Prompting Self-Monitoring of Learning in Self-Paced Computer Based Training: The Effect on Self-Regulation and Learning

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PROMPTING SELF-MONITORING OF LEARNING IN SELF-PACED COMPUTER BASED TRAINING: THE EFFECT ON SELF-REGULATION AND LEARNING

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ABSTRACT

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The purpose of this dissertation was to investigate the effects of prompting students to monitor their use of learning strategies and comprehension while completing self-paced, work-related training in a computer-based learning environment. Study participants included 94 enlisted military volunteers, randomly assigned to one of three groups in the spring of 2012. Changes in strategy use and comprehension were evaluated within and between groups receiving either immediate, delayed or no prompts using multiple methods of measurement, both during and after training. Prompts asked participants to rate their level of agreement to statements regarding their strategy use and comprehension of lesson content.

Dependent variables included declarative knowledge and self-regulation. Declarative knowledge was measured using multiple end-of-lesson tests and a comprehensive end-of-course test. Self-regulation of strategy use was measured using a post-treatment self-report instrument and strategy use scores derived from an evaluation of learner notes. Independent variables included prompts to self-monitor performance; prior knowledge was used as a covariate in all analyses. Multivariate analysis of covariance was used to investigate the effects of the prompts on the combination of self-regulation and comprehension scores at the end of training. Mixed model repeated measures analysis of covariance was used to investigate changes in self-regulation and strategy use during training. Analysis of results revealed no statistically significant effects of the prompting treatments on combined scores of self-regulation and

comprehension by the end of the treatment between groups. Furthermore, there were no significant effects of the prompts on strategy use or comprehension over time between groups.

Findings from this study suggest the addition of prompts in computer-based learning events may not be effective for all learners or learning tasks. In contrast to similar experiments with college students, the prompts failed to influence participant strategy use and learning. Although groups receiving prompts invested more time in training, the additional time did not lead to improved overall strategy use or comprehension scores in comparison to the group that did not receive prompts. By the end of training, average comprehension scores among groups was equivalent and, on average, below passing (80%). The lack of effect on strategy use may have been a result of participants' low prior knowledge, proficiency with learning strategies, task complexity and the value participants assigned to the learning task.

Findings from this study expand the existing body of knowledge regarding the self-regulation of learning in computer-based learning environments, particularly with regard to the population of working adults, whose self-regulation of learning in the workplace has not been extensively investigated. Additionally, this study provides an example of how to employ multiple measures of self-regulation to more fully describe self-regulatory processes in computer-based learning environments, an approach researchers investigating self-regulation have called for.

This dissertation is dedicated to my amazing wife, Diyar. You inspire me to be a better human being, and are a constant reminder to focus on the positive things in life (like you!). I love you.

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CHAPTER 1 INTRODUCTION

Background

Computer-based learning environments (CBLEs) rely on computers to aid learners in achieving an educational goal (Azevedo, 2005). Today, computers have become an integral part of learning in the United States and, because they offer an efficient means of providing training, their use is likely to continue to increase (Allen & Seaman, 2010; Means, Toyama, Murphy, Bakia, & Jones, 2009). Unfortunately, while CBLEs can provide efficiencies in learning, many students struggle to learn in these environments, in part because they lack the ability to effectively self-regulate their learning (Moos & Azevedo, 2009; Winters, Greene, & Costich, 2008). Unlike the traditional classroom, where students receive support from teachers, in many CBLEs students are responsible for managing their own learning (Azevedo, 2005). For those with a high-degree of self-regulation, CBLEs are simply another learning challenge to master; for those who lack effective self-regulation, CBLEs may present a formidable learning task (Azevedo, Moos, Greene, Winters, & Cromley, 2008; Winters et al., 2008). Because of the learning advantages demonstrated by highly self-regulated learners, strategies supporting self-regulation in CBLEs have become the focus of researchers and theorists investigating self-regulation (Boekaerts, Pintrich, & Zeidner, 2000; Schunk & Zimmerman, 1998; Zimmerman & Schunk, 2001).

Self-Regulated Learning

Self-regulated learning is a self-directed process, in which students actively plan, execute and evaluate their learning strategies in order to achieve a learning goal, relative to the contextual constraints of the learning environment (Boekaerts, 1999; Schunk &

Zimmerman, 1998). Models of self-regulation vary by theoretical foundation, but most view self-regulation as a multi-stage process, in which learners apply cognitive strategies to a learning task, monitor performance and modify strategy use to improve performance. According to Winne and Hadwin (1998), self-regulatory processes interact and evolve during four phases of learning. In the first phase, learners interpret and define the task. In the second phase, they establish learning goals and select study tactics and learning strategies to achieve those goals. In the third phase, tactics and strategies are enacted. In the fourth and final phase, learners modify their learning processes, based on evaluations of their performance relative to the learning goal. In general, students are self-regulated when they adapt their performance to address differences between their learning performance outcomes and standards for the learning task.

Through the process of selecting, enacting, monitoring, evaluation and modifying their learning processes, students can develop an effective repertoire of self-regulatory processes that enable them to successfully master a learning task (Zimmerman, 1998). However, while self-regulation can develop naturally over time, even many experienced learners lack effective self-regulatory processes (Pressley & Harris, 2006). To address shortfalls in self-regulation, educators have investigated the effects of training self-regulatory processes (Azevedo & Cromley, 2004; Hattie, Biggs, & Purdie, 1996; Pressley & Harris, 2006; Weinstein, Husman, & Dierking, 2000). Training programs can encompass a wide range of self-regulatory processes, including goal orientation, cognitive strategy use, and metacognitive monitoring of learning (McKeachie, Pintrich, & Lin, 1985; Weinstein et al., 2000). Training programs designed to develop self-regulation can be effective – in fact, research shows that one proven method for

improving learning is to provide strategy training to students (Azevedo & Cromley, 2004; Pressley & Harris, 2006). However, even after receiving instruction designed to improve self-regulation, learners often fail to recall and apply self-regulatory processes when needed, even if they have successfully applied the process in the past (Pressley & Harris, 2006). In the classroom, teachers can provide students reminders to self-regulate; unfortunately, in many CBLEs, particularly asynchronous and self-paced training, students may lack immediate access to external support. Therefore, alternative methods of supporting self-regulation, available when the student is actively learning alone, offer the potential of improving learning. One alternative for supporting self-regulation in CBLEs is the use of prompts encouraging self-regulation (Azevedo & Hadwin, 2005; Sitzmann, Bell, Kraiger, & Kanar, 2009).

Prompts

Prompts address self-regulated learning deficiencies by reminding a student what self-regulatory process to use, and when the process should be used (Pressley & Harris, 2006; Thillmann, Künsting, Wirth, & Leutner, 2009). Prompts are an appealing intervention in CBLEs, as they are relatively easy to incorporate into the training material, and easy for the student to implement. Typically, prompts are one or two sentences added at selected points within a lesson that ask a student to evaluate their progress toward a learning goal, assess their understanding of lesson content, or assess the effectiveness of their learning strategies (Sitzmann & Ely, 2010). For example, asking a student to self-evaluate the likelihood of achieving a passing grade on an end of lesson test during training would remind the student to evaluate their current understanding relative to their learning goal, a key self-regulatory process. Additionally,

the prompt would remind the student to evaluate their learning strategy use (e.g., study time, quality of notes) – noting a weakness, they could adjust their strategy. If modifying the strategy led to success, the student might experience a positive sense of self-efficacy, and be encouraged to apply the strategy, and the process of monitoring strategy use, to a subsequent learning event.

The type of prompting described above is designed to encourage the activation, retrieval and execution of existing SRL processes. In this respect, prompts do not teach, or supplant, a learner's self-regulation; rather they encourage activation of existing self-regulatory processes and, in some cases, help learners more fully develop those processes (Pressley & Harris, 2006). Therefore, an important aspect of embedded prompts encouraging self-regulation is the assumption that learners possess some degree of self-regulatory processes. For example, if the prompt is encouraging students to monitor strategy use, then they must possess some knowledge of strategies that are likely to be effective. The prompting strategy, therefore, is not likely to be effective for every learner, or learning environment. Fortunately, there are some populations that can benefit from prompts. For example, even if they do not possess a high degree of self-regulation, many older adolescents and adults do possess a relatively effective set of learning strategies; furthermore, research has shown that older adolescents and adults benefit from interventions that target supporting existing strategy use (Dignath & Buttner, 2008; Hattie et al., 1996; Pressley & Harris, 2006). Thus, these learners may potentially benefit from prompts supporting existing self-regulatory processes.

Prompting Self-Monitoring of Learning

Recently, researchers have begun to investigate different aspects of prompting self-regulation in CBLEs, including the effects of prompting different self-regulatory processes (e.g., prompting cognitive strategy use, or metacognitive monitoring of learning) (Kauffman, 2004), or the effects of different prompting conditions (e.g., prompting before or during learning) (Azevedo, Cromley, Winters, Moos, & Greene, 2005). One promising line of research has been the investigation of prompts encouraging self-monitoring of learning (Azevedo & Hadwin, 2005; Lee, 2008). Self-monitoring of learning is a key self-regulatory process students enact during the performance phase of self-regulation. When monitoring understanding of lesson content during the learning task, learners not only assess their learning, they assess the effectiveness of their learning strategy (Zimmerman, 1990). This process can lead to strategy refinement and improve learning. While research into prompting self-monitoring of learning in CBLEs has provided insight into the effects of prompts encouraging self-regulation and learning, it is not extensive; thus, researchers have called on more studies to help describe the characteristics of effective of prompts for different learning environments (Kauffman, 2004; Sitzmann et al., 2009; Thillmann et al., 2009). Several factors known to influence the effect of prompting interventions have been identified, including prior knowledge and information processing demands, and warrant further study. Furthermore, an ongoing discussion by self-regulation theorists has been on methodological issues associated with studies of self-regulation, including the efficacy of various methods for measuring self-regulation (Azevedo, Moos, Johnson, & Chauncey, 2010; Schraw, 2010; Winne, 2010).

Prior Knowledge

Prior knowledge has been shown to influence learning in CBLEs; students with a high degree of prior knowledge demonstrate greater learning gains when compared to their peers with low prior knowledge (Azevedo & Cromley, 2004; Azevedo et al., 2005; Greene & Azevedo, 2007). The influence of prior knowledge on learning can be explained by conceptual models of learning strategies enacted during self-regulated learning, which rely on the activation of prior knowledge and establishing relevance between what is known and what is being learned (Weinstein et al., 2000). Researchers investigating the influence of prior knowledge on self-regulation have found that prior domain knowledge not only influences learning, but also affects self-regulation (Greene, Costa, Robertson, Pan, & Deekens, 2010; Moos & Azevedo, 2008). Moos and Azevedo (2008), for example, found that students with low prior knowledge were less likely to plan, monitor and evaluate their learning, while Lee, Lim and Grabowski (2009) found that prior knowledge influenced self-regulation in a self-paced CBLE. In general, research suggests that prior knowledge can influence some self-regulatory processes in CBLE; therefore, prior knowledge should be carefully considered when investigating self-regulation.

Information Processing Demands on Self-Regulation

Regulating learning within a CBLE can be a demanding cognitive task, requiring a high degree of attentional resources as learners must integrate information related to both the learning environment and the learning task (Schraw, 2010). This presents a potential challenge for many learners; from an information processing perspective, the burden on cognitive resources may be greatest at the start of training in CBLEs, when

learners are becoming familiar with the learning environment and the learning task (Clark & Mayer, 2007; Clark, Nguyen, & Sweller, 2006). Students who lack experience with the learning environment may have to invest a significant portion of their cognitive resources in learning how to manage the learning environment, while simultaneously investing cognitive resources to selectively attend to, and process, information to be learned (Moos & Azevedo, 2008). These students may therefore have few cognitive resources available to self-monitor their learning, particularly at the beginning of training. Therefore, for many learners, providing prompts encouraging learners to self-monitor their learning at the beginning of a learning task in a CBLE may actually suppress learning, by placing an additional burden on working memory. The possible additional cognitive processing demands prompts may place on learners is a concern to instructional designers, and researchers have investigated the effects of varying the presentation time of prompts (Sitzmann et al., 2009; Sitzmann & Ely, 2010; Thillmann et al., 2009); however, results have varied across learner populations and learning tasks. Therefore, more study is required to help expand on the existing knowledge base regarding the influence of presentation time of prompts in CBLEs.

Measuring Self-Regulated Learning

Studies of self-regulation often rely on self-report instruments, measuring self-regulation as a static attribute at the end of training. While self-report instruments have provided valuable insights into self-regulatory processes (Garcia & Pintrich, 1995), researchers have shown that students are sometimes inaccurate when self-evaluating their learning (Bol, Hacker, O'Shea, & Allen, 2005). Furthermore, self-reports provided at a single point in time, for example at the end of training, do not help adequately describe

changes in self-regulation over time. Self-regulation is a process that evolves over time, as students engage in a learning task; therefore, recording and analyzing changes over time is an important aspect of research investigating self-regulation.

Several methods have been used to capture self-regulatory changes over time. A common method for capturing self-regulatory processes is through the use of talk aloud protocols, in which learners describe their learning process during a learning task; following training, researchers evaluate transcripts of the protocols for evidence of self-regulation (Azevedo & Cromley, 2004; Azevedo et al., 2005; Azevedo et al., 2008). While talk aloud protocols have been effective at describing changes in self-regulatory processes over time (Azevedo et al., 2010), they can be obtrusive, and potentially influence student's self-regulation (Schraw, 2010). A less intrusive alternative is to rely on trace analysis of learner artifacts, for example learner actions recorded within the CBLE, or notes or reflective journals; these are analyzed after learning occurs for evidence of self-regulatory processes or, in some cases, confirmatory evidence relative to other measures (e.g., self-reports) (Schraw, 2010). In addition to being less intrusive, trace analysis, in combination with other measurement of self-regulation, may help to more accurately describe self-regulatory processes, particularly if these measurements occur over time (Sitzmann et al., 2009).

Problem Statement

Students often struggle to learn in computer-based learning environments; these struggles may be due, in part, to their failure to effectively self-regulate their learning, even when they possess knowledge of effective self-regulatory processes. In the traditional classroom, students may receive external support, including prompts or

direction for regulating their learning, from teachers or peers. How can CBLEs support self-regulation for students that are learning without immediate access to external support? One possible solution is through prompts embedded in the CBLE that remind students to apply key self-regulatory processes, such as self-monitoring of learning performance.

Purpose of Study

The purpose of this dissertation was to determine if prompting students to monitor their strategy use and understanding of lesson content during work related, self-paced, computer based training would lead to improved cognitive and metacognitive self-regulation, in terms of cognitive strategy use, and learning. Additionally, this study expanded on prior research investigating the effect of varying the presentation time of prompts on self-regulation and learning. This study addressed the following research questions.

Research Questions

1. Does prompting self-monitoring of learning in a CBLE improve self-regulated learning in terms of cognitive strategy use, and learning in terms of declarative knowledge, for adults completing work-related computer-based training, controlling for prior domain knowledge?
2. How does the timing of prompts encouraging self-monitoring of learning in a CBLE influence self-regulated learning over time, in terms of cognitive strategy use, for adults completing work-related computer-based training, controlling for prior domain knowledge?

3. How does the timing of prompts encouraging self-monitoring of learning in a CBLE influence learning over time, in terms of declarative knowledge, for adults completing work-related computer-based training, controlling for prior domain knowledge?

Definitions

Prompting self-monitoring of learning, for the purpose of this study, refers to written statements embedded in a CBLE asking students to self-evaluate their cognitive and metacognitive self-regulation in terms of strategy use, and current understanding of lesson content using a Likert-type scale. For example, students may be asked to evaluate their strategy use with the following phrase: "I see how information in the previous lesson relates to this lesson.", or may be asked to evaluate their understanding of lesson content using the following phrase: "I understand which sonar mode of operation to select for detecting moored and bottom mines"; Strongly Agree, Agree, Disagree, Strongly Disagree.

A *Computer Based Learning Environment (CBLE),* for the purpose of this study, refers to self-paced lessons provided via a computer.

Self-regulated Learning is an active process in which students plan and establish learning goals, select appropriate learning strategies, monitor their learning, and modify self-regulatory processes as needed to achieve their learning goal, relative to the contextual constraints of the learning environment (Boekaerts, 1999; Schunk & Zimmerman, 1998).

Self-regulation of strategy use, for the purpose of this study, refers to purposeful use of learning strategies, including rehearsal, elaboration and organizational strategies, in order to achieve a learning goal.

Metacognitive self-regulation, for the purpose of this study, refers to the selection, monitoring and adjustment of effective learning strategies during learning.

Declarative knowledge is factual knowledge, or knowledge of "what". Declarative knowledge includes knowledge of facts, concepts and principles.

Prior domain knowledge encompasses the knowledge individuals possess about a particular area of study (Bruning, Schraw, Ronning, & Norby, 2004). In this study, the domain of interest is aircraft tactical operations; the topic is an airborne mine countermeasure system.

Significance of Study

Many students struggle to learn in CBLEs, in part because they lack the ability to effectively self-regulate their learning (Azevedo & Cromley, 2004). Investigating methods for supporting self-regulation in CBLEs, specifically prompts encouraging self-monitoring of learning, may provide effective guidelines for instructional designers developing computer-based training materials and, as a result, improve learner performance.

Few studies have investigated the characteristics of effective prompts in CBLEs supporting work-related training for adults; most studies have focused on K-12 and college students. This study will contribute to the existing knowledge base regarding the effectiveness of self-monitoring prompts on self-regulation and learning, and the

differential effects of varying the presentation timing of prompts in CBLEs, for adults completing work-related computer-based lessons.

CHAPTER 2 LITERATURE REVIEW

Introduction

The focus of this dissertation was to extend current knowledge regarding the effect of prompts encouraging the self-monitoring of learning on cognitive strategy use and comprehension in self-paced computer-based learning environments (CBLEs). Prior research suggests the timing of prompts may influence their effectiveness; therefore, the differential effects of varying the presentation timing of prompts on self-regulation of strategy use and learning were also investigated in this study.

This chapter provides a review of literature related to prompting self-regulation in CBLEs, and provides a rationale for the prompting strategy used in this study. First, the theoretical foundation for the prompting strategy selected is described, followed by a description of cognitive learning strategies and metacognitive self-regulation. Next, prompting self-monitoring of learning is described, followed by a review of selected studies investigating the effects of prompts on self-regulation and learning. Finally, a summary of the literature review describes the rationale for the prompting strategy investigated in this study.

An Information Processing Model of Self-Regulated Learning

Winne and Hadwin's (1998) information processing model of self-regulation provides the theoretical construct of self-regulation used in this study, and provides the basis for the prompting strategy used in this study. Their model proposes that self-regulation of learning occurs over four recursive phases of learning. In the first phase, learners identify task conditions (e.g., time available to complete, resources available for the task) and cognitive conditions (e.g., prior knowledge, motivation to learn, existing

learning strategies). In the second phase, learners establish their learning goals, relative to the learning task, and consider appropriate cognitive operations to achieve that goal. In phase three, learners select and enact strategies (i.e., cognitive processes) to accomplish the learning task. In the final phase, adaptations to learning processes are made, a result of metacognitive monitoring that occurs within (and across) all phases, as learners reflect on gaps between achievement and goals (Winne & Hadwin, 1998).

Processes occurring across the four phases are described in terms of the learner's Conditions, Operations, Products, Evaluations and Standards (identified using the acronym COPES) (Winne & Hadwin, 2008). Conditions are either internal cognitive conditions (e.g., existing domain knowledge, knowledge of learning strategies, motivation, and self-efficacy) or external task conditions (e.g., time for the learning event, the type of learning environment). Operations are the cognitive processes (e.g., learning strategies) that occur during learning, which result in Products (e.g., the ability to demonstrate a learned task, synthesis of information). Evaluations result from a comparison of learning products to Standards; based on evaluations, a learner may decide to adjust conditions, operations, or standards (Winne & Hadwin, 2008).

The modification of conditions, operations or standards are defining characteristics of self-regulated learners (Winne & Hadwin, 2008). To help identify self-regulatory processes, Winne and Hadwin (2008) proposed an "If-Then-Else" framework for evaluating learner processes, in which "If" refers to conditions, "Then" refers to operations, and "Else" refers to alternative operations. For example, if the task is to memorize a phone number provided during conversation long enough to retrieve a phone from another room and dial the number, then the operation selected might be a rehearsal

strategy in which the numbers are repeated in memory until dialed. If that strategy is not effective, the person might enact the "Else" component of the framework and choose a different strategy, for example a mnemonic device, creating a word using letters associated with the phone key pad. The key element in this process is the transition to "Else"; it is at this stage that learners become truly self-regulated (Winne & Hadwin, 2008).

Through the process of monitoring and evaluating learning products, learners develop and refine their cognitive operations, which in turn can influence conditions and operations enacted during future learning events. Through this recursive process, learners develop the processes needed to learn in a variety of contexts. Therefore, a key element of self-regulating learning is the monitoring of the products and the cognitive processes enacted within the context of the learning environment that may lead to the adaptation of those processes (if needed). While monitoring can encompass a range of conditions, operations, or standards across all phases of self-regulation, in this study the focus is on the effectiveness and adaptation of cognitive learning strategies, based on the learners understanding of lesson content.

Cognitive Learning Strategies

Based on information processing models of cognition, cognitive learning strategies are comprised of conscious, controllable cognitive operations resulting in the purposeful manipulation of information by a learner for storage and later retrieval of that information from memory (Pressley & Harris, 2006; Weinstein et al., 2000). Effective cognitive learning strategies encourage deep processing of information by establishing links between prior knowledge and new information (Jonassen, 1988). Craik and

Lockhart (1972) described varying levels of cognitive processing of information, ranging from sensory (shallow) to semantic (deep) processing. For learning strategies to encourage deep processing, they must activate prior knowledge. By associating existing knowledge "structures" (i.e., schema) in memory with information to be learned, cognitive learning strategies enable learners to assign more meaning, or associations in memory, to the new information. The increased associations with existing schema, in turn, support greater encoding of information in long term memory for later retrieval and use. Weinstein and Mayer (1983) described three categories of cognitive learning strategies; rehearsal, elaboration and organization strategies, supporting either basic or complex learning tasks.

Rehearsal Strategies. Rehearsal strategies are used to select and encode information (Weinstein et al., 2000). Rehearsal strategies supporting basic learning include the repetition of information; for example, repeating multiplication facts, while rehearsal strategies for more complex tasks include copying information from a text into notes, or highlighting or underlining key parts of a sentence (Weinstein et al., 2000).

Elaboration Strategies. Elaboration strategies are designed to make information more meaningful by associating it with existing knowledge (Weinstein et al., 2000). When elaborating, learners add personal information that makes the information to be learned more meaningful (Grabowski & Jonassen, 2004). Elaboration strategies supporting basic tasks include creating mental images to support text, or by creating mnemonics (Weinstein et al., 2000). For more complex tasks, elaboration strategies include describing the information to be learned in a learners own words (paraphrasing),

summarizing the key parts of a text, or explaining the information to another person (Weinstein et al., 2000).

Organizational Strategies. Jonassen (1988) described organizational strategies as beneficial in helping learners see how ideas relate to each other; these strategies require learners to identify what they know, and analyze relationships between ideas. Organizational strategies for basic tasks include sorting information based on common characteristics, while strategies for complex tasks include outlining or creating concept maps of information (Weinstein et al., 2000).

The use of cognitive learning strategies is goal directed, dedicated to a specific purpose, and requires learners to invest effort (Weinstein et al., 2000). Researchers have demonstrated that cognitive learning strategies can be taught, and that academic performance, including self-regulation, can be improved through cognitive strategy training (Hattie et al., 1996). However, knowledge of strategies is unlikely to improve self-regulation or learning alone; learners must also possess a metacognitive awareness of when to use the strategies, and they must monitor those strategies in order to adapt the strategies to support learning (Weinstein et al., 2000). The metacognitive factors affecting self-regulation are described next.

Metacognitive Self-Regulation

As described above, metacognitive monitoring of self-regulation is a key element in the theoretical model of self-regulation framing this study. Pintrich et al, (1991) define metacognitive self-regulation as "the awareness, knowledge and control of cognition" (p. 25). With regard to self-regulation of learning, metacognition includes a learner's self-directed efforts to plan, monitor and evaluate the effectiveness of his or her learning

effort (Dignath & Buttner, 2008; Zimmerman, 1990). Relative to cognitive learning strategies specifically, metacognition refers to an appreciation of the value of strategy for a specific learning task or environment, knowledge of when and where to apply the strategy, and the importance of monitoring the effectiveness of the strategy towards meeting a learning goal (Pressley & Harris, 2006).

Zimmerman (1990) described self-monitoring as a complex activity that requires attention and highly developed reasoning processes, typical of more mature learners. Research of self-monitoring supports this claim; younger children, in particular, have difficulty in monitoring the results of strategy use and, even when they do monitor results, they often fail to attribute those results to their strategy use (Butler & Winne, 1995; Dignath & Buttner, 2008; Zimmerman, 1990). In contrast to children, older adolescents and adults, when prompted, are more likely to monitor learning performance, evaluate the effect of their learning strategies, and attribute outcomes to their strategy use (Zimmerman, 1990). In general, research of self-monitoring of learning suggests monitoring of learning skills develop slowly, and improve with training and practice, particularly for older adolescents and adults (Butler & Winne, 1995; Schraw, 1998; Zimmerman, 1990).

The selection, application, monitoring and adjustment of cognitive learning strategies are important self-regulatory processes. However, the strategies are not likely to improve learning if students fail to apply them, or apply them ineffectively (Zimmerman & Schunk, 2008). While some learners may develop effective self-regulatory processes over time, many learners require training specifically focused on developing the cognitive and metacognitive strategies needed to manage their own

learning. An extensive body of research exists regarding strategy training (Hattie et al., 1996; Pressley & Harris, 2006). In general, research suggests strategy training programs targeting self-regulatory processes can improve self-regulation and learning; however, even after training, students sometimes fail to recall or effectively apply self-regulatory processes, such as applying an effective learning strategy, or monitoring performance, even when they possess the knowledge and skills necessary for self-regulation (Pressley & Harris, 2006). In the traditional classroom, teachers address a failure to recall an appropriate self-regulatory process by providing students reminders; in CBLE, one method to address self-regulatory shortfalls is through the use of prompts.

Prompting Self-Regulation

Prompts are cues or questions reminding students to apply existing self-regulatory processes. Based on the theoretical model of self-regulation used in this study, prompts are meant to support the adaptation of existing processes; what Winne and Hadwin (2008) describe occurring in the "Else" component of self-regulation. Examples of prompts embedded in computer-based lessons include text reminding students to establish a learning goal, or survey type questions that ask a student to rate their level of agreement with a statement regarding their learning performance. These types of prompts offer an economical way to encourage self-regulation; inserting an additional line of text or a screen in a computer-based lesson is relatively simple and inexpensive, and is not likely to consume an excessive amount of time to process.

Prompts encouraging self-monitoring of learning performance should improve strategy use and, ultimately, learning (Kauffman, 2004; Sitzmann et al., 2009). Prior research suggests monitoring strategy use through metacognitive self-regulation (i.e.,

monitoring of performance) can improve learning, particularly for older adolescents and adults (Dignath & Buttner, 2008; Hattie et al., 1996). Hattie et al., (1996), in a meta-analysis of strategy training interventions, found interventions combining metacognitive self-regulation with learning strategy training were more effective than interventions focused solely on learning strategy training alone, although the effect differed between young students and older adolescents. They noted younger students seem to be most responsive to interventions focused on training learning strategies, and less responsive to metacognitive interventions, while the opposite was true for older students. Whereas younger students were focused on initial strategy development, older students, who possessed some effective strategies already, were more likely to monitor and adjust their learning performance (i.e., demonstrate metacognitive self-regulation) (Hattie et al., 1996).

Findings from Hattie, Biggs and Purdie's (1996) meta-analysis were supported in a more recent meta-analysis of self-regulated learning interventions conducted by Dignath and Buttner (2008). They focused on interventions providing direct instruction of self-regulated learning strategies in primary and secondary schools. At the secondary school level, they reported performance was better if programs combined cognitive strategy use with metacognitive self-regulation. In keeping with the Hattie et al., study, younger learners appeared to benefit the most from cognitive strategy training; they hypothesized younger learners lacked the information processing resources needed to concurrently apply metacognitive self-regulation (monitoring of strategy use and comprehension) while simultaneously learning how to apply cognitive learning strategies. Whereas younger students benefited the most from interventions focused on cognitive

strategies alone, strategy training combined with metacognitive self-regulation were more effective for older learners (Dignath & Buttner, 2008). The results of these two meta-analyses, encompassing over twenty years of strategy intervention research, suggest prompts encouraging metacognitive self-regulation of strategy use can improve self-regulation and learning, particularly for older adolescents and adults. In the next section, selected studies investigating the effects of these types of prompts are described.

Prompting Cognitive and Metacognitive Self-Regulation

Researchers have targeted strategy use and metacognitive self-regulation using prompts with positive effect. Berthold, Nückles and Renkl (2007), for example, provided undergraduate psychology students either cognitive, metacognitive or a combination of both types of prompts supporting a writing exercise in a developmental psychology course. Cognitive prompts encouraged the organization or elaboration of lesson content while writing, while metacognitive prompts encouraged monitoring of comprehension during writing. An example of a cognitive prompt included, "How can you best organize the structure of the learning content?" An example of a metacognitive prompt was, "Which main points haven't I understood yet?" After a pretest of prior domain knowledge, participants completed a video-based lesson on developmental psychology. They were then assigned to either a control, cognitive prompt, metacognitive prompt, or mixed prompting group and directed to complete a writing assignment describing the lesson content. The directions for the assignment varied by group, with the cognitive and metacognitive group receiving six prompts each, and the mixed group received three of each type of prompt, over a thirty minute period. After the writing assignment, participants completed a comprehension test and self-assessment of learning success.

Strategy use was measured qualitatively, by two separate raters using a 6-point rating scale based on the use of organization and elaboration strategies in student writings, and by student responses to metacognitive prompts.

Berthold et al., (2007) reported students receiving cognitive plus metacognitive prompts significantly outperformed the control group and metacognitive only group in their use of organization, elaboration and metacognitive strategies, and in learning outcomes. The group receiving only cognitive prompts also demonstrated greater strategy use and, interestingly, greater monitoring of learning. The researchers suggested the cognitive prompts may have served to remind students to monitor their learning, thus acting as metacognitive prompts, in a manner similar to the combined prompting condition. Additionally, Berthold et al., (2007) reported strategy use mediated comprehension; when they analyzed comprehension scores between groups using strategy use as a control variable, no significant differences were found on comprehension, suggesting the prompts improved strategy use, which improved learning.

Similarly, Lee, Lim and Grabowski (2009) provided prompts supporting both cognitive and metacognitive self-regulatory processes to undergraduates completing computer-based training of the human circulatory system. To encourage strategy use, they prompted students to organize and elaborate lesson content in an embedded note field. The researchers supported monitoring of strategy use by prompting students to review their notes, based on the results of answers to embedded questions in the learning environment.

The study included three groups; a control group, a group with prompts for cognitive strategy use (e.g., summarize the information on this screen in the note field),

and a group with prompts for strategy use and monitoring of learning (e.g., incorrect, you need to go back and revise your notes). The groups were further divided by level of prior knowledge, either high or low, based on the results of a pretest. The researchers reported students who received both types of prompts significantly outperformed students in the other two groups; furthermore, students receiving both types of prompts self-reported greater use of self-regulation. They found no effect for prior knowledge, which they attributed to the extremely low prior knowledge of all participants. Unlike the study by Berthold et al., (2007) in this study Lee et al., (2009) did not analyze learner notes to determine if students used the note-taking field, highlighted or elaborated on the information, so the direct effect of prompts on strategy use was not measured.

However, in a subsequent experiment, Lee, Lim and Grabowski (2010) did measure evidence of strategy use in learner notes, using a researcher-developed rubric to qualitatively assess strategy use. Additionally, in this second, follow-up study, the researchers included prior domain knowledge as a covariate, based on prior research demonstrating prior knowledge influenced strategy use and learning. Similar to the first study, the researchers found the combination of cognitive and metacognitive prompts improved self-regulation and learning. Additionally, in this second study the researchers reported students who received both types of prompts demonstrated significantly greater use of cognitive learning strategies, based on their analysis of learner notes (Lee et al., 2010).

Multiple Measures of Self-Regulatory Processes

An advantage of the second experiment conducted by Lee et al., (2010) over the first was the measurement of overt strategy use (i.e., the analysis of learner notes), in

combination with a measure of covert strategy use (i.e., the self-report measure). The reliance on self-reports for measuring self-regulation, while common in self-regulated learning research, often leaves questions with regard to the actual effect of interventions on student self-regulatory processes, as learners are often inaccurate when reporting their use of learning strategies (Clarebout, Horz, Schnotz, & Elen, 2010; Winters et al., 2008). Recently, researchers investigating self-regulation have called for more comprehensive measures of self-regulation, using multiple covert and overt measures, similar to those applied by Lee et al. (2010) in their study (Azevedo et al., 2010; Schraw, 2010).

Kauffman, Ge, Xie and Chen (2008) used multiple measures to evaluate the effects of prompting on self-regulation and learning. They provided undergraduate teacher education students prompts supporting problem solving and self-monitoring of learning during a web-based classroom management case-study. Participants either received no prompts, problem solving prompts, monitoring prompts, or a combination of problem solving and monitoring prompts. Problem solving prompts encouraged students to identify, describe and determine a solution to a case-study problem, while monitoring prompts asked them to self-evaluate their solutions using a 5-point rating scale. In addition to the self-report measures, the researchers used a rubric to measure the quality of student written solutions to the problem presented in the case study, and the quality of their writing. Kauffman et al., (2008) reported students who received the problem solving prompts in combination with monitoring prompts solved more problems, and wrote higher quality responses than students who did not receive prompts, or received only problem solving or monitoring prompts (Kauffman et al., 2008). Thus, prompting a

combination of self-regulatory processes resulted in better learning, as measured using self-reports and a qualitative assessment of learner writings.

Influence of Prior Domain Knowledge

Kauffman et al., (2008) hypothesized the prompts encouraging only monitoring of learning may have been ineffective because the participants possessed very low prior domain knowledge; they suggested the students had to expend their cognitive resources to apply their learning strategy, and therefore lacked the cognitive resources needed to monitor their understanding. Prior research supports this hypothesis; in general, students with high prior domain knowledge use a greater number of advanced learning strategies (e.g., elaboration, organizational), in comparison to students with low prior knowledge, who tend to rely on a few basic strategies (e.g., listing and rehearsal of facts) (Berthold, Röder, Knörzer, Kessler, & Renkl, 2010; Moos & Azevedo, 2008; Pressley & Harris, 2006).

Building on prior research investigating the effect of prior domain knowledge on strategy use, Moos and Azevedo (2008) found that prior domain knowledge had a significant effect on undergraduates self-monitoring of learning in a CBLE. They reported learners with low prior knowledge relied on a few low level learning strategies, and failed to monitor their strategy use and comprehension when learning about the human circulatory system. In contrast, learners with high prior domain knowledge demonstrated greater self-monitoring of learning. Similar to Kauffman et al., (2008) they suggested students with low prior knowledge may have lacked the cognitive resources needed to concurrently apply learning strategies and monitor learning, while students

with high prior domain knowledge had adequate cognitive resources to perform both tasks simultaneously (Moos & Azevedo, 2008).

Implications

Overall, the studies described above provide the following implications:

- Prompts targeting cognitive and metacognitive self-regulatory processes improve self-regulation and learning, particularly for older adolescents and adults.
- Whereas early research of self-regulation relied primarily on self-reports of self-regulation, recent studies incorporate multiple measures of self-regulation that capture overt use of self-regulatory processes.
- Prior domain knowledge influences self-regulation and learning.

The studies described above suggest prompts encouraging the monitoring of strategy use and metacognitive self-regulation can improve self-regulation and learning. Recently, researchers have begun to investigate the influence of prompting characteristics, including the optimal presentation timing of prompts for different types of learning environments (Sitzmann et al., 2009; Sitzmann & Ely, 2010; Thillmann et al., 2009). This line of research is based on principles of information processing, suggesting the timing of prompts may influence cognitive processes while learning. In the next section, selected studies are reviewed describing the effects of varying the presentation time of prompts.

The Timing of Prompts

From a theoretical perspective, prompting self-monitoring of learning during the third (performance) phase of self-regulation, when learners are actively engaged in

applying learning strategies, should encourage self-monitoring and, if necessary, modification of learning strategy employment, thereby improving self-regulation and learning. Intuitively, continuously prompting self-regulation throughout a learning event should be an effective strategy. However, information processing demands may be highest at the start of training in a CBLE, when learners are becoming familiar with the learning environment and content (Clarke, Ayres, & Sweller, 2005). Therefore, providing any additional burden on information processing demands (i.e., prompts encouraging monitoring of learning at the beginning of training) in a CBLE, might actually suppress learning. One strategy to address the potential burden on working memory is to delay prompting at the start of training, providing learner's an opportunity to become familiar with the learning environment and content prior to implementing prompts.

Prompting Before or During Learning

To compare the effects of prompting before and during learning in a CBLE, Thillmann, Künsting, Wirth, and Leutner (2009) varied the timing of prompts for high school physics students using a computer-based lesson describing principles of buoyancy. The researchers provided prompts before and during training, in a sequence that encouraged either generating and processing information, or processing and generating information. Treatments either presented all information needed, thereby encouraging simple processing of information, or the information was presented in a manner that required the learner to generate additional information needed to complete the lesson, thereby encouraging the generation of information. They measured student's strategy use, either generation or processing of information, by analyzing computer log file data in

combination with a self-report instrument. To limit the influence of existing prior domain knowledge on the prompts, the researchers used prior knowledge as a control variable. While the sequence of the prompts had no effect on self-regulation or learning, students provided continuous prompting demonstrated greater learning in comparison to a group provided prompting before the lesson began. Additionally, Thillmann et al., (2009) reported strategy use mediated the effect of the prompts on learning; continuous prompts appeared to improve strategy use, which in turn improved learning.

Immediate versus Delayed Prompting

Sitzmann, Bell, Kraiger and Kanar (2009) investigated the effect of varying the presentation time of prompts in two separate experiments. In the first experiment, college instructors completed ten self-paced, web-based lessons providing declarative and procedural knowledge of the Blackboard learning management system (LMS). The timing of prompts varied across three groups: a control group receiving no prompts, an immediate group receiving prompts at the start of training, and a delayed group receiving prompts midway through training. Two prompts were provided at the end of each of ten lessons. Examples of prompts included, "Are the study tactics I have been using effective for learning the training material?", and "Do I understand all of the key points of the training material?" Trainees responded to prompts using a five-point scale, ranging from 1 = *strongly disagree* to 5 = *strongly agree*. To measure learning, participants completed an end-of-course test. The test contained 10 multiple-choice questions assessing declarative knowledge, and the students logged on to the LMS to complete 10 questions assessing procedural knowledge. Two assessment questions evaluated knowledge for each of the 10 lessons. Thus, the researchers were able to

evaluate changes in learning over time for the course, by comparing scores between groups using the two questions representing content from each of the 10 lessons.

In addition to evaluating the differential effect of varying the timing of prompts, Sitzmann et al., (2009) investigated changes in self-regulation and learning over time. From a theoretical perspective, an important aspect of self-regulation is the recursive nature of the process; student's self-regulation varies over time, as they adapt and refine their self-regulatory processes. However, few studies of SRL in CBLE evaluate changes over time; most rely on between subjects' designs evaluating self-regulation as a static event at the end of an intervention. Therefore, Sitzmann et al., (2009) addressed changes over time using a mixed-model, within-subjects experimental design.

Sitzmann and her colleagues compared differences within each group's learning over time. The control group's scores declined over time, ending .18 standard deviations (SD) below the mean. The immediate prompting group's scores increased over the first four lessons, and then remained constant, ending approximately .08 SD above the mean. The delayed group's scores were .09 SD below average for the first four modules, and then steadily increased until they were .22 SD above average by the end of the course. Thus, the delayed prompts resulted in the greatest increase in learning by the end of training, and immediate prompts improved performance in comparison to the control group, whose scores declined steadily over time. Additionally, the researchers reported the immediate prompting group's scores were not suppressed over the first five modules in comparison to the other two groups, suggesting the prompts did not induce a burden on information processing at the start of learning (Sitzmann et al., 2009).

In their second experiment, Sitzmann et al., (2009) investigated the effects of prompts on undergraduates basic (i.e., declarative and procedural) and strategic (i.e., conditional) knowledge while learning a complex task, using a computer-based radar-tracking simulation. In this experiment, the researchers investigated the influence of cognitive ability (based on SAT/ACT scores) and task self-efficacy (based on self-reports) on the effect of prompting self-regulation, in addition to comparing differences over time for immediate and delayed prompts. Prompts, the same used in the first study, were presented at the end of each of nine training sessions. Performance was measured using the results of students demonstration of basic (e.g., engaging targets correctly) and strategic (e.g., engaging greatest threat) performance during the nine sessions.

A comparison of scores between groups revealed a significant difference on basic (declarative and procedural) knowledge between groups, with both prompting conditions (immediate and delayed) scoring significantly higher than the control group (Sitzmann et al., 2009). There were no significant differences between groups for strategic performance. For both basic and strategic performance, an analysis of scores within groups over time revealed that, similar to the first experiment, the control group's performance declined over time, while the immediate and delayed groups' improved. For basic tasks, the immediate prompting scores were above average, and remained constant throughout training, while the delayed conditions scores were average, then increased when the prompting began. By the end of training, control, immediate and delayed scores for basic knowledge were .32 SD below, .08 SD above, and .21 SD above average, respectively. Similar to the first experiment, the delayed condition led to the highest performance by the end of training.

For strategic performance, scores for the immediate condition increased, and then leveled off, while the delayed condition remained constant until the prompts began, at which time scores increased before leveling off at the end of training. By the end of training, scores for the control, delayed and immediate conditions were .25 SD below, .11 SD above, and .16 SD above average. Unlike basic knowledge, for strategic performance, the immediate condition resulted in the greatest increase in performance. Additionally, similar to the first study, the immediate prompts did not suppress learning, suggesting the prompts do not induce significant demands on information processing at the start of training. Finally, the researchers reported students with higher task self-efficacy and cognitive ability benefited more from the prompts than students with lower self-efficacy and cognitive ability.

The first experiment provided web-based, work-related, self-paced training to college instructors, while the second experiment provided computer-based training in a controlled environment to college undergraduates. Prompting led to improved or stable performance over time in both experiments, while scores for participants who did not receive prompts decreased over time. In both experiments, delaying prompts led to improved performance for basic tasks, while in the second experiment, the immediate prompts led to greater performance for strategic tasks. Sitzmann et al., (2009) hypothesized that for basic tasks, the delayed prompts may have encouraged students to maintain on task performance. While the learners were likely to be engaged at the start of the task, as they became familiar with the content and learning environment, their interest may have waned over time. The addition of the prompts midway through the training may have encouraged participants to remain engaged in the task, thereby

improving performance (Sitzmann et al., 2009). For strategic tasks, the researchers hypothesized the more demanding nature of the task may have required the continuous support afforded by the prompts, thus the immediate condition resulted in greater performance by the end of training (Sitzmann et al., 2009).

In both experiments, providing prompts at the start of training did not suppress learning; in fact, scores were higher for the immediate prompting condition at the start of training in comparison to the control and delayed groups. While the participants in their study did not demonstrate suppressed performance because of the prompts, experimental groups included participants who were academically proficient, who may have already possessed an effective repertoire of strategies and, therefore, may not have experienced additional cognitive demands when processing the prompts. Therefore, the researchers recommended that future studies investigate the influence of timing on performance for less academically proficient learners (Sitzmann et al., 2009).

In a subsequent experiment, Sitzmann and Ely (2010) investigated the influence of several mediating factors on the effects of prompts, including the presentation timing of the prompts. They provided prompts to adults completing a voluntary web-based course providing free Microsoft Excel training. Participants included 479 working adults, approximately 30% were high school graduates, and approximately 70% were college graduates; 68% were employed full-time, 11% part-time, the average age was 42 years and 56% were female. The researchers varied the presentation time of prompts across six conditions; no prompts, prompts before training, continuously, delayed, during the first half of training, or delayed until the second half of training. Prompts asked students questions encouraging monitoring of strategy use and comprehension. Students

responded to the prompts using a 5-point scale. A self-report survey was used to measure self-regulatory activity, and a multiple-choice test was used to measure declarative and procedural knowledge. The researchers also measured time on task, and attrition. They found a positive effect for continuous prompting, the only treatment having an effect on learning and attrition.

The results of their study demonstrated prompts can improve learning, and the presentation time of prompts does influence the effect on learning declarative and procedural knowledge (Sitzmann & Ely, 2010). However, the lack of effect for the delayed condition contradicted findings from the previous experiment conducted by Sitzmann et al., (2009) in which students receiving delayed prompts demonstrated greater declarative knowledge by the end of training, in comparison to a control group and a group receiving continuous prompting. One reason for the conflicting results may have been the high attrition rate, which included over one third of study participants; the authors hypothesized that students who may have benefited from the delayed prompting may have quit the training before the prompts were able to influence their performance (Sitzmann & Ely, 2010). Alternately, the learners may have been less academically proficient than the college instructors and undergraduates included in the previous study, and therefore may have benefited more from the continuous prompts.

Implications

Overall, studies investigating the influence of timing on prompting self-regulation provide the following implications:

- Prompting self-regulation during training is more effective than prompting before training begins.

- Providing prompts at the beginning of training in a CBLE does not impose significant information processing demands on learners, or suppress learning. However, it should be noted that the learners in these studies were academically proficient, and may have automated multiple learning strategies, reducing or eliminating any negative effects on information processing the prompts may have induced.
- The effect of immediate versus delayed prompts is not clear. While proficient learners seemed to benefit from delayed prompts in one study, in a subsequent study immediate prompts were more effective.
- Using multiple measures of self-regulation and learning over time can provide insight into changes in learners self-regulation and learning.

Summary

Although CBLEs are commonly used in education and training, many students struggle to learn in such environments, in part because they fail to recall and apply effective self-regulatory processes when learning. The Winne and Hadwin (1998) theoretical model of self-regulation proposes recursive phases of self-regulation, in which learners evaluate task conditions, establish goals and select strategies, enact those strategies; throughout all phases of learning, students monitor and evaluate the effectiveness of their processes, relative to standards. If performance does not align with standards, then students adapt their learning conditions, processes or standards. The adaptation of learning defines self-regulation of learning, which can be evaluated using an If-Then-Else framework, in which "If" refers to task conditions, "Then" refers to strategies enacted, and "Else" refers to adaptations of processes based on monitoring.

Within this theoretical framework, a key self-regulatory process is the monitoring of learning performance; as students evaluate learning products, they adapt cognitive operations for processing information. Therefore, providing student's reminders, or prompts, to monitor their learning can improve performance, if the prompts are presented in a manner that supports effective cognitive processing.

Based on the literature, prompting students to monitor their learning in a CBLE should improve self-regulation and learning. However, prior research has primarily focused on the effect of prompts on learners who possess a high degree of academic proficiency. Few studies have investigated the effect of these types of prompts on adults completing work-related training, or adults who do not possess a high degree of academic proficiency. Therefore, in this study, the effects of prompts encouraging the monitoring of learning were investigated for enlisted military personnel, completing work-related, self-paced computer-based training.

While the studies described in this review of the literature suggest prompting during the performance phase of learning is more effective than prompting prior to learning, the effect of immediate versus delayed prompts on self-regulation and learning in a CBLE is less clear. Therefore, in this study, the timing of prompts was varied to determine the most effective strategy for this population of learners. In addition to the presentation timing of prompts, the literature suggests the effectiveness of prompts may be influenced by prior domain knowledge. To mitigate the influence of prior domain knowledge on the prompting intervention used in this study, prior knowledge was measured using a pretest, and used as a covariate.

As self-regulation is a recursive process that develops during learning, measurements of self-regulatory processes over time may provide a more accurate picture of the effect of prompts on self-regulation. As learners monitor and modify their strategy use to improve learning performance, their self-regulatory processes and overall learning could change throughout the learning event. Therefore, in this study, changes in self-regulation and comprehension were evaluated over time. Finally, the literature reviewed suggests multiple measures may more accurately describe a student's use of self-regulatory processes, and these measures should evaluate students' covert and overt self-regulation. In this study, in addition to self-report measures, an analysis of learner notes were used to measure strategy use, a strategy employed in prior studies investigating the effect of prompts (Berthold et al., 2007; Lee et al., 2010).

In the following chapter, the research method used to answer the following research questions is described:

Research Questions

1. Does prompting self-monitoring of learning in a CBLE improve self-regulated learning in terms of cognitive strategy use, and learning in terms of declarative knowledge, for adults completing work-related computer-based training, controlling for prior domain knowledge?
2. How does the timing of prompts encouraging self-monitoring of learning in a CBLE influence self-regulated learning over time, in terms of cognitive strategy use, for adults completing work-related computer-based training, controlling for prior domain knowledge?

3. How does the timing of prompts encouraging self-monitoring of learning in a CBLE influence learning over time, in terms of declarative knowledge, for adults completing work-related computer-based training, controlling for prior domain knowledge?

CHAPTER THREE METHODOLOGY

This study investigated the effects of prompting self-monitoring of learning on self-regulation of strategy use and learning for students completing work-related training in a computer-based learning environment. Additionally, this study investigated the differential effects of varying the presentation time of prompts on self-regulation and learning. This chapter describes the study's design, including the participants, variables, treatments, measurement instrument, procedures and data analysis.

Sample

A total of 94 active duty enlisted military personnel assigned to military aviation units on the U.S. Atlantic coast participated in this study. Prior to the study, a required sample size was estimated using G*Power, a power analysis software program that calculates sample size based on statistical test, alpha, required power and effect size (Faul, Erdfelder, Buchner, & Lang, 2009). For this study, an alpha of .05, power of .90 and moderate effect size (.06, .5) were chosen. Two estimates of required sample size were calculated for this study, one for repeated measures analysis of variance and one for multivariate analysis of variance, the statistical tests used to evaluate changes over time and between groups, respectively. A sample size of 27 was determined based on alpha .05, power .90, and effect size .5 for a repeated measures analysis of variance with three groups and six dependent measures. A sample size of 39 participants was determined for alpha .05, power .90, and effect size .06 for a multivariate analysis of variance with three groups and two response variables. Although the power analysis suggested a sample of 39 would have sufficient power, Fraenkel and Wallen (2009) suggest a minimum sample

size of 30 participants per cell for moderate effect and power; therefore, for this study the minimum cell size was 30 participants.

Prior to gathering data, an application requesting permission to conduct research was submitted to, and approved by, the University Institutional Review Board in the Fall of 2011. Volunteers were solicited via e-mail to their unit commanding officers (Appendix A). Although participation was voluntary, to provide incentive to complete the study, each participant was entered into a drawing for an electronic notebook (iPad). The number of entries per individual into the drawing varied depending on the following criteria: for completing the study, one entry, for scoring an 80-89% on the post-test, one entry, for scoring 90-100% one entry. Therefore, a student who completed the study and passed with a score of 90% or better was entered into the drawing three times. Additionally, for every 10 participants, a $20 gift certificate was awarded.

Of the 94 participants, 90 completed all components of the study. Four cases were missing data; a result of a computer failures. These four cases were eliminated from further analysis, leaving 90 cases in the final data set. In the final data set, the average age of participants was 24 years, 80% were males, they had completed 13 years of education, four years of military service, and their average rank was E4 (military enlisted ranks range from E1 to E9). Demographic data for the participants are included in Table 1.

Table 1 *Participants Demographic Data*

Variable		N	Percent
Gender	Male	72	80.0%
	Female	18	20.0%
Rank	E4 and below	67	74.5%
	E5	13	14.4%
	E6 and above	10	11.1%
Age	19-23	57	63.3%
	24-28	20	22.2%
	29-40	13	14.4%
Years of Education	12	42	46.7%
	13	19	21.1%
	14	20	22.2%
	15 or more	9	10%

Variables

Independent Variables

This study included one independent variable, prompts encouraging monitoring of learning. Prior knowledge was used as a covariate in this study.

Dependent Variables

This study included two dependent variables, learners' cognitive and metacognitive self-regulation of learning and learners' declarative knowledge.

Treatment Materials

Computer-based Lessons

Treatment materials were developed using an existing computer-based course consisting of six lessons used by the population of interest for this study, military personnel (U.S. Navy, 2011). The course includes facts, concepts, principles and procedures for employing a sonar system used to detect anti-ship mines during military operations. Lessons describe the capability of the sonar system, employment procedures, and principles associated with analyzing sonar data. Each of the six lessons in the original course included a title slide, an introduction, a list of learning objectives, information screens with text and static or dynamic images, and an end of lesson quiz. On average, each lesson included 36 screens of text and supporting graphics, and included 4,350 words. Readability statistics were calculated using Microsoft Word; the Flesch-Kincaid Grade Level was 8.9. The content included in this course represents the type of computer-based training material the population of interest for this study routinely completes.

Modified Lessons

The six lessons used in this study were modified from SCORM 1.2 format, delivered via a learning management service (LMS), to a presentation format using Microsoft PowerPoint and visual basic programming. Converting the lessons to PowerPoint allowed the researcher to modify the lessons to include the prompting treatment. The lessons were presented to participants' in full-screen kiosk presentation mode, and participants navigated within the lesson using action buttons (e.g., back, home, and forward) on the screen. A visual basic macro was used to disable the computer

keyboard escape button to restrict participants computer actions to moving within the lesson content (i.e., participants were not able to exit the course until the final lesson was finished, although they could move about within each lesson).

Each of the modified lessons included the same components as the original lessons (a title slide, introduction, lesson learning objectives, a series of information screens related to each objective, end-of-lesson tests) and, depending on the treatment group, screens with prompts encouraging self-monitoring of learning (described below). The introductory screen for the first lesson provided to the groups receiving prompts was modified to provide the following text, similar to text used during prior research investigating the effect of prompts in a CBLE (Sitzmann et al., 2009):

> "Research has shown that self-monitoring of learning is an important learning strategy. However, many students forget to monitor their understanding of lesson content in computer-based training. In this lesson, several screens will ask you to evaluate your learning, using a 4-point scale. Please read the question carefully and provide an honest answer."

The six modified lessons, on average, included 49 screens of text and supporting graphics, five learning objectives, three prompts, and approximately 3,765 words. After modifying the lessons with prompts, readability statistics were calculated using Microsoft Word; Flesch-Kincaid Grade Level was 8.9, equal to the original lessons. The number of learning objectives, screens and prompts for each of the six modified lessons are provided in Table 2.

Table 2 *Number of Objectives, Screens and Prompts per Lesson*

	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
Learning Objectives	4	8	3	7	8	5
Screens	38	57	51	46	49	52
Prompts (Total)	3	4	3	4	4	3
Understanding	1	2	1	2	3	1
Strategy Use	2	2	2	2	1	2

Prompting Treatments

Depending on the treatment group, lessons were modified to include prompts encouraging monitoring of understanding of lesson content and monitoring of cognitive strategy use. There were 10 prompts encouraging monitoring of understanding, and 11 prompts encouraging monitoring of strategy use in the course. The wording of prompts to monitor understanding was based on lesson content, and the wording of prompts to monitor strategy use were derived from questions included in the self-regulation questionnaire used in this study, the Motivated Strategies for Learning Questionnaire (MSLQ), described in the measurement instruments section of this chapter. Each of the six lessons contained either three or four prompts, distributed equally throughout the lesson; prompts were distributed to encourage self-monitoring throughout the lesson. An example of a prompt to monitor understanding included in a lesson was, "I understand how sound "channels" created by different water temperatures can influence the FLS or VSS sonar's ability to detect a mine".. An example of a prompt to monitor strategy use included in a lesson was, "My notes include all of the important information from this

lesson". Learners responded to prompts using a 4-item Likert scale (Strongly Agree, Agree, Disagree, Strongly Disagree). Regardless of participants' response to the prompt, the lesson automatically advanced to the next screen (although participants could navigate back to a previous point in the lesson if desired). A complete list of prompts is included in Appendix D. The six lessons were modified to support three treatment groups, as described below.

Treatment 1: Immediate Prompting of Self-Monitoring of Learning

In the immediate prompting condition, prompts began in the first lesson, following the introductory statement describing the benefits of monitoring learning. The prompts were provided three times during the first, third and sixth lesson, and four times during the second, fourth and fifth lesson, for a total of 21 prompts (ten prompts for monitoring understanding, and 11 prompts for monitoring strategy use). A screen shot of a prompting screen is provided in Figure 1.

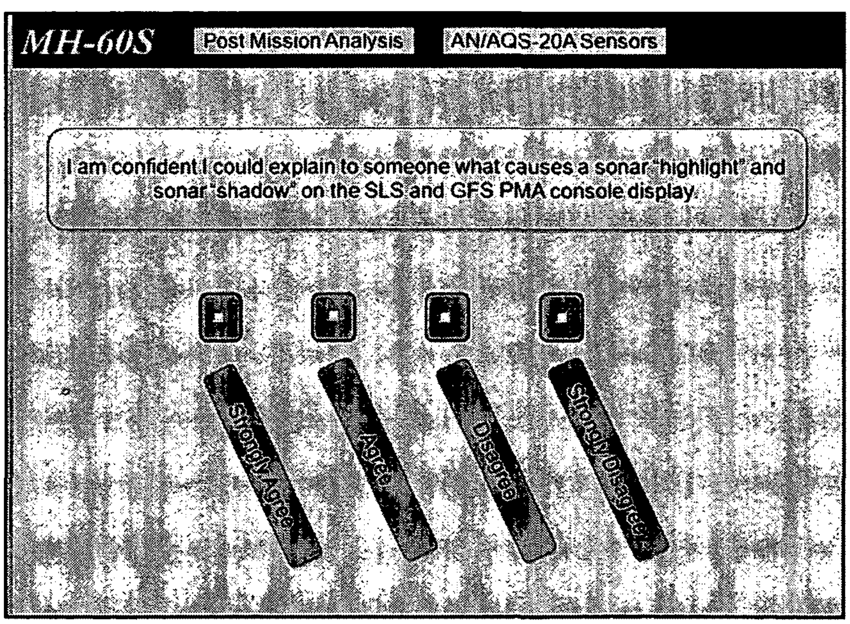


Figure 1. Sample screen shot of prompting screen from lesson.

Treatment 2: Delayed Prompting of Self-Monitoring of Learning

In the delayed prompting condition, the prompts began in the fourth lesson, following the introductory statement describing the benefits of monitoring learning. There were four prompts in lessons four and five and three prompts in lesson six, for a total of 11 prompts (six prompts for monitoring understanding, and five prompts for monitoring strategy use).

Control Treatment: No Prompting

The control group treatment did not include the introductory statement describing the benefits of monitoring learning, and there were no prompts provided in any of the six lessons.

End of Lesson Tests

Six end-of-lesson tests were modified by the researcher using existing questions from the original lessons and lesson content. Lesson one included five multiple-choice questions, lessons two through six included ten multiple-choice questions. An example of a quiz question is provided below.

The Single Pass Shallow (SPS) mode is used to detect and classify______________.

A. close-tethered mines only

***B. bottom, close-tethered and in-volume mines**

C. bottom mines only

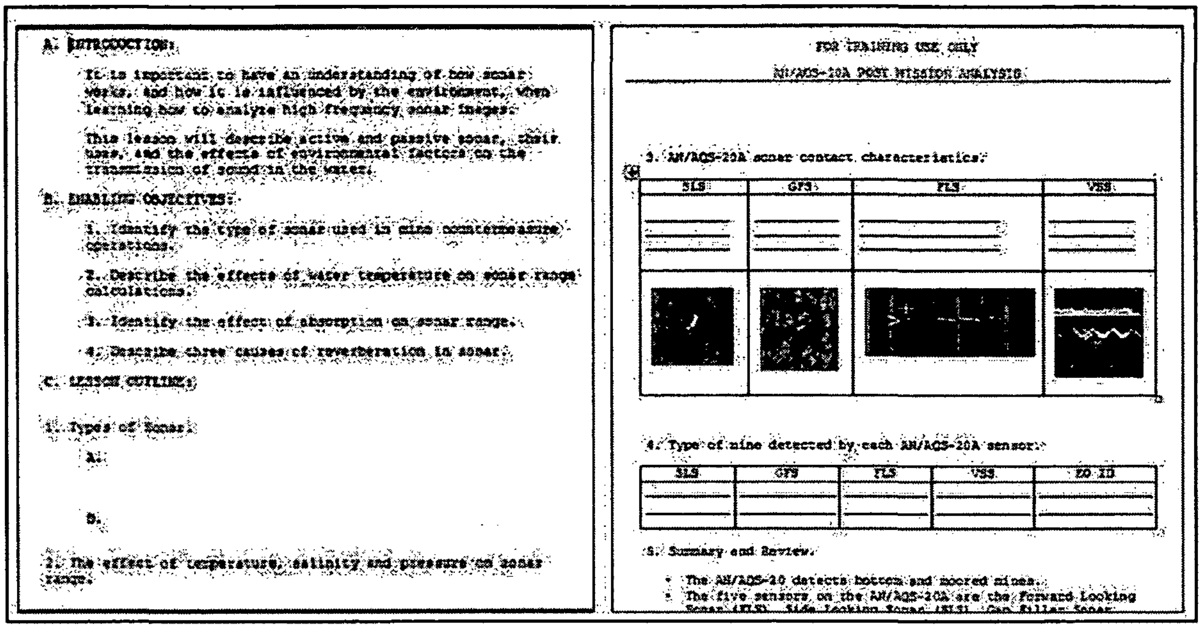
D. floating mines

Visual basic coding was used to provide feedback (e.g., "Correct" or "Incorrect, the correct answer is B") for test questions, and to automatically transition participants to the

next test question. The lesson would not advance until an answer was selected for each question. Upon completion of a lesson test, visual basic coding automatically transitioned participants to the next lesson. Lesson tests are described in further detail in the instruments section.

Student Guide

In addition to the six computer-based lessons, an existing paper-based student guide developed for students attending classroom instruction related to the sonar system described in the computer-based course was used in this study (U.S. Navy, 2008). Student guides are typically a required component of formal training programs in the military; students use the student guides to take notes and to aid studying. The student guide was modified by the researcher to reflect only the lesson material included in the computer-based lessons; the original version of the student guide included material related to physical characteristics of the sonar system and aircraft system emergency procedures not included in the computer-based lessons. For each lesson, the student guide included an introduction, a list of learning objectives, an outline of the lesson with a section for taking notes for each learning objective, blank areas for free-form note-taking, and a summary of the lesson. The outline section included either bullets related to lesson content, fill in the blank sentences related to lesson content, or tables related to lesson content. The student guide used for this study included 21 pages and 2,623 words. Readability statistics were calculated using Microsoft Word; Flesch-Kincaid Grade Level was 9.5. An example of two typical pages from the student guide is provided in Figure 2.



A. INTRODUCTION:

It is important to have an understanding of how sonar works, and how it is influenced by the environment, when learning how to analyze high frequency sonar images.

This lesson will describe active and passive sonar, their uses, and the effects of environmental factors on the transmission of sound in the water.

B. ENABLING OBJECTIVES:

1. Identify the type of sonar used in mine countermeasure operations.

2. Describe the effects of water temperature on sonar range calculations.

3. Identify the effect of absorption on sonar range.

4. Describe three causes of reverberation in sonar.

C. LESSON OUTLINE:

1. Types of Sonar:

A.

B.

2. The effect of temperature, salinity and pressure on sonar range.

FOR TRAINING USE ONLY

AN/AQS-20A POST MISSION ANALYSIS

3. AN/AQS-20A sonar contact characteristics:

SLS	GFS	FLS	VSS

4. Type of mine detected by each AN/AQS-20A sensor:

SLS	GFS	FLS	VSS	EO ID

5. Summary and Review.

- The AN/AQS-20 detects bottom and moored mines.
- The five sensors on the AN/AQS-20A are the Forward Looking

Figure 2. Example of Student Guide.

In addition to the computer-based lessons and student guides, the study included a 25-question pretest and post test (the same items were used for both tests), a self-regulation survey, and an evaluation instrument used to assess participants' use of rehearsal, organization and elaboration strategies in their student guides. A subject matter expert reviewed all materials for content validity, and the primary researcher, a military education and training specialist, reviewed all materials for appropriate design and format. Instruments used in this study are described in the following sections.

Pilot Study

To establish instrument reliability, a subset of participants (N=50) were treated as a pilot study, using the same treatments, measurement instruments and procedures used in the main study. Participants in the pilot study completed all components of the study, including the pretest, six lessons, six embedded lesson tests, post test and self-regulation survey. Reliability of the six end-of-lesson test questions and posttest questions were

evaluated using Cronbach's alpha values, corrected item total correlation values and score-if-item-deleted values. Inter-rater reliability scores were used to assess the student guide evaluation instrument. Details related to assessing instrument reliability are provided in the measurement instruments section, below.

Measurement Instruments

Prior Knowledge and Post Test

The same test was used for the prior knowledge and post test. The test consisted of 25 multiple-choice questions measuring declarative knowledge of the lesson content. Each question was worth one point, thus the total possible score was 25. The test was created by the researcher using a combination of existing test questions and test questions created based on lesson content. A subject matter expert reviewed the test for content validity. Test item reliability was evaluated using an analysis of Cronbach's Alpha, corrected item total correlation and scale if item deleted values. One item, item 10, exhibited a negative correlation value and was removed; Cronbach's Alpha for the remaining 24 items was .76. Correlation values for the 25 test items are provided in Appendix E.

End-of-Lesson Tests

Each lesson included a multiple-choice test, assessing declarative knowledge of lesson content. Tests were created by the researcher using a combination of existing test questions and questions derived from lesson content. A subject matter expert reviewed tests for content validity. Lesson one included a five question test, lessons two through six each included a ten question test. One point was awarded for each correct response, thus the total possible scores for the six tests were 5, 10, 10, 10, 10 and 10. The six

lesson tests items are provided in Appendix C. Each test was evaluated for reliability using an analysis of Cronbach's Alpha, corrected item total correlation and scale if item deleted values. Cronbach's Alpha values for the six tests with all items included were .14, .42, .48, .49, .24 and .52, respectively. To address low reliability of scores, tests one and two and tests five and six were combined. After removing items based on corrected item correlation values, Cronbach's Alpha for the four tests were .49, .54, .49, and .57, respectively. Corrected item total correlations for each test, and tests with items removed are provided in Appendix F.

Self-Regulation Questionnaire

The Motivated Strategies for Learning Questionnaire (MSLQ), a self-report instrument designed to assess motivation and use of learning strategies by college students was used to measure cognitive and metacognitive components of self-regulation in this study (Pintrich et al., 1991). The MSLQ is one of two commonly used self-report measures of SRL, the other being the Learning and Study Strategies Inventory (LASSI), developed by Weinstein, Palmer and Schulte (Garcia & Pintrich, 1995). While both self-report instruments are regularly used in studies of SRL, the MSLQ was chosen for this study because it was designed to address aspects of SRL relative to a specific course or context, as opposed to more general strategy training supporting strategy use across domains. In this study, the treatments include information related to a specific context, a sonar system used to conduct naval mine countermeasure operations. Permission to use the MSLQ is included in Appendix C.

The MSLQ includes a total of 81 questions distributed among fifteen Learning Strategies Scales; 26 questions distributed among four scales related to self-regulation of

cognition and metacognition were used for this study. The MSLQ was designed to be used either in whole, or in parts, depending on the context of the training being provided (Pintrich et al., 1991). For this study, the four scales being used include: rehearsal, organization, elaboration, and metacognitive self-regulation scales (Appendix C). These four scales were chosen because they measure the cognitive and metacognitive components of SRL explored in this study; cognitive learning strategy (rehearsal, organization and elaboration scales) use, and metacognition (metacognitive self-regulation scale). Following is an example of an MSLQ question, "When reading material in a lesson, I try to relate the material to what I already know". MSLQ questions were modified for this study; the word "class" was replaced with the word "course" or "lesson" in the questions. Likert scores on the survey range from 7 = "very true of me", to 0 = "not at all true of me". Scores for each of the scales in the MSLQ are calculated by averaging the scores for the items within that scale; thus scores may range from 0 to 7.

Three hundred and eighty college students were used to establish reliability measures for the MSLQ (Pintrich et al., 1991). A reliability coefficient should range from 0.0 to 1.0, with scores of 1 indicating the greatest reliability (Fraenkel & Wallen, 2009). The reliability of the four scales chosen for this study (rehearsal, elaboration, organization, metacognitive self-regulation) in the original instrument were 0.69, 0.76, 0.64 and 0.79, respectively. Cronbach's Alpha for the four scales during this study were equivalent to the original instrument evaluation (.75, .80, .70 and .75), and Cronbach's Alpha for the four scales combined was .91. Cronbach's Alpha and correlation values for each of the items included in the self-regulation survey are provided in Appendix G.

Validity for the MSLQ scales were evaluated using two confirmatory factor analyses, one for the motivation scales and one for the learning strategies scales (Pintrich et al., 1991). The authors report the motivation and strategy scales were both correlated in the expected direction relative to academic performance (Pintrich et al., 1991). While they note the correlations were modest, the authors suggest the MSLQ does represent a reliable and valid method for measuring motivation and strategy use in the classroom (Pintrich et al., 1991).

Finally, the MSLQ includes a demographic questionnaire, which was modified for this study. The following data were gathered; age, rank, years of education and gender. These data were used to describe the population and verify homogeneity of the three groups, as described above.

Student Note-taking Evaluation

For this study, strategy use was evaluated using two methods; self-report scores, based on the MSLQ scales, and scores derived from an evaluation of student's use of rehearsal, organization or elaboration strategies in their notes, for each lesson objective. A scoring guide, based on prior studies evaluating strategy use in notes, was developed to evaluate learner notes (Lee et al., 2010). The guide provided a definition and examples of rehearsal, organizational and elaboration strategy use in learner notes, based on definitions and examples provided by Weinstein (2000) and Jonassen (1988). Raters awarded zero, one, two or three points for each learning objective; one point each for demonstrating either a rehearsal, organization or elaboration strategy. Thus, a total score of three was possible for each learning objective, yielding possible scores of 12, 21, 9, 21, 21 and 15 for each of the six lessons.

This scoring guide was refined during the pilot evaluation; during the pilot study, the second rater, who was not intimately familiar with the content, could not determine if the information participants provided was accurate, even if it represented the use of a rehearsal, organization or elaboration strategy. Therefore, in addition to evaluating the use of rehearsal, organization and elaboration strategies, the scoring process was modified to include an assessment as to the accuracy of the information in the notes. In this manner, notes were evaluated for evidence of strategy use, and evidence of accuracy of information included. The researcher identified information related to each lesson objective from the course material, and inserted the relevant information in a student guide. The student guide was then evaluated by a Subject Matter Expert for validity. This student guide was then used to provide examples of accurate information, based on lesson content, related to each learning objective in the course for the second rater.

During the initial assessment of the scoring guide, the first and second rater differed on scoring participants who applied multiple strategies to a single learning objective (i.e., a participant may have listed material (a rehearsal strategy) and created a diagram (an organization strategy) and written a summary of the content related to the objective (an elaboration strategy)). One rater awarded a single point for the learning objective, while the second rater awarded a point for each instance of strategy use for the learning objective. After discussion, the raters agreed that one point should be awarded for each observed use of a strategy.

Furthermore, the raters differed on their strategy for awarding points for organizational strategy use. In some cases, participants created a table or diagram to organize information, while in other instances they used an existing table in the student

guide. During the initial assessment, the two raters differed; one awarded "organizational" points if a student created a new diagram or table, while the other rater awarded points for either creating a diagram or table, or using an existing table or diagram included in the study guide. After discussing the different scoring approaches, the raters agreed to award a point for organizational strategy use only if the student created a table or diagram; students who used an existing table to restate existing information from the lesson were awarded a point for use of a rehearsal strategy.

Finally, there were five learning objectives related to identifying sonar contacts on a sonar display screen for which no students took notes. After discussion between the two raters, these objectives were eliminated from the scoring guide; as a result, the total possible points for each of the six lessons was 12, 21, 6, 21, 15 and 9. An image of the scoring guide is provided in Figure 3.

Lesson Number	Objective Number	No notes (Did not take any notes for this lesson objective).	Evidence of rehearsal strategy use. (Copied text verbatim from lesson screen, listed information from the lesson related to the objective, highlighted or underlined information in notes, created a mnemonic). Information is accurate.	Evidence of organizational strategy use (Established relationships among lesson information, created a concept map or an outline of lesson, identified most important ideas from lesson. Used a table to organize information from screens. Created or used an existing diagram or chart to organize information). Information is accurate.	Evidence of elaboration strategy use (Paraphrased, summarized, created questions, created analogies. Related lesson information to prior knowledge/previous lessons). Information is accurate.	Score (0-3)
1	1 of 4		1	1	0	2
1	2 of 4		1	0	0	1
1	3 of 4		0	0	1	1
1	4 of 4		1	0	0	1
	Total	0	3	1	1	5

Figure 3. Scoring guide for participant notes.

After discussing differences and modifying the scoring process as described above, the two raters selected and evaluated 30 student guides, 10 from each treatment group. Inter-rater reliability was high, 96%. Because inter-rater reliability was high, the researcher independently rated student guide notes for all remaining study participants. Additionally, note scores for lessons one and two, and lessons five and six were combined, to align with scores for lessons tests, which were combined to address low reliability, as described above. Evaluation guidelines for notes are included in Appendix C. An example of participant notes demonstrating the use of an organizational strategy, a diagram organizing information related to a learning objective, is provided in Figure 4.

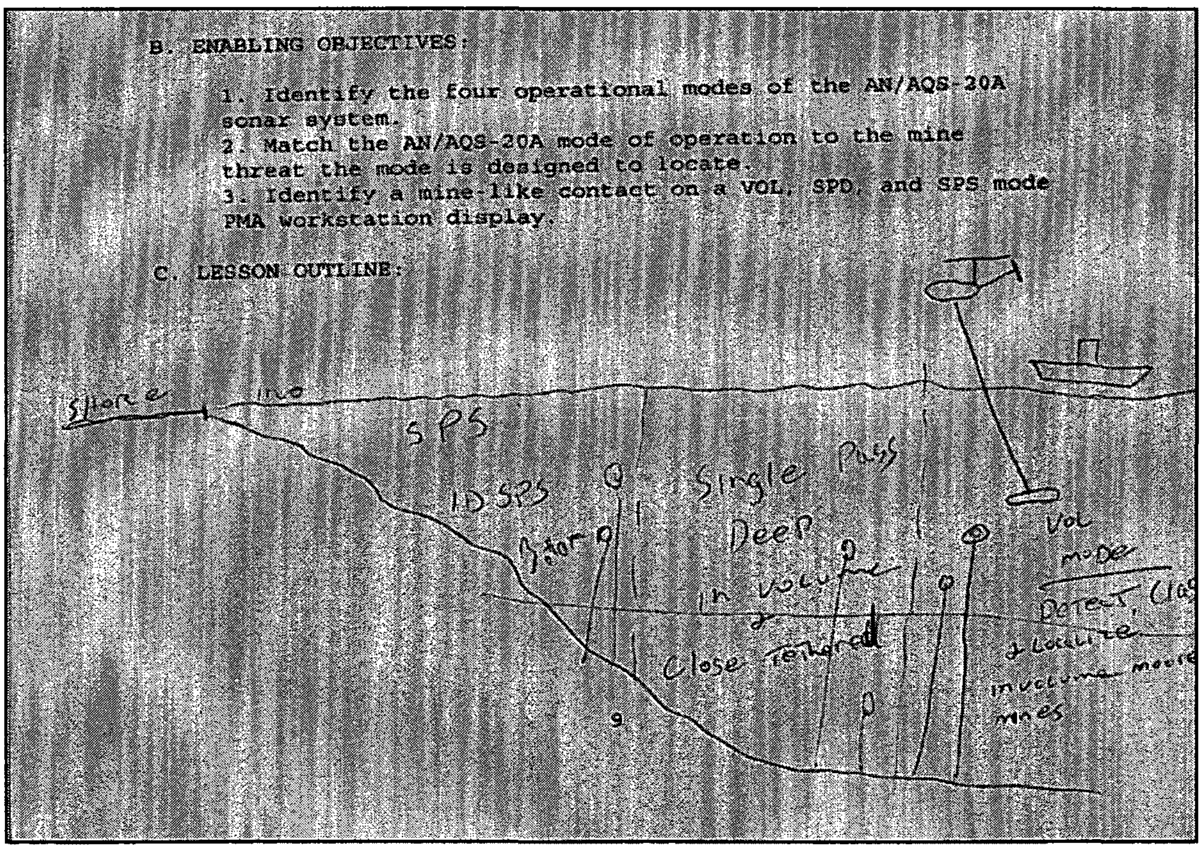


Figure 4. Example of a student's use of an organizational strategy in the student guide.

Post Test

The 25 question post test was the same test used for the pretest. Table 3 provides a summary of instrument item reliability.

Table 3 *Measurement Instruments, Items and Reliability*

Instrument		Number of Items	Alpha	Inter-rater Reliability
Pretest		24 items	.76	
Lesson Tests				
	Lesson Test 1 and 2	14 items, 1 point each	.49	
	Lesson Test 3	9 items, 1 point each	.54	
	Lesson Test 4	10 items, 1 point each	.49	
	Lesson Test 5 and 6	14 items, 1 point each	.57	
Notes (combined)				.96
	Notes 1 and 2	11 items; 3 point each		
	Notes 3	2 items, 3 points each		
	Notes 4	7 items, 3 points each		
	Notes 5 and 6	8 items, 3 points each		
Self-Regulation Survey		26 items	.91	
	Rehearsal	4 items, 0-7 rating scale	.75	
	Organization	4 items, 0-7 rating scale	.80	
	Elaboration	6 items, 0-7 rating scale	.70	
	Metacognitive Self-Regulation	12 items, 0-7 rating scale	.75	
Post Test		24 items	.76	

Procedures

Participants were recruited via their military unit using electronic mail (Appendix A). An iPad 2 and 10 $20 gift certificates were used as incentives to participate in the study. The researcher coordinated dates and times for participants to complete the study via their unit training department. Time to complete the course varied from 52 to 187 minutes; the average time to complete the course for the group receiving no, immediate or delayed prompts was 104, 120 and 108 minutes, respectively (average of 110 minutes). There were 14 sessions conducted, and the number of participants per session ranged from 3 to 13. The study took place in a military training facility learning resource center computer lab; the computer lab included five rows of desks, each row with three desktop Windows-based computers with 17-inch monitors. Additionally, the lab included an instructor computer workstation, connected to a projector. There were a total of 16 networked computers. The computers were not connected to the internet, and no information related to the lesson content was located on the computers. Each of the three computers on each row had one of three different treatments loaded onto the computer hard drive. Prior to participants arriving at the lab, a requisite number of computers, with different treatment versions loaded, were turned on for the sessions, with the monitors turned off.

When the participants arrived at the lab, they were told to select any available workstation; in this manner, treatments were randomly assigned to participants. After all participants were seated, the researcher distributed and reviewed the informed consent form; after participants signed the consent form, the researcher distributed the paper-based pretest. After completing the pretest, the researcher distributed paper copies of the

self-regulation survey. After completing the survey, the researcher directed participants to verify that all pretest and survey questions had been answered. The researcher then collected the pretest and survey, verified all 25 pretest and 26 survey questions had been answered, and distributed student guides, pens and highlighters. Participants were directed to turn on their computer monitors; the computer-based lessons were present on the screens, and participants were directed to proceed through the computer-based lessons at their own pace, taking notes if desired.

As described in the materials section, the participants completed the embedded computer-based lesson tests as part of the lesson, and were unable to exit the course until all lessons were complete. After completing the lessons, the final screen directed the participants to prepare for a comprehensive unit test, and notify the researcher when they were ready to take the test. When participants stated they were ready, the researcher provided the post-treatment self-regulation survey to participants. After participants completed the survey, the researcher gathered the survey, verified all 26 items were answered, and provided the paper-based end-of-lesson test. Participants were directed to notify the researcher when they were complete. Once complete, the researcher verified all test questions were answered, thanked participants for their efforts, and directed them to depart the lab.

Data Collection

Data for the paper-based pretest, pre-intervention self-regulation survey, post-intervention self-regulation survey and post-test were recorded by the researcher using a Microsoft Excel spreadsheet, and transposed to SPSS. The researcher verified all test and survey questions were answered by participants during the treatment to insure there were

no missing data. Scores for the six embedded lessons were recorded by the computer; a visual basic macro was used to force students to answer each question before proceeding through the lesson. Requiring answers insured there were no missing data from the six embedded tests participants completed (computer failures did result in missing test scores; those cases were removed from the analysis). Test scores were transposed from the computer to an Excel spreadsheet by the researcher. As described in the measurement instruments section, scores for participant notes were calculated by the researcher, and entered into an Excel spreadsheet. After collecting data, data were screened by group for missing values, outliers, normality, homogeneity of variance, and linearity. Results of data screening and preparation appear in chapter 4.

Data Analysis

Research Question 1

Does prompting self-monitoring of learning in a CBLE improve self-regulated learning in terms of cognitive strategy use, and learning in terms of declarative knowledge, for adults completing work-related computer-based training, controlling for prior domain knowledge?

Multivariate analysis of covariance (MANCOVA) was used to answer research question 1. MANCOVA was selected because it offers an effective means to examine the relationship between the two dependent variables among the three groups, while controlling for factors known to influence self-regulation and learning. Additionally, prior research suggests SRL and achievement are modestly correlated, an ideal situation for using multivariate analysis techniques (Schunk, 1998). Furthermore, multivariate analysis techniques help reduce Type I errors by avoiding probability pyramiding

associated with using multiple univariate measures (Schunk, 1998). Finally, multivariate analysis of variance is routinely used to compare the effects of interventions on self-regulation between-groups; evaluating between-group measures using MANCOVA will allow for comparison with similar studies. Descriptions of the variables used for the MANCOVA are provided in Table 4.

Table 4 *MANCOVA Variables*

Independent Variable (1)	Dependent Variables (2)	Covariate
Prompting (Three groups: Immediate, Delayed, No Prompts).	DV-1: SRL in terms of cognitive and metacognitive strategy use. Measured using average score of six note-trace scores and post-intervention MSLQ score. DV-2: Declarative knowledge. Measured using average of six lesson test scores and unit post-test score.	CV-1: Prior domain knowledge. Measured using pre-intervention prior-knowledge test score.

Research Question 2

How does the timing of prompts encouraging self-monitoring of learning in a CBLE influence self-regulated learning over time, in terms of cognitive strategy use, for adults completing work-related computer-based training, controlling for prior domain knowledge?

A mixed-model repeated measures analysis of covariance (RM-ANCOVA) was used to answer research question 2. Mixed-model RM-ANCOVA was selected because it offers an effective means to evaluate changes in self-regulation over time within groups, and compare changes between groups. Descriptions of the variables used for the mixed-model RM-ANCOVA are provided in Table 5.

Table 5 *Mixed-model RM-ANCOVA variables*

Between-Subjects Factor	Within-Subjects Factor	Covariate
Prompting (Three groups: Immediate, Delayed, No Prompts).	Time 1 through 6: Lesson 1 through Lesson 6 note-trace analysis scores.	CV-1: Prior domain knowledge. Measured using pre-intervention prior-knowledge test score.

Research Question 3

How does the timing of prompts encouraging self-monitoring of learning in a CBLE influence learning over time, in terms of declarative knowledge, for adults completing work-related computer-based training, controlling for prior domain knowledge?

A mixed-model repeated measures analysis of covariance (RM-ANCOVA) was used to answer research question 3. Mixed-model RM-ANCOVA was selected because it offers an effective means to evaluate changes in learning over time within groups, and compare changes between the three groups. Descriptions of the variables used for the mixed-model RM-ANCOVA are provided in Table 6.

Table 6 *Mixed-model RM-ANCOVA Variables*

Between-Subjects Factor	Within-Subjects Factor	Covariate
Prompting (Three groups: Immediate, Delayed, No Prompts).	Time 1 through time 6: Lesson 1 through 6 test scores. Time 7: Unit test score.	CV-1: Prior domain knowledge. Measured using pre-intervention prior-knowledge test score.

CHAPTER FOUR RESULTS

The purpose of this study was to determine if prompting students to evaluate their understanding of lesson content and monitor their strategy use during work related, self-paced, computer based training would lead to improved self-regulation and learning. Additionally, this study expanded on prior research investigating the effect of varying the presentation time of prompts on self-regulation and learning. This study addressed the following research questions.

1. Does prompting self-monitoring of learning in a CBLE improve self-regulated learning in terms of cognitive strategy use, and learning in terms of declarative knowledge, for adults completing work-related computer-based training, controlling for prior domain knowledge?
2. How does the timing of prompts encouraging self-monitoring of learning in a CBLE influence self-regulated learning over time, in terms of cognitive strategy use, for adults completing work-related computer-based training, controlling for prior domain knowledge?
3. How does the timing of prompts encouraging self-monitoring of learning in a CBLE influence learning over time, in terms of declarative knowledge, for adults completing work-related computer-based training, controlling for prior domain knowledge?

Data Preparation

Prior to statistical analysis, variables were screened for missing data. As described in the methods section, four cases were removed from the data set due to missing data (a result of computer failures). Data were then screened by treatment group

for univariate outliers, normality and homogeneity of variance and, for variables used in multivariate analysis (i.e., prior knowledge, self-regulation and declarative knowledge) multivariate outliers, normality, linearity and homogeneity of variance-covariance.

Z-score values exceeding z = 3 were identified as potential outliers. These data were then examined to assess potential errors in data entry and to verify participants were representative of the target population. No data entry errors were identified, and participants were representative of the target population for this study. Several options were considered for addressing outliers, including leaving the outliers within the analysis with no change, eliminating the outliers by variable, eliminating the outlier by case, transforming the variable or truncating the variables to recode outliers with acceptable minimum or maximum variables. Outliers can have detrimental effects on the statistical tests selected for this study, and initial tests of normality and homogeneity of variance revealed outliers significantly influenced the distribution of data. Therefore, to reduce the influence of outliers on the distribution of the variables (and subsequent statistical tests), the option of leaving outliers with no change was discarded. Because of the relatively small size of the sample (30 per group, 90 total), elimination of outliers by variable and case were also discarded as an option. As Osborne and Overbay (2004) described, transformation can be used to address outliers, however in this study, using multivariate analysis, multiple variables would have required transformation, increasing the complexity of analysis. Therefore, truncation of outliers to acceptable minimum and maximum values was chosen to address outliers within the data.

Outliers in the following variables, AGE (4 outliers), Years of Service (8 outliers), QUIZ12 (1 outlier), QUIZ4 (1 outlier), QUIZ56 (4 outliers), NOTES4 (6

outliers), NOTES56 (4 outliers), COMP (6 outliers) and POSTSRL (4 outliers) were replaced with acceptable minimum and maximum values; all other variables were within three standard deviations of the mean. Mahalanobis Distances of variables included in multivariate tests were less than 18.467, the critical value of chi-square (df = 3) at the .001 level, indicating multivariate outliers were not present within the data set.

Normality of all variables was evaluated using an inspection of normal Q-Q plots, bivariate scatterplots and an assessment of Z-scores. Variables in which normality was tenable were evaluated using Z-score values of skewness and kurtosis; all values were less than 2.58, indicating the values did not significantly violate assumptions of normality (Field, 2009). Finally, homogeneity of variance-covariance matrices were evaluated for prior knowledge, post treatment self-regulation and comprehension scores using Box's Test; results were not significant, $p = .299$, indicating equality of covariance among the variables included in multivariate analyses. Data from the remaining 90 cases therefore met all assumptions for conducting statistical analyses. Descriptive statistics for all variables, by treatment group, are included in Appendix H.

After screening data, demographic data (age and years of education) and pre-treatment measures (prior knowledge and self-regulation) were evaluated. One way analysis of variance (ANOVA) indicated the three treatment groups did not significantly differ in age, $F\ (2, 87) = .123; p > .05$, Years of Education, $F\ (2, 87) = .70; p > .05$, prior knowledge scores, $F\ (2, 87) = 1.48; p > .05$ and pre-treatment self-regulation scores, $F\ (2, 87) = .07; p > .05$. Additionally, time spent to complete the lessons was evaluated; prior to the analysis, the variable TIME was transformed using square root values to address mild positive skew. The groups did not significantly differ in the amount of time taken to

complete the lessons, $F(2, 87) = 1.49; p > .05$. Mean and standard deviation values of demographic, pre-treatment measures and time to complete lessons, by treatment group (N = 30 for each group), are provided in Table 7.

Table 7 *Mean and SD of Age, Years of Education, Prior Knowledge and Pre-Treatment SRL by Treatment Group*

	Group 1 No Prompt	Group 2 Immediate	Group 3 Delayed
Variable	M (SD)	M (SD)	M (SD)
Age	24.0 (5.0)	23.8 (4.2)	24.0 (4.80)
Years of Education	13.1 (1.04)	12.8 (1.10)	13.1 (1.31)
Prior Knowledge	.347 (.073)	.333 (.084)	.368 (.079)
Self-Regulation	4.91 (.933)	4.87 (.973)	4.96 (.885)
Time (minutes)	103.90 (24.45)	120.20 (41.35)	107.57 (32.70)

Combined Effects of Self-Regulation and Declarative Knowledge

A one way multivariate analysis of covariance was conducted to evaluate the effect of prompting self-regulation of learning on two dependent variables; self-regulation and comprehension. As described above, data were transformed to address outliers. Participant post self-regulation survey scores (four cases) were transformed to address cases with scores below 3.12; scores were then transformed to percentage values and combined with self-regulation scores derived from an analysis of student notes. Self-regulation survey scores were based on average scores of rehearsal, organization, elaboration and metacognitive self-regulation scores. Prior to analyzing composite scores, scores for each sub-scale were compared between groups. One way analysis of

variance revealed no significant differences in rehearsal, F (2, 87) = .207; $p > .05$, organization, F (2, 87) = .062; $p > .05$, elaboration, F (2, 87) = .357; $p > .05$ and metacognitive self-regulation scores, F (2, 87) = .267; $p > .05$. Scores for rehearsal, organization, elaboration strategy use and metacognitive self-regulation are provided in Table 8.

Table 8 *Rehearsal, Organization, Elaboration Strategy Use and Metacognitive Self-regulation Scores*

	Rehearsal (N=30)	Organization (N=30)	Elaboration (N=30)	Metacognitive Self-Regulation (N = 30)
Group	M(SD)	M(SD)	M(SD)	M(SD)
Group 1 (No Prompt)	5.20 (1.06)	4.97 (1.22)	5.23 (1.10)	4.61 (.985)
Group 2 (Immediate)	5.20 (1.20)	4.89 (1.24)	5.09 (1.12)	4.75 (.888)
Group 3 (Delayed)	5.35 (.837)	4.86 (1.19)	4.98 (1.15)	4.59 (.736)

Post-test comprehension scores (four cases) were transformed to address cases with scores below .57; post-test comprehension scores were then combined with the average score from four end-of-lesson test scores. Prior knowledge was used as a covariate. There were no significant differences among the three prompting strategies on the dependent measures, Wilks's $\Lambda = .987$, $F(4, 170) = .274$, $p = .893$. Table 9 presents

mean scores and standard deviations for composite measures of comprehension and self-regulation; Figure 5 displays comprehension and self-regulation scores by group.

Table 9 *Comprehension and Self-regulation Scores*

	Comprehension		Self-Regulation	
Group	M	SD	M	SD
Group 1 No Prompt (N=30)	.765	.116	.415	.086
Group 2 Immediate (N=30)	.727	.154	.407	.085
Group 3 Delayed (N=30)	.749	.126	.401	.071

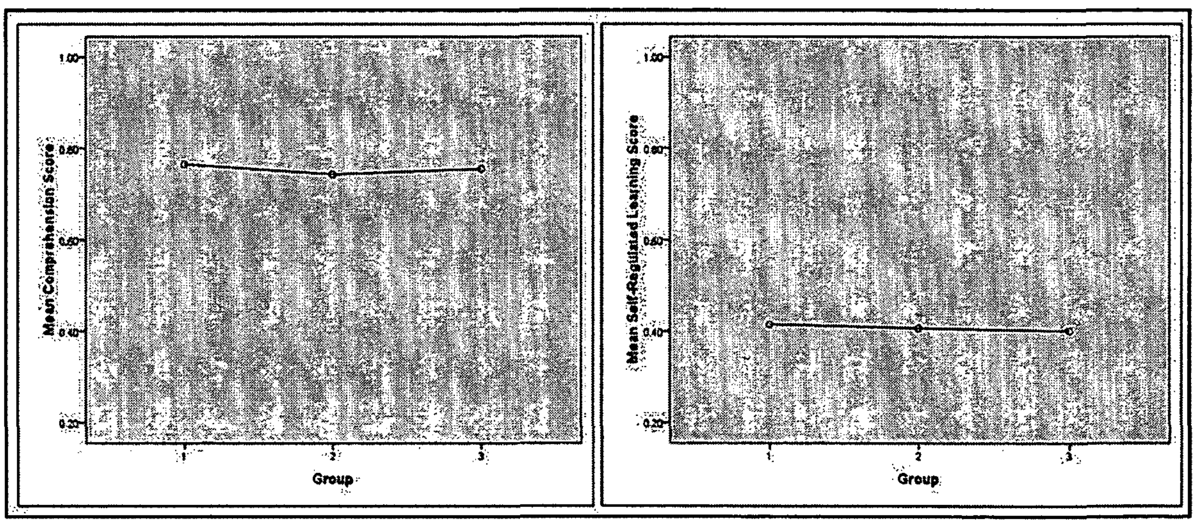


Figure 5. Composite comprehension and self-regulated learning scores, based on average of individual lesson and post-treatment measures, by group.

Effects of Prompting on Self-Regulation over Time

Changes in participant self-regulation during the treatment were analyzed using a two-way mixed design repeated measures analysis of covariance. Treatment (immediate, delayed or no prompts) was the between subjects factor and self-regulation of cognitive

strategy use (measured at four times during the treatment by analyzing participant notes) was the within-subjects factor. Prior knowledge, based on pre-test scores, was used as a covariate. Self-regulation scores were based on composite scores of rehearsal, organization and elaboration strategy use. Prior to comparing composite scores, individual note scores for rehearsal, organization and elaboration strategy use were compared. A one-way analysis of covariance revealed no significant differences between groups on rehearsal strategy use scores, $F(2, 87) = .175$; $p > .05$, organization scores, $F(2, 87) = .115$; $p > .05$, and elaboration scores, $F(2, 49.7) = 1.07$; $p > .05$. Scores for rehearsal, organization and elaboration strategy use are provided in Table 10.

Table 10 *Rehearsal, Organization and Elaboration Strategy Use Scores*

	Rehearsal (N=30)	Organization (N=30)	Elaboration (N=30)
Group	M(SD)	M(SD)	M(SD)
Group 1 (No Prompt)	1.57 (1.02)	.017 (.067)	.044 (.138)
Group 2 (Immediate)	1.48 (1.23)	.011 (.042)	.106 (.292)
Group 3 (Delayed)	1.39 (1.12)	.011 (.051)	.039 (.104)

Using composite scores of strategy use, Levene's Test of Equality of Error Variances was significant, indicating non-equality of variance of the dependent variable, note scores, across the groups. Therefore, data were transformed; scores for each of the groups' four note scores were transformed by taking the inverse square root of data for each variable. Using the transformed data, Box's Test of Equality of Covariance Matrices was not statistically significant ($p > .106$), indicating the covariance matrices of the dependent variable were equal across groups. Mauchly's Test of Sphericity indicated

the assumption of sphericity had been violated, $\chi 2(5) = 121.995$, $p < .000$, therefore a Greenhouse-Geisser correction was used. The interaction effect of Treatment X SRL of Strategy Use was not significant, $F(4.266, 183.436) = 1.966$, $p > .05$, partial $\eta^2 = .04$, and the interaction effect of Treatment X Prior Knowledge, the covariate, was not significant, $F(2.133, 183.436) = .125$, $p > .05$, partial $\eta^2 = 0$. Levene's Test of Equality of Error Variances was non-significant for each within-subjects group and the between-subjects main effect of the prompting treatment was not significant, $F(2, 86) = 1.005$, $p > .05$, partial $\eta^2 = .02$, indicating differences in the four strategy use scores were equivalent between the three treatment groups. Finally, the within-subjects main effect of self-regulation of strategy use was statistically significant, $F(2.133, 183.436) = .3.374$, $p < .05$, although the effect was small, partial $\eta^2 = .04$. Bonferroni adjusted multiple comparison tests ($p < .05$) indicated self-regulation scores between time one and time two, and time two and time three, significantly decreased, while scores between times three and four did not differ significantly. Self-regulation of strategy use scores based on participant notes are provided in Table 11. Figure 6 displays strategy use scores by group at times one through four.

Table 11 *Self-Regulation of Strategy Use Scores by Treatment Group*

	Group 1 (N=30) (No Prompt)	Group 2 (N=30) (Immediate)	Group 3 (N=30) (Delayed)
Lesson	M(SD)	M(SD)	M(SD)
Lesson12	.208 (.111)	.206 (.154)	.178 (.114)
Lesson3	.172 (.155)	.117 (.109)	.106 (.111)
Lesson4	.046 (.061)	.032 (.044)	.049 (.075)
Lesson56	.032 (.044)	.033 (.043)	.034 (.048)

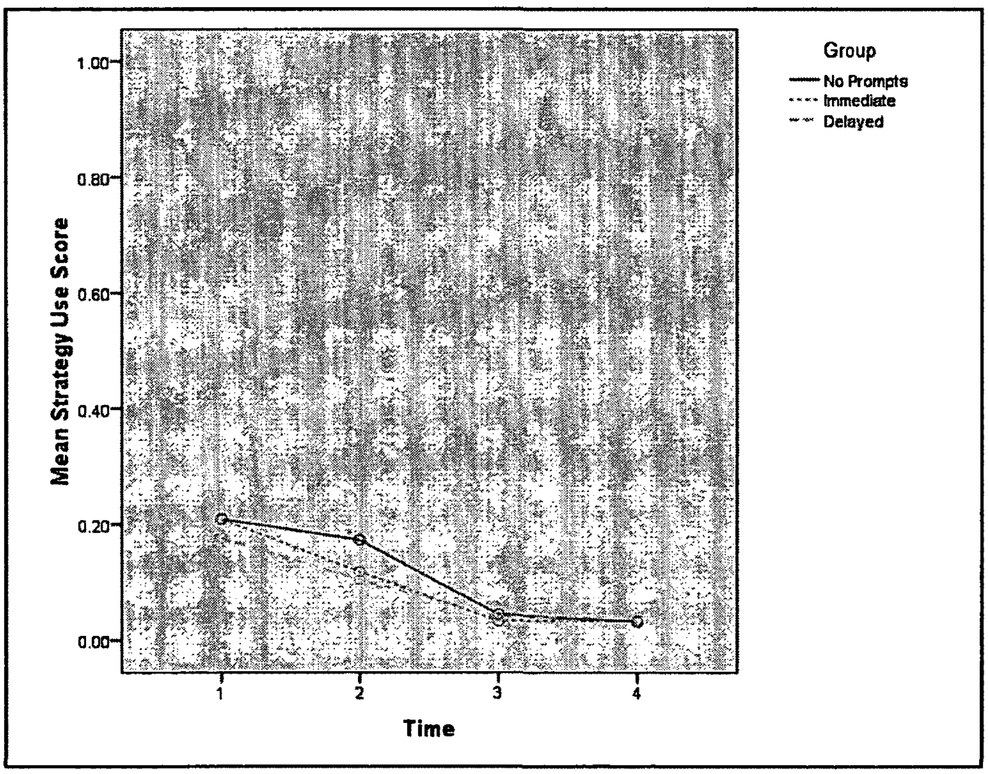


Figure 6. Self-regulation of strategy use scores by treatment group, at times one through four.

Effects of Prompting on Comprehension over Time

Changes in participant comprehension during the treatment was analyzed using a two-way mixed design repeated measures analysis of covariance. Treatment (no prompts, immediate, or delayed) was the between subjects factor and comprehension, based on four end-of-lesson test scores, was the within-subjects factor. Prior knowledge, based on pre-test scores, was used as a covariate. Box's Test of Equality of Covariance Matrices was not statistically significant ($p > .321$), indicating the covariance matrices of the dependent variable were equal across groups. Mauchly's Test of Sphericity indicated the assumption of sphericity had been violated, $\chi 2(5) = 12.095$, $p = .034$, therefore a Greenhouse-Geisser correction was used. The interaction effect of Treatment X Comprehension was not significant, $F(5.497, 236.367) = 1.028$, $p > .05$ and the interaction effect of Treatment X Prior Knowledge, the covariate, was not significant, $F(2.748, 236.367) = 1.384$, $p > .05$. Levene's Test of Equality of Error Variances was non-significant for each within-subjects group; an assessment of the between-subjects main effect of the prompting treatment was not significant, $F(2, 86) = .557$, $p > .05$, indicating differences in the four comprehension scores were equivalent between the three treatment groups. Finally, the within-subjects main effect of comprehension was not statistically significant, $F(2.748, 236.367) = .697$, $p > .05$, indicating comparable comprehension scores within the groups during the treatment. Comprehension scores are provided in Table 12. Figure 7 displays scores by group at times one through four.

Table 12 *Comprehension Scores by Treatment Group*

	Group 1 (N=30) (No Prompt)	Group 2 (N=30) (Immediate)	Group 3 (N=30) (Delayed)
Lesson	M (SD)	M (SD)	M (SD)
Lesson12	.798 (123)	.769 (.149)	.780 (.134)
Lesson3	.785 (.165)	.689 (.215)	.722 (.197)
Lesson4	.806 (.110)	.806 (.137)	.800 (.128)
Lesson56	.680 (.158)	.678 (.207)	.682 (.162)

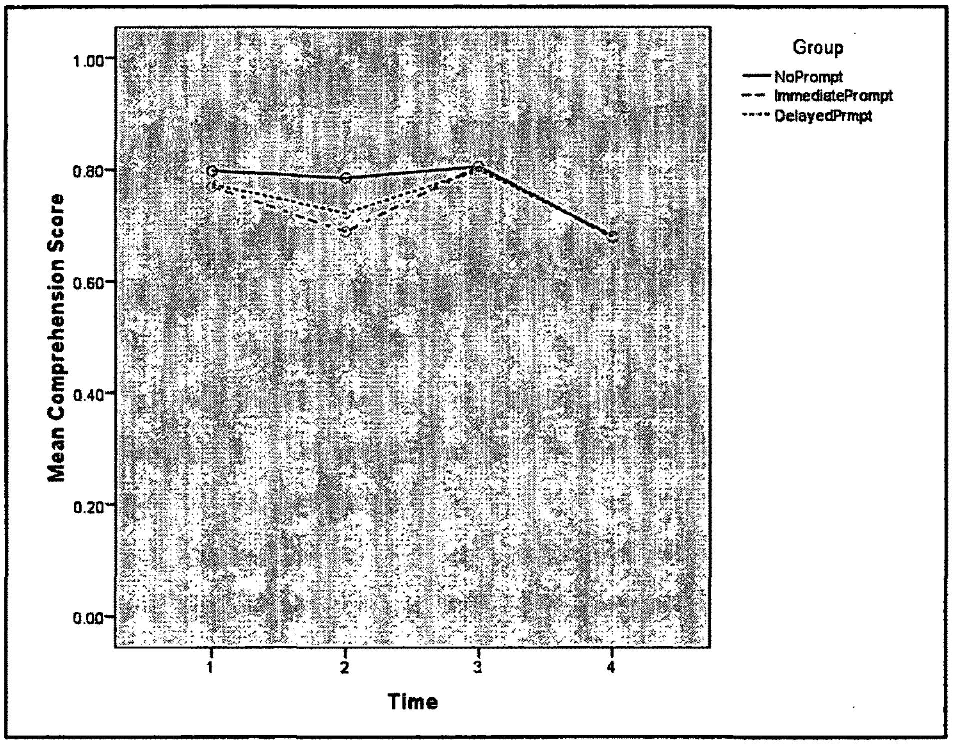


Figure 7. Comprehension scores by treatment group, at times one through four.

CHAPTER FIVE DISCUSSION

The purpose of this dissertation was to investigate the effects of prompting students to monitor their use of learning strategies and comprehension while completing self-paced, work-related training in a computer-based learning environment. Study participants included 94 enlisted military volunteers, randomly assigned to one of three groups in the spring of 2012. Changes in strategy use and comprehension were evaluated within and between groups receiving either immediate, delayed or no prompts. Prompts asked participants to rate their level of agreement to statements regarding their strategy use and comprehension of lesson content.

Dependent variables included declarative knowledge and self-regulation. Declarative knowledge was measured using multiple end-of-lesson tests and a single comprehensive end-of-course test. Self-regulation of strategy use was measured using a post-treatment self-report instrument and strategy use scores derived from an evaluation of learner notes for each lesson in the computer-based course. Independent variables included the prompting treatment; prior knowledge was used as a covariate in all analyses. Multivariate analysis of covariance was used to investigate the effects of the treatments on the combination of self-regulation and comprehension scores by the end of training. Mixed model repeated measures analysis of covariance was used to investigate changes in self-regulation and strategy use during training.

From a theoretical perspective, prompts reminding students to enact self-regulatory processes should be an effective strategy to promote learning, a position supported by theory (Winne & Hadwin, 1998) and prior prompting research (Bannert & Reimann, 2012; Lee et al., 2010; Sitzmann et al., 2009; Sitzmann & Ely, 2010; Thillmann

et al., 2009). While prior research has demonstrated the efficacy of the prompting strategy in computer-based training, results of this study were less conclusive. Although participant comprehensions and self-regulation of strategy use scores varied by groups, the differences between groups did not reach statistical significance. The following sections discuss the findings of this study with regard to strategy use and comprehension, implications for instructional design, study limitations and suggestions for further research.

Effect of Prompts on Strategy Use

Strategy use was evaluated using multiple measures, including self-reports and an analysis of learner notes. Self-reporting of cognitive strategy use, based on the average of four MSLQ strategy use scale scores, was equivalent between groups receiving no, immediate or delayed prompts by the end of training (5.00, 4.98 and 4.95, respectively, average 4.98, SD .06). Similarly, demonstrated strategy use scores (based on scores for rehearsal, organization and elaboration use within participant notes) were equivalent between groups by the end of training (0.11, 0.10, and 0.09, average 0.10, SD .01) for groups receiving no, immediate or delayed prompts, respectively). The number of participants taking notes differed slightly between groups; the group receiving no prompts had the highest percentage of note takers at the start of training, followed by the delayed group and the immediate group (27, 25 and 24 of 30 participants took notes, respectively). However, the difference in the number of note takers did not lead to significant differences in note taking scores between groups by the end of training.

An evaluation of strategy use within groups revealed a statistically significant decrease in strategy use scores over time; additionally, the number of participants taking

notes decreased during training. At the start of training, 85% of participants were voluntarily taking notes; by the end of training, only 26% elected to take notes. The number of participants taking notes differed between groups receiving no (27), immediate (24) or delayed (25) prompts at the start of training; by the final lesson each group had eight participants still taking notes. In addition to an overall decline in the number of participants taking notes, the type of strategies demonstrated in the notes changed over time; while there was some use of elaboration and organizational strategies at the start of training, by the end of training participants taking notes relied exclusively on rehearsal strategies.

The group receiving prompts throughout training did spend more time (120 minutes) completing the lesson in comparison to the group that did not receive prompts (103 minutes). Time to complete the lessons was significantly correlated to note scores for all participants, $r = .45$, $p < .01$; the more time spent completing the training, the greater the amount of notes taken, and the higher the note score. An analysis of time and note scores for each group revealed significant correlations between time and note scores for each, r greater than or equal to .45, $p < .05$, suggesting the prompts did not differentially affect the group's note-taking. Participants with higher note scores, regardless of group, spent more time in the lesson. However, more time and higher note scores did not lead to learning gains, as measured by end of lesson tests or the final comprehensive test.

Overall, the prompts appeared to have little effect on participant's strategy use as measured by self-reports or note scores, and note scores declined significantly over time for all users, regardless of whether or not they received prompts. Note taking did not

increase over time, nor did the quality of the notes increase; in fact, both declined over time. Based on the data, participants who took notes did so regardless of group, and the amount and types of notes they took were similar between groups, suggesting the prompts did not influence note taking. The prompts did increase time in the lesson (and note taking); however, that increase in time did not translate to significant differences in note scores between groups, overall scores of self-regulation, or comprehension scores. Based on the data, the prompts not only failed to improve strategy use and comprehension, they made learning less efficient, by increasing the time students spent in training without improving comprehension. The only group appearing to benefit from the prompts was the delayed prompting group, who had the lowest strategy use scores at the start of training, yet finished the training with scores slightly higher than the other two groups (although those differences were not statistically significant). At the start of training, the delayed group's scores (.18) were one standard deviation (.02) below average (.20); by the end of training their scores were average (.04), while the other two groups were both one SD (.01) below average (.03, .03).

If the prompts had produced effects equivalent to prior studies, then participants would have not only continued to invest effort in their strategy use, the strategies demonstrated would have been more appropriate for the learning content, which increased in complexity as the course progressed (Pieschl, Stahl, Murray, & Bromme, 2011). Prior research investigating prompts suggest that, as the complexity of the content increases, students who effectively self-regulate their learning enact the types of strategies encouraging meaningful processing of lesson content (i.e., organizational and elaboration strategies) (Pieschl et al., 2011). What might have led to the lack of effect of

the prompts on strategy use? Results of this study and prior research suggest several factors might have influenced strategy use, including participant's prior knowledge, existing repertoire of learning strategies, the perceived complexity of the learning content, and perceived task value.

Prior Knowledge

Prior knowledge has been shown to reliably predict self-regulation of learning, in that learners possessing a high degree of prior knowledge are more likely to self-regulate their learning strategies during training, in comparison to learners who exhibit low prior knowledge, who are more likely to rely on basic learning strategies (e.g., summarizing) to regulate their learning (Moos & Azevedo, 2008). Additionally, learners with low prior knowledge may have to invest a majority of cognitive resources to process lesson information, leaving few resources available to self-regulate (Greene et al., 2010). In this study, prior knowledge was measured for use as a covariate, and was found to be low (and equivalent) among all three groups (average score of 35.5% for all users); the lack of prior knowledge may have forced participants to forgo investing cognitive resources in more demanding learning strategies to focus on processing lesson content, leading to the rapid decline in strategy use, and overall reliance on basic strategies while learning.

Existing Strategy Use

In addition to low prior knowledge of the learning topic, participants may have lacked sufficient knowledge of, and skills in applying, the more cognitively demanding types of learning strategies measured during training, specifically organizational and elaboration strategies. In this study, participants were assumed to possess a range of learning strategies, including rehearsal, organization, elaboration and metacognitive self-

regulation of strategy use. While participant's self-reported use of organization and elaboration strategies was equivalent to self-reported use of rehearsal strategies, analysis of student notes revealed the majority of students (over 90%) relied exclusively on rehearsal type strategies when taking notes and, as described above, by the end of training no participants demonstrated the use of organization or elaboration strategies in their notes. Thus, although they reported using organization and elaboration strategies while learning, few students actually used such strategies during the treatment. One possible explanation is they simply were not proficient in the use of organization and elaboration strategies, even though they recognized the strategies when described to them in the survey (i.e., they were aware of the strategies, but not proficient enough in their use to apply them, even when prompted to do so).

Prior research has demonstrated that even more academically proficient students benefit from additional support for self-regulating their learning (Azevedo & Cromley, 2004; Bannert & Reimann, 2012). Bannert and Reimann (2012), for example, provided self-regulatory training in combination with prompts to undergraduates, while Azevedo and Cromley (2004) provided undergraduates a thirty minute training session on self-regulatory processes prior to learning with hypermedia; in both studies students receiving training learned more and demonstrated greater use of self-regulatory processes in comparison to a group that did not receive the training. Based on their demonstrated strategy use, participants in this study may have benefited from training supporting the self-regulation of strategy use.

Complexity of the Learning Content

Complexity of the learning content may also have influenced participant's strategy use. Theoretically, learners regulate their self-regulatory processes while learning to adapt to a variety of internal and external factors (e.g., self-monitoring of learning, motivation to learn, feedback from a teacher). For more complex tasks, students who are self-regulated learners should adapt their learning processes, by investing more time and engaging in more effective learning strategies. Conversely, for less complex tasks, learners may decide that little effort is required to accomplish their learning goals (i.e., why invest a significant amount of time and effort in learning if it is not needed to pass the course).

In this study, participants demonstrated strategy use at the start of training, but the amount and quality of use declined significantly over time. The decrease in strategy use may have been a result of participants evaluating the complexity of the course training material as low; low enough that basic rehearsal strategies, such as listing information in their notes, or recycling information in memory, were sufficient to complete the training. Thus, they may have felt little need to invest effort in more cognitively demanding strategies, the type encouraging deep processing of information (i.e., the retrieval of relevant prior knowledge, associating that knowledge with new information from the lesson, and encoding the information into long term memory). Ultimately, the reliance on basic learning strategies and overall decrease in strategy use may have led to non-significant differences in learning among participants.

Motivation and Task Value

Across most constructs of self-regulation, motivation is a key element in student's ability to effectively self-regulate their learning. Motivation is comprised of multiple factors, including a learner's self-efficacy, the goals they establish for learning, theories of learning, attributions and task value (Eccles & Wigfield, 2002). Researchers investigating achievement motivation and self-regulation have shown positive relationships between task value, strategy use and learning performance. Zusho, Pintrich & Coppola (2003), investigating the effect of motivation on strategy use and learning, found undergraduate chemistry students task value, rehearsal and elaboration strategy use declined over the course of a semester, and that self-efficacy and task value scores more accurately predicted learning performance in comparison to cognitive ability, as measured by SAT scores. Artino (2009) evaluated college undergraduates' task value during online learning; based on self-report data, findings suggested task value beliefs were the strongest predictors of elaboration and metacognitive strategy use. Findings from these two studies were consistent with prior research suggesting task values help determine, in part, the level of effort learners invest in the self-regulation of strategy use, which in turn affect learning performance (Pintrich & De Groot, 1990; Wigfield, Hoa, & Klauda, 2008; Wolters & Pintrich, 1998).

The topic selected for this study, a naval mine detection system, was relevant to the participants, naval aviation aircrew assigned to helicopter squadrons. The subject of the treatment was a system designed for the aircraft participants operate on a daily basis. However, the system described in the learning materials is not yet operationally deployed. Thus, the learners were aware the training material, although relevant to their

aircraft, was not likely to be of immediate value. This may have affected the participants' motivation to invest effort in the learning task, which they may have felt would have little immediate value to them upon returning to the workplace. Having assigned a low value to the learning task relative to their job assignments, participants may have been less motivated to engage in effortful strategy use.

Effects of Prompts on Comprehension

Participants receiving prompts, either at the beginning of the study or mid-way through the lessons, failed to outperform students who did not receive prompts on tests of declarative knowledge. This result conflicts with prior research regarding the effect of prompting students to self-regulate their learning on comprehension (Berthold et al., 2007; Berthold et al., 2010; Lee et al., 2009, 2010; Schwonke, Hauser, Nückles, & Renkl, 2006; Sitzmann et al., 2009; Sitzmann & Ely, 2010). However, the lack of significant differences in comprehension between groups in this study is not surprising, given the prompts did not significantly influence strategy use. The prompts were intended to encourage learners to modify their strategy use, engage with the content and, as a result, improve learning. As the prompts did not influence strategy use, a lack of effect on learning could be expected. Prior research investigating the effect of prompts on learning in computer-based learning environments support this explanation; Kauffman (2004) found learner's strategy use significantly influenced performance in a web-based course of educational measurements. Likewise, Thillmann et al. (2009) found the positive effects of prompting on learning were significantly influenced by strategy use in a computer-based physics lesson; students who failed to apply effective learning strategies did not perform as well as students who did apply a wide range of effective strategies.

Additionally, Berthold et al. (2007) found the significant effects of prompts on writing learning protocols and performance were mediated by strategy use; when strategy use was included as a control variable, significant differences in group performance failed to reach significance. As described above, the prompting treatment failed to encourage participants to invest significant effort in strategy use. Regardless of the cause, the lack of effect on strategy use likely led to the lack of significant differences in learning between groups.

Varying the Presentation Time of Prompts

In addition to investigating the effect of prompts on strategy use and comprehension, this study explored the effect of varying the presentation time of prompts on learning. From an information processing perspective, including prompts at the beginning of training may increase cognitive processing demands on working memory, particularly when students are first becoming familiar with the content and learning environment (Moos, 2009; Sitzmann et al., 2009). Alternately, for adults possessing an automated set of learning strategies, prompts encouraging strategy use may not pose significant demands on cognitive processing (Thillmann et al., 2009). Prior research investigating the differential effects of varying the timing of prompts is limited, and results of studies have been conflicting. For example, in one experiment Sitzmann et al. (2009) found delayed prompts superior to immediate prompts, while in a second experiment immediate prompts proved more effective at improving performance. She suggested results may have been influenced by high attrition rates in the second study (Sitzmann & Ely, 2010). Thillmann et al. (2009), however, found that continuous prompting had the greatest influence on performance in a computer-based physics lesson.

In this study, the prompts did not lead to differences in comprehension among groups, either during training or at the end of training. Therefore, no conclusions may be drawn with regard to their effect on participant's ability to process lesson content.

Implications for Instructional Design

Implications from this study with regard to the instructional design of computer-based lessons include:

Design of computer-based training materials

This study demonstrated that prompting students to self-monitor their learning in a computer-based learning environment may not be enough to improve self-regulation and performance for all learning contexts. The prompting strategy embedded in the computer-based lessons in this study did not lead to significant differences in strategy use or learning between groups.

Results of this study suggest the nature of the learning task may influence learners' enactment of self-regulatory processes, particularly with regard to choice of learning strategy and willingness to invest time and effort in using those strategies. Realistically, learners are unlikely to invest a significant amount of effort in learning if they perceive the learning content to be of little immediate value to them, particularly working adults, who may reasonably expect work-related training to be relevant when they return to the workplace. Additionally, if the learners perceive the learning task to be of low complexity, they are unlikely to invest significant effort in strategy use. Therefore, when designing computer-based training for adults, designers should carefully evaluate the relevance and complexity of the learning task.

Research Methods

This study included two methods for evaluating students self-regulated strategy use; a self-report instrument and an evaluation of learner notes. Although self-reports of self-regulation are commonly used, researchers have called on more comprehensive measures of learner's self-regulatory processes (Zimmerman, 2008). This study included an evaluation instrument developed to provide an assessment of students' strategy use demonstrated in their notes. The data gathered from the evaluation instrument provided insight into the processes students actually employed while learning, and helped more fully explain the effects of the treatment. For example, while self-reports suggested learners were equally likely to employ rehearsal, elaboration or organizational strategies; analysis of participant notes revealed they primarily relied on rehearsal strategies. Without the data describing demonstrated strategy use, a different picture would have emerged from the study. Therefore, future research of self-regulatory processes should include, where possible, instruments gathering more overt measures of learners' self-regulatory processes.

This study employed multiple measures of self-regulation of strategy use and learning over time. In keeping with the theoretical construct of self-regulation as a process that varies over time, participants in this study did demonstrate changes in strategy use during the learning event. Those changes would not have been observed without the use of multiple measures during training, or by relying on end-of-training assessments alone. Ultimately, the use of measures at multiple points during learning helped to more fully describe participants' self-regulation and learning over time. Therefore, a recommendation from this study for researchers investigating self-regulatory

processes is to include measurements of learner self-regulatory processes at multiple times during training.

Study Limitations

Participants in this study were enlisted military personnel assigned to naval aviation units, training materials were limited to self-paced, computer-based instruction, and learner notes were paper-based, available external to the computer. Additionally, the treatment was a short-term intervention; the six lessons took, on average, 110 minutes to complete. Therefore, care should be taken before attempting to generalize findings from this study to different populations and learning environments. As discussed above, the learners may have found the level of difficulty and task value of the treatment did not warrant a significant investment in strategy use; thus, the nature of the learning content may have influenced participants' self-regulatory strategy use and comprehension. Although participants' existing self-regulatory processes were measured prior to the treatment, measures were based on self-report data which, as demonstrated in this study, may not accurately reflect self-regulatory processes enacted during learning. Finally, participants were provided incentives to volunteer for this study; therefore, participants' motivation to complete the lessons may not reflect the motivation of students completing the lesson for credit, thereby biasing results.

Future Research

This study generated a number of questions for future studies, including: (1) Prior knowledge was very low for all participants in this study and, as described above, may have influenced participants capacity to invest sufficient cognitive resources in effortful strategy use. Future studies should investigate the effect of the prompts in similar

learning contexts with learners with varying degrees of prior knowledge. (2) As described above, the prompts may have failed to influence strategy use due to a lack of proficiency with self-regulatory processes. Learners may have simply lacked the knowledge or ability to apply a wide range of complex self-regulatory strategies. Future research could include assessments of existing self-regulatory processes at the beginning of training. These data could be used to identify deficiencies in self-regulatory processes and provide learners training targeting their specific needs as part of the learning event. Embedding training in concert with prompts could provide less academically proficient learners with strategies to improve self-regulation and learning in self-paced computer-based learning environments. (3) The perceived complexity of the learning task may have influenced participants' choice and application of strategy use. As demonstrated in this study, many failed to select and apply the types of effortful learning strategies likely to lead to improved learning performance. Future studies should evaluate the influence of task complexity on self-regulatory processes in computer-based learning environments for working adults. (4) Strategy selection and enactment may have been a result of learners assessing the content as low in task value for their work environment. How do we convince working adults of the value, especially when long-term value may not be obvious to the learner, during computer-based training? Future research should further explore the role of task value on strategy use in computer-based learning, particularly for working adults, a population that has not been the focus of extensive prior research in this area.

Conclusion

Computers are an integral part of learning in the United States, in educational institutions and the workplace, and their use is likely to increase in the future (Allen & Seaman, 2010; Means et al., 2009). Unfortunately, while computer-based learning environments can provide efficiencies in learning, many students struggle to learn in these environments, in part because they lack the ability to effectively self-regulate their learning (Moos & Azevedo, 2009; Winters et al., 2008). This study sought to expand on prior research investigating the effects of prompting self-regulation in computer-based learning environments, based on an information processing model of self-regulation. Participants in this study were enlisted military personnel, completing self-paced, work-related computer-based training; participants varied from prior research investigating prompts in computer-based learning environments supporting college undergraduate and graduate students. Results differed from prior research; in this study, the prompting strategy failed to significantly influence self-regulation of strategy use and learning. However, findings from this study did support prior research indicating the addition of prompts in computer-based training are not likely to suppress learning (Sitzmann et al., 2009; Thillmann et al., 2009).

This study investigated self-regulation as a cognitive process based on the theoretical model proposed by Winne and Hadwin (1998); the model provides a framework for explaining the results of this study. Based on the model, self-regulation occurs when a learner adapts the conditions, operations or standards they apply to a learning task. Within the model, those adaptations may be evaluated using an "If-Then-Else" framework (Winne & Hadwin, 2008). Data from this study suggests participants

did not adapt their learning over time; they evaluated the learning environment, the learning task, existing prior knowledge and learning strategies, established a learning goal and then (most participants) selected and enacted rehearsal leaning strategies. As they progressed through the training, their demonstrated use of the rehearsal strategy use declined significantly and comprehensions scores never averaged over 80%, the minimum score needed to pass. Results suggest participants never enacted the "Else" component of the self-regulatory model used in this study, in which a learner evaluates their performance relative to a standard, and then adapts their learning operations to improve results (Winne & Hadwin, 2008). The prompts used in this study were meant to support participants' enactment of the "Else" step of self-regulatory adaptation of learning, by reminding participants to monitor their strategy use and understanding while learning and, as a result of that monitoring, adjust their strategies as needed. Participants in this study, although they were aware their scores were below passing and were reminded to monitor strategy use, never adapted their learning processes.

Findings from this study indicate that prior knowledge may influence the effectiveness of the prompting strategy, and learners may need additional support to effectively self-regulate their learning in CBLEs, above support provided by prompting alone. Participants in this study did not demonstrate a wide range of complex learning strategies, and the prompts failed to encourage strategy use or improve comprehension. Although participants initially invested time and effort in taking notes, use declined significantly during the study, and by the end of training few students took notes, or elected to review lesson material or their prior to taking the final test. Participants in this study may have not possessed sufficient knowledge to enact effective strategies, even

with the prompts; they may have benefited from additional support, for example training in self-regulatory processes. Additionally, the complexity and perceived value of the learning task may have influenced participant's strategy use. As they progressed through the course, participants may have determined that basic rehearsal strategies were sufficient to achieve their learning goal. Furthermore, having place a low value on the learning tasks, participants may have elected more effortful strategy use was not warranted over the course of the treatment.

This study answered calls by SRL researchers to employ multiple measures of self-regulatory processes (including demonstrated processes), instead of relying on self-report measures alone (Zimmerman, 2008). Furthermore, this study sought to address concerns by researchers suggesting that more studies investigate changes over time, using within-subject methods (Sitzmann et al., 2009). Ultimately, the use of multiple measurement instruments, and multiple measures over time, helped describe the results of the experiment.

This study contributes to the existing research regarding the effect of prompting self-regulation in computer-based learning environments. It describes effects of the prompting strategy for a different population, and supports calls by researchers to incorporate more comprehensive measures of self-regulation as a process that changes over time.

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Appendix A

PROPOSAL TO SUPERVISORS

From: Mr. Chris Coburn, Helicopter Sea Combat Weapons School Atlantic
To: Commanding Officer, Helicopter Sea Combat Squadron TWO, FIVE, NINE, TWO-TWO, TWO-SIX, TWO-EIGHT, EIGHT-FOUR.

SUBJ: Aircrew Computer-based Courseware Evaluation

Skippers,

I am conducting a study evaluating the design of the computer-based training materials enlisted naval aircrew complete, as part of a doctoral program at Old Dominion University, and as part of an ongoing analysis of the SWTP training materials. I am respectfully requesting your support in soliciting aircrewman (AW) volunteers from the Norfolk-based HM/HS/HSC squadrons. My goal is to improve the training materials sailors must complete, and this study will help me identify strategies that do, or do not, improve their computer-based training. As part of the study, the AW's will be asked to complete six lessons and a questionnaire describing their learning strategies. The lessons and questionnaire take approximately three hours to complete. Participation is voluntary; however, those who participate will be entered in a drawing to win a new iPad. My goal is to include approximately 100 aircrewmen in my study; your support and the AWS's participation are greatly appreciated.

The study will be conducted in HSC Weapons School Atlantic Classroom 2, on the second deck of building SP-250. I will conduct the experiment in approximately 8 separate 3 hour sessions. With your permission, I will coordinate directly with a squadron POC that you identify to set up a date and time that is most convenient for personnel in your squadron, if they are available, and would like to participate.

My phone number and email are: (757) 322-2046, christopher.coburn@navy.mil.

I am standing by to address any questions you may have regarding this study.

V/R,
Chris Coburn
Training Specialist, HSC Weapons School Atlantic

Appendix B

INFORMED CONSENT FORM

PROJECT TITLE: Evaluating computer-based training materials.

INTRODUCTION: The purpose of this form is to provide you information that may affect your decision whether to say YES or NO to participation in this research, and to record the consent of those who say YES. This research will take place in building SP-250, Second Deck, Classroom 2, NAS Norfolk, Virginia.

RESEARCHER: Mr. Chris Coburn, Helicopter Sea Combat Weapons School Atlantic Training Specialist.

DESCRIPTION OF RESEARCH STUDY: This study will investigate different ways of designing computer-based training materials that enlisted personnel use. Groups of enlisted personnel will complete lessons that are designed differently, and their scores will be compared between groups to see if one design is more effective than another. Participants will complete a pre-test, a questionnaire, six computer-based lessons, six lesson tests, a post-test, and another questionnaire. This study should take approximately 4 hours to complete, and will include approximately 100 aircrewmen.

EXCLUSIONARY CRITERIA: Only enlisted personnel will participate in this study.

RISKS AND BENEFITS: RISKS: There are no known risks to you through participation in this study. BENEFITS: Enlisted personnel may benefit by improvements made to courseware (based on the study results).

COSTS AND PAYMENTS: There are no costs or payments for participating in this study. Participants will be included in a drawing for an electronic tablet (iPad).

CONFIDENTIALITY: Any data you provide for this study will remain in the custody of the researcher. Any personalized information captured will be generalized to protect your privacy in any report produced as a result of this study. The results of this study may be used in reports, presentations, and publications; however, the researcher will insure that the data cannot be associated with your personal information.

WITHDRAWAL PRIVILEGE: It is OK for you to say NO. Even if you say YES now, you are free to say NO later, and walk away or withdraw from the study -- at any time.

VOLUNTARY CONSENT: By signing this form, you are saying several things. You are saying that you have read this form or have had it read to you, that you are satisfied that you understand this form, the research study, and its risks and benefits. The researcher should have answered any questions you may have had about the research. If

you have any questions later on, then the researcher (Mr. Chris Coburn, (757) 322-2046) should be able to answer them.

Subject's Printed Name & Signature	**Date**

INVESTIGATOR'S STATEMENT

I certify that I have explained to this subject the nature and purpose of this research, including benefits, risks, costs, and any experimental procedures. I have described the rights and protections afforded to human subjects and have done nothing to pressure, coerce, or falsely entice this subject into participating. I am aware of my obligations under state and federal laws, and promise compliance. I have answered the subject's questions and have encouraged him/her to ask additional questions at any time during the course of this study. I have witnessed the above signature on this consent form.

Investigator's Printed Name & Signature	**Date**

Appendix C

INSTRUMENTS

PERMISSION TO USE THE MSLQ

From: Janie Knieper <jknieper@umich.edu>
To: ccobu001@odu.edu
Date: Fri, Mar 25, 2011 at 4:03 PM
Subject: MSLQ info
Mailed-by: umich.edu
Dear Mr. Chris Coburn,
Thank you for your inquiry. Please see the attached MSLQ manual and background article. You have permission to use it. You can report any findings to mslq@umich.edu. If you would like a hardcopy of the manual you can receive one by sending $20 US dollars made out to the "University of Michigan" to:
Marie Bien
University of Michigan
Combined Program in Education and Psychology
1413 School of Education
610 East University Avenue
Ann Arbor, MI 48109-1259

Good luck. Janie Knieper

Janie C. Knieper, Administrative Specialist
University of Michigan
Combined Program in Education and Psychology
1406 School of Education
610 East University Avenue
Ann Arbor, MI 48109-1259
e-mail: jknieper@umich.edu phone: (734) 763-0680 fax: (734) 615-2164
****
The MSLQ is in the public domain, and so you are welcome to use it for research purposes, as long as the instrument is cited appropriately. I've attached a copy of the MSLQ manual, and of a chapter that Paul Pintrich and I wrote about the MSLQ.
Teresa
****
Teresa Garcia Duncan, Ph.D.
Senior Fellow
ICF International
9300 Lee Highway
Fairfax, VA 22031-6050
TEL: (703) 225-2326, FAX: (703) 934-3740, MOBILE: (571) 296-5162, EMAIL: tduncan@icfi.com

MODIFIED MOTIVATED STRATEGIES FOR LEARNING QUESTIONNAIRE

MOTIVATED STRATEGIES FOR LEARNING QUESTIONNAIRE

All of your responses are strictly confidential. The attached questionnaire asks you about your study habits during training.

THERE ARE NO RIGHT OR WRONG ANSWERS TO THIS QUESTIONNAIRE. THIS IS NOT A TEST.

Please answer the following questions:

Age: ________ Rate/Rank: ______ Gender: Male / Female

How many years of formal education do you have (12 for high school, 13 for one year of college, etc)?

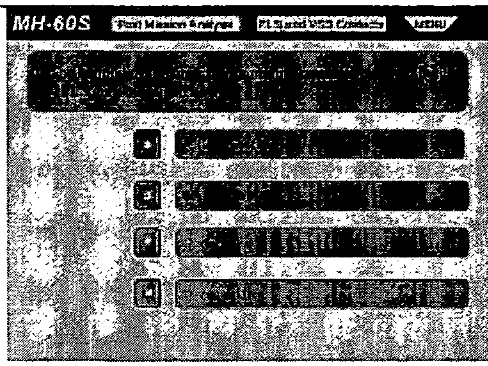
____

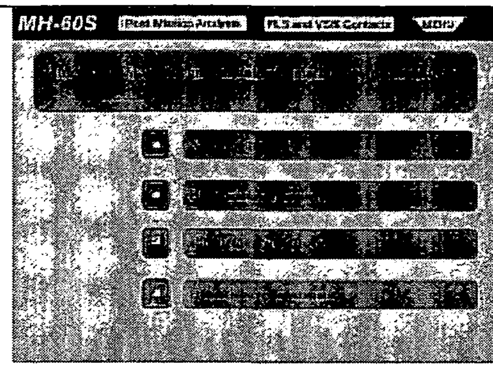
Please respond to the questionnaire as accurately as possible, reflecting your attitudes and behaviors during training. Use the scale below to answer the questions. If you think the statement is very true of you, select 7; if a statement is not at all true of you, select 1. If the statement is more or less true of you, select the number between 1 and 7 that best describes you.

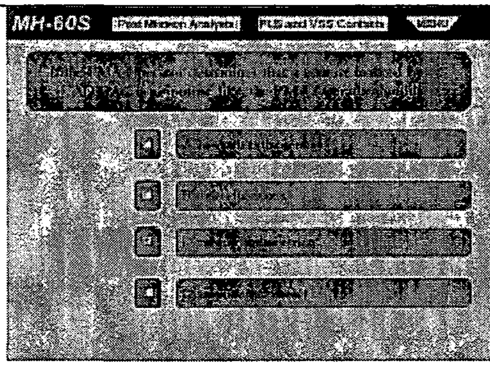
1.	When I study the readings in this lesson, I outline the material to help me organize my thoughts.	1 Not at all true of me	2	3	4	5	6	7 Very true of me
2.	During class time I often miss important points because I'm thinking of other things.	1 Not at all true of me	2	3	4	5	6	7 Very true of me
3.	When reading information in this lesson, I make up questions to help focus my reading.	1 Not at all true of me	2	3	4	5	6	7 Very true of me
4.	When I study for a course like this, I practice saying the material to myself over and over.	1 Not at all true of me	2	3	4	5	6	7 Very true of me
5.	When I become confused about something I'm reading for this lesson, I go back and try to figure it out.	1 Not at all true of me	2	3	4	5	6	7 Very true of me
6.	When I study for a lesson test, I go through the lesson information and my notes and try to find the most important ideas.	1 Not at all true of me	2	3	4	5	6	7 Very true of me
7.	If course information is difficult to understand, I change the way I read the material.	1 Not at all true of me	2	3	4	5	6	7 Very true of me
8.	When studying for this type of course, I read my notes and lesson information over and over again.	1 Not at all true of me	2	3	4	5	6	7 Very true of me
9.	I make simple charts, diagrams, or tables to help me organize lesson material.	1 Not at all true of me	2	3	4	5	6	7 Very true of me
10.	When I study for a test, I pull together information from different sources, such as lectures, readings, and discussions.	1 Not at all true of me	2	3	4	5	6	7 Very true of me
11.	Before I study new lesson material thoroughly, I often skim it to see how it is organized.	1	2	3	4	5	6	7

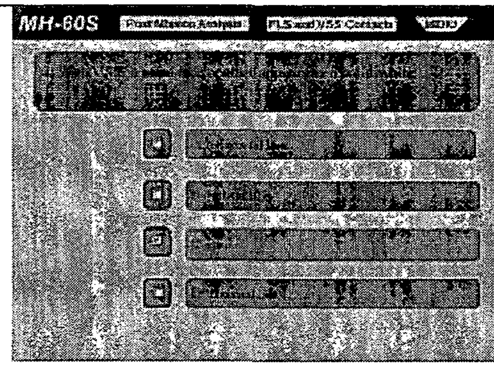
		Not at all true of me						Very true of me
12.	I ask myself questions to make sure I understand material I have been studying.	O 1 Not at all true of me	O 2	O 3	O 4	O 5	O 6	O 7 Very true of me
13.	I try to change the way I study in order to fit individual lesson requirements and different teaching styles.	O 1 Not at all true of me	O 2	O 3	O 4	O 5	O 6	O 7 Very true of me
14.	I often find that I have been reading information in this lesson but don't know what it was all about.	O 1 Not at all true of me	O 2	O 3	O 4	O 5	O 6	O 7 Very true of me
15.	I memorize key words to remind me of important concepts in the lesson.	O 1 Not at all true of me	O 2	O 3	O 4	O 5	O 6	O 7 Very true of me
16.	I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying for the test.	O 1 Not at all true of me	O 2	O 3	O 4	O 5	O 6	O 7 Very true of me
17.	I try to relate ideas in a current course to ideas in other courses whenever possible.	O 1 Not at all true of me	O 2	O 3	O 4	O 5	O 6	O 7 Very true of me
18.	When I study for this lesson test, I go over my notes and make an outline of important concepts.	O 1 Not at all true of me	O 2	O 3	O 4	O 5	O 6	O 7 Very true of me
19.	When reading material in a lesson, I try to relate the material to what I already know.	O 1 Not at all true of me	O 2	O 3	O 4	O 5	O 6	O 7 Very true of me
20.	When I study for a test, I write brief summaries of the main ideas from lessons.	O 1 Not at all true of me	O 2	O 3	O 4	O 5	O 6	O 7 Very true of me
21.	I try to understand the material in these types of lessons by making connections between the information in the lesson and information from lectures/discussions.	O 1 Not at all true of me	O 2	O 3	O 4	O 5	O 6	O 7 Very true of me
22.	I make lists of important items for lessons and memorize the lists.	O 1 Not at all true of me	O 2	O 3	O 4	O 5	O 6	O 7 Very true of me
23.	When studying for the lesson test I try to determine which concepts I don't understand well.	O 1 Not at all true of me	O 2	O 3	O 4	O 5	O 6	O 7 Very true of me
24.	When I study for the lesson test, I set goals for myself in order to direct my studying.	O 1 Not at all true of me	O 2	O 3	O 4	O 5	O 6	O 7 Very true of me
25.	If I get confused taking notes during a lesson, I make sure I sort it out afterwards.	O 1 Not at all true of me	O 2	O 3	O 4	O 5	O 6	O 7 Very true of me
26.	I try to apply ideas from information in the lesson to other learning activities such as lecture and discussion.	O 1 Not at all true of me	O 2	O 3	O 4	O 5	O 6	O 7 Very true of me

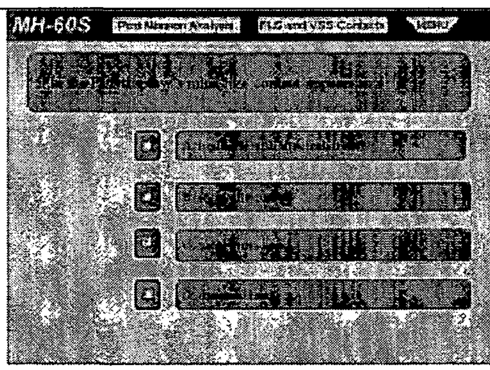
EXAMPLE LESSON QUIZ

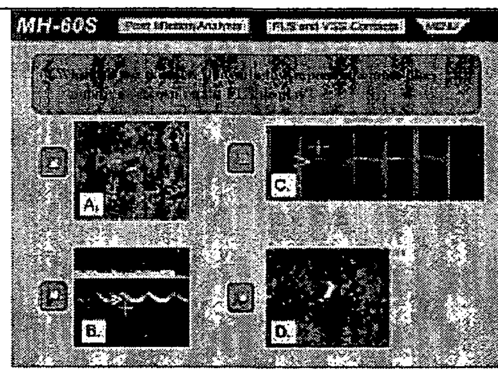


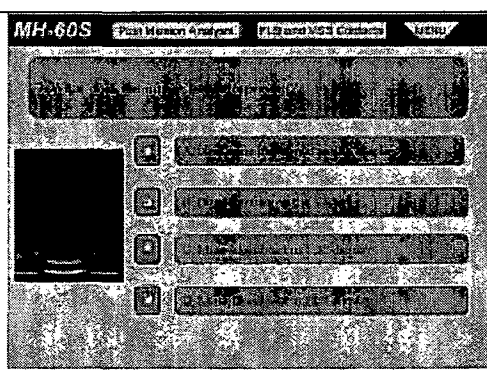


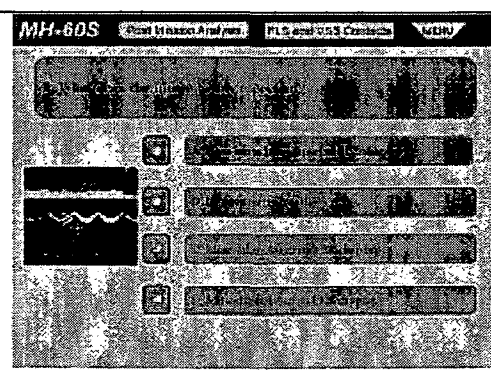


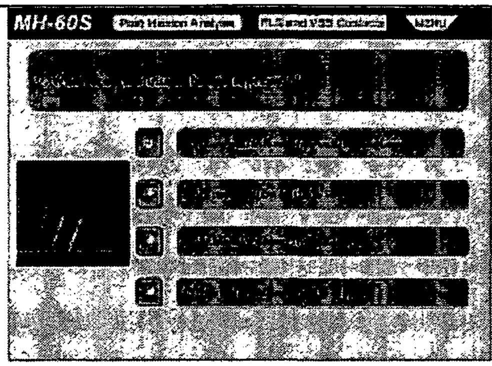


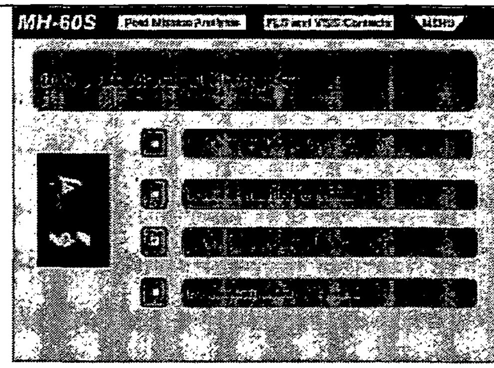









MH-60S


MH-60S

PRE-TEST / POST TEST

1. What type of sonar is used for mine countermeasures?
A. Active
B. Passive

2. Which two factors work to diminish the intensity of sound in the sea?
A. Absorption and spreading
B. Scattering and reflection
C. Reverberation and absorption
D. Reflection and spreading

3. What are the three types of reverberation that affect sonar?
A. Multi-path, side lobe, and gradient
B. Surface, volume, and bottom
C. Near-range, medium-range, and far-range
D. Temperature, pressure, and salinity

4. What are the two categories of moored mines?
A. Close-tethered and in-volume
B. Bottom and buried
C. Acoustic and magnetic
D. Contact and seismic

5. The primary purpose of the Side Look Sonar (SLS) is ____________.
A. detection, classification and localization of mine-like contacts on or near the sea floor.
B. detection and classification of mine-like contacts in the volume.
C. the detection and classification of moored mines.
D. route surveys and bottom mapping.

6. The primary use of the _________ is the detection, classification, and localization of mine-like contacts located on or near the seafloor.
A. Volume Search Sonar
B. Gap Filler Sonar
C. Forward Look Sonar
D. Bottom Search Sonar

7. The _________ is designed to detect, classify, and localize moored mines (close-tethered and in-volume).
A. Volume Search Sonar
B. Gap Filler Sonar
C. Side Look Sonar
D. Bottom Search Sonar

8. Single Pass Shallow (SPS) Mode is used to detect and classify _____.

A. bottom mines
B. floating mines
C. in-volume mines
D. near surface mines

9. The _______ Mode is used to detect, classify, and localize close-tethered moored mines and in-volume moored mines.
A: Single Pass Deep
B. Single Pass Shallow
C. Electro-optic ID
D. Volume

10. Mine tether length must be greater than _____ feet to use Volume Mode.
A. 150
B. 30
C. 10
D. 250

11. Single Pass Deep (SPD) Mode is used to detect, classify, and localize bottom mines.
A. True
B. False

12. How do peaks and valleys on the bottom affect minehunting sonar?
A. Increase reverberation and reflection
B. Increase turbidity
C. Increase sonar absorption
D. Increase the sonar dispersivity

13. Rock or sand bottoms will ____ the energy from sonar.
A. reflect
B. refract
C. absorb
D. enhance

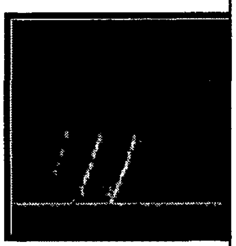
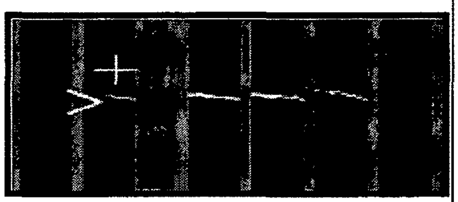
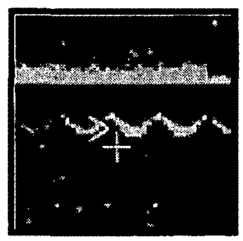
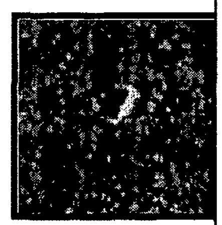
14. Minehunting sonars must compensate for absorption so that the Post Mission Analysis (PMA) operators can determine___.
A. highlights and shadows
B. mine type
C. mine location
D. if an object is man-made

15. A contact with an attached shadow can indicate a bottom mine on the Side Look Sonar display.
A. True
B. False

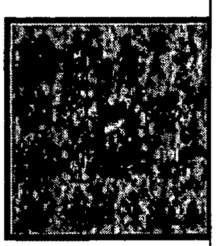
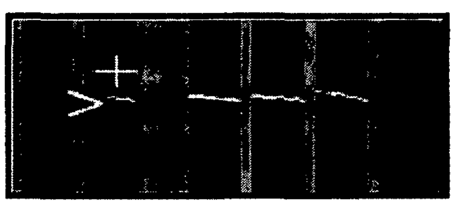
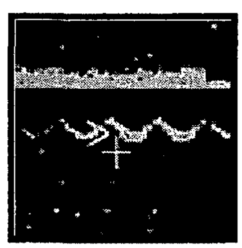
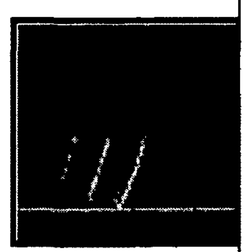
16. In the ________ Display window, a moving object will appear as either a few pixels that vanish quickly or as pixels that angle up or down on the display.
A. Side Look Sonar
B. Forward Look Sonar
C. Gap Filler Sonar
D. Volume Search Sonar

17. Why would a single mine have two highlights on a SLS display?
A. Two highlights may be a result of multiple sonar "pings".
B. The sonar may be producing a highlight "shadow-image".
C. Some long mines may only reflect energy at the ends, making it appear as two highlights.
D. A moored mine might have a highlight from its anchor, and from the mine.

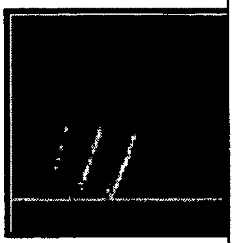
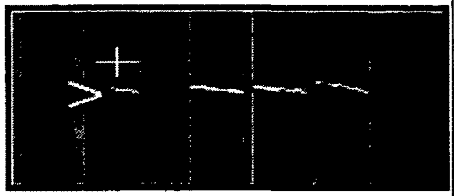
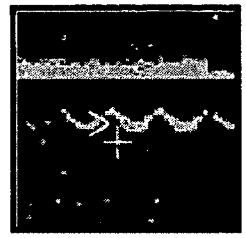
18. Which of the contacts shown below represent a mine-like contact as shown on the FLS display?

A.	B.	C.	D.
			

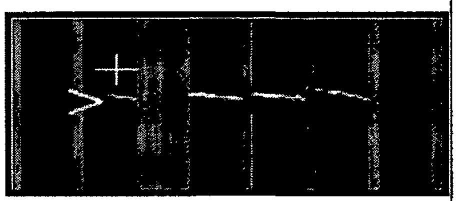
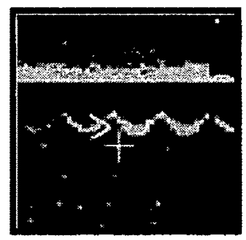
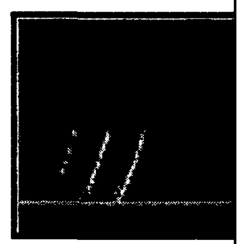
19. Which of the contacts shown below represent a NON-mine like contact as shown on the FLS display?

A.	B.	C.	D.
			

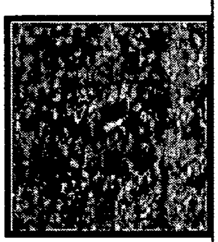
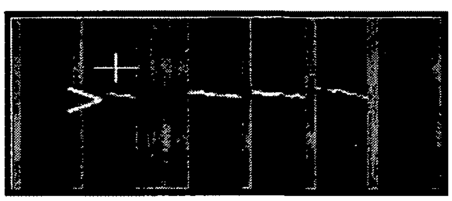
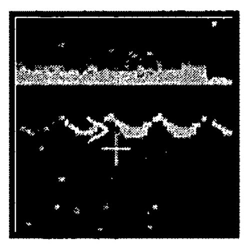
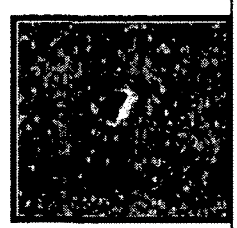
20. Which of the contacts shown below represents a moored mine-like contact on the VSS display?

A.	B.	C.	D.
			

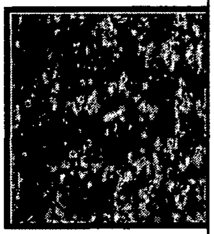
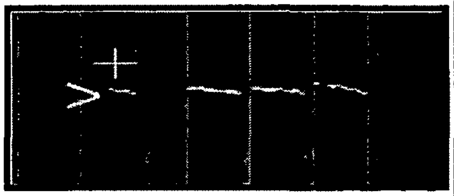
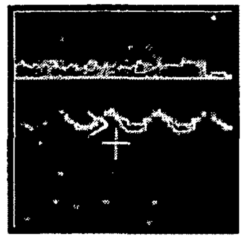
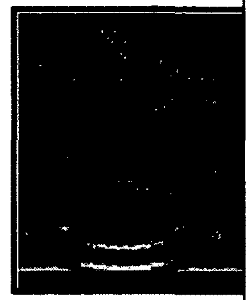
21. Which of the contacts shown below represent a mine-like contact as shown on the GFS display?

A.	B.	C.	D.
			

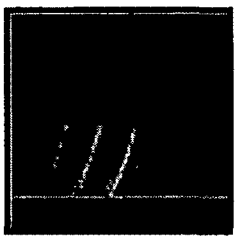
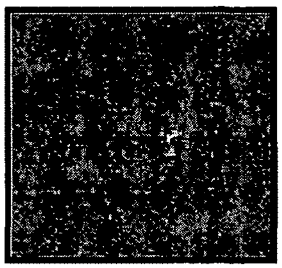
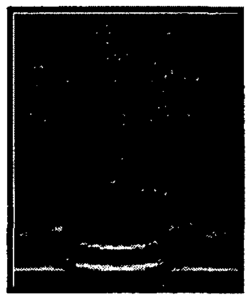
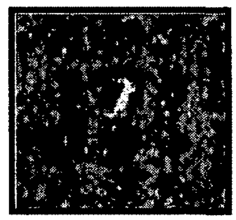
22. Which of the contacts shown below represent a mine-like contact as shown on the port SLS display?

A.	B.	C.	D.
			

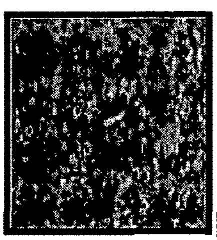
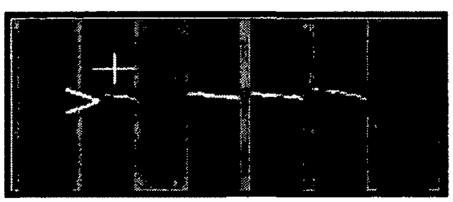
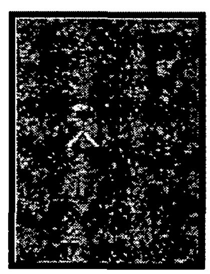
23. Which of the contacts shown below represents bottom return on the VSS display?

A.	B.	C.	D.
			

24. Which of the contacts shown below may represent a moored mine?

A.	B.	C.	D.
			

25. Which of the contacts shown below is most likely a non-mine like object, as shown on a GFS display?

A.	B.	C.	D.
			

STUDENT GUIDE NOTE EVALUATION INSTRUMENT

Lesson Number	Objective Number	No notes (Did not take any notes for this lesson objective).	Evidence of rehearsal strategy use. (Copied text verbatim from lesson screen, listed information from the lesson related to the objective, highlighted or underlined information in notes, created a mnemonic). Information is accurate.	Evidence of organizational strategy use (Established relationships among lesson information, created a concept map or an outline of lesson, identified most important ideas from lesson. Used a table to organize information from screens. Created or used an existing diagram or chart to organize information). Information is accurate.	Evidence of elaboration strategy use (Paraphrased, summarized, created questions, created analogies. Related lesson information to prior knowledge/previous lessons). Information is accurate.	Score (0-3)
1	1 of 4		1	1	0	2
1	2 of 4		1	0	0	1
1	3 of 4		0	0	1	1
1	4 of 4		1	0	0	1
	Total	0	3	1	1	5

For each objective, did the participant list items from the lesson related to the objective in the student guide? Did they highlight or underline information related to the objective in their notes? Did they create a mnemonic device? Was the information they listed, underlined, highlighted or included in a mnemonic accurate (review student guide example if needed)? If so, award one point for rehearsal strategy use.
For each objective, did the participant create or use an existing diagram, table, matrix, or concept map showing a relationship among ideas related to the objective in the student guide? Was the information accurate (review student guide example if needed)? If so, award one point for organization strategy use.
For each objective, did the participant summarize or paraphrase information, or relate information related to the objective to other information (from previous experience/knowledge or from within the lesson) in the student guide (review student guide example if needed)? Was the information accurate? If so, award one point for elaboration strategy use.

Appendix D

PROMPTS

Lesson 1 Prompts	I think that what I already know about sonar (and similar things, like radar) will probably help make learning the material in this course easier.
	I think my note taking and study tactics are pretty effective for learning from computer-based lessons.
	I feel confident I can describe the three types of reverberation that cause backscatter.
Lesson 2 Prompts	I know what I need to focus on in this lesson.
	I am confident I could explain to someone what causes a sonar "highlight" and sonar "shadow" on the SLS and GFS PMA console display represent.
	I can match each of the AN/AQS-20A sensors described so far to the types of mines they detect.
	Tables and diagrams in my notes help me keep the information from this lesson organized.
Lesson 3 Prompts	I can see how information in the previous lesson relates to this lesson.
	I feel confident that I could explain how to identify a sonar contact for the four different operating modes of the AN/AQS-20A to another student.
	I feel like I could write an effective summary of this lesson in my own words.
Lesson 4 Prompts	I can see how the information in this lesson will build on the previous lessons that introduced the characteristics of sonar contacts.
	I understand how bottom type can degrade a PMA operators ability to distinguish highlights and shadows.
	I understand how sound "channels" created by different water temperatures could influence the FLS or VSS sonars ability to "see" a mine.
	After reviewing my notes, I could explain the effects of the different ocean bottom types on sonar performance to someone else trying to learn this material.
Lesson 5 Prompts	I understand how environmental factors, in combination with information about enemy mines, will help during the evaluation of contact data during post-mission analysis.
	I understand what type of mine might have one highlight, and what type might have two.
	I understand what parts of the contact must be measured.
	My notes include all of the important information from this lesson.
Lesson 6 Prompts	I can identify a mine-like contact on the FLS display.
	I feel like I understand the FLS contact classification process well enough to pass the end of lesson, and end of course test.
	Tables and diagrams in my notes help me keep lesson information organized.

Appendix E

ITEM ANALYSIS OF PRIOR KNOWLEDGE/POST TEST

25-Question Test			Test, Question 10 Removed		
Alpha	Item Number	Corrected item-total correlation	Alpha	Item Number	Corrected item-total correlation
.757	Q1	-*	.818	Q1	-
	Q2	.223		Q2	.816
	Q3	.155		Q3	.823
	Q4	-*		Q4	-
	Q5	.365		Q5	.804
	Q6	.330		Q6	.811
	Q7	.180		Q7	.816
	Q8	.342		Q8	.803
	Q9	.441		Q9	.803
	Q10	-.140		Q10	-
	Q11	.430		Q11	.805
	Q12	.118		Q12	.818
	Q13	.244		Q13	.816
	Q14	.392		Q14	.807
	Q15	.208		Q15	.814
	Q16	.281		Q16	.815
	Q17	.347		Q17	.811
	Q18	.385		Q18	.803
	Q19	.456		Q19	.806
	Q20	.328		Q20	.816
	Q21	.461		Q21	.810
	Q22	.378		Q22	.803
	Q23	.105		Q23	.818
	Q24	.316		Q24	.808
	Q25	.306		Q25	.808

* Items 1 and 4 had zero variance and were not included in reliability measure.

Appendix F

INDIVIDUAL LESSON TESTS AND COMBINED LESSON TESTS

RELIABILITY DATA

	Original Tests – All Items			Modified Tests - Items Removed		
Test	Item Number	Corrected item-total correlation	Alpha	Item Number	Corrected item-total correlation	Alpha
Lesson Test 1			.141	QUIZ12		.487
	Q1	-.001		Q1	.024	
	Q2	.330		Q2	.182	
	Q3	.011		Q3	.099	
	Q4	.222		Q4	.279	
	Q5	-.030		Q5	.120	
Lesson Test 2			.402			
	Q1	.438		Q1	.500	
	Q2	.061		Q2	.163	
	Q3	-.044		Q3	.223	
	Q4	-.079		Q4	.030	
	Q5	.198		Q5	.100	
	Q6	.121		Q6	--	
	Q7	.219		Q7	.138	
	Q8	.166		Q8	.100	
	Q9	.199		Q9	.299	
	Q10	.330		Q10	.349	
Lesson Test 3			.420	QUIZ3		.536
	Q1	.195		Q1	.348	
	Q2	.085		Q2	.148	
	Q3	-.021		Q3	.048	
	Q4	.274		Q4	.246	
	Q5	.109		Q5	.287	
	Q6	.072		Q6	.205	
	Q7	.188		Q7	.294	
	Q8	.344		Q8	.337	
	Q9	.380		Q9	.227	
	Q10	-.036		--		
Lesson Test 4			.436	QUIZ4		.501
	Q1	.075		Q1	.147	
	Q2	.124		Q2	.378	

	Q3	.157		Q3	.159	
	Q4	.400		Q4	.172	
	Q5	.191		Q5		
	Q6	.187		Q6	.143	
	Q7	.365		Q7	.283	
	Q8	.110		Q8	.296	
	Q9	.153		Q9	.375	
	Q10	.069		Q10	.211	
Lesson Test 5			.191	QUIZ56		.620
	Q1	.063		Q1	.127	
	Q2	.101		Q2	--	
	Q3	-.050		Q3	.247	
	Q4	.018		Q4	--	
	Q5	-.106		Q5	--	
	Q6	.266		Q6	.397	
	Q7	.106		Q7	.162	
	Q8	-.005		Q8	.232	
	Q9	.376		Q9	.099	
	Q10	.043		Q10	--	
Lesson Test 6			.580			
	Q1	.205		Q1	.130	
	Q2	.393		Q2	.206	
	Q3	.086		Q3	.194	
	Q4	.241		Q4	--	
	Q5	.120		Q5	.158	
	Q6	.311		Q6	.395	
	Q7	.172		Q7	.251	
	Q8	.431		Q8	.394	
	Q9	.415		Q9	.413	
	Q10	.268		Q10	.280	

Appendix G

SELF-REGULATION SURVEY RELIABILITY DATA

Construct		Number of Items	Alpha	Item Number	Corrected item-total correlation
Self-Regulation		26	.910		
	Rehearsal	4	.746	Q39	.487
				Q46	.590
				Q59	.577
				Q72	.551
	Elaboration	6	.807	Q53	.414
				Q62	.472
				Q64	.505
				Q67	.671
				Q69	.790
				Q81	.553
	Organization	4	.695	Q32	.677
				Q42	.198
				Q49	.463
				Q63	.635
	Metacognitive Self-Regulation	12	.772	Q33	.071
				Q36	.604
				Q41	.472
				Q44	.669
				Q54	.602
				Q55	.641
				Q56	.437
				Q57	-.052
				Q61	.370
				Q76	.418
				Q78	.433
				Q79	.433

Appendix H

DEPENDENT VARIABLES DESCRIPTIVE MEASURES

PRE-TEST			
Group	M (SD)	Skewness (SE)	Kurtosis (SE)
Group 1 (No Prompt)	.347 (.073)	.351 (.427)	.069 (.833)
Group 2 (Immediate)	.333 (.085)	-.260 (.427)	-.645 (.833)
Group 3 (Delayed)	.368 (.079)	-.529 (.427)	-.290 (.833)
PRE-SURVEY			
Group	M (SD)	Skewness (SE)	Kurtosis (SE)
Group 1 (No Prompt)	4.91 (.934)	-.286 (.427)	-.056 (.833)
Group 2 (Immediate)	4.87 (.973)	-.494 (.427)	-.490 (.833)
Group 3 (Delayed)	4.96 (.885)	-.274 (.427)	.515 (.833)
QUIZ12 (Levene .316)			
Group	M (SD)	Skewness (SE)	Kurtosis (SE)
Group 1 (No Prompt)	.797 (.123)	-.281 (.427)	-.438 (.833)
Group 2 (Immediate)	.769 (.149)	-.258 (.427)	-.987 (.833)
Group 3 (Delayed)	.774 (.134)	-.446 (.427)	-.806 (.833)
QUIZ3 (Levene .270)			
Group	M (SD)	Skewness (SE)	Kurtosis (SE)
Group 1 (No Prompt)	.785 (.165)	-.529 (.427)	-.584 (.833)
Group 2 (Immediate)	.689 (.215)	-.150 (.427)	-.880 (.833)
Group 3 (Delayed)	.722 (.197)	.000 (.427)	-1.11 (.833)
QUIZ4 (Levene .126))			
Group	M (SD)	Skewness (SE)	Kurtosis (SE)
Group 1 (No Prompt)	.806 (.110)	-.242 (.427)	-.906 (.833)
Group 2 (Immediate)	.806 (.137)	.109 (.427)	-1.51 (.833)
Group 3 (Delayed)	.799 (.128)	.094 (.427)	-1.42 (.833)
QUIZ56 (Levene .067)			
Group	M (SD)	Skewness (SE)	Kurtosis (SE)
Group 1 (No Prompt)	.680 (.158)	-.545 (.427)	.075 (.833)
Group 2 (Immediate)	.677 (.207)	-.368 (.427)	-.940 (.833)
Group 3 (Delayed)	.682 (.162)	-.137 (.427)	-.278 (.833)
NOTES12			
Group	M (SD)	Skewness (SE)	Kurtosis (SE)
Group 1 (No Prompt)	.208 (.111)	-.253 (.427)	-.622 (.833)
Group 2 (Immediate)	.206 (.154)	.018 (.427)	-1.16 (.833)
Group 3 (Delayed)	.178 (.114)	-.197 (.427)	-.922 (.833)
NOTES3			
Group	M (SD)	Skewness (SE)	Kurtosis (SE)
Group 1 (No Prompt)	.172 (.155)	.486 (.427)	-.623 (.833)
Group 2 (Immediate)	.117 (.109)	.385 (.427)	-.609 (.833)
Group 3 (Delayed)	.106 (.111)	.586 (.427)	-.589 (.833)

NOTES4			
Group	M (SD)	Skewness (SE)	Kurtosis (SE)
Group 1 (No Prompt)	.046 (.061)	1.03 (.427)	-.323 (.833)
Group 2 (Immediate)	.032 (.044)	.899 (.427)	-.900 (.833)
Group 3 (Delayed)	.049 (.075)	1.16 (.427)	-.393 (.833)
NOTES56			
Group	M (SD)	Skewness (SE)	Kurtosis (SE)
Group 1 (No Prompt)	.032 (.044)	.924 (.427)	-.872 (.833)
Group 2 (Immediate)	.033 (.043)	.809 (.427)	-.981 (.833)
Group 3 (Delayed)	.034 (.048)	.920 (.427)	-1.04 (.833)
SRL			
Group	M (SD)	Skewness (SE)	Kurtosis (SE)
Group 1 (No Prompt)	5.01(.928)	-.115(.427)	.043 (.833)
Group 2 (Immediate)	5.02 (.874)	-.657 (.427)	-.356 (.833)
Group 3 (Delayed)	4.97 (.825)	-.071(.427)	-.155 (.833)
COMPREHENSION			
Group	M (SD)	Skewness (SE)	Kurtosis (SE)
Group 1 (No Prompt)	.763 (.146)	-.476 (.427)	-.640 (.833)
Group 2 (Immediate)	.720 (.189)	-.142 (.427)	-1.15 (.833)
Group 3 (Delayed)	.765 (.124)	.122 (.427)	-.706 (.833)

VITAE

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EDUCATION

Ph.D. (Instructional Design & Technology)
2012 Old Dominion University, Norfolk, VA

M.S. Ed. (Elementary Education)
2005 Old Dominion University, Norfolk, VA

B.S. (Electrical Engineering)
1993 University of North Florida, Jacksonville, FL

PROFESSIONAL EXPERIENCE

2008 – Present Helicopter Sea Combat Weapons School, U.S. Navy, Norfolk VA
Instructional Systems Specialist

- Primary advisor to organization leadership regarding the design, implementation and evaluation of instructional programs.
- Manage instructor training and evaluation programs.
- Evaluate training program effectiveness.
- Design training interventions (resident, distance learning, simulator and aircraft training events).

2006-2008 Center for Naval Intelligence, U.S. Navy, Virginia Beach, VA
Program Manager, Integrated Learning Environment Projects

- Managed multiple projects integrating web-based curriculum into naval intelligence training programs.
- Designed instructional programs for U.S. Navy intelligence personnel.

2004-2006 Center for Naval Intelligence, U.S. Navy, Virginia Beach, VA
Director of Information Systems

- Managed information technology support for resident (San Diego, CA, Virginia Beach, VA) and distance learning programs for U.S. Navy intelligence personnel.

2001-2004 Navy Intelligence Training Center, U.S. Navy, Virginia Beach, VA
Department Head, Advanced Intelligence Analysis Training Programs

- Managed day to day operations of training programs. Designed, developed, implemented and evaluated instructional programs.

1983 – 2006 U.S. Navy

- Naval Intelligence Officer.