook content validity was as follows. The same two information literacy instruction experts who provided feedback on instrument validity were again contacted and agreed to assist the researcher. The experts were provided a copy of the ACRL information literacy standards along with a copy of the script to be used in the audiobook. After the experts reviewed the audiobook script along side the ACRL information literacy standards, the present researcher met with both experts to discuss the script. The feedback from the experts included the identification of a number of typos in the script, suggestions on clarifying particular sections of the script and identifying more appropriate images to use in the visual component of the script. For example, the experts suggested expanding the term ‘databases’ to ‘article databases’ and expanding the definitions of the database examples. Overall feedback was that the audiobook script provided appropriate information literacy instruction with respect to ‘determining the extent of information needed’, the first ACRL standard.

Pilot Testing

A pilot test was completed with convenience sample of 18 first-year Doctor of Nursing Practice (DNP) students. The pilot testing took place in a DNP classroom on the campus of a medium-sized United States west coast university. One participant failed to complete the posttest and that individual's results were omitted from this analysis. The resultant sample included 17 students. The pretest (17 items) took a total of 12 minutes for all students to complete. During the information literacy instructional intervention, students were given printed screen shots with minimal text and asked by the researcher to follow along as the intervention script was read aloud. Figure 13 illustrates the sequencing of the pilot test alongside subsequent Experiments 1 and 2.

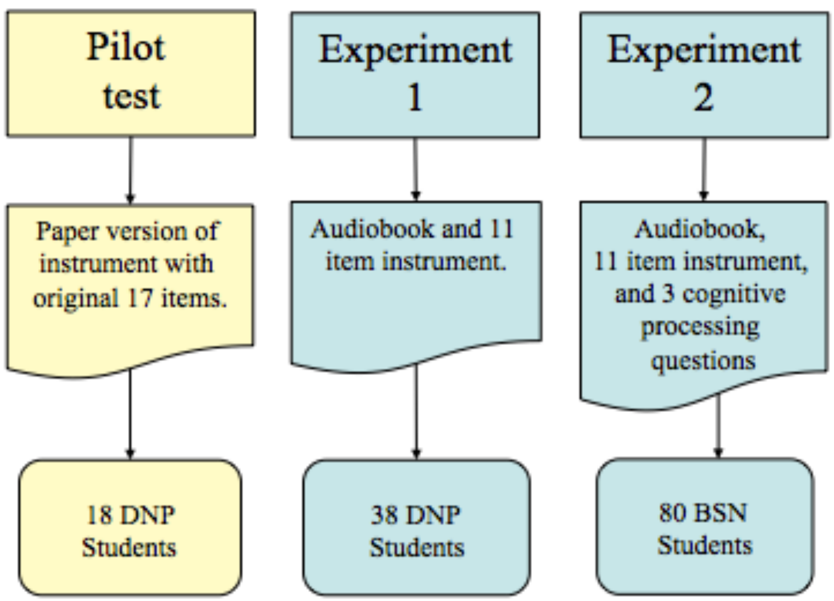

Figure 13. Pilot test, Experiment 1 and Experiment 2 with description of instruments and sample populations.

The pilot study consisted of 17 multiple-choice items. For Experiments one and two, the number of multiple-choice items was reduced to 10, and an essay-style question was added as an ill-defined problem. A “do not know” option was added to Experiments 1 and 2. There was no “do not know” option on the pilot instrument. For Experiment 2, three scale items were added to the assessment used in Experiment 1. Appendix C contains the full script as used in Experiments 1 and 2. Because of these changes from the pilot version, data from the pilot test were not included in the final results.

The pilot intervention required approximately eight and one-half minutes to complete. Directly after the intervention, students completed the posttest (duration eleven minutes). The question order was identical between the pretest and posttest. Only surface features of test items were changed between the pretest and posttest. Changing surface features on items involves making minor alterations to the wording of test items while keeping the concept being assessed the same between pretest and posttest. The changing of surface features thereby allows statistical comparison of items between pretest and posttest as the constructs being measured are unchanged (Gerjets, et al., 2006; Quilici & Mayer, 1996). The overall duration of the pilot study was approximately 32 minutes.

An analysis of the pilot study results was completed as follows. Pre and posttest difference scores were calculated for the 17-item instrument. The mean difference score was 0.69 and the standard deviation was 1.88, resulting in a Cohen’s d of 0.37. An analysis of item mean scores was then completed, revealing seven items that appeared to lack sufficient difficulty (item mean scores ranged from 0.75 to 0.94). Removing the insufficiently difficult items from the analysis resulted in a pretest posttest mean difference score of 1.06, a standard deviation of 1.43 and a Cohen’s d of 0.74 for the remaining 10 items. Based upon these results, the present study was limited to 10 items from the pilot test.

Additionally, one open-ended, essay style item was added to the assessment. This additional item was designed to assess students' responses to an ill-defined problem. It was anticipated that the reduction of pretest and posttest items to 11 from a pilot group of 17 questions would result in a small reduction in the overall time required for the intervention. Furthermore, based upon analysis of pilot results, the researcher added one item ("I Don't Know") to each question. Adding a 'don't know' option to the list of possible responses to both pretest and posttest questions reduced the probability that respondents correctly guessed an answer and added an option for participants to truthfully answer a question when they did not know the correct answer. Additionally, item analysis suggested that question 16 had unpredictable results. This unpredictability was evident as participants with both higher and lower total scores were able to answer the item correctly on the posttest. Although no obvious reasons for these unpredictable results were apparent, one possible cause might be fatigue, as this item was designed to have multiple correct answers might require more effort to complete than others on the assessment. Based upon this analysis, the item was moved to the end of the test, to reduce the potential of test fatigue as a factor in the results.

A focus group study was conducted with the same group of DNP students after they completed all parts of the intervention, and the researcher asked the participants if they had any feedback regarding the intervention. Participants noted that the wording on question number eleven was slightly confusing. Based upon the lack of item difficulty, this question will be removed from the final assessment. Participants also noted that the posttest lacked scales for the reporting of cognitive processing. The omission of scales in the instrument was an oversight by the researcher. The researcher improvised during the intervention and wrote the two scales on the classroom whiteboard. Finally, it was apparent from focus group feedback that the choice by the researcher to assess cognitive processing as part of responding to each of the posttest questions was redundant and confusing. Although it was assumed by the researcher that cognitive processing could be assessed at the individual item level as has been done with recent studies (Musallam, 2010), the design of the present study did not lend itself to this approach. Therefore, the researcher revised the posttest in such a way as to ask participants to report cognitive processing only at the beginning of the posttest. The removal of repeated assessments of cognitive processing resulted in a small reduction in the time participants require to complete the posttest. The final version of the instrument is located in Appendix B.

Population

The present study used a sample of graduate and undergraduate nursing students at a mid-sized, private western United States college. This population was the pool from which pilot participants and intervention participants were selected. This population was chosen as they are generally considered a group that would benefit from information literacy instruction and may have not been exposed to information literacy instruction during their tenure in college. The convenience sample size for the DNP group was 38 students and 80 students in the BSN group. Demographic data were not captured as part of the present study. However, national data indicate that approximately 94% of DNP program graduates are female and 92% are non-white Hispanic (Chism, 2010). National demographic data for recently graduated BSN students indicate that approximately 10%

are male and approximately 22% are non-white Hispanic (HRSA, 2010). Visual evaluation of the samples used in the present study suggests that student group demographics were not dramatically different than national trends.

Protection of Human Subjects

All rights of the study participants were protected in accordance with the standards and policies of the University of San Francisco's Institutional Review Board. Study participants received a consent form and affirmed their consent prior participation in the study. Completed consent forms were stored in a secure location. Participation was anonymous, confidential and participants were not identified by name in the reporting of study results. Samples of the informed consent forms for the BSN and DNP groups are located in Appendix D.

Instrumentation

Participants completed a pretest and a posttest of information literacy skills. Questions on the pretest and posttest include items modified from the B-TILED (Beile-O'Neil, 2005) and SAILS (2001) instruments as well as items designed by the researcher. Only surface features were changed on items, thereby differentiating pretest and posttest items, while allowing for comparison of results between tests. The instrumentation for measurement of the five dependent variables is as follows.

Measurement of the first two dependent variables: 1) student difference scores on an multiple choice set of questions related to information literacy assessment, 2) student difference scores on an essay-style set of questions related to information literacy assessment, were based upon items from the B-TILED (Beile-O'Neil, 2005) and the Standardized Assessment of Information Literacy Skills (SAILS, 2001) instruments. The researcher developed additional test items. The B-TILED was developed as an instrument to assess the information literacy skills of teacher education students at a large, urban university and contains of 22 test items and 13 demographic and self-perception questions. The B-TILED was designed to assess the extent to which students had mastered all five of the ACRL information literacy standards.

The B-TILED was developed from an original set of 62 items published by the Project SAILS team. The SAILS instrument, also know of as the *Library and Information Skills Quiz,* was first published in 2001 and is a standardized test of information literacy skills that was developed to cover all five areas of information literacy (SAILS, 2001). The mapping of SAILS items to ACRL standards was performed by Beile-O'Neil (2005). The current study used 12 items from the *Library and Information Skills Quiz,* one test item from the B-TILED and five items designed by the researcher.

The items developed by the researcher fell into two categories: items built from existing instruments and researcher-designed test items. Four of the items assisted in measuring specific information literacy skills related to 'determining the extent of information needed' that were not adequately covered by the B-TILED or SAILS instruments. One item was developed by the researcher to specifically address students' ability to solve ill-defined problems. This item was presented as an open-ended essay type item, where students wrote their responses by hand. The ill-defined problem answers were scored using a rubric designed by the researcher.

The selection of a subset items from the *Library and Information Skills Quiz* and the B-TILED instruments stems from the fact that neither instrument was designed with a singular focus on ACRL standard one, determining the extent of information needed.

There are no known instruments that are limited to only ACRL standard one. The selected items from the *Library and Information Skills Quiz* and the B-TILED plus the addition of new items designed by the present researcher represented a battery of test questions that, in this researcher's judgment, allowed for the assessment of the first ACRL information literacy standard. An expert panel of information literacy instruction librarians evaluated the final battery of 11 items for content validity and item complexity prior to final implementation of the study.

Appendix G identifies each of the test items with their exact text, correct answers (items 2-11), and the source (B-TILED, SAILS or researcher designed). The items are listed as they appear in the pretest. Surface features of each item were altered between the pretest and the posttest.

Ill-defined Problem Assessment Question

The researcher designed ill-defined essay-style question assessed students' ability to effectively solve a unique information literacy problem. This question was presented in the pretest and the posttest as an open-ended item and participants were asked to write their responses by hand. Responses were analyzed using a rubric (Figure 16) based upon the ACRL information literacy performance indicators for determining the extent of information needed (Appendix E).

The first question on the pretest and posttest were structured to elicit individual responses for three components of an ill-defined problem. Students were given a full page to answer to each sub-problem within the ill-defined problem. Figure 14 provides the pretest version of the ill-defined essay-style question.

	You are researching the topic of **'medication errors'** for a 20-page research paper and you are unfamiliar with the topic. Where would you start your research? What kinds of resources would use and what strategies would you use to decide if they are appropriate for your research paper?	
Page 1.	Where would you start your research?	Answer:
Page 2.	What kinds of resources would use?	Answer:
Page 3.	What strategies would you use to decide if the resources chosen are appropriate for your research paper?	Answer:

Figure 14. Ill-defined problem essay-style question.

The structure of question one is consistent with the research on modular worked-out examples (Gerjets, et al., 2004). Additionally, it was anticipated that intentionally structuring the ill-defined essay-style question such that respondents were required to address each component of the ill-defined problem separately simplified the scoring process. Analysis of test item one had two dependent variables and was based upon the researcher designed rubric (Figure 16) that follows the ACRL information literacy standards for determining the extent of information needed (ACRL, 2000). A panel of experts in information literacy instruction scored responses to the ill-defined problem using the rubric.

Multiple-choice Assessment Questions

An example of an assessment multiple choice problem question is provided in Figure 14. Column one provides the original test item as written by the present researcher or, as used in earlier studies (Beile-O'Neil, 2005; SAILS, 2001). Column two identifies the source of the test item and the correct answer. A number of the assessment questions were modified by the researcher from earlier studies, and are identified as necessary in column three with the modified version of the original question. Column four provides the posttest version of the question. The 10 multiple-choice questions are designed to assess specific information literacy skills that were covered during the audiobook component of the intervention. Surface features of items were changed between the pretest and posttest. For example, assessment item one asks students as part of the pretest to answer a series of questions addressing how they would approach researching the topic “medication errors”. On the posttest a surface feature of the question was modified such that the topic addressed “patient falls” but the goals of the question (information literacy skills) was not changed between the pre and posttest versions. Appendix B includes the complete 11-item pretest and 11-item posttest.

Test item (correct answers, identified in **bold**)	**Source Test and Item Number**	**Pretest Item**	**Posttest Item**
Your professor has assigned a paper on **the whole language movement.** You are not familiar with the topic, so you decide to read a brief history and summary about it. Which of the following sources would be best? a. a book on the topic, such as *Perspectives on **whole language learning**: A case study* b. a general encyclopedia, such as **Encyclopedia Britannica** c. an article on the topic, such as "Whole language in the classroom: A student teacher's perspective." **d. an education encyclopedia, such as *Encyclopedia of Education***	B-TILED – 8 **Correct answer: D**	Your professor has assigned a paper on **alternative women's health therapies**. You are not familiar with the topic, so you decide to read a brief history and summary about it. Which of the following sources would be best? a. a book on the topic, such as *Perspectives on **alternative women's health therapies**: A case study* b. a general encyclopedia, such as **Encyclopedia of Medicine** c. an article on the topic, such as "**Alternative women's health therapies in the clinic: A student nurse's perspective."** **d. an Nursing encyclopedia, such as *Encyclopedia of Nursing*** **e. do not know.**	Your professor has assigned a paper on **nutritional issues in nursing home care**. You are not familiar with the topic, so you decide to read a brief history and summary about it. Which of the following sources would be best? a. a book on the topic, such as *Perspectives on **nutritional issues in nursing home care**: A case study* b. a general encyclopedia, such as **Encyclopedia of Aging** c. an article on the topic, such as " "**Factors associated with low body mass index and weight loss in nursing home residents"** **d. an Nursing encyclopedia, such as *Encyclopedia of Nursing & Allied Health*** **e. do not know.**

Figure 15. Information literacy assessment multiple-choice question example.

Information Literacy Rubric

The rubric for scoring the ill-defined problem is shown in Figure 16 and was developed from an rubric used at St. Johns University ("Information literacy rubric," 2006). The information literacy performance indicators match the four ACRL information literacy standards for 'determining the extent of information needed' (Appendix E). The researcher developed an operational definition for each level of information literacy skill. The rubric was not subjected to an assessment of content validity.

Information literacy performance indicator	**Level of information literacy skill**				
	Level 0	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Defines and articulates information needs	Does not define or articulate information needs	Minimal articulation OR definition of information needs	Moderate articulation AND definition of information needs	Competent articulation AND definition of information needs	Fully articulates and defines information needs
Identifies types and formats of information needed	Does not identify a type of information or specify an information format	Minimal identification of an information type OR an information format	Moderate identification of an information type AND an information format	Competent identification of an information type AND information format	Fully identifies multiple types of information AND information formats
Weighs costs and benefits of information	Does not identify a cost or a benefit of an information format or source	Identifies a cost OR benefit of an information format or source	Identifies a cost AND a benefit of an information format or source	Identifies costs AND benefits of multiple information formats or sources	Identifies costs AND a benefits of multiple information format or source as well as articulates the tradeoffs of choices
Revaluates information needs	Does not show evidence of evaluation of information sources	Demonstrates minimal evaluation of sources	Demonstrates evaluation of sources differentiated by type of source	Demonstrates evaluation of sources differentiated by type of source and shows evidence of refining search based on evaluation	Fully differentiates reevaluation based on resource type and articulates how the final paper is influenced by reevaluation of information needs

Figure 16. Information literacy question scoring rubric for ill-defined problem.

A numeric score was assigned to responses by a panel of information literacy experts based upon their assessment of the level to which the performance indicator was met. Possible scores on the ill-defined problem question ranged from zero (no evidence) to 4 (expert). Figure 17 provides an overview of the how each expert was instructed to differentiate and score different levels of information literacy skill.

	Level of information literacy skill				
	Level 0	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Information literacy performance level	Does not define or articulate information needs	Information literacy expertise typically seen with college freshmen	Information literacy skills expected from a typical college senior	Information literacy skills expected from a graduate student	Fully articulates and defines information needs
Guidelines for determining and separating levels of information literacy skill	Student shows no evidence of information literacy skill	Students exhibit a novice level of expertise 'determining the extent of information needed'	Student responses will indicate that they have written multiple research papers and may have received limited or basic information literacy instruction	Student responses will indicate that they have completed more advanced research writing than undergraduates and were be more likely to have received advanced information literacy instruction	Fully meets all of the requirements for an information literacy standard

Figure 17. Ill-defined problem scoring rubric guidelines.

The expert panel referred to the ACRL information literacy standards and performance indicators (Appendix E) if there was any ambiguity as to the degree to which an individual response satisfies a performance indicator.

Interrater Reliability

Scoring of the ill-defined problem (pretest and posttest question number one) was completed for all respondents by the present researcher. A second library professional with expertise in information literacy scored a random sample of five responses to the essay-style question for comparison the first set of scores. Scoring was completed using the information literacy rubric designed by the present researcher. The first test of interrater reliability resulted in an agreement rate of 66% for the random sample of question one results, where perfect agreement between raters would be 100%. A generally accepted minimum agreement rate of 80% (Moore, 1983) was not attained on the first attempt. Therefore, the present researcher met with the second rater to discuss differences in scoring. The literature suggests that three issues related to interrater reliability differences that should be investigated: 1) rater's skill, insight and experience, 2) the clarity of coding rules and 3) ambiguity of the data (Holsti, 1969). After discussing differences in scoring using Holsti's (1969) suggested areas for reaching agreement, a revised coding yielded a revised interrater reliability percentage of 97%.

Information Literacy Assessment Questions

An item from the *Library and Information Skills Quiz* (SAILS, 2001) not selected for the assessment was used as the primary example to develop the information literacy examples for instruction in the present study. Sample item for intervention:

> *You have been assigned a comprehensive (20 page) research paper on the impact of Title IX on high school sports programs. (Title IX legislation sought to ensure gender equity for sports programs.) Which of the following strategies is best to locate information?*

This original question above was revised as follows by the researcher with the intent of making it more relevant to the BSN and DNP students in the present study:

> *You are researching the topic of 'medication errors' for a 20-page research paper and you are unfamiliar with the topic. Where would you start your research? What kinds of resources would use and what strategies would you use to decide if they are appropriate for your research paper?*

The dependent variables extraneous processing and generative processing was measured via participant's subjective ratings of mental effort. The present study used two modified survey items (DeLeeuw & Mayer, 2008; Musallam, 2010; Swaak & de Jong, 2001) that monitor the constructs of extraneous and generative processing as participants complete the instructional component of the study. The present study used the following modified versions of the Musallam (2010) questions: 1) *How easy or difficult is it for you to understand information literacy at this time?* This item was used to measure generative processing, 2) *How easy or difficult is it for you to pay attention during the presentation?* This question was used to measure extraneous processing. These two items were used by Musallam (2010) in a study of chemistry and were developed from prior studies that measured cognitive processing (DeLeeuw & Mayer, 2008; Swaak & de Jong, 2001).

Using self-report items to assess cognitive processing are consistent with recent research. For example, DeLeeuw and Mayer (2008) note that although there are multiple measures of cognitive processing, single item measures immediately following learning can be effective. DeLeeuw and Mayer build upon earlier studies (Paas & Van Merriënboer, 1994) that used single item, self-report scales to measure cognitive processing. Past studies suggest that individuals have little difficulty self-reporting and internal consistency has been reported between .90 and .82 (Paas, 1992; Paas & Van Merriënboer, 1994). Furthermore, single item assessments are relatively simple to obtain, impose low interference on the overall intervention, do not require complex statistical analysis and have been found to have high face validity (Paas, 1992). For the purposes of the present study, these factors in addition to practical considerations (e.g. time allowed for the intervention) led to the decision to use single items during the posttest to assess extraneous and generative processing. A recent study that used single measures of cognitive processing noted that while a practical approach to measurement, this assessment strategy may not fully account for prior knowledge and therefore must be recognized as possible a research limitation (Musallam, 2010).

The generative processing (GP) and extraneous processing (EX) questions, as modified from Musallam (2010), will appear as follows (Figure 18) and used the same 9-point scale:

Question GP) How easy or difficult is it for you to understand information literacy at this time?

1	2	3	4	5	6	7	8	9
Very Easy								Very Difficult

Question EX) How easy or difficult was it for you to pay attention during the presentation?

1	2	3	4	5	6	7	8	9
Very Easy								Very Difficult

Figure 18. Generative processing and extraneous processing assessment scales.

The fifth dependent variable, essential processing, was measured using subjective ratings of mental effort. The present study used a scale developed by Pass and Van Merriënboer (1993) and subsequently modified for more recent studies in the domain of chemistry (Knaus, et al., 2009; Musallam, 2010). The measure of essential processing (Figure 18) was used in a manner consistent with earlier studies; a single question to assess mental effort was presented to the study participants directly before the posttest. The scale on this question was modified to a 9-point scale, rather than the 5-point scale used in earlier studies (Knaus, et al., 2009; Musallam, 2010), thereby allowing for comparisons across all three cognitive processing measures.

Please rank how much mental effort you used to make sense of the information literacy presentation:

1	2	3	4	5	6	7	8	9
Very Little Mental Effort								Very Much Mental Effort

Figure 19. Essential processing assessment scale.

Mental effort, discussed in the literature as essential processing, represents the cognitive activity that occurs in working memory during problem solving. The structure and complexity of the material, coupled with the amount of information the learner needs to retain in working memory, has a direct effect on the learners' ability to engage in effective essential processing (Brunken, et al., 2003). The current study proposed that complex information literacy problems, specifically when presented as ill-defined problems, can be difficult for students and that difficulty is seen as high mental effort. Complexity of test items was assessed using feedback from expert information literacy instruction librarians. There are no known standards for presenting ill-defined problems as part of an educational intervention. Therefore, the present author interpreted the limited body of research involving ill-defined problems and cognitive processing management to design the essay-style question. Whereas a well defined problem has well-defined givens, goals and problem solving operators, an ill-defined problem does not have givens, goals or operators (Rourke & Sweller, 2009). Ill-defined problems lack a definitive answer, answers are heavily dependent upon the problem's conception and require the learner to use working memory to retrieve relevant concepts and map them to the task at hand (Ashley, et al., 2000).

Therefore, the assessment of mental effort in the current study relies upon the use of examples that are sufficiently complex and meet the definition of ill-defined problems. Subjective scales for measuring generative processing are generally considered an effective method for the measurement of this component of cognitive processing (Ayres, 2006; Paas & Van Merriënboer, 1993).

Pilot Instruction and ACRL Information Literacy Standards

The use of hypothetical learning situations has been suggested as an effective method for information literacy instruction (Neely, 2006b). The instructional intervention used a combination of practical library instructional guidelines as well as hypothetical situations to illustrate the intended learning outcomes. The ACRL standard for determining the extent of information needed is broken down into four performance indicators (Appendix E).

Performance indicator 1.1 states that "the information literate student defines and articulates the need for information" (ACRL, 2000). A hypothetical situation was used to illustrate the intended learning outcomes as they relate to the first performance indicator. As the B-TILED and the *SAILS Library and Information Skills Quiz* omit performance indicator three (the information literate student considers the costs and benefits of acquiring the needed information), that performance indicator was omitted from the present study. Additionally, the resources selected that meet the current studies objectives do not provide useable examples of previously used instructional interventions that "weigh costs and benefits of information". Therefore, that information literacy performance indicator was omitted from the intervention. However, the rubric used to assess responses to the essay-style question in allows for responses that address this performance indicator, thereby avoiding potentially penalizing individuals who might address this issue in their responses.

Intervention

The instructional intervention was based on the work of experts in the field of information literacy instruction (Cook & Cooper, 2006). The work of Cook and Cooper (2006) was chosen in part due to the authors explicit connection of ACRL information literacy standards to the instructional methods discussed in their work. The content of the intervention was based upon a question from the *Library Information Skills Quiz* (SAILS, 2001):

> *You have been assigned a comprehensive (20 page) research paper on the impact of Title IX on high school sports programs. (Title IX legislation sought to ensure gender equity for sports programs.) Which of the following strategies is best to locate information?*

This original question design was revised as follows by the researcher so that it appears more relevant to the graduate and undergraduate nursing students in the present study:

> *You are researching the topic of 'medication errors' for a 20-page research paper and you are unfamiliar with the topic. Where would you start your research? What kinds of resources would use and what strategies would you use to decide if they are appropriate for your research paper?*

The question upon which the content of the instructional intervention was modeled meets the generally accepted definition of an ill-defined problem, where the givens, goals or operators of the learning exercise may not be explicitly clear to the learner (Rourke & Sweller, 2009). The methodology was a descriptive design and the intervention will present information literacy instruction in a worked-out example, audiobook format.

The instructional session was comprised of four timed sections. The pre-instruction section informed the participants about the format and duration of the intervention as well as provided an overview of information literacy. The second section of the intervention was the pretest. The third section comprises the multimedia information literacy instruction and the fourth section was the posttest. The total estimated time for the intervention is 50 minutes.

The fifteen-minute instructional section of the intervention covered the first set of ACRL information literacy standards associated with 'determining the extent of information needed' (ACRL, 2000) and was presented as the multimedia audiobook component of the intervention. Information literacy standard one states that "the information literate student determines the nature and extent of the information needed" (ACRL, 2000). This first step has multiple sub-goals, including students' ability to define and articulate information needs (ARCL standard 1.1), use multiple sources of information such as print and electronic databases (ACRL standard 1.2) and reevaluate the types and amounts of information needed as they progress through a learning exercise (ACRL standard 1.4). While the ACRL standards (Appendix E) include two additional goals in step one, the current study focused primarily on these two aspects of step one.

Audiobook Instructional Content

Components of the audiobook instructional intervention were based on the work of researchers (Cook & Cooper, 2006) who implemented an information literacy instructional session that was built around students locating library resources where the assignment was researching a speech using resources related to history. The duration of the instructional session upon which the current intervention was based was ninety minutes. For the purposes of the current study, only sections of the ninety-minute instructional session were selected. The two selected components selected from Daugherty (2006) map to the current studies interest in ACRL standard one, determine the extent of information needed. The researcher modified the content where applicable so that it would better resonate with graduate and undergraduate nursing students.

The multimedia content for the intervention also builds upon the work of Daugherty (2006), whose information literacy instruction session learning objectives were, “scan through print and electronic chronologies to increase familiarity with specific decades (ACRL standard 1.1.3) and identify the differences between print indexes and electronic indexes” (Cook & Cooper, 2006, p. 25). Daugherty began the instruction by describing a possible research topic to students in a one-time information literacy instruction session. The research question used in Daugherty’s intervention centered on finding historical information for a hypothetical in-class presentation by student participants. The instructor asked students “what they know about life between 1880 and 1890, 1890 and 1900, and so on” (Cook & Cooper, 2006, p. 26), noting that the search engine Google would not yield relevant information. Once the topic had been introduced, the author posed the question “where should you begin to find information for this assignment” (Cook & Cooper, 2006, p. 26). In-class instruction included introducing students to general reference resources and library databases.

Additional components of the intervention were modeled after the work of Childers & Renne (2006), who used Venn diagrams to illustrate effective search techniques wherein the primary instructional objective was for students to complete a literature review. The instructional sessions’ objectives covered multiple ACRL standards, including determining the extent of information needed. The authors used Venn diagramming to illustrate how ill-defined problems that include multiple concepts can be researched using library resources.

In addition, parts of the intervention were built using the work of Feeney as well as Childers and Renne (2006). Feeney developed an information literacy instruction session for journalism majors while Childers and Renne developed library instruction for education graduate students. The instruction developed by Feeney was designed to meet multiple ACRL Information literacy standards. Childers & Renne also developed their instruction to meet multiple ACRL standards. The current instructional design borrows only elements from these two information literacy instructional designs related to ACRL standard one, determining the extent of information needed and focus on identifying reference sources. Screenshots of the final version of the intervention are located in Appendix F.

Instructional Intervention and Modular Worked-out Examples

The following section discusses the proposed modular worked-out example audiobook instructional script. Prior to implementation, the proposed script was evaluated for content validity and complexity. The proposed intervention was presented to the study participants in audiobook format and contained approximately 1,100 words. The timeline allowed for 15 minutes for the instructional intervention. The pilot study confirmed that reading the script aloud could be completed in the time allotted for this component of the overall intervention. Allowing for generally accepted speech comprehension thresholds of approximate 200 words-per-minute (Tauroza & Desmond, 1990), no confounding of results was experienced related to the rate at which the text is read during the intervention.

Modular Worked-out Examples

Whereas conventional example approaches to problem solving challenge the learner to engage with problems as one complete unit, often at a surface level, modular worked-out examples break down complex problems into a logical progression of more easily solved sub-problems. The proposed information literacy instructional script was developed by the present author with the intent of breaking down a complex, ill-defined information literacy problem (determining the extent of information needed) into a logical progression of steps thereby reducing cognitive processing. The information literacy instruction will be presented in an audiobook format.

The instructional intervention audiobook met a number of cognitive processing management principals. Figure 20 provides an overview of cognitive processing principle, the types of cognitive processing associated with the principal and the instructional design technique employed in the audiobook.

Cognitive Processing Principle	Cognitive Load Source	Instructional Intervention Cognitive Processing Management Technique
Complexity effect (element interactivity)	Essential	Cognitive processing effects are only seen with complex learning materials
Modality effect	Extraneous	Students learn better from text and pictures if the text is presented as spoken rather than written text
Redundancy effect	Extraneous	Limiting redundancy of text, images and spoken words increases learning opportunity
Variable examples effect	Generative	Changing surface features on examples enhances learning
Worked-example effect	Extraneous	Worked-example instructional design
Sequencing effect	Extraneous	Organize learning tasks from simple to complex.

Figure 20. Cognitive processing principle, cognitive load source and audiobook design technique to manage cognitive load.

Audiobook Intervention Format

The proposed method to deliver instruction using an audiobook format was modeled after earlier research (Prion & Mitchell, 2007b, 2008). Audiobooks typically include a voice narration component, are divided into chapters or individual segments of content and have summative images related to the content. These elements are then combined into a single digital file. One of the advantages associated with audiobooks include the portability of this type of material. Audiobooks can be delivered via software programs such as iTunes or other multimedia distribution methods where and when the learner needs the content. Additionally, audiobooks can be designed to be accessible on multiple technology platforms such as portable iPod-like devices as well as PC and Macintosh computers, making them accessible to both individual learners as well as creating the opportunity for instructors to play the files in classrooms or other learning situations to groups of students. Other advantages of audiobooks include the ability to add chapters and bookmarks, which can facilitate learners returning to specific sections of the material without having to replay the entire file.

This combination of design and accessibility features, represented as a single multimedia file, creates the potential for an audiobook to contain all of the learning materials required to meet an instructional designers learning objectives (Prion & Mitchell, 2007a). By example, an audiobook can help learners in 'determining the extent of information needed' within the context of information literacy instruction. Prior studies have also combined audiobooks with handouts and other visual materials to augment the learning objectives (Prion & Mitchell, 2007b). The use of multimedia learning materials in audiobook format has shown promise in as addressing the limitations of working memory as well as managing cognitive processing (Mousavi, Low, & Sweller, 1995; Prion & Mitchell, 2007a, 2008). See Appendix C for the full intervention script.

Procedures

The procedures for Experiment 1 and Experiment 2 were identical. The first step in the procedures process included obtaining permission from the Dean of the College of Nursing at the University of San Francisco. Once permission from the Dean was secured, individual instructors were contacted and permission obtained to conduct Experiments 1 and 2 during regularly scheduled instruction time. Both experiments took place in instructor's classrooms.

Both experiments began with a brief verbal introduction by the researcher. The introduction included information regarding the purpose of the study and the position of the researcher as a doctoral candidate collecting data for a study. The researcher distributed copies of the informed consent letter to each student and collected completed forms. None of the participants in Experiment 1 or Experiment 2 declined to participate.

The treatment was divided into multiple steps, each contained in the audiobook. The content and sequencing of the steps was identical for both experiments. The audiobook began with an introduction of the concepts to be discussed and the purpose of the study. The audiobook was played on a large screen that was easily seen and heard by all students in the class. Once the introduction was complete, the researcher paused the audiobook and distributed a printed copy of the assessment containing the pretest and posttest. Each paired copy of the pretest and posttest handout was individually numbered for scoring and tracking purposes. The individual numbering of the handouts did not identify individual participants by name or school ID. All participants were exposed to the same audiobook (see Appendix C for complete audiobook script).

The introduction was approximately two minutes in length. After the instruction, students were instructed that they had 15 minutes to complete the pretest. The pretest included one essay-style ill-defined problem and ten multiple-choice questions and was identical for both experiments. Once all of the participants completed the pretest, they were instructed to put aside the printed materials. The researcher then started the intervention section of audiobook. This section took eight minutes and sixteen-seconds (8:16) to complete. Once the intervention was complete, students were instructed that they had 15 minutes to complete the posttest. The posttest used for Experiment 1 included one essay-style ill-defined problem and ten multiple-choice questions. The posttest for Experiment 2 included one essay-style ill-defined problem, ten multiple-choice questions and three cognitive processing assessment questions.

Data Analysis

Ill-defined Problem

Dependent variable one, the ill-defined problem presented as essay-style question number one, was scored using a researcher-designed rubric on a scale of 0 – 4 (see scoring rubric, Figure 16). Mean scores, standard deviations and difference scores for each part of the ill-defined information literacy question was provided comparing pretest and posttest results. A Cohen's *d* effect size was reported. The guidelines for interpreting Cohen's effect sizes are .2 = small, . .5 = medium and, .8 = large (Cohen, 1988). Based upon these results, the researcher discussed if there was a significant change in scores between the pretest and the posttest with respect to the ill-defined essay style question.

Multiple Choice Questions

Mean scores, standard deviations and difference scores were calculated for the second dependent variable, represented on the assessment as multiple-choice test items 2-11. A Cohen's *d* effect size was reported for the second dependent variable. Based upon these results, the researcher discussed if there was a significant change in scores between the pretest and the posttest.

Cognitive Processing Assessments

Means and standard deviations were calculated with respect to the posttest to address research questions two, three and four**.** In addition, correlations between extraneous processing, essential processing and generative processing are discussed. Separate scaled instruments were used for the three components of cognitive processing being assessed. Based upon these results, the researcher discussed the levels of extraneous, generative and essential processing respectively within the context of this study as well as how these results compared to in relation to recent cognitive processing research (Musallam, 2010; Rourke & Sweller, 2009).

Summary

This study investigated the effects of a multimedia presentation as an instructional method to manage the cognitive processing associated with information literacy instruction at the graduate and undergraduate levels of nursing education. The multimedia presentation was developed by the researcher using instructional design techniques associated with modular worked-out examples and consistent with techniques used in prior studies in the domain of cognitive processing management. Students from one DNP class were the subjects in Experiment 1. Experiment 2 consisted of BSN students from two sections of the same class (Applied Assessment and Nursing Fundamentals Across The Lifespan II: Alterations in Health and Illness). The same instructor taught both sections of the course. Both DNP and BSN groups were convenience samples.

Prior to the treatment, students completed a pretest to assess differences in prior knowledge with respect to information literacy. The treatment consisted of an eight-minute and sixteen-second (8:16) multimedia presentation covering information literacy instruction specific to ‘determining the extent of information needed,’ the first step in developing information literacy skills. The treatment was followed by a posttest. The pretest and posttest for Experiment 1 included the essay-style ill-defined problem and the set of multiple-choice questions. Experiment 2 included the essay-style ill-defined problem, the set of multiple-choice questions, and three questions related to the assessment of cognitive processing.

With respect to the multiple choice questions, mean scores, standard deviations and difference scores was calculated for the pretest and posttest results. With respect to the essay style ill-defined problem, mean scores, standard deviations and difference scores was calculated for the pretest and posttest results. Effect sizes were calculated for both essay-style ill-defined question responses and the multiple-choice set of questions. The format and sequencing of the pretest and posttest questions essay-style questions and multiple-choice questions were identical between the pretest and posttest.

The three cognitive processing questions that were used in Experiment 2 employ identical 9-point scales and are designed to assess generative processing, essential processing and extraneous processing. Results for the cognitive processing questions were analyzed using means and standard deviations. Additionally, correlations were calculated between each of the three types of cognitive processing.

IV. RESULTS

The purpose of this study was to investigate the use of a multimedia presentation as an instructional method to manage the cognitive processing associated with information literacy instruction at the graduate and undergraduate levels of nursing education. The multimedia presentation was designed using instructional design techniques associated with modular worked-out examples, a technique consistent with prior cognitive processing management studies (Paas & van Gog, 2006).

Methodologically, the present descriptive study was divided into two experiments. Experiment 1 examined pretest and posttest differences for graduate-level Doctor of Nursing Practice (DNP) students (*n*=38) with respect to performance differences on an information literacy assessment. Students completed an 11-question pretest, were exposed to a multimedia instructional session that was eight minutes and sixteen-seconds (8:16) in duration, then completed a posttest. Experiment 1 had two dependent variables: 1) student difference scores (pretest and posttest) on a multiple-choice set of questions related to information literacy assessment, and 2) student difference scores (pretest and posttest) on an essay-style set of questions related to information literacy assessment. Experiment 1 had one independent variable: test time with two levels 1) pretest and 2) posttest.

Experiment 2 replicated Experiment 1, as it used the same 11-question information literacy assessment and eight minutes and sixteen-second (8:16) multimedia intervention. Experiment 2 extended upon Experiment 1 by adding three questions designed to assess the three types cognitive processing associated with the multimedia intervention; generative processing, essential processing and extraneous processing. Additionally, Experiment 2 sampled undergraduate nursing (BSN) students (*n*=80).

Both DNP and BSN groups were convenience samples from intact nursing classes from the same mid-size, west coast academic institution. Experiment 2 had five dependent variables: 1) student difference scores (pretest and posttest) on an multiple choice set of questions related to information literacy assessment, 2) student difference scores (pretest and posttest) on an essay-style set of questions related to information literacy assessment, 3) a self-report measure of extraneous processing, 4) a self-report measure of generative processing and, 5) a self-report measure of essential processing, respectively. Experiment 2 had one independent variable, test time with two levels: 1) pretest and 2) posttest.

Experiment 1

Participants in Experiment 1 were Doctor of Nursing Practice (DNP) students. This convenience sample was from an intact class of students in their first year of the DNP program. Statistical analysis was completed using Marley Watkins (2008) software and Microsoft Excel (2011) software.

Research Question One

What is the level of change in nursing students' ability to determine the extent of information needed after a multimedia presentation using modular worked-out examples addressing information literacy (instructional treatment)?

Experiment 1 investigated whether or not there was a difference in student's ability to determine the extent of information needed using a pretest and posttest methodology. Study participants completed an 11-item pretest, were exposed to an eight-minute and sixteen-second (8:16) multimedia intervention (audio combined with slides comprised of text and graphics), then students completed a posttest.

Analysis of the 11-item instrument was separated by dependent variable: 1) student difference scores (pretest and posttest) on an multiple choice set of questions related to information literacy assessment, 2) student difference scores (pretest and posttest) on an essay-style set of questions related to information literacy assessment. Analysis of the first dependent variable focused on questions 2-11 that made up the multiple-choice exam. Correct answers were coded with a score of 1 and incorrect answers were coded with a zero. The maximum raw performance score on questions 2-11 was 10. See Table 1 for students mean scores on the pretest and posttest multiple-choice items.

Table 1

Means, Standard Deviations, and Dependent Samples t-test for Multiple Choice Questions on the Information Literacy Assessment

	Statistic	Pretest (n=38)	Posttest (n=38)	Difference Scores	Cohen's *d* *
Multiple Choice Questions	Mean SD	4.37 1.15	6.08 1.66	1.71 1.59	1.08

* Guidelines for interpreting Cohen's effect sizes are .2 = small, .5 = medium, .8 = large (Cohen, 1988)

The observed Cohen's *d* (1.08) indicates a large effect size (Cohen, 1988) with respect to students ability to solve multiple-choice items related to the first step in information literacy ability, determining the extent of information needed. The correlation between pretest and posttest for the multiple-choice questions revealed a positive relationship (r = .51, $p < .01$).

Analysis of the second dependent variable focused on pretest and posttest scores on an ill-defined problem, wherein students responded to an essay-style question. The essay-style question was designed to assess participants' ability to solve an ill-defined problem related to information literacy, specifically determining the extent of information needed. Students were asked to respond in written form to the following question (pretest): "*You are researching the topic of 'medication errors' for a 20-page research paper and you are unfamiliar with the topic."* This ill-defined problem was followed by three separate questions: 1) *Where would you start your research*? 2) *What kinds of resources would use*? and, 3) *What strategies would you use to decide if they are appropriate for your research paper*? The posttest version of the question substituted 'patient falls' for 'medication errors' in the body of the question. The maximum raw score on this question was 12, with a maximum score of four for each of the three separate questions. See Table 2 for student scores on the pretest and posttest ill-defined problem essay-style question.

Table 2

Means, Standard Deviations, and Dependent Samples t-test for the Ill-Defined Problem Question on the Information Literacy Assessment

	Statistic	Pretest (n=38)	Posttest (n=38)	Difference Scores	Cohen's *d*
Ill-Defined Problem	Mean SD	3.39 .99	4.32 1.15	.92 1.26	0.73*

* Guidelines for interpreting Cohen's effect sizes are .2 = small, .5 = medium, .8 = large (Cohen, 1988).

The observed Cohen's *d* (0.73) indicates a medium effect size (Cohen, 1988) with respect to students' ability to solve an ill-defined problem related to information literacy, specifically determining the extent of information needed. The correlation between pretest and posttest for the ill-defined questions revealed a positive relationship ($r = .31$, $p < .01$).

Experiment 2

Participants in Experiment 2 were Bachelor of Science in Nursing (BSN) students. This convenience sample was from two intact classes of students in their first year of the BSN program. Institutional regulations dictate that undergraduate nursing students do not take nursing classes in their first year of study. Therefore, all of the participants had completed at least one year of general education prior to participating in the present study. Statistical analysis was completed using Marley Watkins (2008) software and Microsoft Excel (2011) software.

Research Question One

What is the level of change in nursing students' ability to determine the extent of information needed after a multimedia presentation using modular worked-out examples addressing information literacy (instructional treatment)?

The first research question investigated whether or not there was a difference in student's ability to determine the extent of information needed between pretest and posttest. Study participants completed an 11-item pretest, were exposed to an eight-minute sixteen-second (8:16) multimedia intervention (audio combined with slides comprised of text and graphics), and then completed a posttest.

Analysis of the 11-item instrument was separated by dependent variable: 1) student difference scores (pretest and posttest) on an multiple choice set of questions related to information literacy assessment, 2) student difference scores (pretest and posttest) on an essay-style set of questions related to information literacy assessment. Analysis of the first dependent variable focused on questions 2-11 wherein questions on the pretest and posttest used a multiple-choice format. Correct answers were coded with a score of 1 and incorrect answers were coded with a zero. The maximum raw performance score on questions 2-11 was 10. See Table 3 for students mean scores on the pretest and posttest multiple-choice items.

Table 3

Means, Standard Deviations, and Dependent Samples t-test for Multiple Choice Questions on the Information Literacy Assessment

	Statistic	Pretest (n=80)	Posttest (n=80)	Difference scores	Cohen's *d*
Multiple Choice Question	Mean	4.60	5.55	.95	4.90*
	SD	1.55	1.82	1.74	

* Guidelines for interpreting Cohen's effect sizes are .2 = small, .5 = medium, .8 = large (Cohen, 1988).

The observed Cohen's *d* (0.55) indicates a medium effect size (Cohen, 1988) with respect to students ability to solve multiple-choice items related to the first step in information literacy ability, determining the extent of information needed. The correlation between pretest and posttest for the multiple-choice questions revealed a positive relationship ($r = .48$, $p < .01$).

Analysis of the second dependent variable focused on pretest and posttest scores on an ill-defined problem, designed to assess participants' ability to solve an ill-defined problem related to information literacy, specifically determining the extent of information needed. Students were asked to respond in written form to the following question (pretest): "*You are researching the topic of 'medication errors' for a 20-page research* *paper and you are unfamiliar with the topic."* This ill-defined problem was followed by three separate questions: 1) *Where would you start your research*? 2) *What kinds of resources would use*?, and 3) *What strategies would you use to decide if they are appropriate for your research paper*? The posttest version of the question substituted 'patient falls' for 'medication errors' in the body of the question. The maximum raw score on this question was 12, with a maximum score of four for each of the three separate questions. See Table 4 for student scores on the pretest and posttest ill-defined problem essay-style question.

Table 4

Means, Standard Deviations, and Dependent Samples t-test for the Ill-Defined Problem Question on the Information Literacy Assessment

	Statistic	Pretest (n=80)	Posttest (n=80)	Difference scores	Cohen's *d*
Ill-Defined Problem	Mean	4.24	4.93	.69	0.67*
	SD	1.12	1.03	1.02	

* Guidelines for interpreting Cohen's effect sizes are .2 = small, .5 = medium, .8 = large (Cohen, 1988)

The observed Cohen's *d* (0.67) indicates a medium effect size (Cohen, 1988) with respect to students ability to solve an ill-defined problem related to information literacy, specifically determining the extent of information needed. The correlation between pretest and posttest for the ill-defined questions revealed a positive relationship ($r = .55$, $p < .01$).

Research Questions Two, Three and Four

2. What is the level of *extraneous processing* for students during the instructional treatment?
3. What is the level of *generative processing* for students during the instructional treatment?
4. What is the level of *essential processing* for students during the instructional treatment?

Experiment 2 built upon Experiment 1 through the addition of three questions designed to assess students' cognitive processing immediately after the multimedia audiobook presentation. The generative processing question (GP) was, *How easy or difficult is it for you to understand information literacy at this time?* The essential processing question (EP) was, *Please rank how much mental effort you used to make sense of the information literacy presentation.* The extraneous processing question (EX) was, *How easy or difficult was it for you to pay attention during the presentation?* These questions were designed in light of prior research (DeLeeuw & Mayer, 2008; Musallam, 2010). Each of the three cognitive processing questions used a similar nine-point scale wherein a response of one indicated low effort or difficulty and a response of nine indicated the highest level of effort or difficulty. See Table 5 for cognitive processing means and standard deviations.

Table 5

*Cognitive Processing Means and Standard Deviations for Generative Processing (GP), Essential Processing (EP) and Extraneous Processing (EX)**

	Statistic	GP	EP	EX
Cognitive Processing Measure	Mean	2.98	3.31	4.55
	SD	1.80	1.76	2.45

* (BSN, n=80)

Each measure of cognitive processing used the same 1-9 scale. As a group, the mean scores on these three variables appear relatively low. The extraneous processing is the highest of the three scores. Comparing the differences between these three variables revealed the following results. There were statistically significant differences between generative processing and extraneous processing, $t(79) = 6.84$, $p < .001$ and between essential processing and extraneous processing was $t(79) = 4.37$, $p < .001$. There was no statistically significant difference between essential processing and generative processing was $t(79) = 1.69$, $p = .09$.

In addition to the dependent-samples *t* tests, Cohen's *d* effect sizes were also calculated. The guidelines for interpreting Cohen's effect sizes are .2 = small, .5 = medium and, .8 = large (Cohen, 1988).

Table 6

*Effect Sizes Between Three Dependent Variables Measuring Cognitive Processing**

Variable	EX	EP	GP
Extraneous Processing (EX)			
Essential Processing (EP)	.49		
Generative Processing (GP)	.77	.19	

* (BSN, n=80)

The effect size between generative processing and extraneous processing effect size as well as between extraneous processing and essential processing were statistically significant. The largest difference was between generative processing and extraneous processing. The comparison of generative processing and essential processing pair was not statistically significant.

Correlations among the three measures of cognitive processing are shown in Table 7**.** The correlation between extraneous processing and essential processing was the lowest of the three measures (r = .31), indicating that there was a low to moderate interaction between participants difficulty paying attention during the multimedia presentation (EX) and the amount of mental effort (EP) reported. The correlation between generative processing (GP) and extraneous processing (EX) was the highest of the three measures (r = .57) and suggests a moderate correlation. The correlation between generative processing (GP) and essential processing (EP) (r = .52) and suggests a moderate correlation between these two components of cognitive processing.

Table 7

*Correlations Among Three Dependent Variables Measuring Cognitive Processing**

Variable	EX	EP	GP
Extraneous Processing (EX)			
Essential Processing (EP)	.31		
Generative Processing (GP)	.57	.52	

*(p < . 01, n= 80)

Ancillary Analysis

One avenue of inquiry was not in the original research questions but appeared worthy of additional exploration. Ancillary analysis was conducted to investigate the items used on the posttest to see if there were any differences in terms of responses. Standard deviations and mean scores for each test item were calculated for posttest results. High scores indicated that students performed well on a posttest assessment item. A review of the posttest scores by Bachelor of Nursing (BSN) and Doctor of Nursing Practice (DNP) revealed the following results.

Table 8

Posttest scores by group for essay-style (EQ) question and multiple-choice questions (MQ1-10)

		EQ	MQ1	MQ2	MQ3	MQ4	MQ5	MQ6	MQ7	MQ8	MQ9	MQ10
DNP *	Mean	0.36	0.47	0.63	0.76	0.89	0.89	0.37	0.89	0.16	0.26	0.74
	SD	1.16	0.51	0.49	0.43	0.31	0.31	0.49	0.31	0.37	0.45	0.45
BSN **	Mean	0.41	0.59	0.75	0.55	0.89	0.88	0.23	0.63	0.19	0.24	0.65
	SD	1.04	0.50	0.44	0.50	0.32	0.33	0.42	0.49	0.39	0.43	0.48

* DNP (Doctor of Nursing Practice, n=38)
** BSN (Bachelor of Science Nursing, n=80)

The first interesting set of results suggests that three items were particularly difficult (MQ8, MQ9, MQ6). An analysis by the present researcher of the wording for MQ8 suggests that it is not particularly difficult nor is the underlying information literacy concept excessively complex. Therefore, it appears reasonable to assume that spending additional time during the treatment on this concept might have been needed. The format for MQ9 was different than the other multiple-choice questions. All of the other multiple choice questions had only one correct answer, while MQ9 asked respondents to select 'all that apply'. In this case it seems reasonable that more explicit question instructions might have been needed and could partially explain the lower scores on this item. Question MQ6 does not appear poorly worded nor is the underlying information literacy concept of primary sources excessively difficult. Therefore, it appears reasonable to assume that spending additional time during the treatment on this concept, or modifying the instructional content such that the concept was more explicit might have been beneficial.

Two posttest items appear to have been particularly easy. Questions MQ4 and MQ5 were both emphasized by receiving slightly more instructional time during the intervention, explaining at least in part these results. Finally, the results from MQ3 and MQ7 illustrate cases where there was over a 20% difference between BND and DNP. One possible explanation for the between-group differences with respect to MQ3 is that DNP students, as seasoned nursing practitioners, are more familiar with databases such as CINAHL than BSN students are. With respect to MQ7, there is nothing obvious about the question content or structure that explains the between group differences. Additional research into these differences would be beneficial. While cases such as these highlight higher, lower and group difference scores, overall between group item score differences appear minor.

Summary of Results

The purpose of this study was to investigate the use of a multimedia presentation as an instructional method to manage the cognitive processing associated with information literacy instruction at the graduate and undergraduate levels of nursing education. The multimedia presentation was designed using techniques associated with modular worked-out examples.

This study was divided into two experiments. Experiment 1 examined pretest, posttest performance differences on an information literacy assessment for graduate-level Doctor of Nursing Practice (DNP) students. Experiment 1 results showed a multiple choice question pretest (M = 4.37, SD = 1.15) to posttest (M = 6.08, SD = 1.66) score increase. The results for DNP students indicated a large effect size (d= 1.08) for the multiple-choice component of the assessment. Earlier studies of learning transfer and worked-out examples found similar results (Paas & Van Merriënboer, 1994). Ill-defined problems typically associated with retention (Rourke & Sweller, 2009) were also investigated. Results from the ill-defined problem component of the assessment indicated a medium effect size (d = 0.73). Responses to the ill-defined problem question showed a similar pattern to the multiple-choice question results, with pretest (*M* = 3.39, *SD* = .99) to posttest (*M* = 4.32, *SD* = 1.15) score increases.

Experiment 2 replicated Experiment 1, insofar as it used the same 11-question information literacy assessment. Experiment 2 sampled undergraduate nursing (BSN) students and results for the multiple choice question pretest (*M* = 4.60, *SD* = 1.55) to posttest (*M* = 5.55, *SD* = 1.82) indicated an increase similar to the DNP group. The results indicated a medium effect size (d= 0.55) for the multiple-choice questions. Earlier studies of learning transfer and worked-out examples found similar results (Paas & Van Merriënboer, 1994). Additionally, ill-defined problems typically associated with retention (Rourke & Sweller, 2009) were investigated. The BSN group results indicated a medium effect size (d = 0.67). The ill-defined problem results showed a similar pattern to the multiple-choice question results, with pretest (*M* = 4.24, *SD* = 1.12) to posttest (*M* = 4.93, *SD* = 1.03) score increases.

Where Experiment 2 built upon Experiment 1 was the addition of three cognitive processing assessment questions. Whereas prior research found a mixture of positive and negative correlations between the three measures of cognitive processing (DeLeeuw & Mayer, 2008), the present study found all three measures to be positively correlated.

Summarizing the results across Experiment 1 and Experiment 2, both BSN and DNP groups' mean scores increased from pretest to posttest on the multiple-choice questions as well as the ill-defined problem. The BSN students pretest scores were higher than DNP students on the multiple-choice questions and the ill-defined problem. However, the magnitude of score increase from pretest to posttest for the BSN group was lower than observed with the DNP group. In addition, the effect size for the BSN group was lower than that of the DNP group. It is important to note that although increases in multiple-choice and ill-defined question scores were observed, these scores were well below the maximum. Overall, low scores on both sets of questions indicate that the BSN and DNP students neither began, nor completed, the study highly proficient with respect to information literacy. The cognitive processing results from the BSN group revealed that the correlation between extraneous processing and essential processing was the lowest of the three correlations, while the remaining correlations were similar.

The results across two experiments involving undergraduate and graduate nursing students indicate that in terms of both multiple-choice and ill-defined problem questions, consistent, positive results were found, all of which were indicated by moderate to large effect sizes. It appears from these results that a brief multimedia presentation can increase students' ability to respond to an ill-defined problem, as well as multiple-choice questions, in an effective manner.

V. DISCUSSION OF RESULTS

The purpose of this study was to investigate the use of a multimedia presentation as an instructional method to manage the cognitive processing associated with information literacy instruction at the graduate and undergraduate levels of nursing education. The multimedia presentation was developed using instructional design techniques associated with modular worked-out examples and was consistent with techniques used in prior studies in the domain of cognitive processing management (Mayer, 2005). This chapter presents a summary and discussion of this study. First, the study is summarized, including a restatement of the research problem. Second, limitations of the study are discussed. Third, findings are discussed and conclusions are made. Fourth, educational and research implications are identified. Finally, a summary of this chapter is presented.

Summary of the Study

Information literacy skills include the ability to determine the extent of information needed, access the needed information effectively and efficiently, evaluate information and its sources critically, incorporate selected information into one's knowledge base and use information effectively to accomplish a specific purpose (ACRL, 2000; 2008). The present study focused on the first step in building information literacy skills, specifically 'determining the extent of information needed.' The theoretical lens through which information literacy skills were presented is discussed in the literature as ill-defined problems (Rourke & Sweller, 2009). Ill-defined problems typically do not have well-defined givens, goals and operators (Rourke & Sweller, 2009). The present study argues that the first step in building information literacy skills, 'determining the extent of information needed' when students are faced with a task such as writing a research paper on an unfamiliar topic, meets the definition of an ill-defined problem. Whereas much of the research supporting cognitive processing theory was developed using well-defined problems (Mayer, 2009; Plass, et al., 2010), there is a limited body of research investigating the relationship between ill-defined problems and the cognitive processing associated with solving them.

Additionally, the research literature suggests that interventions using worked-out examples, and specifically modular worked-out examples, are particularly effective methods for managing cognitive processing with respect to well-defined problems (Scheiter, et al., 2009; Sheiter, et al., 2009). However, in the domain of ill-defined problems, there are no comparable studies that employed a modular worked-out example approach. It appears that building effective information literacy skills, a real-world ill-defined problem, through modular worked-out examples is a potentially fruitful research area. The present study addresses these apparent gaps in the literature. This descriptive study was divided into two experiments and the results from each will be discussed below.

Experiment 1 examined pretest and posttest differences for graduate-level Doctor of Nursing Practice (DNP) students (n=38) with respect to performance differences on an information literacy assessment. Experiment 1 addressed research question one: What is the level of change in nursing students' ability to determine the extent of information needed after a multimedia presentation using modular worked-out examples addressing information literacy (instructional treatment)? Students completed an 11-question pretest, were exposed to a brief multimedia instructional session that was eight minutes and sixteen-seconds (8:16) in duration, and then completed a posttest. Experiment 1 had two dependent variables; 1) student difference scores on a multiple choice set of questions related to information literacy assessment and 2) student difference scores (pretest and posttest) on an essay-style set of questions related to information literacy assessment. Experiment 2 replicated Experiment 1, insofar as it used the same 11-question information literacy assessment and eight minutes and sixteen-second (8:16) multimedia intervention. Both DNP and BSN groups were convenience samples from intact nursing classes from the same mid-size, west coast academic institution.

The first research question regarding information literacy used for both Experiment 1 and Experiment 2 had two dependent variables; 1) student difference scores (pretest and posttest) on a multiple choice set of questions related to information literacy assessment and 2) student difference scores on an essay-style set of questions related to information literacy assessment. Results from the multiple-choice set of questions from the DNP group indicated a large effect ($d = 1.08$). Results from the BSN group indicated a medium effect size ($d = .55$). The correlation between pretest and posttest for the multiple-choice questions revealed a positive relationship ($r = .51$, $p < .01$) with respect to the DNP sample. The correlation between pretest and posttest for the multiple-choice questions revealed a similar relationship ($r = .48$, $p < .01$) to the BSN sample. Results from the ill-defined problem indicate moderate to large effect sizes for both DNP ($d = .73$) and BSN ($d = .67$) for groups. The correlation between pretest and posttest for the ill-defined questions revealed a positive relationship ($r = .31$, $p < .01$) with respect to the BSN sample. The correlation between pretest and posttest for the ill-defined questions revealed a positive relationship ($r = .55$, $p < .01$) with respect to the BNS sample.

Experiment 2 extended upon Experiment 1 by adding three questions designed to generative processing, essential processing and extraneous processing. Experiment 2 had four dependent variables: 1) student difference scores (pretest and posttest) on an information literacy assessment, 2) a self-report measure of extraneous processing, 3) a self-report measure of generative processing and, 4) a self-report measure of essential processing. Experiment 2 sampled undergraduate nursing (BSN) students (*n*=80).

The three cognitive processing questions were asked directly after the multimedia intervention and before the ill-defined problem and multiple-choice questions on the posttest in Experiment 2. Each question used a 9-point scale and asked participants to rate, 1) the difficulty they experienced with the difficulty of the information literacy content of multimedia presentation, 2) the amount of mental effort needed to make sense of the multimedia presentation, and 3) how easy or difficult it was to pay attention during the multimedia presentation. The correlations for each combination of cognitive processing were; .31 for extraneous processing and essential processing; .57 for generative processing and extraneous processing; .52 for essential processing and generative processing. The mean scores for generative processing (2.98) and essential processing (3.31) were lower than expected, given the maximum score for each variable was nine. The relatively higher mean score for extraneous processing (4.55) was also unanticipated. Given that the instructional design was intended to lower extraneous processing and increase generative processing, the overall results for all three variables was unexpected in light of recent research (DeLeeuw & Mayer, 2008; Musallam, 2010).

Limitations

This study was limited by factors related to the sample and the methodology. Generalizing the results to populations beyond first-year nursing students (BSN) and first-year Doctor of Nursing (DNP) students is cautioned as convenience samples were used for both groups. Additionally, the definition of 'first-year' for both BSN and DNP students will vary between colleges and universities, as will the admission requirements for different accredited nursing programs. Although the pretest-posttest methodology used provides control for prior knowledge in this study, the overall educational experience of nursing students will vary between different colleges and universities. Additionally, it should be noted that intervention took place in a naturalistic classroom environment unlike prior lab-based studies (DeLeeuw & Mayer, 2008). Finally, the BSN intervention took place during the midterm examination period for nursing students, a particular stressful time of the semester. These environmental factors may have caused unpredictable results, especially with regard to students' self-reported levels of cognitive processing.

With respect to methodology, while a pilot study was completed, minor changes were made to the instrument after the pilot study. The ill-defined problem prompt for the DNP group was modified slightly for the BSN group. Whereas the DNP group had less than one page to respond to the essay-style questions, the test form for the BSN group was modified to allow more space on a single page for responses. This change to the question prompt may have led to more detailed responses to the ill-defined problem question by the BSN group.

With respect to the first dependent variable, although the multiple-choice questions used on the instrument were developed from previously validated instruments (Beile-O'Neil, 2005; SAILS, 2001), changes were made to the original questions such as modifying questions so they resonated with nursing students. For example, where the original question used terminology that resonated with a political science major, the revised question used nursing terminology. Whereas changing terminology was not intended to alter the underlying information literacy concept, it is conceivable that changes were introduced but not revealed during the pilot validation step. Additionally, a ‘do not know’ response option was added to each multiple-choice question that was not present in the original instruments. With respect to the second dependent variable, the ill-defined problem question was modeled after a single study (Rourke & Sweller, 2009), as there are no known studies that have evaluated information literacy as an ill-defined problem. Although the present study provides an apparently successful framework for developing ill-defined information literacy problems, additional research in this area is needed.

Subjective measures were used to assess the remaining three dependent variables: essential processing, generative processing and extraneous processing respectively. Whereas subjective scale-based questions related to mental effort and difficulty have been frequently used in cognitive processing research, questions remain about the efficacy of this approach to cognitive processing measurement (Brunken, et al., 2003; DeLeeuw & Mayer, 2008). The use of mental effort and difficulty ratings coupled with performance scores to assess essential processing relies heavily on the control of the extraneous and generative processing (Ayres, 2006; Musallam, 2010). Given the additive nature of essential processing, generative processing and extraneous processing, the results from this study, coupled with prior research (Brunken, et al., 2003; Musallam, 2010; Plass, et al., 2010), suggests that additional confirmation of the connections between mental effort ratings and cognitive processing are needed.

The instrument was constructed and modified from multiple sources, thereby introducing a number of additional limitations. The process of creating the instrument used for the present study resulted in a unique instrument, as multiple, independently developed assessment measures were compiled for the present study. While steps were taken to validate the instrument and limited pilot testing was completed, it is unknown if these steps were adequate. From a review of the literature, it would appear that the present study was the first to combine cognitive processing management techniques, information literacy instruction, a multimedia intervention, ill-defined problems and modular worked-out examples. Therefore, it is conceivable that the final instrument might not adequately or accurately measure the intended information literacy constructs or conform to known assessments of cognitive processing. The limited steps taken to pilot test and validate the instrument would benefit from additional research.

Similarly, the use of one item to measure each type of cognitive processing might not be the ideal approach, given the combination of multimedia, information literacy, ill-defined problems and modular worked-out examples. Although the literature supports single items measuring generative, essential and extraneous processing, the scales as well as the test questions would benefit from additional research. Also, the present study did not attempt to measure long-term transfer of information literacy skills. Although the effect sizes (Cohen’s d) reported were medium to large, it is unknown if these results have any long-term effect. Finally, the present study was limited to an assessment of only one component of information literacy. Additional research that also divides the construct into multiple, independently delivered instructional modules would be beneficial.

With respect to the present study, prior research suggests that a score of 57% on the B-TILED information literacy scale constitutes a minimum information literacy competency score (Beile-O'Neil, 2005; Cannon, 2007). As was seen in the present study, this minimum was not met. One possible explanation is that graduate teacher education students receive information literacy instruction more frequently than graduate and undergraduate nursing students. Another possible explanation is that the reduction of the B-TILED on the present study from all five of the ACRL information literacy standards to only the first standard, determining the extent of information needed, creates an instrument that assesses the construct in a unique way. Additional research comparing B-TILED and the present study would be helpful.

Discussion

Although a substantial increase in scores on both multiple-choice problems and the ill-defined problem was observed, there was considerable room for improvement with respect to both groups of students. The increased effects for both BSN and DNP students occurred even though overall scores did not approach test score ceilings for either type of problem. It would be useful to investigate if the continued use of multimedia would result in similar score gains, and therefore radically increase results over a series of information literacy presentations as opposed to a single presentation. For example, an additional intervention where students receive a series of multimedia interventions beginning with ‘determining the extent of information needed’ then followed with a tutorial designed to address the second step in information literacy could lead to similarly large gains in learning. It is conceivable that there could be important additive effects given that medium to large effect sizes were found using a brief, eight-minute multimedia intervention covering only the first part of the total set of information literacy skills.

The medium to large effect sizes found in the present study with respect to traditional multiple-choice questions and the ill-defined problem are consistent with prior research. For example, Mayer (2005) summarized earlier cognitive processing management studies and reported that effect sizes slightly above or below 1.00 are not uncommon. However, it appears from a review of the research literature that few of these earlier focused on ill-defined problems such as information literacy skill development. Recent studies of ill-defined problems did not measure cognitive processing (Rourke & Sweller, 2009). Performance results related to ill-defined problems are additionally important because studies that have used cognitive processing theory as the theoretical basis for instruction reported similar effect sizes (Rourke & Sweller, 2009).

One area where the present study provides unique contributions to the research literature is in the use of information literacy as ill-defined problem instructional content. The between-group differences on the ill-defined problem were expected. DNP students have likely been outside of formal educational systems for an extended period of time, while BSN students were approximately halfway complete with their second consecutive year of college. The higher effect sizes for the DNP group can be partially explained by the assumption that they have had limited recent experience solving problems related to information literacy in an academic setting, suggesting they had more room for gains with respect to information literacy skill development. Prior studies comparing low and high prior-knowledge groups reported similar results (Gerjets, Scheiter, & Catrambone, 2006; Rourke & Sweller, 2009). However, additional research involving information literacy instruction with high-prior knowledge and low-prior knowledge students is needed.

The present study contributes to the research by providing tentative insights into the cognitive processing associated with modular worked-out examples. As was reported in the results from the present study, medium to large effect sizes were found for both BSN and DNP students. Whereas Rourke and Sweller (2009) demonstrated the advantages of worked-examples over problem-solving practice exercises, the present study relied solely on worked-out examples. Furthermore, this study contributes to the research literature by adding the instructional topic of information literacy to what has previously been a body of example-based research in math, science and technology (Mayer, 2005, 2009; Van Gerven, Paas, & Tabbers, 2006; Van Gerven, et al., 2002). Additional research into the efficacy of modular worked-out examples in comparison to other example-based instructional design techniques are needed to confirm these tentative results.

Key findings in this study were the correlations between cognitive processing measurement results. For example, DeLeeuw and Mayer (2008) report correlations of .12 between extraneous processing and essential processing, .13 between extraneous processing and generative processing and .33 between essential processing and generative processing. The present study found a correlation of .31 between extraneous processing and essential processing, .57 between extraneous processing and generative processing and .52 between essential processing and generative processing. While positive results for generative processing and essential processing were similar between the present study and earlier research (DeLeeuw & Mayer, 2008), the relatively high extraneous processing correlation with generative processing (.57) was unexpected. Possible explanations for the differences might be attributable to a number of circumstances. First, the present study took place in a naturalistic environment, not in a laboratory. Second, the BSN students completed the intervention during mid-term examinations. This combination of possible environmental effects could explain why the sample rated extraneous processing as high when compared to prior studies (DeLeeuw & Mayer, 2008; Musallam, 2010).

Research and Educational Implications

The implications of the current study are discussed in two parts. First, research implications are discussed, specifically in the areas of ill-defined problems, modular worked-out examples and subjective measures cognitive processing. Second, educational implications are discussed, specifically the use of multimedia instructional techniques in the domain of information literacy instruction.

Research Implications

The present study suggests that the cognitive processing associated with ill-defined problems can be effectively managed using modular worked-out examples. Whereas one prior study found advantages to the use of examples as a method to teach ill-defined problems in the domain of visual literacy, the Rourke and Sweller (2009) study did not assess cognitive processing. Whereas Rourke and Sweller (2009) identify their instructional design method as 'worked examples', they did not specifically identify modular worked-out examples as their instructional design approach. Additional research into the relationships between worked examples, and specifically modular worked-out examples and cognitive processing are needed. Also, additional research evaluating the relationships between ill-defined problems and cognitive processing is needed.

This study conceptualized information literacy as an ill-defined problem. Additional research is needed to further validate the use of ill-defined problem instructional design techniques as a method to presenting information literacy instruction. Whereas a review of the literature revealed studies that successfully employed the cognitive theory of multimedia learning and studies related to ill-defined problems (Mayer, 2005; Rourke & Sweller, 2009), the information literacy instruction research literature with respect to these proven approaches to instructional design would benefit from additional study. The findings reported in this study appear to be a promising first step.

Results from this study suggest a relationship between modular worked-out examples and cognitive processing. This finding supports prior research involving cognitive processing management and modular worked-out examples (Gerjets, et al., 2004, 2006) noting that this instructional design technique allows students to break down complex problems into smaller, more easily processed pieces that can be conveyed to the leaner separately (Gerjets, et al., 2004). Additionally, results from the present study are consistent with research reporting that modular worked-out examples are an effective cognitive processing management technique (Gerjets, et al., 2004; Van Gerven, et al., 2002; Van Gerven, Paas, Van Merriënboer, et al., 2006; van Merriënboer, et al., 2006). Additional research with regards to the relationships between modular worked-out examples and ill-defined problems and their combined effects on cognitive processing are needed.

Although subjective measures of cognitive processing have been discussed extensively in the literature (Ayres, 2006; DeLeeuw & Mayer, 2008), results from this study reveal correlational differences not observed in prior studies. Specifically, correlations between essential processing, generative processing and extraneous processing were higher than recent studies (DeLeeuw & Mayer, 2008). For example, DeLeeuw and Mayer (2008) report a correlation of .13 ($p < .05$) between generative processing and extraneous processing. Additional investigations of the higher correlation found in the present study between generative processing and extraneous processing (.57) are needed. Furthermore, investigations into the correlations found in the present study with respect to essential processing and generative processing (.52) would benefit from additional research. DeLeeuw and Mayer (2008) report a lower correlation of .33 ($p < .01$) for essential processing and generative processing. The differences between these findings suggest that the use of subjective assessment techniques traditionally used for cognitive processing measurement would benefit from additional research, especially in the context of studying ill-defined problems presented using modular worked-out examples. Finally, additional research regarding the effectiveness of subjective cognitive processing assessment techniques when multimedia interventions are employed, specifically in naturalistic classroom environments, is needed.

Although the effect sizes were medium to large and the treatment times for both experiments were low at just over eight minutes, additional research should be conducted to examine if there is additional room to increase student scores. Students pretest scores were low, and while they increased markedly, the posttest scores were remained low. Additional research should be conducted to assess the extent to which these apparent advantages of using brief multimedia presentations, modular worked-out examples in conjunction with ill-defined problems might have even greater potential to deliver information literary instruction. It is possible that while practical, brief multimedia pretentions with information literacy as the instructional content are not an optimal combination.

Building upon the present study, one potential way to improve multimedia information literacy instruction might include increasing the duration of the intervention. Although there are practical advantages to brief interventions, the present study revealed approximately a one-point increase in scores from pretest to posttest. While the score gains pretest to posttest was substantial, both sets of scores on the overall scale of 1-10 were low at both points. Perhaps increasing the duration of the intervention might increase test score gains. Additionally, the modification of the instrument to allow for student interaction with the presentation (e.g. self-paced instruction) might have positive effects on student learning.

Educational Implications

Information literacy has been identified as a complex topic for students to learn (Eisenberg, et al., 2004; Jacobson & Xu, 2004). The educational implications presented here are appropriate for librarians and faculty who provide information literacy instruction at the graduate and undergraduate school levels and are related to modular worked-out examples and the use of multimedia.

The first educational implication suggests the use of modular worked-out examples as an effective way to present information literacy instruction. Modular worked-out examples break down complex problems into a logical progression of more easily solved sub-problems, thereby requiring learners to keep fewer problem solution elements in working memory (Gerjets, et al., 2006; Sheiter, et al., 2009). Research suggests that optimally balancing essential processing, generative processing and extraneous processing can be achieved using a modular worked-out example approach to instructional design. Furthermore, a modular worked-out example approach can lead to increases in generative processing (Gerjets, et al., 2004). Results from the present study suggest that using a modular worked-out example method of instructional design has the potential to successfully manage cognitive processing and increases student performance.

The second educational implication involves the use of multimedia presentations for delivering information literacy instruction. Multimedia instruction provides a number of advantages over other instructional formats and offers instructional designers unique opportunities not necessarily found in traditional instruction (Clark & Mayer, 2003). For example, both the instructor and the learner can reuse a multimedia instructional module. Assuming the necessary equipment is in place (e.g. a computer is available or the student has a smartphone) the learning module can be reused at a time and place convenient to the learner, or can be inserted into a course as needed by the instructor. A second possibility afforded to the instructional designer with respect to multimedia is the ability to standardize instruction. In this scenario the instructor creates one standardized instructional module that can be delivered with exactly the same content, formatting and sequencing for all learners. Multimedia learning modules such as the one developed for the present study offer instructional consistency with respect to content, flexibility in terms of delivery by faculty and, viewing and reviewing complex instruction by students. The cognitive benefits of delivering instruction using the principals of multimedia learning have been shown to optimize individuals working memory during learning (Mayer, 2005, 2009). Furthermore, the present study confirms the benefits of using multimedia instructional modules designed for nursing students in a naturalistic classroom environment can be effective.

Healthcare and nursing informatics with respect to information literacy is an emerging area of research represents the third educational implication. Although effective evidence-based nursing practice requires the practitioner to be adept at information literacy skills, these same skills have not been consistently integrated into nursing education at the graduate or undergraduate levels. Recent research notes that “nursing educational programs, organizations, and hospitals must dedicate resources to improve the nurses’ ability to access and define practice problems, search and evaluate the evidence available, and integrate it into their practice” (Ross, 2010, p. 70). Additionally, researchers note that one of the primary barriers to nurses using information resources such as databases typically provided by academic libraries is a lack of time when on the job or in the classroom (Pravikoff, et al., 2005; Ross, 2010). One way to address these concerns and barriers is through the use of brief multimedia information literacy instructional modules such as the one developed for the present study. Evidence-based practice for nurses’ requires information literacy skills. Brief multimedia instructional modules developed in light of the most recent cognitive processing management literature provide a promising initial step in addressing the needs of evidence-based nursing instruction.

Summary

The purpose of this study was to investigate the use of a multimedia presentation as an instructional method to manage the cognitive processing associated with information literacy instruction at the graduate and undergraduate levels of nursing education. The present study supports a number of research agendas in the areas of ill-defined problems, modular worked-out examples, cognitive processing management methods, and subjective methods for measuring cognitive processing (Brunken, et al., 2003; DeLeeuw & Mayer, 2008; Gerjets, et al., 2004; Rourke & Sweller, 2009). This study adds to the research by combining ill-defined problems, modular worked-out examples and cognitive processing management with the field of information literacy instruction into a single study. Heretofore, information literacy instruction has not benefited from analysis from the perspective of the cognitive theory of multimedia learning (Mayer, 2005). Additionally, this study provides additional support to recent studies addressing the efficacy multimedia instruction in the classroom (Mayer, 2005; Musallam, 2010).

Results from this study showed positive pretest-posttest changes in Experiment 1 (DNP) and Experiment 2 (BSN) with respect to students ability to 'determine the extent of information needed' as the skill relates to information literacy. Results from the ill-defined problem indicate moderate to large effect sizes for both DNP (d = .73) and BSN (d = .67) groups. The results from the multiple-choice set of questions for the DNP group indicated a large effect (d = 1.08) and the BSN group indicated a medium effect size (d = .55).

Additional research with respect to ill-defined problems and their relationship to cognitive processing management techniques should be conducted. Specifically, research related to maximizing essential processing during ill-defined problem solving is needed. Whereas modular worked-out examples have been extensively studied in the domains of science, mathematics, and technology, additional research into their efficacy with respect to ill-defined problems is needed. Finally, with respect to research implications, additional research into the use of subjective measures of cognitive processing with ill-defined problem solving should be conducted.

The educational implications of the present study include a call for additional research into the relationship of information literacy instruction conceptualized as ill-defined problems. Although the information literacy research strongly suggests that problems such as 'determining the extent of information needed' are complex (Eisenberg, et al., 2004; Jacobson & Xu, 2004), additional research into the complexity of information literacy, specifically from a cognitive processing perspective, is needed. The application of modular worked-out examples as a method for delivering information literacy instruction would benefit from additional research. While modular worked-out examples have been shown to have advantages in science, mathematics and technology, a review of the literature revealed no prior research combining this instructional design technique with information literacy instruction. Finally, the use of multimedia presentations as a method to manage cognitive processing, especially in naturalistic classroom settings, would benefit from additional research. Although recent studies within the instructional domain of chemistry have investigated the use of multimedia designed to manage cognitive processing (Musallam, 2010), additional research in the area of information literacy is needed.

REFERENCES

AACN. (2012). Essentials Series. Retrieved January 11, 2012, from http://www.aacn.nche.edu/education-resources/essential-series

ACRL. (2000). Information Literacy Competency Standards for Higher Education. Retrieved February 2, 2009, from http://www.ala.org/ala/mgrps/divs/acrl/standards/informationliteracycompetency.cfm

ACRL. (2004a). *Academic library trends and statistics for Carnegie classification. Doctoral-granting institutions* (No. 1547-9013). Chicago: Association of College and Research Libraries.

ACRL. (2004b). *Academic library trends and statistics for Carnegie classification. Master's colleges and universities, baccalaureate colleges* (No. 1544-4481). Chicago: Association of College and Research Libraries.

ACRL. (2008). Association of College and Research Libraries Information Literacy Toolkit, The Standards: Step-by-Step. Retrieved November 11, 2010, from http://ala.org/ala/mgrps/divs/acrl/issues/infolit/standards/steps/index.cfm

ALA. (1989). *Presidential committee on information literacy: Final report*. Chicago.

Ashley, K., Chi, M., Pinkus, R., & Moore, J. (2000). Modeling learning to reason with cases in engineering ethics: A test domain for intelligent assistance: National Science Foundation (granting agency).

Atkinson, R., Catrambone, R., & Merrill, M. (2003). Aiding transfer in statistics: Examining the use of conceptually oriented equations and elaborations during subgoal learning *Journal of Educational Psychology, 95*, 762-773.

Atkinson, R., Derry, S., Renkl, A., & Wortham, D. (2000). Learning from examples: instructional principles from the worked examples research. *Educational Research, 70*, 181-214.

Ayres, P. (2006). Impact of reducing intrinsic cognitive load on learning in a mathematical domain. *Applied Cognitive Psychology, 20*, 287-298.

Baddeley, A. D. (1986). *Working memory*. Oxford: Oxford University Press.

Baddeley, A. D. (1992). Working memory. *Science, 255*(5044), 556-559.

Baddeley, A. D. (2007). *Working memory, thought, and action*. New York: Oxford University Press.

Beile-O'Neil, P. (2005). *Development and validation of the Beile test of information literacy for education (B-TILED).* (Doctoral Dissertation, University of Central Florida, 2005). Retreived from ProQuest Dissertations and Theses (AAT 1016019641).

Bloom, B. S. (1956). *Taxonomy of educational objectives: The classification of educational goals* (1st ed.). New York,: Longmans, Green.

Borg, G., Bratfisch, O., & Dorni'c, S. (1971). On the problems of perceived difficulty. *Scandinavian Journal of Psychology, 12*, 249–260.

Bramley, G. (1969). *A history of library education*. Hamden, CT.: Archon Books.

Brunken, R., Plass, J., & Leutner, D. (2003). Direct measurement of cognitive load in multimedia learning. *Educational Psychologist, 53*, 53-61.

Burkhardt, J. (2007). Assessing library skills: A first step to information literacy. *portal: Libraries and the Academy, 7*(1), 25-40.

Cannon, T. H. (2007). *Closing the digital divide: An assessment of urban graduate teacher education students' knowledge of information literacy and their readiness to integrate information literacy into their teaching.* (Doctoral Dissertation, University of San Francisco, 2007).

Carlson, R., Chandler, P., & Sweller, J. (2003). Learning and understanding science instructional material. *Journal of Educational Psychology, 95*(3), 629-640.

Carty, B., & Rosenfeld, P. (1998). From computer technology to information technology. Findings from a national study of nursing education. *Computers in Nursing 16*, 259-265.

Catrambone, R. (1994). Improving examples to improve tranfer to novel problems. *Memory and Cognition, 22*, 606-615.

Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction, 8*(4), 293-332.

Chandler, P., & Sweller, J. (1996). Cognitive load while learning to use a computer program. *Applied Cognitive Psychology, 10*(2), 151-170.

Chism, L. A. (2010). *The doctor of nursing practice: A guidebook for role development and professional issues*. Sudbury, Mass.: Jones and Bartlett Publishers.

Clark, L. A., & Watson, D. (1995). Constructing validity: Basic issues in objective scale development. *Psychological Assessment, 7*(3), 309-319.

Clark, R., & Mayer, R. (2003). *E-Learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning* (1st ed.). San Francisco: Jossey-Bass/Pfeiffer.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, N.J.: L. Erlbaum Associates.

Cook, D., & Cooper, N. (2006). *Teaching information literacy skills to social sciences students and practitioners: A casebook of applications*. Chicago: Association of College and Research Libraries.

Corono, L. (Ed.). (2001). *Education across a century: The centenial volume*. Chicago: National Society for the Study of Education.

Courey, T., Benson-Soros, J., Deemer, K., & Zeller, R. A. (2006). The Missing Link: Information Literacy and Evidence-Based Practice as a New Challenge for Nurse Educators. *Nursing Education Perspectives, 27*(6), 320-323.

Cox, C. N., & Lindsay, E. B. (2008). *Information literacy instruction handbook*. Chicago: Association of College and Research Libraries.

Creswell, J. W. (2003). *Research design: Qualitative, quantitative, and mixed method approaches* (2nd ed.). Thousand Oaks, CA.: Sage Publications.

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior, 19*(4), 450-466.

DeFranco, F. M., & Bleiler, R. (2003). *Evaluating library instruction*. Washington, D.C.: Assoc. of Research Libraries, Office of Leadership and Management Services.

DeLeeuw, K., & Mayer, R. E. (2008). A comparison of three measures of cognitive load: Evidence for separable measures of intrinsic, extraneous, and germane load *Journal of Educational Psychology, 100*, 223-234.

Detlor, B., Julien, H., Willson, R., Serenko, A., & Lavallee, M. (2011). Learning outcomes of information literacy instruction at business schools. *Journal of the American Society for Information Science & Technology, 62*(3), 572-585.

Dick, W., Carey, L., & Carey, J. O. (2005). *The systematic design of instruction* (6th ed.). Boston: Pearson/Allyn & Bacon.

Dick, W., Carey, L., & Carey, J. O. (2009). *The systematic design of instruction* (7th ed.). Upper Saddle River, NJ: Pearson/Merrill Publishers.

Donaldson, K. (2000). Library research success: Designing an online tutorial to teach information literacy skills to first-year students. *The Internet and Higher Education, 2*, 237-251.

Eisenberg, M., Lowe, C. A., & Spitzer, K. L. (2004). *Information literacy: Essential skills for the information age* (2nd ed.). Westport, CT.: Libraries Unlimited.

Englebardt, S. P., & Nelson, R. (2002). *Health care informatics: An interdisciplinary approach*. St. Louis, Mo.: Mosby.

Farber, E. (1999). College libraries and the teaching/learning process: A 25-year reflection. *The Journal of Academic Librarianship, 25*(3), 171-177.

Farmer, L. S. J., & Henri, J. (2008). *Information literacy assessment in K-12 settings*. Lanham, MD.: Scarecrow Press.

Fishman, J. A., & Galguera, T. (2003). *Introduction to test construction in the social and behavioral sciences: A practical guide*. Lanham, MD: Rowman & Littlefield Publishers.

Gerjets, P., Scheiter, K., & Catrambone, R. (2004). Designing instructional examples to reduce intrinsic cognitive load: Molar versus modular presentation of solution procedures. *Instructional Science, 32*, 33-58.

Gerjets, P., Scheiter, K., & Catrambone, R. (2006). Can learning from molar and modular worked examples be enhanced by providing instructional explanations and prompting self-explanations. *Learning and Instruction, 16*, 104-121.

Gins, P. (2005). Meta-analysis of the modality effect. *Learning and Instruction, 15*, 313-331.

Grant, M. J., & Brettle, A. J. (2006). Developing and evaluating an interactive information skills tutorial. *Health Information & Libraries Journal, 23*(2), 79-88.

Graves, J., & Corcoran, S. (1989). The study of nursing informatics. *Journal of Nursing Scholarship, 21*, 227-231.

Guenther, J. (2006). Mapping the literature of nursing informatics. *Journal of the Medical Library Association, 94*, 92-98.

Hambleton, R. K., Swaminathan, H., & Rogers, H. J. (1991). *Fundamentals of item response theory*. Newbury Park, CA.: Sage Publications.

Hart, S., & Staveland, L. (Eds.). (1988). *Development of experimental and theoretical research*. Amsterdam: North Holland.

HRSA. (2010). *The registered nurse population: Findings from the 2008 national sample survey of registered nurses* U.S. Department of Health and Human Services Health Resources and Services Administration.

Information literacy rubric. (2006). Retrieved May 1, 2010, from http://www.stjohns.edu/academics/libraries/services/is

Jacobs, S., Rosenfeld, P., & Haber, J. (2003). Information literacy as the foundation for evidence-based practice in graduate nursing education: a curriculum-integrated approach. *Journal of Professional Nursing, 19*, 320-328.

Jacobson, T., & Mark, B. (2000). Separating wheat from chaff: Helping first-year students become information savvy. *The Journal of General Education, 49*, 256-278.

Jacobson, T., & Xu, L. (2004). *Motivating students in information literacy classes*. New York: Neal-Schuman Publishers.

Kalyuga, S. (2007). Enhancing instructional efficiency in interactive e-learning environments: A cognative load perspective. *Educational Psycholgy Review, 19*(37), 387-399.

Kalyuga, S. (2009a). Knowledge Elaboration: A cognative load perspective. *Learning and Instruction, 19*, 402-410.

Kalyuga, S. (2009b). *Managing cognitive load in adaptive multimedia learning*. Hershey, PA: Information Science Reference.

Kalyuga, S., Chandler, P., Tuovinen, J., & Sweller, J. (2001). When problem solving is superior to studying worked examples. *Journal of Educational Psychology*, 579-588.

Kirschner, P. A. (2009). Cognitive load theory: Implications of cognitive load theory on the design of learning. *Learning and Instruction, 12*, 1-10.

Kitchener, K. (1983). Cognition, metacognition, and epistemic cognition: A three-level model of cognitive processing. *Human Development, 4*, 222-232.

Knaus, K. J., Murphy, K. L., & Holme, T. A. (2009). Designing chemistry practice exams for enhanced benefits: An instrument for comparing performance and mental effort measures. *Journal of Chemical Education, 86*, 827-830.

Ku, Y.-L., Sheu, S., & Kuo, S.-M. (2007). Efficacy of Integrating Information Literacy Education Into a Women's Health Course on Information Literacy for RN-BSN Students. *Journal of Nursing Research, 15*(1), 67-77.

Luchins, A., & Luchins, E. (1991). Task complexity and order effects in computer presentation of water jug problems. *Journal of General Psychology, 118*, 45-72.

Mayer, R. E. (1981). Frequency norms and structural analysis of algebra story problems into families, categories, and templates. *Instructional Science, 10*, 135-175.

Mayer, R. E. (2001). *Multimedia Learning*. New York: Cambridge University Press.

Mayer, R. E. (2005). *The Cambridge handbook of multimedia learning*. New York: Cambridge University Press.

Mayer, R. E. (2008). Applying the science of learning: Evidence-based principles for the design of multimedia instruction. *American Psychologist, 63*(8), 760-769.

Mayer, R. E. (2009). *Multimedia learning* (2nd ed.). Cambridge ; New York: Cambridge University Press.

Mayer, R. E., & Chandler, P. (2001). When learning is just a click away: Does simple user interaction foster deeper understanding of multimedia messages? *Journal of Educational Psychology, 94*(2), 390-397.

Mayer, R. E., Dow, G., & Mayer, S. (2003). Multimedia learning in an interactive self-explaining environment: What works in the design of agent-based microworlds. *Journal of Educational Psychology, 95*, 806-813.

Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitve load in multimedia learing. *Educational Psychologist, 38*(1), 43-53.

Mayer, R. E., & Moreno, R. (2007). Interactive multimodal learning environments *Educational Psychology Review, 19*(9), 309-326.

Meyer, K., Hunt, S., Hopper, M., Thakkar, K., Tsoubakopoulos, V., & Van Hoose, K. (2008). Assessing information literacy instruction in the basic communications course. *Communication Teacher, 22*, 22-34.

Microsoft. (2011). Excel. Redmond WA: Microsoft.

Moreno, R., & Mayer, R. E. (2000). Engaging students in active learning: The case for personalized multimedia messages *Journal of Educational Psychology, 92*(4), 724-733.

Mousavi, Y., Low, R., & Sweller, J. (1995). Reducing cognitive load by mixing auditory and visual presentation modes. *Journal of Educational Psychology, 87*.

Musallam, R. (2010). *The effects of using screencasting as a multimedia pre-training tool to manage intrinsic cognitive load of chemical equilibrium in instruction for advanced high school chemestry students.* (Doctoral Dissertation, University of San Francisco. 2010) Retreived from PorQuest Dissertations and Theses (AAT 3416991).

Neely, T. Y. (2006a). *Information literacy assessment: Standards-based tools and assignments*. Chicago: American Library Association.

Neely, T. Y. (2006b). *Information literacy assessment: Standards-based tools and assignments*. Chicago: American Library Association.

O'Connor, L. G., Radcliff, C. J., & Gedeon, J. A. (2002). Applying systems design and item response theory to the problem of measuring information literacy skills. *College & Research Libraries, 63*(6), 528-543.

Paas, F. (1992). Training strategies for attaining transfer of problem-solving skills in statistics: A cogntive load approach. *Journal of Educational Psychology, 38*, 429-434.

Paas, F., Camp, G., & Rikers, R. (2001). Instructional compensation for age-related cognitive declines: Effects of goal specificity in maze learning. *Journal of Educational Psychology, 93*, 181-186.

Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive load theory and instructional design: Recent developments. *Educational Psychologist, 38*, 1-4.

Paas, F., Tuovinen, J., Tabbers, H., & Van Gerven, P. (2003). Cognitive load measurement as a means to advance cognitive load theory. *Educational Psychologist, 38*, 63-71.

Paas, F., & van Gog, T. (2006). Optimising worked-example instruction: Different ways to increase germane cognitive load. *Learning and Instruction, 19*, 185-199.

Paas, F., & Van Merriënboer, J. (1993). The efficiency of instructional conditions: An approach to combine mental effort and performance measures *Human Factors, 35*, 737-743.

Paas, F., & Van Merriënboer, J. (1994). Variability of worked examples and transfer of geometrical problem-solving skills: A cognitive-load approach. *Journal of Educational Psychology, 86*(1), 122-133.

Paivio, A. (1986). *Mental representations: A dual coding approach*. New York: Oxford University Press.

Pettersson, R. (2002). *Information design: An introduction*. Amsterdam: John Benjamins Publishing Company.

Pettersson, R. (2009). Visual literacy and message design. *TechTrends: Linking Research and Practice to Improve Learning, 53*, 38-40.

Plass, J. L., Moreno, R., & Brünken, R. (2010). *Cognitive load theory*. New York: Cambridge University Press.

Polit, D., & Beck, C. (2008). *Nursing research: Generating and assessing evidence for nursing practice*. Philadelphia: Lippincott.

Pravikoff, D. S., Tanner, A. B., & Pierce, S. T. (2005). Readiness of U.S. Nurses for Evidence-Based Practice: Many don't understand or value research and have had little or no training to help them find evidence on which to base their practice. *AJN The American Journal of Nursing, 105*(9), 40-51.

Prion, S., & Mitchell, M. (2007a). *Audiobooks for meaningful learning.* Paper presented at the Proceedings of E-Learn 2007 World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education, Quebec City, Canada.

Prion, S., & Mitchell, M. (2007b). *Just-in-time audio for effective student learning.* Paper presented at the Proceedings of the Ed Media World Conference on Educational Multimedia, Hypermedia & Telecommunications, Vancouver, Canada.

Prion, S., & Mitchell, M. (2008). *Audiobooks and cognitive load.* Paper presented at the Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education, Chesapeake, VA.

Quilici, J., & Mayer, R. E. (1996). Role of examples in how students learn to categorize statistics word problems. *Journal of Educational Psychology, 88*, 144-161.

Reed, S. K. (1999). *Word problems: Research and curriculum reform*. Mahwah, N.J.: Lawrence Erlbaum Associates.

Reisslein, J., Atkinson, R., Seeling, P., & Reisslein, M. (2006). Encountering the expertise reversal effect with a computer-based environment on electrical circuit analysis. *Learning and Instruction, 16*, 92-103.

Renkl, A. (1997). Learning from worked-out examples: A study on individual differences. *Cognitive Science, 12*, 529-556.

Rikers, R., Van Gerven, P., & Schmidt, H. (2004). Cognitive load theory as a tool for expertise development. *Instructional Science, 32*, 173-182.

Rockman, I. F. (2004). *Integrating information literacy into the higher education curriculum: Practical models for transformation*. San Francisco: Jossey-Bass.

Rosenberg, W. M., Deeks, J., Lusher, A., Snowball, R., Dooley, G., & Sackett, D. (1998). Improving searching skills and evidence retrieval. *Journal of the Royal College of Physicians of London, 32*(6), 557-563.

Ross, J. (2010). Information Literacy for Evidence-Based Practice in Perianesthesia Nurses: Readiness for Evidence-Based Practice. *Journal of PeriAnesthesia Nursing, 25*(2), 64-70.

Rourke, A., & Sweller, J. (2009). The worked-example effect using ill-defined problems: Learning to recognise designers' styles. *Learning and Instruction, 19*, 185-199.

Ruggenberg, S. (2008). *The effect of simulated clinical experience on knowledge, near transfer, and far transfer in nursing education.* (Doctoal Dissertation). University of San Francisco, San Francisco.

Rumble, J., & Noe, N. (2009). Project SAILS: Launching Information Literacy Assessment Across University Waters. *Technical Services Quarterly, 26*(4), 287-298.

Saba, V. K., & McCormick, K. A. (2011). *Essentials of nursing informatics* (5th ed.). New York: McGraw-Hill Medical.

SAILS. (2001). Project Sails: Project for the standardized assesment of information literacy skills. Retrieved August 22, 2010, from https://http://www.projectsails.org/sails/aboutSAILS.php?page=aboutSAILS

Salden, R., Paas, F., & Van Merriënboer, J. (2006a). A comparison of approaches to learning task selection in the training of complex cognitive skills. *Computers in Human Behavior, 22*, 321-333.

Salden, R., Paas, F., & Van Merriënboer, J. (2006b). Personalized adaptive task selection in air traffic control: Effects on traning efficiency and transfer. *Learning and Instruction, 16*, 350-362.

Scharf, D., Elliot, N., Huey, H., Briller, V., & Joshi, K. (2007). Direct assessment of information literacy using writing portfolios. *Journal of Academic Librarianship, 44*(4), 462-478.

Scheiter, K., Gerjets, P., Vollman, B., & Catrambone, R. (2009). The impact of learner characteristics on information utilization strategies, cognitive load experienced, and performance in hypermedia learning. *Learning and Instruction, 19*, 387-401.

Schraw, G. J., Dunkle, M., & Bendixen, L. (1995). Cognitive processes in well-defined and ill-defined problem solving. *Applied Cognitive Psychology, 9*, 523-538.

Schunn, C., McGregor, M., & Saner, L. (2005). Expertise in ill-defined problem-solving domains as effective strategy use. *Memory and Cognition, 33*, 1377-1387.

Sheiter, K., Gerjets, P., Vollman, B., & Catrambone, R. (2009). The impact of leaner characteristics on infomation utilization strategies, cognitive load expereienced, and performance in hypermedia learning. *Learning and Instruction, 19*, 387-401.

Shorten, A., Wallace, C., & Crookes, P. A. (2001). Developing information literacy: A key to evidence-based nursing. *International Nursing Review, 48*(2), 86-92.

Smith, P. L., & Ragan, T. J. (2005). *Instructional design* (3rd ed.). Hoboken, NJ: J. Wiley & Sons.

Stark, R., Mandl, H., Gruber, H., & Renkl, A. (2002). Conditions and effects of example elaboration. *Learning and Instruction, 21*, 39-60.

Swaak, J., & de Jong, T. (2001). Discovery simulations and the assessment of intuitive knowledge. *Journal of Computer Assisted Learning, 17*, 284-294.

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and Instruction, 4*(4), 295-312.

Sweller, J. (1999). *Instructional design in technical areas*. Melbourne: Australian Council for Educational.

Sweller, J. (2010). Element interactivity and intrinsic, extraneous, and germane cognitive load. *Educational Psycholgy Review, 22*, 123-138.

Sweller, J., & Chandler, P. (1994). Why some material is difficult to learn. *Cognition and Instruction, 12*, 185-233.

Sweller, J., van Merriënboer, J., & Paas, F. (1998a). Cognitive architecture and instructional design *Educational Psychology Review, 10*(3), 251-296.

Sweller, J., van Merriënboer, J., & Paas, F. (1998b). Cognitive architecture and instructional design. *Educational Psychology Review, 10*(3), 251-297.

Tauroza, S., & Desmond, A. (1990). Speech rates in British English. *Applied Linguistics, 11*, 90-105.

Thede, L. Q., & Sewell, J. P. (2010). *Informatics and nursing: Competencies & applications* (3rd ed.). Philadelphia: Wolters Kluwer.

Thompson, H. A. (2007). *Sailing into the future: Charting our destiny: Proceedings of the Thirteenth National Conference of the Association of College and Research Libraries, March 29-April 1, 2007, Baltimore, Maryland*. Chicago: Association of College and Research Libraries.

Tindall-Ford, S., Chandler, P., & Sweller, J. (1997). When two sensory modes are better than one. *Journal of Experimental Psychology: Applied, 3*(4), 257-287.

Tucker, M. (1980). User education in academic libraries: A century in retrospect. *Library Trends, 21*(1), 9-27.

Uribe, D., Klein, J., & Sullivan, H. (2003). The effect of computer-mediated collaborative learning on solving iII-defined problems *Educational Technology Research and Development, 51*, 5-19.

Van Gerven, P., Paas, F., & Tabbers, H. (2006). Cognitive aging and computer-based instructional design: Where do we go from here? *Educational Psycholgy Review, 18*, 141-157.

Van Gerven, P., Paas, F., Van Merriënboer, J., & Schmidt, H. (2002). Cognitive load theory and aging: Effects of worked examples on training efficiency. *Learning and Instruction, 12*, 87-105.

Van Gerven, P., Paas, F., Van Merriënboer, J., & Schmidt, H. (2006). Modality and variability as factors in training the elderly. *Applied Cognitive Psychology, 20*, 311-320.

van Merriënboer, J., Kester, L., & Paas, F. (2006). Teaching complex rather than simple tasks: Balancing intrinsic and germane load to enhance transfer of learning. *Applied Cognitive Psychology, 20*, 343-352.

van Merriënboer, J., Kirschner, P. A., & Kester, L. (2003). Taking the load off a learner's mind: Instructional design for complex learning. *Educational Psychologist, 38*(1), 5-13.

van Merriënboer, J., Schuurman, J., De Croock, M., & Paas, F. (2002). Redirecting learners' attention durring traning: Effects on cognitive load, transfer performance and training efficiency. *Learning and Instruction, 12*, 11-37.

van Merriënboer, J., & Sweller, J. (2005). Cognitie load theory and complex learning: Recent developments and future directions. *Educational Psycholgy Review, 17*(2), 147-177.

Vogt, W. P. (2005). *Dictionary of statistics and methodology: A nontechnical guide for the social sciences* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Watkins, M. (2008). Simple t. Retrieved October 1, 2011, from http://edpsychassociates.com/Watkins3.html

Westelinck, K., Valcke, M., De Craene, B., & Kirschner, P. (2005). Multimedia learning in social sciences: Limitations of external graphical representations. *Computers in Human Behavior, 21*, 555-573.

Wittrock, M. (1990). Generative processes of comprehension. *Educational Psychologist, 24*(4), 345-375.

Wright, B. D., & Stone, M. H. (1979). *Best test design*. Chicago: Mesa Press.

APPENDIX A: Content Expert Rating Sheet

Content Expert Rating Sheet

The questions on this sheet are intended for a dissertation pretest and posttest. The pretest and posttest questions have different surface features (e.g. the terminology or background is different between the pre and posttest, but the ACRL information literacy standard assessed is the same).

Four areas are being measured (ACRL Information Literacy Standard 1 – Determine the extent of information needed):

- **Defines and articulates information needs.**
- **Identifies types and formats of information needed**
- **Weighs costs and benefits of information**
- **Reevaluates information needed**

Three item types are provided.

- Standard multiple-choice items with four possible responses, and one best choice (question 2-10)
- Multiple-choice items with four responses (question #11)
- Open-ended question: the respondent will have 5 minutes to write a response (question #1)

A copy of the full instrument has also been provided – you are welcome to mark it up if corrections are suggested. Please return both the rating sheets and the full instrument to Shawn P. Calhoun (707-965-2862, calhouns@usfca.edu). Thank you.

Instructions for content experts:
Please select the best answer to the following questions, supplementing your answer with comments as you deem necessary. If you have any questions about the rating sheets, please contact Shawn P. Calhoun (707-965-2862, calhouns@usfca.edu) immediately.

Your professor has assigned a paper on alternative women's health therapies. You are not familiar with the topic, so you decide to read a brief history and summary about it. Which of the following sources would be best?

a. A book on the topic, such as *Perspectives on alternative women's health therapies: A case study*

b. A general encyclopedia, such as *Encyclopedia of Medicine*

c. An article on the topic, such as *"Alternative women's health therapies in the clinic: A student nurse's perspective."*

d. An Nursing encyclopedia, such as *Encyclopedia of Nursing*

1.	Does the question clearly relate to **one or more** of the four areas being measured? (**question #1 only**) Comment:	☐Yes ☐No
1a.	Does the question clearly relate to **one** the four areas being measured? (**question #2-11**) Comment:	☐Yes ☐No
2.	In which areas does it fit best? (**question 1 only**) ☐ Defines and articulates information needs. ☐ Identifies types and formats of information needed ☐ Weighs costs and benefits of information ☐ Reevaluates information needed Comment:	
2a.	In which single area does it fit best? (**questions 2-11**) ☐ Defines and articulates information needs. ☐ Identifies types and formats of information needed ☐ Weighs costs and benefits of information ☐ Reevaluates information needed Comment:	
3	Is the intent of the question clear? Comment:	☐Yes ☐No

4.	Is the language of the question clear and unambiguous? Comment:	☐Yes ☐No
5.	Is the question clear and unambiguous in its content? Comment:	☐Yes ☐No
6.	Is there only one correct answer? Comment:	☐Yes ☐No
7.	Is the question written at an appropriate level for graduate nursing students? Comment:	☐Yes ☐No
8.	Is the format of the question (e.g. use of terms, specific situation cited, grammar) clear and understandable? Comment:	☐Yes ☐No
9.	Do you suggest a change in format? Comment:	☐Yes ☐No
10.	Within the domain of information literacy instruction and, based on your experience, is please rate the proposed question on a scale from easy (1) to extremely difficult (10)?	1-10

APPENDIX B: Information Literacy Assessment Items

DNP Pretest

PRE-Assessment

Name____________________

Date_____________________

Question #1:

This is a timed question. You will have 5 minutes to complete your answer. There are 3 parts to this question.

You are researching the topic of ‘medication errors’ for a 20-page research paper and you are unfamiliar with the topic.

1) Where would you start your research?

You are researching the topic of ‘medication errors’ for a 20-page research paper and you are unfamiliar with the topic.

2) What kinds of resources would use?

You are researching the topic of ‘medication errors’ for a 20-page research paper and you are unfamiliar with the topic.

3) What strategies would you use to decide if they are appropriate for your research paper?

Question #2:

Your professor has assigned a paper on alternative women's health therapies. You are not familiar with the topic, so you decide to read a brief history and summary about it. Which of the following sources would be best?

A. A book on the topic, such as Perspectives on alternative women's health therapies: A case study
B. A general encyclopedia, such as the Encyclopedia of Medicine
C. An article on the topic, such as "Alternative women's health therapies in the clinic: A student nurse's perspective."
D. A nursing encyclopedia, such as the Encyclopedia of Nursing
E. Do not know

Question #3:

While observing a class, you overhear one teacher mention to another that they are designing their pathophysiology unit using a "constructivist" approach. You are not certain what this means, so decide to search for:

A. Background information on the topic
B. Editorials on the topic
C. Literature reviews on the topic
D. Research articles on the topic
E. Do not know

Question #4:

Most CINAHL documents published since 1937 are available:

A. As articles in medical journals
B. As chapters in books
C. As electronic documents
D. As proceedings in conference reports
E. Do not know.

Question #5:

Scholarly journals are unique research tools because they include:

A. News reports and demographic information
B. Articles with bibliographies
C. Articles reviewed by experts in the area of your research topic
D. The author's opinions about controversial subjects
E. The latest news and information about your research topic

F. Do not know

Question #6:

When asked by your professor to locate peer-reviewed information where would you start your search?

A. Websites about your research assignment topic
B. A personal interview with your instructor
C. Journals related to your topic
D. Search engines such as Google
E. Do not know

Question #7:

Which of the following is considered a primary source?

A. Journal articles about "Postmodern Nursing and Beyond"
B. A work such as "Postmodern Nursing and Beyond" by Jean Watson
C. Books written about "Postmodern Nursing and Beyond"
D. A doctoral thesis written about "Postmodern Nursing and Beyond"
E. Do not know

Question #8:

You need to find journal articles on the topic of gender differences in nursing student achievement to complete a paper. Which of these would be a good way to start?

A. Page through recent journals
B. Use a research database
C. Use a Web search engine
D. Use the library catalog
E. Do not know

Question #9:

You need to find background information on the trends in qualitative assessments of nursing practice. A good place to look would be:

A. Digest of Nursing Statistics
B. Nursing Almanac
C. Encyclopedia of Nursing
D. Nursing textbook
E. Thesaurus of CINAHL Descriptors
F. Do not know

Question #10:

Most library databases have basic and advanced searching interfaces. Which of the following can you only do in advanced searching? (Check all that apply.)

A. Add search connectors between terms
B. Enter multiple search terms
C. Search for a single keyword
D. Search multiple terms by field
E. Do not know

Question #11:

Which of the following statements is generally true about a Web search engine (for example, Google, AltaVista, etc.)?

A. Does not search most research databases
B. Searches most research databases
C. Searches peer-reviewed materials
D. Uses controlled vocabulary to search
E. Do not know

Please STOP and wait for next steps.

DNP Posttest

POST-Assessment

Question #1:

This is a timed question. You will have 5 minutes to complete your answer. There are 3 parts to this question.

You are researching the topic of 'patient falls' for a 20-page research paper and you are unfamiliar with the topic.

1) Where would you start your research?

2) What kinds of resources would use?

3) What strategies would you use to decide if they are appropriate for your research paper?

Question #2:

Your professor has assigned a paper on nutritional issues in nursing home care. You are not familiar with the topic, so you decide to read a brief history and summary about it. Which of the following sources would be best?

A. A book on the topic, such as Perspectives on nutritional issues in nursing home care: A case study
B. A general encyclopedia, such as Encyclopedia of Aging
C. An article on the topic, such as " "Factors associated with low body mass index and weight loss in nursing home residents"
D. An Nursing encyclopedia, such as Encyclopedia of Nursing & Allied Health
E. Do not know

Question #3:

While observing a class, you overhear one teacher mention to another that they are designing their pharmacology unit using a "cognitive theory" approach. You are not certain what this means, so decide to search for:

A. Background information on the topic
B. Editorials on the topic
C. Literature reviews on the topic
D. Research articles on the topic
E. Do not know

Question #4:

CINAHL research articles published since 1937 are available:

A. As articles in medical journals
B. As chapters in books
C. As electronic documents
D. As proceedings in conference reports
E. Do not know

Question #5:

When searching databases, scholarly journals are unique research tools because they include?

A. Demographic information and news reports
B. Articles with bibliographies
C. Articles reviewed by experts in the area of your research topic
D. The author's opinions about controversial subjects
E. The latest news and information about your research topic
F. Do not know

Question #6:

When asked by your professor to locate peer-reviewed information where would you start your search?

A. Websites about your research assignment topic
B. A personal interview with your instructor
C. Journals related to your topic
D. Search engines such as Google
E. Do not know

Question #7:

Which of the following is considered a primary source:

A. Journal articles about "Nursing: The Philosophy and Science of Caring"
B. A work such as "Nursing: The Philosophy and Science of Caring" by Jean Watson
C. Books written about "Nursing: The Philosophy and Science of Caring"
D. A doctoral thesis written about " Nursing: The Philosophy and Science of Caring"
E. Do not know

Question #8:
You need to find journal articles on the topic of gender differences in DNP (Doctor of Nursing Practice) student achievement to complete a paper. Which of these would be a good way to start?

A. Page through recent journals
B. Use a research database
C. Use a Web search engine
D. Use a library catalog
E. Do not know

Question #9:
You need to find background information on the trends in quantitative assessments of nursing student career choices. A good place to look would be:

A. Digest of Nursing Statistics
B. Nursing Almanac
C. Encyclopedia of Nursing
D. Nursing textbook
E. Thesaurus of CINAHL Descriptors
F. Do not know

Question #10:
Many library research databases have basic and advanced searching interfaces. Which of the following can you only do in advanced searching techniques? Check all that apply.

A. Add search connectors between terms
B. Enter multiple search terms
C. Search for a single keyword
D. Search multiple terms by field
E. Do not know

Question #11:
Which of the following statements is generally true about a Web search engine (for example, Bing, Google, Yahoo, etc.)?

A. Does not search most library journal article databases
B. Searches most research databases
C. Searches peer-reviewed materials
D. Uses controlled vocabulary to search
E. Do not know

Thank You!!

BSN Pretest:

PRE-Assessment

Name____________________

Date_____________________

Question #1:

This is a timed question. You will have 5 minutes to complete your answer. There are 3 parts to this question.

You are researching the topic of 'medication errors' for a 20-page research paper and you are unfamiliar with the topic.

1) Where would you start your research?

You are researching the topic of 'medication errors' for a 20-page research paper and you are unfamiliar with the topic.

2) What kinds of resources would use?

You are researching the topic of 'medication errors' for a 20-page research paper and you are unfamiliar with the topic.

3) What strategies would you use to decide if they are appropriate for your research paper?

You are researching the topic of 'medication errors' for a 20-page research paper and you are unfamiliar with the topic.

3) What strategies would you use to decide if they are appropriate for your research paper?

Question #2:

Your professor has assigned a paper on alternative women's health therapies. You are not familiar with the topic, so you decide to read a brief history and summary about it. Which of the following sources would be best?

A. A book on the topic, such as Perspectives on alternative women's health therapies: A case study
B. A general encyclopedia, such as the Encyclopedia of Medicine
C. An article on the topic, such as "Alternative women's health therapies in the clinic: A student nurse's perspective."
D. A nursing encyclopedia, such as the Encyclopedia of Nursing
E. Do not know

Question #3:

While observing a class, you overhear one teacher mention to another that they are designing their pathophysiology unit using a "constructivist" approach. You are not certain what this means, so decide to search for:

A. Background information on the topic
B. Editorials on the topic
C. Literature reviews on the topic
D. Research articles on the topic
E. Do not know

Question #4:

Most CINAHL documents published since 1937 are available:

A. As articles in medical journals
B. As chapters in books
C. As electronic documents
D. As proceedings in conference reports
E. Do not know

Question #5:

Scholarly journals are unique research tools because they include:

A. News reports and demographic information
B. Articles with bibliographies
C. Articles reviewed by experts in the area of your research topic
D. The author's opinions about controversial subjects
E. The latest news and information about your research topic
F. Do not know

Question #6:

When asked by your professor to locate peer-reviewed information where would you start your search?

A. Websites about your research assignment topic
B. A personal interview with your instructor
C. Journals related to your topic
D. Search engines such as Google
E. Do not know

Question #7:

Which of the following is considered a primary source?

A. Journal articles about "Postmodern Nursing and Beyond"
B. A work such as "Postmodern Nursing and Beyond" by Jean Watson
C. Books written about "Postmodern Nursing and Beyond"
D. A doctoral thesis written about "Postmodern Nursing and Beyond"
E. Do not know

Question #8:

You need to find journal articles on the topic of gender differences in nursing student achievement to complete a paper. Which of these would be a good way to start?

A. Page through recent journals
B. Use a research database
C. Use a Web search engine
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Question #9:

You need to find background information on the trends in qualitative assessments of nursing practice. A good place to look would be:

A. Digest of Nursing Statistics
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C. Encyclopedia of Nursing
D. Nursing textbook
E. Thesaurus of CINAHL Descriptors
F. Do not know

Question #10:

Most library databases have basic and advanced searching interfaces. Which of the following can you only do in advanced searching? (Check all that apply.)

A. Add search connectors between terms
B. Enter multiple search terms
C. Search for a single keyword
D. Search multiple terms by field
E. Do not know

Question #11:

Which of the following statements is generally true about a Web search engine (for example, Google, AltaVista, etc.)?

A. Does not search most research databases
B. Searches most research databases
C. Searches peer-reviewed materials
D. Uses controlled vocabulary to search
E. Do not know

Please STOP and wait for next steps.

BSN Posttest:

POST-Assessment Part A

You have one minute to complete the following three questions. When you are done, please wait – do not continue until instructed.

Question # GP 1) How easy or difficult is it for you to understand information literacy at this time?

1	2	3	4	5	6	7	8	9
Very Easy								Very Difficult

Question # EP 1) Please rank how much mental effort you used to make sense of the information literacy presentation:

1	2	3	4	5	6	7	8	9
Very Little Mental Effort								Very Much Mental Effort

Question # EX 1) How easy or difficult was it for you to pay attention during the presentation?

1	2	3	4	5	6	7	8	9
Very Easy								Very Difficult

Please STOP and wait for next step.

POST-Assessment Part B

Question #1:

This is a timed question. You will have 5 minutes to complete your answer. There are 3 parts to this question.

You are researching the topic of 'patient falls' for a 20-page research paper and you are unfamiliar with the topic.

1) Where would you start your research?

You are researching the topic of 'patient falls' for a 20-page research paper and you are unfamiliar with the topic.

2) What kinds of resources would use?

You are researching the topic of 'patient falls' for a 20-page research paper and you are unfamiliar with the topic.

3) What strategies would you use to decide if they are appropriate for your research paper?

Question #2:

Your professor has assigned a paper on nutritional issues in nursing home care. You are not familiar with the topic, so you decide to read a brief history and summary about it. Which of the following sources would be best?

A. A book on the topic, such as Perspectives on nutritional issues in nursing home care: A case study
B. A general encyclopedia, such as Encyclopedia of Aging
C. An article on the topic, such as " "Factors associated with low body mass index and weight loss in nursing home residents"
D. An Nursing encyclopedia, such as Encyclopedia of Nursing & Allied Health
E. Do not know

Question #3:

While observing a class, you overhear one teacher mention to another that they are designing their pharmacology unit using a "cognitive theory" approach. You are not certain what this means, so decide to search for:

A. Background information on the topic
B. Editorials on the topic
C. Literature reviews on the topic
D. Research articles on the topic
E. Do not know

Question #4:

CINAHL research articles published since 1937 are available:

A. As articles in medical journals
B. As chapters in books
C. As electronic documents
D. As proceedings in conference reports
E. Do not know

Question #5:

When searching databases, scholarly journals are unique research tools because they include?

A. Demographic information and news reports
B. Articles with bibliographies
C. Articles reviewed by experts in the area of your research topic
D. The author's opinions about controversial subjects
E. The latest news and information about your research topic
F. Do not know

Question #6:

When asked by your professor to locate peer-reviewed information where would you start your search?

A. Websites about your research assignment topic
B. A personal interview with your instructor
C. Journals related to your topic
D. Search engines such as Google
E. Do not know

Question #7:

Which of the following is considered a primary source:

A. Journal articles about "Nursing: The Philosophy and Science of Caring"
B. A work such as "Nursing: The Philosophy and Science of Caring" by Jean Watson
C. Books written about "Nursing: The Philosophy and Science of Caring"
D. A doctoral thesis written about " Nursing: The Philosophy and Science of Caring"
E. Do not know

Question #8:

You need to find journal articles on the topic of gender differences in DNP (Doctor of Nursing Practice) student achievement to complete a paper. Which of these would be a good way to start?

A. Page through recent journals
B. Use a research database
C. Use a Web search engine
D. Use a library catalog
E. Do not know

Question #9:
You need to find background information on the trends in quantitative assessments of nursing student career choices. A good place to look would be:

A. Digest of Nursing Statistics
B. Nursing Almanac
C. Encyclopedia of Nursing
D. Nursing textbook
E. Thesaurus of CINAHL Descriptors
F. Do not know

Question #10:
Many library research databases have basic and advanced searching interfaces. Which of the following can you only do in advanced searching techniques? Check all that apply.

A. Add search connectors between terms
B. Enter multiple search terms
C. Search for a single keyword
D. Search multiple terms by field
E. Do not know

Question #11:

Which of the following statements is generally true about a Web search engine (for example, Bing, Google, Yahoo, etc.)?

A. Does not search most library journal article databases
B. Searches most research databases
C. Searches peer-reviewed materials
D. Uses controlled vocabulary to search
E. Do not know

End. Thank YOU!

APPENDIX C: Modular Worked-out Example Audiobook Script

Introduction Slide

My name is Shawn Calhoun and I am a doctoral student in Education at the University of San Francisco. The purpose of this study is to assess new ways to deliver information literacy instruction to university students. Information Literacy is the ability to identify what information is needed, understand how the information is organized, identify the best sources of information for a given need, locate those sources, evaluate the sources critically, and share that information. It is the knowledge of commonly used research techniques.

You are free to withdraw from this study at any time. All information and results for individuals participating in the study will be kept confidential. Only aggregate results will be reported as a part of this study. Your decision to participate or withdraw from the study will not affect your grade or standing in this course. This is a self-assessment, not a test. No grade will be assigned and your instructor will not have access to your individual results.

Participation in this study will take approximately 50 minutes, including this introduction. After this introduction, you will take a eleven-question pretest about information literacy. One of the questions is essay-style and the remaining 10 questions are multiple choice. Please select the answer that you think best answers the question. After the first 11-question test, I will lead you though a 10 minute instruction session covering a number of topics related to information literacy. After the instruction session, there will be another brief 11-question assessment.

We will now move on to the first self-assessment on BlackBoard. You will have 15 minutes to compete the first set of 11 questions. on BlackBoard. *

* *BlackBoard software was not used for the DNP or BSN group. Instructions were given verbally to complete the pretest and posttest using a printed version of the assessment.*

Slide 1

We will now move to a brief instruction session. Please follow-along as I read aloud.

Slide 2

Please take a moment to review the research question on your screen. If you start your research online at the library homepage, the first task is to take a minute to look carefully at your assignment:

Working on unfamiliar research topics begins with familiarizing yourself with the subject. While going straight to Google is what many students will do when faced with an unfamiliar topic, this approach will no necessarily search the best sources for research papers assigned by your instructor. Online resources that have not been checked for accuracy are not always the best place to start your research.

If you go to the library in person, your first stop should be at the reference desk. The reference desk is staffed by librarians who are knowledgeable about resources, both print as well as electronic, that can help you with your research paper. If you cannot get to the library, start your research at the library website homepage.

Slide 3

Analyzing this question involves breaking it down into manageable, relevant components with consideration of the overall assignment criteria.

This is a 20 page assignment and is “comprehensive” in nature. You will need resources from academic and other experts in the field. Magazine articles from popular sources like Health Magazine will not help you make the grade. You will need journal articles and other scholarly sources.

Medication errors is a broad, but important piece of information. Medication errors is more specific than “hospital injuries” which could be used in many contexts other than nursing.

Medication errors can impact many different types of patients. For this paper “male patients” is where you will need to focus your research.

Elderly care facility is another important component of this research question and differentiates your assignment from other locations such as hospitals.

Slide 4

Summarizing the steps to analyzing a research question, what you now have is an actionable next step that might read:

I need “journals articles and scholarly works that include information about ‘medication errors’ and ‘male patients’ and ‘elderly care facilities’ ”.

Slide 5

When beginning your research there are different types of resources that can assist you in beginning your assignment:

Encyclopedias: Encyclopedias provide summary and background information when you are just learning about a new topic. While they are usually not considered sources for your final paper, they will give you a good overview of a topic. Examples of encyclopedias include:

the Encyclopedia of Nursing & Allied Health
the Encyclopedia of Nursing

General Reference Sources: General reference sources are similar to encyclopedias and will give you a good place to learn about new topics. Examples of general reference sources include books in the library reference collection such as annual reports, almanacs and government documents.

Databases: Databases include resources that are often most appropriate for college-level writing and research. They will be discussed in more detail shortly.

Slide 6

Key Words: Once you have familiarized yourself with the area you plan to write on, its important to develop a strategy for finding the information you need from scholarly journals. One of the best sources for finding scholarly articles is to locate them in your libraries online databases. Searching library databases is often done using key word searching. Identifying key words brings us back to the original statement we've been working with:

The key words in this statement are Medication errors, male patients and elderly care facilities.

Slide 7

Often research questions contain multiple concepts, such as Medication Errors and Elderly Care Facilities. Simply typing them into a search engine such as Google might return unusable or unreliable results. This is where library databases combined with more complex search strategies come in. Considering the research question we have been working with, you are looking for the intersection of multiple concepts or ideas. Finding resources that cover one of these, or even two might not help you with your research. The best resources will be those that overlap and cover all three. Library databases can be your best tool with this sort of problem.

Slide 8

Databases: Databases are resources selected by librarians and faculty are widely considered the best sources for scholarly information online. Scholarly information includes research and reviews by scholars in the fields of study you are going to write research papers about. Not only do experts write the articles, independent experts review them before being published. This step is known of as peer-review. Research is often first published in the journals that are available in databases. Databases often include multiple journals and are often specific to academic disciplines. Examples of databases include:

CINAHL Plus

Gale Virtual Reference
LexisNexis Statistical Insight

Databases are a good place to locate primary sources. Primary sources include journal articles reporting new research or findings. A secondary source interprets earlier findings and includes things like encyclopedias.
As you can see from this screen, at the top of the page are multiple search boxes, where you can enter your concepts and key words.

Slide 9

The way you use databases when you have multiple concepts or key words is to enter them separately and add them together using the “and” feature built into library databases.

Using multiple search terms with the "and" option with limitation options such as full text and peer reviewed allows you to restrict results to very specific criteria.

In this example, Peer Reviewed returns only research that has been reviewed by professionals in the field. Occasionally when you search databases, your results will include article citations, but not the entire article as it was written. Full Text returns only complete articles.

Slide 10

Using these search strategies (“and” full text and peer reviewed), the database creates a search which meets your research needs when faced with research assignment containing multiple related concepts.

The database will create a search that returns only articles with “Medication Errors” and “Elderly Care Facilities” and “Male Patients” in them. Regardless of the database you use, each will offer you the ability to create these powerful searches.

We have now completed the information literacy instruction. Please complete the following assessment in BlackBoard. *

* *Blackboard was not used for the DNP or BSN group. Instructions were given verbally to complete the pretest and posttest using a printed version of the assessment.*

APPENDIX D: Informed Consent

DNP Informed Consent

USF Consent to be a Research Subject

Purpose and Background
Mr. Shawn P. Calhoun, a graduate student in the School of Education at the University of San Francisco, is conducting a study on the knowledge of information literacy skills of Doctor of Nursing Practice students. Information literacy skills include the ability to determine the extent of information needed, access the needed information effectively and efficiently, evaluate information and its sources critically, incorporate selected information into one's knowledge base and use information effectively to accomplish a specific purpose. Information literacy proficiency translates into students' ability to engage in rigorous curricula as well as produce academically sound work. The study will explore the students' information literacy skills before and after a multimedia instructional session.

I am being asked to participate because I am Doctor of Nursing Practice student.

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

1. I will take a brief assessment of information literacy skills.
2. I will watch and listen to a multimedia information literacy instructional presentation.
3. I will complete a brief assessment after the multimedia presentation.

The total duration of the information literacy session is approximately 50 minutes.

Risks and/or Discomforts
1. It is possible that some of the questions may make me feel uncomfortable, but I am free to decline to answer any questions I do not wish to answer or stop my participation at any time.

2. Participation in research may mean a loss of confidentiality. Study records will be kept as confidential as is possible. No individual identities will be used in any reports or publications resulting from the study. Study information will be coded and kept in locked files at all times or computer files with security passwords. Only study personnel will have access to the files.

3. Because the time required for my participation may be up to 50 minutes, I may become tired or disinterested in this study.

Minimization of Potential Risks
The researcher will take every effort to minimize any potential risks to the subjects.

Benefits
The potential benefit of participating in this study is that I will be helping future Doctor of Nursing Practice students by participating in a process designed to evaluate

multimedia instructional modules focused on information literacy.

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

Reimbursement/Compensation to Subjects
There will be no reimbursement or compensation to me as a result of taking part in this study.

Confidentiality of Records
Study records will be kept as confidential as possible. No individual identities will be used in any reports or publications resulting from this study. Study information will be coded and kept in locked files at all times or computer files with security passwords. Only the researcher will have access to these files.

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

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

Subject's Signature / Date

_______________ / ________________

Signature of Person Obtaining Consent / Date

_______________ / ________________

BSN Informed Consent

USF Consent to be a Research Subject

Purpose and Background
Mr. Shawn P. Calhoun, a graduate student in the School of Education at the University of San Francisco, is conducting a study on the knowledge of information literacy skills of Nursing students. Information literacy skills include the ability to determine the extent of information needed, access the needed information effectively and efficiently, evaluate information and its sources critically, incorporate selected information into one's knowledge base and use information effectively to accomplish a specific purpose. Information literacy proficiency translates into students' ability to engage in rigorous curricula as well as produce academically sound work. The study will explore the students' information literacy skills before and after a multimedia instructional session.

I am being asked to participate because I am Nursing student.

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

1. I will take a brief assessment of information literacy skills.
2. I will watch and listen to a multimedia information literacy instructional presentation.
3. I will complete a brief assessment after the multimedia presentation.

The total duration of the information literacy session is approximately 50 minutes.

Risks and/or Discomforts
1. It is possible that some of the questions may make me feel uncomfortable, but I am free to decline to answer any questions I do not wish to answer or stop my participation at any time.

2. Participation in research may mean a loss of confidentiality. Study records will be kept as confidential as is possible. No individual identities will be used in any reports or publications resulting from the study. Study information will be coded and kept in locked files at all times or computer files with security passwords. Only study personnel will have access to the files.

3. Because the time required for my participation may be up to 50 minutes, I may become tired or disinterested in this study.

Minimization of Potential Risks
The researcher will take every effort to minimize any potential risks to the subjects.

Benefits
The potential benefit of participating in this study is that I will be helping future Nursing students by participating in a process designed to evaluate multimedia instructional

modules focused on information literacy.

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

Reimbursement/Compensation to Subjects
There will be no reimbursement or compensation to me as a result of taking part in this study.

Confidentiality of Records
Study records will be kept as confidential as possible. No individual identities will be used in any reports or publications resulting from this study. Study information will be coded and kept in locked files at all times or computer files with security passwords. Only the researcher will have access to these files.

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

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

Subject's Signature / Date

_______________ / ________________

Signature of Person Obtaining Consent / Date

_______________ / ________________

APPENDIX E: ACRL (2000) Standard One, Performance Indicators, and Outcomes

The information literate student determines the nature and extent of the information needed.

Performance Indicators:

1. The information literate student defines and articulates the need for information.

   Outcomes Include:

   a. Confers with instructors and participates in class discussions, peer workgroups, and electronic discussions to identify a research topic, or other information need
   b. Develops a thesis statement and formulates questions based on the information need
   c. Explores general information sources to increase familiarity with the topic
   d. Defines or modifies the information need to achieve a manageable focus
   e. Identifies key concepts and terms that describe the information need
   f. Recognizes that existing information can be combined with original thought, experimentation, and/or analysis to produce new information

2. The information literate student identifies a variety of types and formats of potential sources for information.

   Outcomes Include:

   a. Knows how information is formally and informally produced, organized, and disseminated
   b. Recognizes that knowledge can be organized into disciplines that influence the way information is accessed
   c. Identifies the value and differences of potential resources in a variety of formats (e.g., multimedia, database, website, data set, audio/visual, book)
   d. Identifies the purpose and audience of potential resources (e.g., popular vs. scholarly, current vs. historical)
   e. Differentiates between primary and secondary sources, recognizing how their use and importance vary with each discipline
   f. Realizes that information may need to be constructed with raw data from primary sources

3. The information literate student considers the costs and benefits of acquiring the needed information.

   Outcomes Include:

   a. Determines the availability of needed information and makes decisions on broadening the information seeking process beyond local resources (e.g., interlibrary loan; using resources at other locations; obtaining images, videos, text, or sound)
   b. Considers the feasibility of acquiring a new language or skill (e.g., foreign or discipline-based) in order to gather needed information and to understand its context
   c. Defines a realistic overall plan and timeline to acquire the needed information

4. The information literate student reevaluates the nature and extent of the information need.

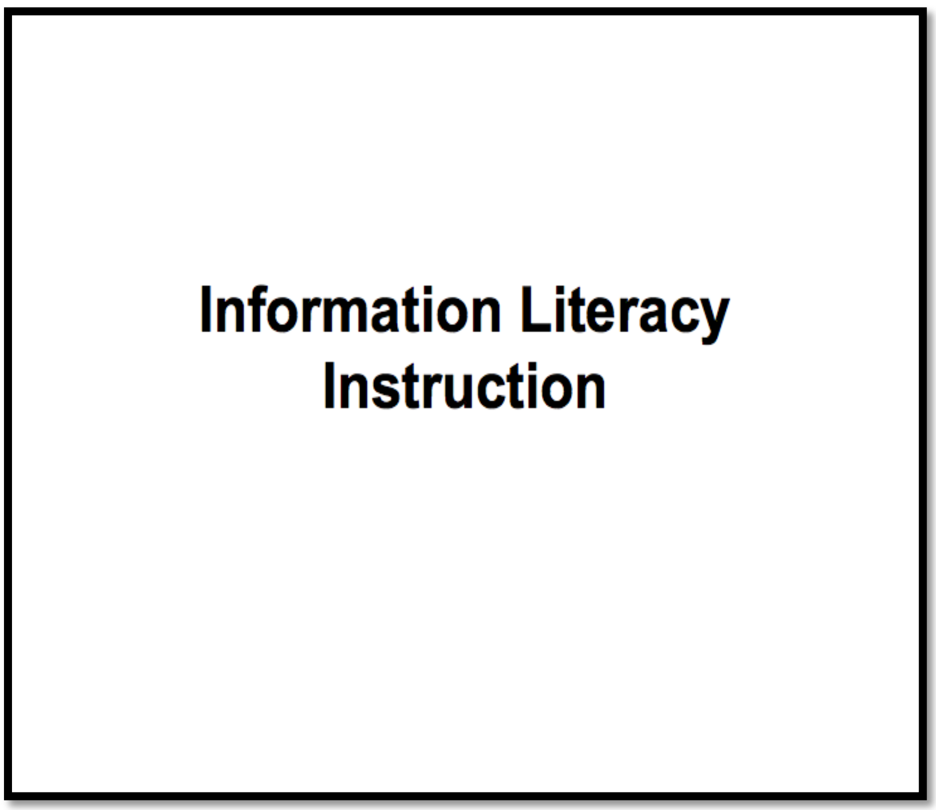
   Outcomes Include:

   a. Reviews the initial information need to clarify, revise, or refine the question
   b. Describes criteria used to make information decisions and choices

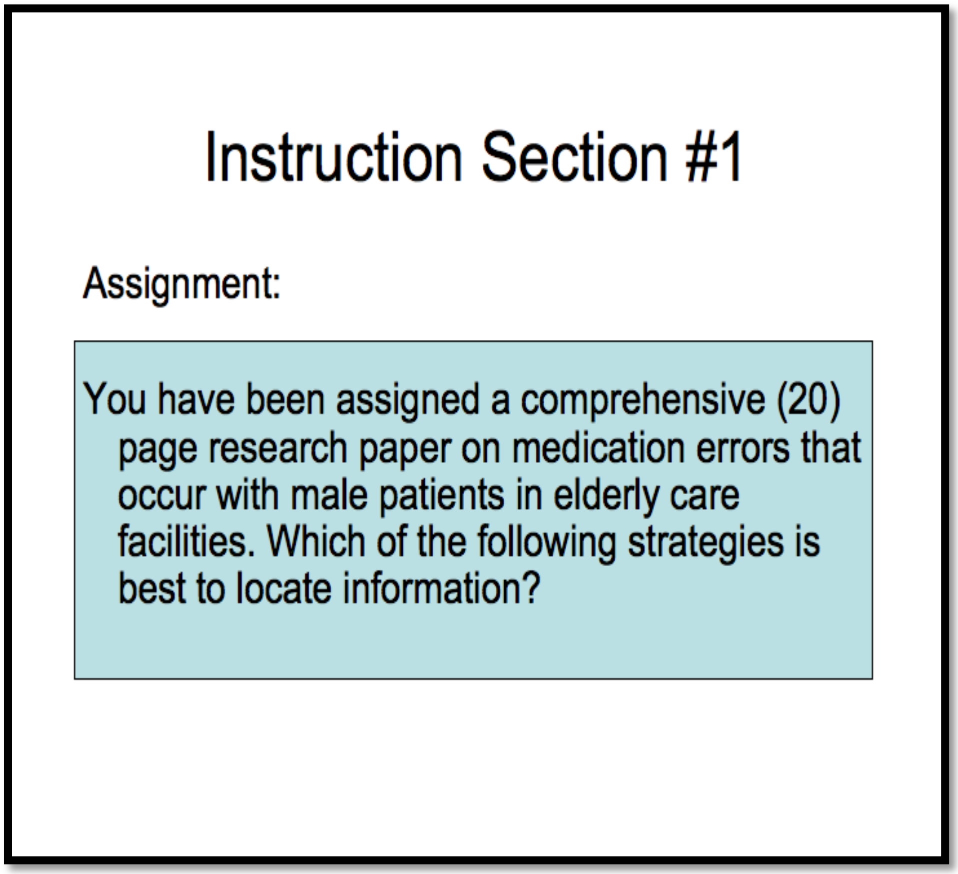
APPENDIX F: Instructional Intervention Screenshots

To access the multimedia audiobook use the following URL:

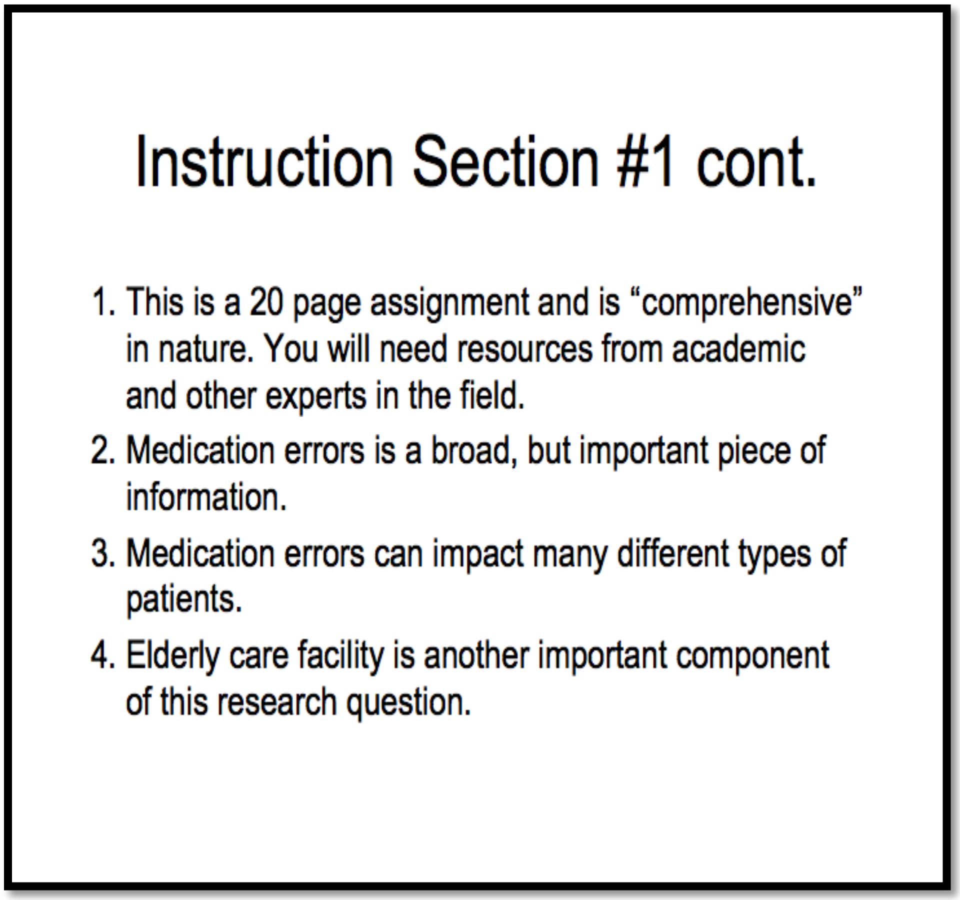
http://vimeo.com/24756665



1 minute and 38 second mark.

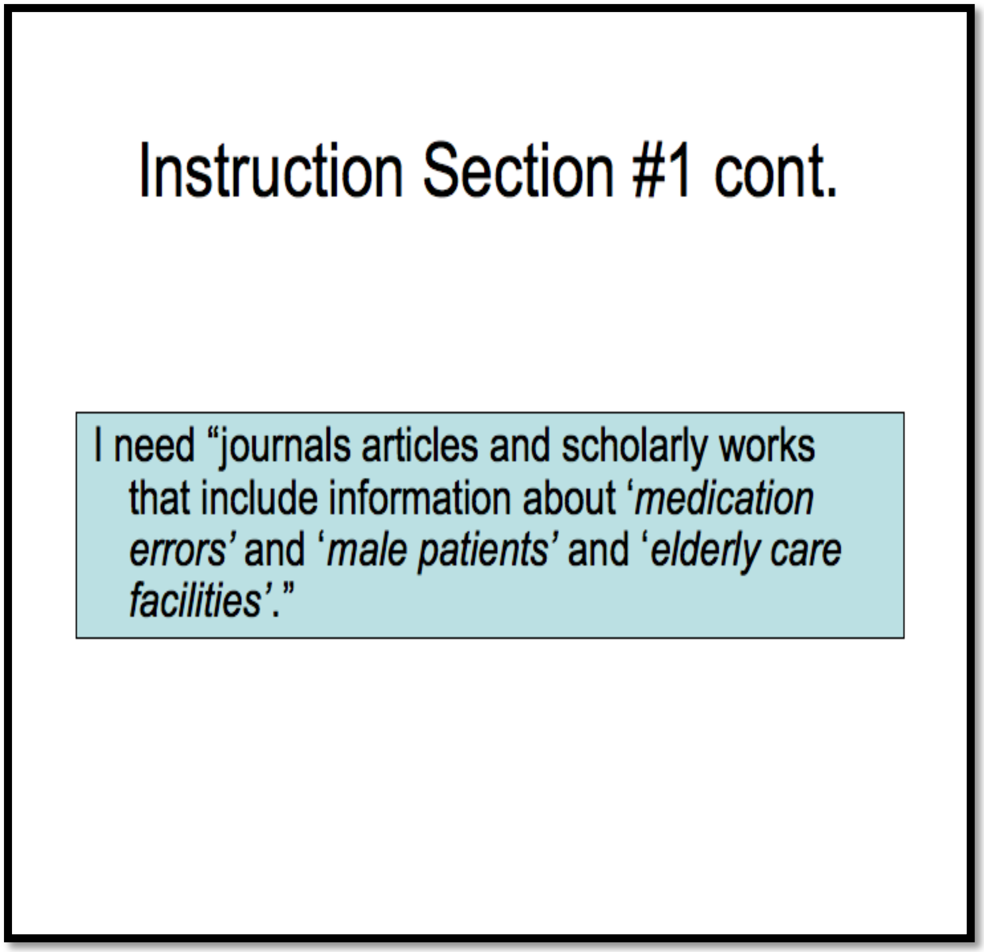


2 minute and 33 second mark.

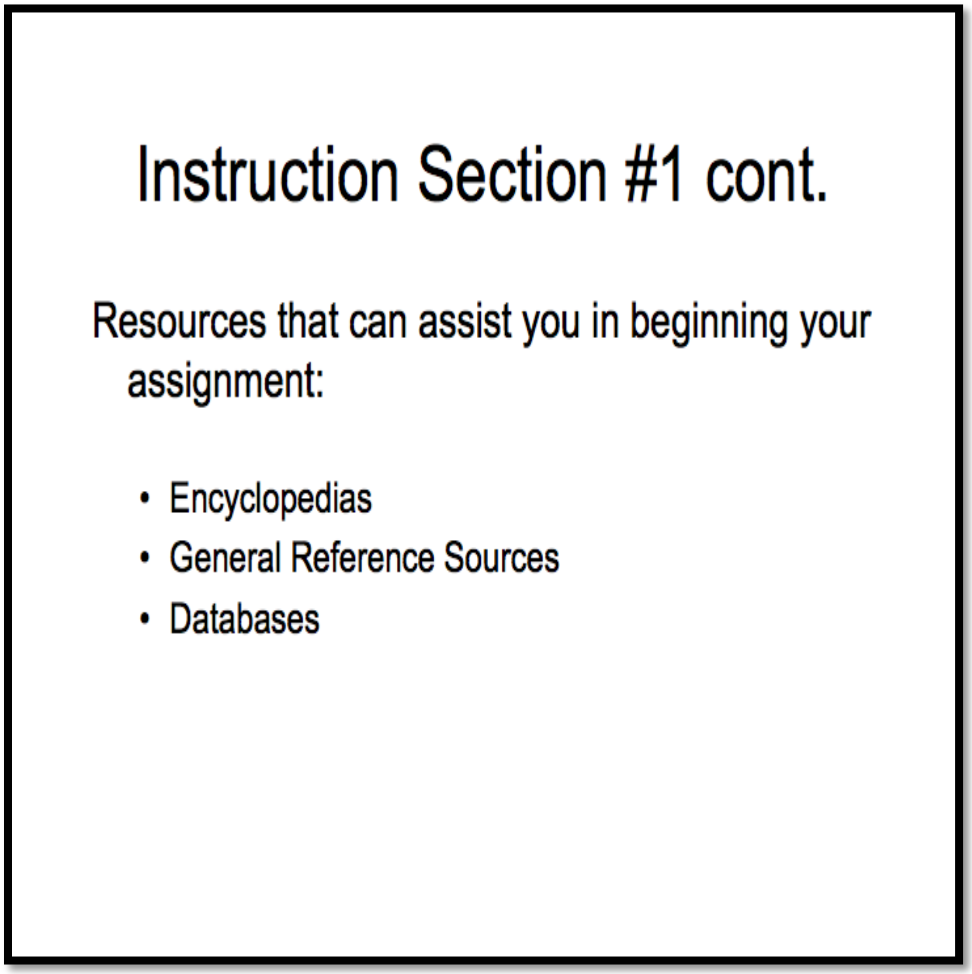


3 minute and 29 second mark.

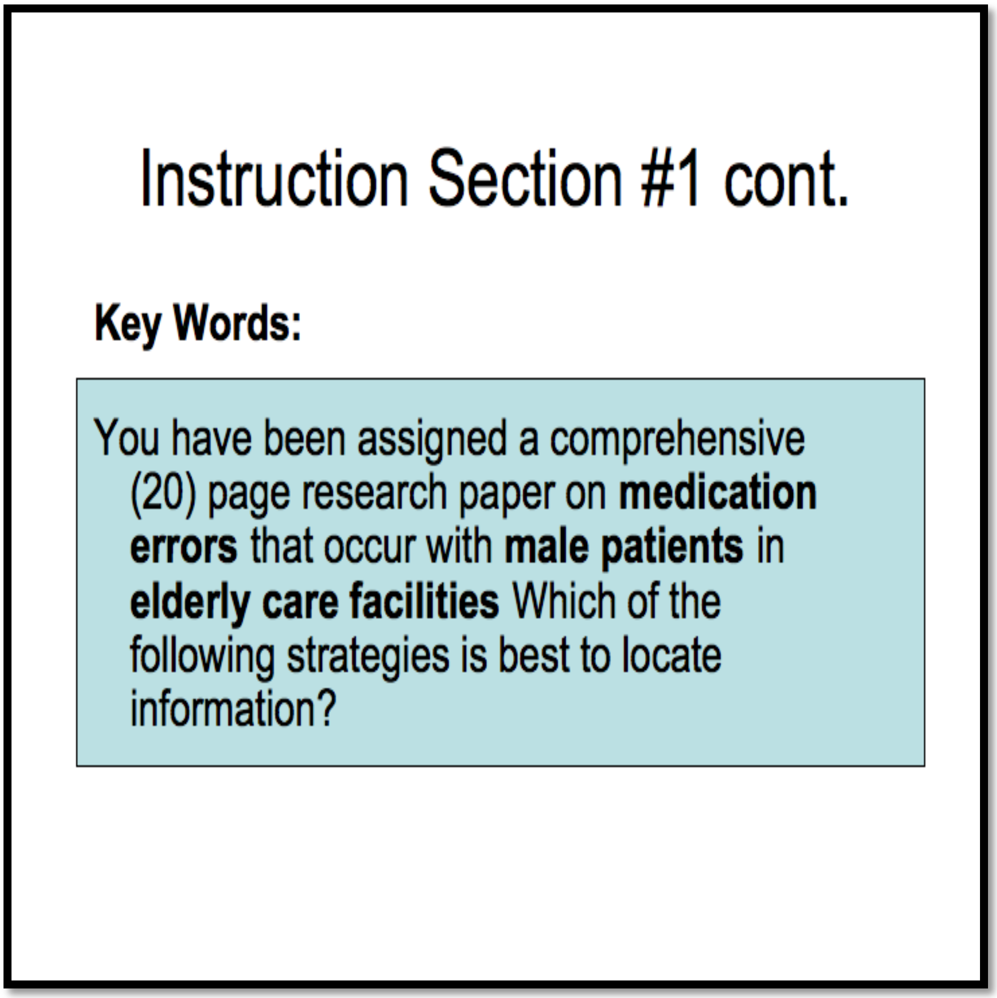
3 minute and 46 second mark.



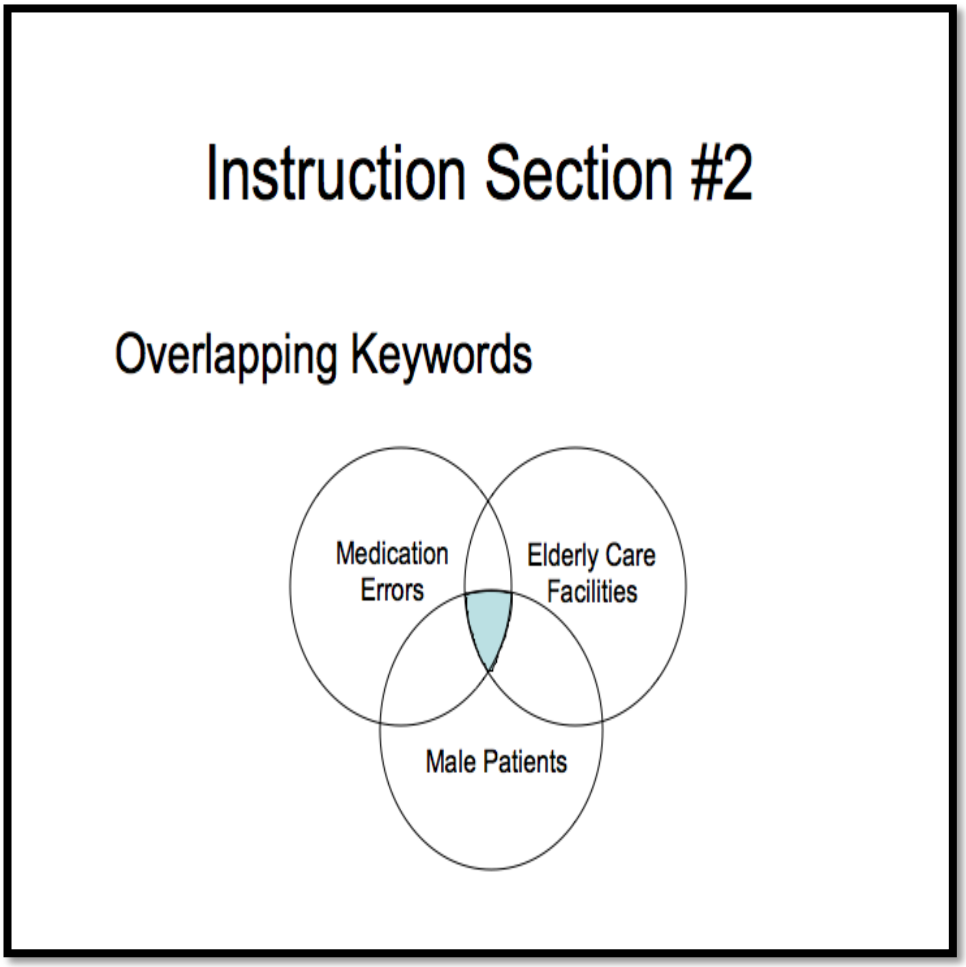
3 minute and 47 second mark.



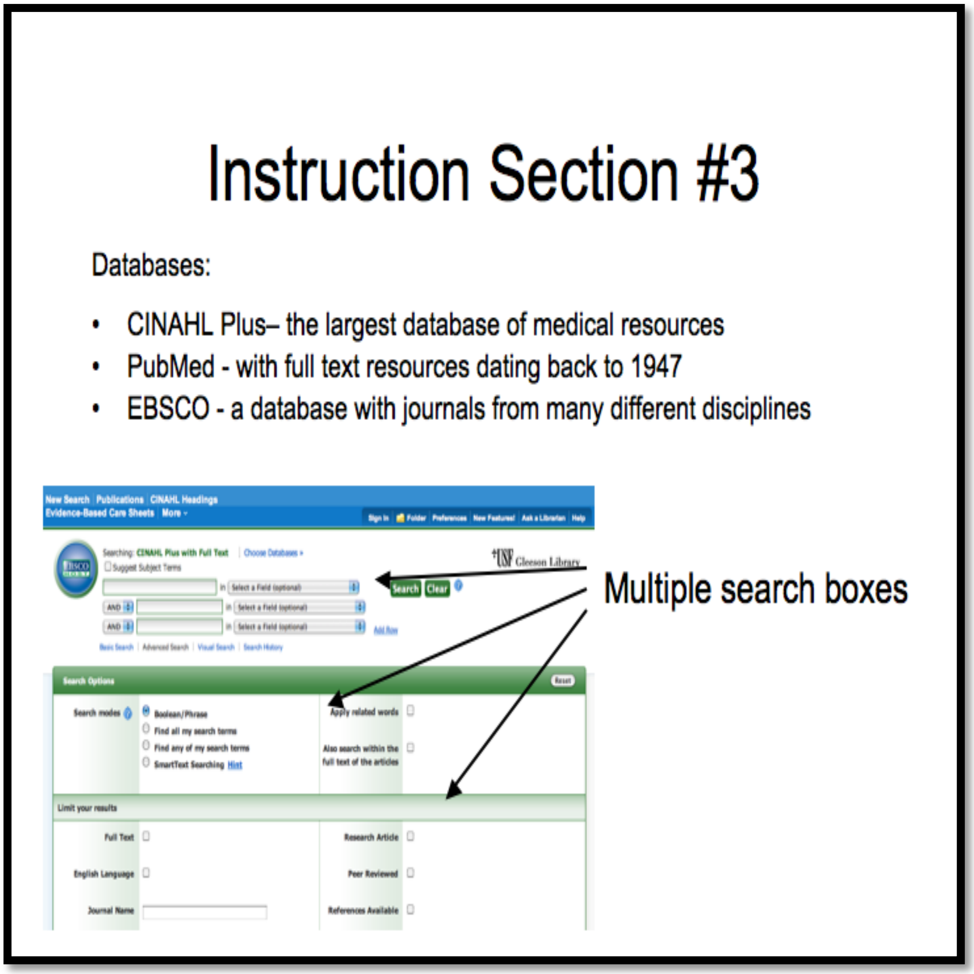
4 minute and 37 second mark.



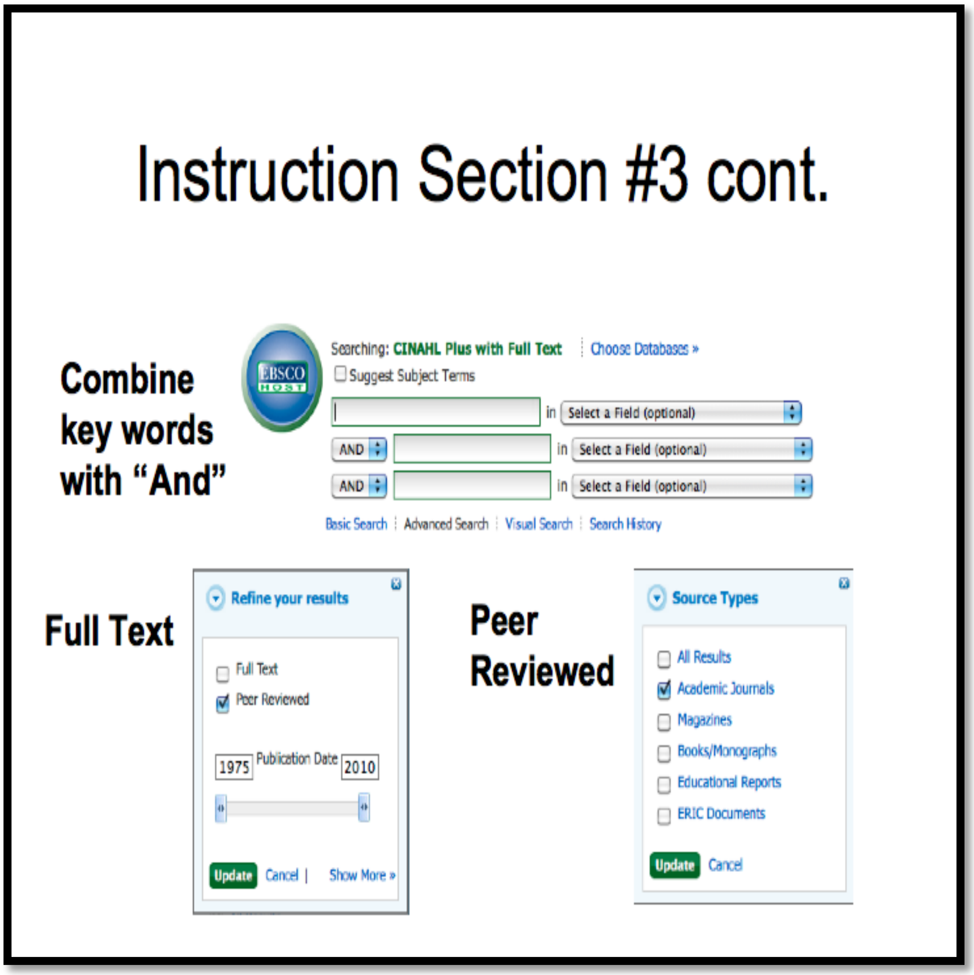
5 minute and 9 second mark.



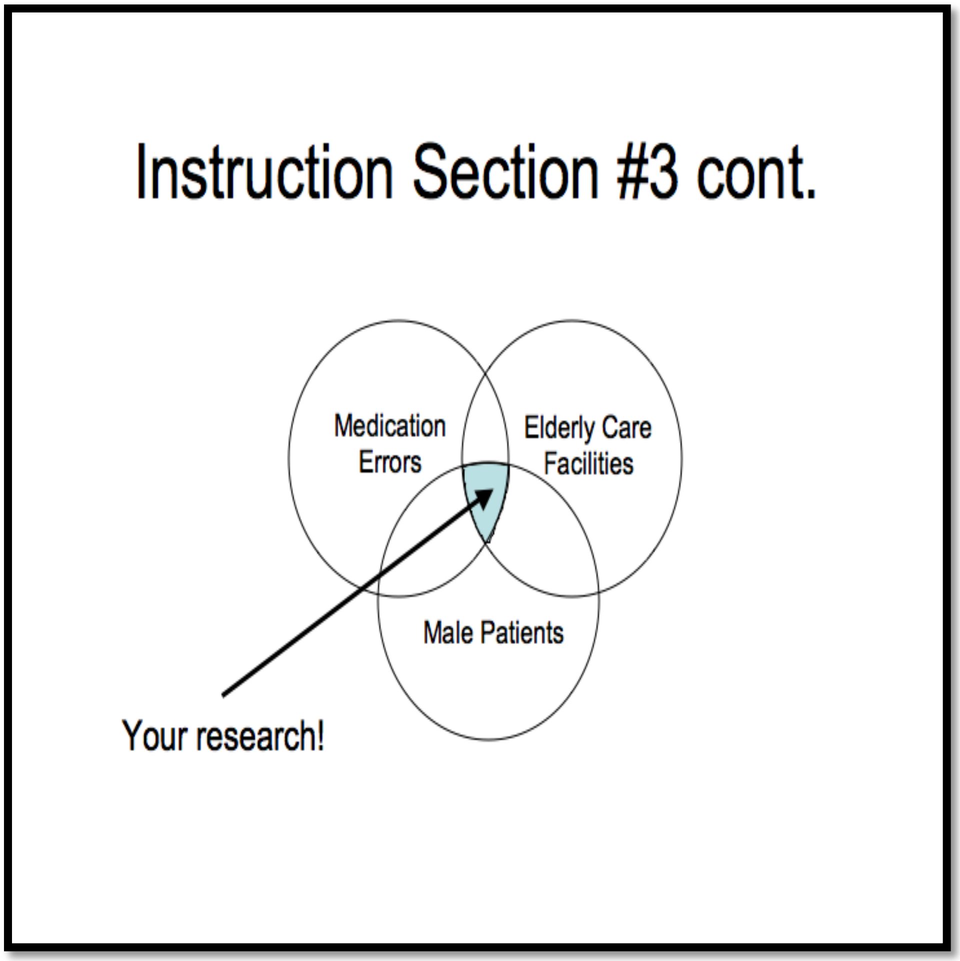
5 minute and 50 second mark.



6 minute and 57 second mark.



7 minute and 33 second mark.



The total duration of audiobook is eight minutes and sixteen seconds.

APPENDIX G: Pretest Items, Item source with Correct Item.

Question #2:

Your professor has assigned a paper on alternative women's health therapies. You are not familiar with the topic, so you decide to read a brief history and summary about it. Which of the following sources would be best?

A. A book on the topic, such as Perspectives on alternative women's health therapies: A case study
B. A general encyclopedia, such as the Encyclopedia of Medicine
C. An article on the topic, such as "Alternative women's health therapies in the clinic: A student nurse's perspective."
D. A nursing encyclopedia, such as the Encyclopedia of Nursing
E. Do not know

Source: B-TILED
Correct item: D

Question #3:

While observing a class, you overhear one teacher mention to another that they are designing their pathophysiology unit using a "constructivist" approach. You are not certain what this means, so decide to search for:

A. Background information on the topic
B. Editorials on the topic
C. Literature reviews on the topic
D. Research articles on the topic
E. Do not know

Source: Library and Information Skills Test
Correct Item: A

Question #4:

Most CINAHL documents published since 1937 are available:

A. As articles in medical journals
B. As chapters in books
C. As electronic documents
D. As proceedings in conference reports
E. Do not know.

Source: Library and Information Skills Test (modified by researcher)
Correct Item: C

Question #8:

You need to find journal articles on the topic of gender differences in nursing student achievement to complete a paper. Which of these would be a good way to start?

A. Page through recent journals
B. Use a research database
C. Use a Web search engine
D. Use the library catalog
E. Do not know

Source: Library and Information Skills Test (modified by researcher)
Correct Item: B

Question #9:

You need to find background information on the trends in qualitative assessments of nursing practice. A good place to look would be:

A. Digest of Nursing Statistics
B. Nursing Almanac
C. Encyclopedia of Nursing
D. Nursing textbook
E. Thesaurus of CINAHL Descriptors
F. Do not know

Source: Library and Information Skills Test (modified by researcher)
Correct Item: C

Question #10:

Most library databases have basic and advanced searching interfaces. Which of the following can you only do in advanced searching? (Check all that apply.)

A. Add search connectors between terms
B. Enter multiple search terms
C. Search for a single keyword
D. Search multiple terms by field
E. Do not know

Source: Library and Information Skills Test (modified by researcher)
Correct Items: A, B and D

Question #5:

Scholarly journals are unique research tools because they include:

A. News reports and demographic information
B. Articles with bibliographies
C. Articles reviewed by experts in the area of your research topic
D. The author's opinions about controversial subjects
E. The latest news and information about your research topic
F. Do not know

Source: Researcher designed item
Correct Item: C

Question #6:

When asked by your professor to locate peer-reviewed information where would you start your search?

A. Websites about your research assignment topic
B. A personal interview with your instructor
C. Journals related to your topic
D. Search engines such as Google
E. Do not know

Source: Researcher designed item
Correct Item: C

Question #7:

Which of the following is considered a primary source?

A. Journal articles about "Postmodern Nursing and Beyond"
B. A work such as "Postmodern Nursing and Beyond" by Jean Watson
C. Books written about "Postmodern Nursing and Beyond"
D. A doctoral thesis written about "Postmodern Nursing and Beyond"
E. Do not know

Source: Library and Information Skills Test (modified by researcher)
Correct Item: B

Question #2:

Your professor has assigned a paper on alternative women's health therapies. You are not familiar with the topic, so you decide to read a brief history and summary about it. Which of the following sources would be best?

A. A book on the topic, such as Perspectives on alternative women's health therapies: A case study
B. A general encyclopedia, such as the Encyclopedia of Medicine
C. An article on the topic, such as "Alternative women's health therapies in the clinic: A student nurse's perspective."
D. A nursing encyclopedia, such as the Encyclopedia of Nursing
E. Do not know

Source: B-TILED
Correct item: D

Question #3:

While observing a class, you overhear one teacher mention to another that they are designing their pathophysiology unit using a "constructivist" approach. You are not certain what this means, so decide to search for:

A. Background information on the topic
B. Editorials on the topic
C. Literature reviews on the topic
D. Research articles on the topic
E. Do not know

Source: Library and Information Skills Test
Correct Item: A

Question #4:

Most CINAHL documents published since 1937 are available:

A. As articles in medical journals
B. As chapters in books
C. As electronic documents
D. As proceedings in conference reports
E. Do not know.

Source: Library and Information Skills Test (modified by researcher)
Correct Item: C