Winter 2014

The Effect of Self-Regulated Learning Strategy Training and Question Generation on Metacognitive Awareness and Achievement Among College Students Enrolled in Science Courses

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THE EFFECT OF SELF-REGULATED LEARNING STRATEGY TRAINING AND QUESTION GENERATION ON METACOGNITIVE AWARENESS AND ACHIEVEMENT AMONG COLLEGE STUDENTS ENROLLED IN SCIENCE COURSES

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A Dissertation Submitted to the Faculty of Old Dominion University in Partial Fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY

EDUCATION

OLD DOMINION UNIVERSITY
December 2014

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ABSTRACT

THE EFFECT OF SELF-REGULATED LEARNING STRATEGY TRAINING AND QUESTION GENERATION ON METACOGNITIVE AWARENESS AND ACHIEVEMENT AMONG COLLEGE STUDENTS ENROLLED IN SCIENCE COURSES

Derrick L. Wilkins
Old Dominion University, 2014
Director: Dr. Linda Bol

Transitioning from high school students to college students can be a difficult task for students who do not know how to regulate their own study processes. Literature in the areas of metacognition, self-regulated learning (SRL), and question generation suggest a correlation between metacognitive awareness, SRL, and achievement. The present study was guided by efforts to improve college students’ achievement by promoting generative learning strategies and metacognitive awareness. Fifty-one undergraduate students enrolled in a general education biology course at a southeastern university participated in this three-week experimental study. The researcher used the Metacognitive Self-Regulation Scale of the Motivated Strategies for Learning Questionnaire (Pintrich, Smith, Garcia, & McKeachie, 1991) to examine changes in participants’ metacognitive awareness after completing a self-paced online training module. Calibration accuracy was also used to measure metacognitive monitoring. Exam scores were used to measure achievement. One-way ANOVA’s did not reveal significant differences between the treatment and control groups’ mean scores on the metacognitive awareness or achievement measures. However, descriptive results within the treatment group revealed trends similar to those reported in the literature. Students who generated primarily application questions scored higher on the exam than students who generated primarily
recall questions. Recommendations for future research, which include increasing the sample size and extending the treatment beyond three weeks, would increase the likelihood of revealing significant group differences.

*Keywords*: metacognition, self-regulation, question generation, calibration.
Copyright, 2014, by Derrick L. Wilkins, All Rights Reserved.
This dissertation is dedicated to my ancestors and my beloved parents who persevered through life's challenges, and have instilled within me the tenacity to succeed. Because of you, I am.
ACKNOWLEDGEMENTS

During my formative years, I was taught to thank people who were generous enough to share of their time and other resources with me. I could not have accomplished this feat without the assistance of generous people. I say, “Thank you.”

I thank the faculty in the Darden College of Education for their guidance as I explored the merit of effectively and efficiently designed instruction.

I thank the members of my dissertation committee. Dr. Bol, my chair and mentor, guided me on the final ascent of my dissertation journey. She provided timely and thorough feedback every step of the way. Her expertise in the area of calibration proved invaluable. Dr. Morrison, from my very first semester until the dissertation defense, exemplified a genuine commitment to the profession. His seemingly exhaustive knowledge of the literature kept me on the right path. Dr. Katsioloudus provided a fresh perspective that allowed me to see clearly the possibilities of my research.

I also thank others who assisted me on this journey. I thank my colleagues who listened to my rambles; reassured me in times of uncertainty; assisted me during my data collection and analysis processes; and, monitored my progress along the way.

I thank my family and friends for their continued encouragement, love, and support. As a part of my extended family, I thank my church family for their continued prayers on my behalf as their pastor.

Most of all, I thank God for entrusting me with the ability to learn, lead, and love through service to humanity.

I shall forever be grateful to you for your contributions to my success!
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CHAPTER I
INTRODUCTION AND LITERATURE REVIEW

Introduction

When high school students transition to university freshman they are often surprised when they discover their academic performance skills that yielded success in high school do not produce comparable results in higher education. Similar to previous years, fewer than half of college-bound seniors in 2013 were academically prepared for the rigors of college-level coursework (The College Board, 2011, 2012, 2013b). The university’s brisk instructional pace, the breadth and depth of content, the expectation for independent out-of-class learning that requires synthesizing and utilizing knowledge can present significant challenges for new college students (Nordell, 2009). Whereas bright high school graduates are challenged by the university’s demand for self-initiative and autonomy (Perry, Hladkyj, Pekrun, & Pelletier, 2001), this challenge is greater for students who are unprepared and must take remedial courses prior to taking a full college-level course load upon entering the university (Chen, Wu, & Tasoff, 2010; Venezia, 2006).

To minimize the challenge of this new world for students, colleges might consider training students to use appropriate strategies to improve achievement. The inclusion of metacognition, self-regulated learning (SRL), and learning strategy instruction may provide unique opportunities for students to develop skills which contribute to their achievement (Brown, 1987; Flavell, 1979; Weinstein & Mayer, 1986; Zimmerman, 1990).
According to one point of view, when students learn to tap into the realm of cognitive awareness, they are better suited to monitor their comprehension and control their resources to achieve their learning goals (Brown, 1987). Metacognition is generally defined as self-awareness of and knowledge of one’s thinking and the ability to comprehend, control, and regulate one’s cognitive processes (Brown, 1987; Flavell, 1979; Schraw & Moshman, 1995; Zimmerman, 2002). At its seminal core, metacognition has been defined as thinking about one’s own thinking (Flavell, 1971). Metacognition involves learners’ assessing their understanding, evaluating the effectiveness of their use of cognitive strategies, and appropriately revising strategies to achieve desired outcomes (Nietfeld, Cao, & Osborne, 2005). Thus, metacognitively aware students are more effective learners, have higher use of strategies, and control their own learning (Jacobs & Paris, 1987).

Effective instruction should not only encourage students to self-assess, but it should inspire students to take charge of their learning. SRL is generally defined as an active learning process in which students guide and direct their own learning (Pintrich, 1995; Zimmerman, 2002). Although identification of SRL skills vary across the literature, three of these skills are consistent throughout: planning, monitoring, and evaluation (Schraw & Moshman, 1995). These autonomous skills are demonstrated when learners set personal goals and identify task-related strategies, monitor their behavior relative to their goals, and reflect on the effectiveness of the strategies in order to increase their effectiveness and efficiency in subsequent learning tasks (Zimmerman, 2002).

SRL theories assert that students actively participate in the learning process by monitoring and controlling their cognition, motivation, and behavior (Pintrich, 1995;
In order to regulate their cognition, students must analyze the learning task and utilize effective learning strategies suitable for the task (Nordell, 2009; Zimmerman, 1998).

Therefore, the inclusion of learning strategy instruction may provide learners with skills that could be applied to various learning situations. Learning strategies have been defined as behaviors that aid learners in constructing new knowledge (Weinstein, Ridley, Dahl, & Weber, 1989). The strategies provide useful techniques for students to use during learning (Weinstein & Mayer, 1986). A substantial amount of learning strategy research has been conducted over the past 40 years (Mayer, 1980; Weinstein, 1977; Weinstein, Underwood, et al., 1980; Wittrock, 1974). Research findings have consistently linked effective use of learning strategies and student achievement.

Metacognition, SRL, and learning strategies are teachable skills (Schraw, 1998; Weinstein, Wicker, Cubberly, Underwood, & Roney, 1980; Zimmerman, 1998). The self-regulated use of learning strategies allows students to assume more control of their own learning (Weinstein, Acee, & JaeHak, 2011). These constructs have been shown to enhance student achievement as supported by the cited literature in the next section.

Whereas metacognition facilitates self-awareness of learners’ thinking about their thinking, self-regulated learning (SRL), on the other hand, facilitates learners’ capacity to control their use of internal and external resources, inclusive of learning strategies, to improve achievement. The question remains of how these constructs, similar yet different, impact student achievement at different developmental levels (Dinsmore, Alexander, & Loughlin, 2008; Schunk, 2008) and in different disciplines.
SRL training may be an effective strategy to improve achievement among college students. Previous studies have shown a correlation between metacognition and self-regulated learning (Schraw & Dennison, 1994; Sperling, Howard, Staley, & DuBois, 2004; Vrugt & Oort, 2008). As learners become more metacognitively aware, they will become better equipped to improve their SRL skills and strategy use which could improve achievement. The purpose of this study is to extend existing research on the efficacy of SRL strategy training and question generation on college students’ metacognitive awareness and achievement.

**Literature Review**

The following literature review will provide a synthesis of selected literature on the foundational perspective of metacognition, SRL, and learning strategy instruction with an emphasis on question generation as a strategy to foster comprehension. This review suggests these three constructs are teachable skills which can be used to extend educational research on strategy training in authentic domain-specific learning environments.

**Metacognition**

Metacognition emerged as a construct in the 1970s from the seminal writings of Flavell (1979) in his proposed model of cognitive monitoring. This model articulated the monitoring of cognitive enterprises through the actions of, and interactions among, four key areas: metacognitive knowledge, metacognitive experiences, goals, and actions (Flavell, 1979). For example, a learner may have an acquired belief that she is better at chemistry than biology (knowledge). Based upon the learner’s perceived lack of understanding of a statement that the instructor makes (experience), she may decide to
read supplementary materials (action) in order to master the learning objective (goal). Subsequently, this model was used to formulate how one thinks about one’s own cognition. Although researchers have provided numerous definitions of metacognition (e.g., Dinsmore et al., 2008; Dunlosky, 1998; Flavell, 1979; Hacker, 1998), a general definition of metacognition includes two constructs—knowledge of cognition and regulation of cognition (Brown, 1987; Flavell, 1987; Schraw & Dennison, 1994; Sperling et al., 2004).

Knowledge of cognition refers to learners’ understanding of their own knowledge and how they learn (Brown, 1987; Keren, 1991; Sperling et al., 2004). It consists of three kinds of metacognitive awareness: declarative, procedural, and conditional (Brown, 1987; Garner, 1990; Keren, 1991; Paris, Cross, & Lipson, 1984; Schraw & Moshman, 1995). Declarative knowledge refers to knowing “about” things. Procedural knowledge, on the other hand, refers to knowing “how to do” things. And conditional knowledge refers to knowing “when to” use procedural knowledge. For example, a learner may be aware of self-monitoring techniques such as monitoring attention and question generation (declarative). A subset of these learners may actually know how to self-generate questions (procedural) in specific learning circumstances (conditional).

Regulation of cognition refers to learners’ ability to manipulate their individual cognitive resources to facilitate learning (Brown, 1987; Schraw & Dennison, 1994; Sperling et al., 2004). It consists of planning, selecting, monitoring, evaluating, and debugging. Previous studies have shown that regulation of cognition improves academic performance in areas such as metacognitive awareness, strategy use, and awareness of knowledge gaps (e.g., Keren, 1991). Furthermore, previous studies have also suggested
knowledge of cognition and regulation of cognition are strongly related (Schraw & Dennison, 1994; Sperling et al., 2004). Consequently, metacognitive awareness strategy instruction can potentially enhance students' achievement (Brown & Palinscar, 1989; Cross & Paris, 1988).

Students who are metacognitively aware deliberately think about their learning needs and apply appropriate learning strategies to regulate aspects of their learning (Burchard & Swerdzewski, 2009; Schraw & Dennison, 1994). Furthermore, metacognitive awareness enables students to regulate strategies and thought processes in order to effectively and efficiently use available cognitive resources. Research indicates a significant difference in students’ metacognitive awareness and regulation for students who receive metacognitive strategy instruction (Burchard & Swerdzewski, 2009). When students are metacognitively aware and self-regulate, their achievement is likely to improve (Camahalan, 2006; Carnell, 2007; Everson & Tobias, 1998; Hammann & Stevens, 1998; Nordell, 2009; Romainville, 1994; Schraw & Dennison, 1994; Sungur, 2007; Young & Fry, 2008).

When students lack the skills required to self-identify problems with their selection and use of cognitive strategies, it impedes their ability to diagnose and modify their strategy use in order to correct the problem. Nordell (2009) proposed a study skills model that taught students strategies to self-assess so they would be able to identify weaknesses in their learning strategies and correct them. Nordell presented four identical one-hour workshops to college freshmen in an introductory biology course after they had taken their first exam. The workshop consisted of a PowerPoint presentation and interactive exercises. The participants completed three self-assessments of learning
exercises in the beginning of the workshop. Next, the researcher presented a series of study skills strategies that students could use in and out of class. Subsequently, students who attended the workshops demonstrated a significantly higher performance on the second exam than those students who did not participate.

Since college students are required to read and synthesize content from various academic sources, metacognitive awareness equips them with self-monitoring skills to assess their comprehension of reading assignments. In a between-group quasi-experimental study, Boulware-Gooden, Carreker, Thornhill, and Joshi (2007) investigated the effectiveness of metacognitive awareness strategy instruction on sixth-grade students' reading comprehension. There were significant differences between the treatment and control groups' vocabulary acquisition and reading comprehension.

Metacognitive theory may be used to inform the design of instructional units. For example, Brown and Palincsar (1982) coined the phrases “informed training” and “self-control training” to describe how strategy training might be presented to learners. Informed training prescribes giving students the rationale of the strategy to be learned and helping them see the relationship between the strategy use and their subsequent learning achievements. Self-control training, on the other hand, provides training in executive control functions which include planning, checking, monitoring, and overseeing the activity induced. Both of these approaches provide significant advantages over blind training in which only the trainers are informed of the rationales and efficacy of the strategies to be learned (Wong, 1985). Informed training might facilitate strategy maintenance and transfer.
Existing research has examined metacognitive training, and it has been shown to
effect achievement. Students who practice metacognitive monitoring experience
improvements in academic performance (Bol, Hacker, Walck, & Nunnery, 2012; Hacker,
Bol, Horgan, & Rakow, 2000; Keren, 1991; Nietfeld et al., 2005; Nietfeld & Schraw,
2002). In order to assess learners’ capacity to monitor their cognition, researchers have
used self-reporting instruments and psychological constructs to assess metacognitive
awareness (Hacker et al., 2000; Pintrich et al., 1991; Schraw & Dennison, 1994).

Calibration and Metacognition

To further clarify how psychological constructs are used to gauge learners’
metacognitive awareness, researchers have explored the efficacy of calibration, a type of
self-monitoring, which measures the degree to which learners’ beliefs about how well
they will perform on a task match their performance (Bol, Hacker, O’Shea, & Allen,
2005; Keren, 1991). For example, prior to taking an exam, students will predict the
percentage of correct answers they will obtain; or, after taking the exam, students may
postdict the percentage of correct responses they think they obtained. Researchers have
used measures such as absolute differences and signed differences to compare judgments
with the actual score (Bol et al., 2005; Schraw, 2009). Absolute difference is computed
by taking the absolute difference between the predicted or postdicted score and the actual
performance score (Schraw, 2009). The closer the difference is to 0, the greater the level
of calibration accuracy. Signed differences, on the other hand, are computed similarly to
the absolute calculation except the signed difference is preserved. Positive scores indicate
overconfidence in calibration, and negative scores indicate under confidence.
Can calibration accuracy be improved? Interventions designed to improve metacognitive accuracy have met with mixed success. However, there is some support in the literature which demonstrates the efficacy of interventions designed to improve calibration accuracy. For example, incentives, reflection guidelines, and group monitoring have enhanced calibration accuracy (Bol et al., 2005; Bol et al., 2012; Hacker, Bol, & Bahbahani, 2008; Hacker et al., 2000; Nietfeld & Schraw, 2002; Schraw, 2009).

Calibration accuracy has been correlated with students’ performance level. Whereas Bol and colleagues (2005) did not find that overt practice manipulation improved students’ prediction or postdiction accuracy, they did find a significant difference between higher and lower achieving students’ calibration accuracy. Lower achieving students seemed to be less metacognitively aware than higher achieving students as measured by calibration accuracy. Other researchers have reported similar findings (e.g., Hacker et al., 2000; Nietfeld et al., 2005). The results consistently showed that lower achieving students were much less accurate and overconfident. In contrast, high achieving students were more accurate, and sometimes underconfident. These findings have been replicated in other studies (e.g., Bol & Hacker, 2001; Hacker et al., 2008; Hacker et al., 2000).

Not only is calibration accuracy influenced by students’ performance level, it might also be influenced by the time of the judgment. Studies show that postdictive accuracy is more accurate than predictive accuracy. Bol et al. (2012), for example, reported students were slightly overconfident with their predictions; however, they were slightly underconfident in their postdictions. Consistent with prior metacognition research, this suggests students are more accurate in their judgments after they have taken
an exam than they are prior to taking it (e.g., Glenberg & Epstein, 1985; Lovelace & Marsh, 1985; Maki & Serra, 1992). Presumably, students base their postdictions on their experience of having taken the exam.

An advantage of calibration studies is comparing judgments with actual performance scores could mitigate researchers' concerns regarding the sole use of self-reported data to measure metacognitive awareness. Numerous studies report findings based upon self-report measures of metacognition and self-regulation without providing evidence to substantiate whether or not the self-reported data reflect actual behavior (Dinsmore et al., 2008; Schunk, 2008). This present study may further corroborate the accuracy or inaccuracy of self-reported data.

**Self-Regulated Learning (SRL)**

As metacognition evolved from the seminal work of Flavell (1979), SRL theory, a component of metacognition, emerged in the 1980s as a result of Bandura's (1977) work on self-regulation in academic settings (Dinsmore et al., 2008). SRL posits that students actively participate in the learning process by monitoring and controlling their cognition, motivation, and behavior (Pintrich, 1995; Winne & Hadwin, 1998; Zimmerman, 1986, 1989). Whereas the major models of SRL present varying perspectives on self-regulation (e.g., Bockaerts, 1997; Pintrich, 2004; Schunk, 2001; Zimmerman & Kitsantas, 1997), all of the models consistently feature goal setting, metacognition, and the use of cognitive strategies. Self-regulated learners set goals; choose appropriate learning strategies that lead to attaining goals; monitor their progress; and, make adjustments to their behavior, motivation, and subsequent goals necessary to make progress (Butler & Winne, 1995). When students self-regulate, they are able to effectively choose the best strategy for the
specific learning condition (Bruning, Schraw, Norby, & Ronning, 2004). Hence, SRL is fundamental to effective academic learning (Boekaerts, 1997; Butler & Winne, 1995; Winne, 1995; Zimmerman, 1990).

Zimmerman’s (2000) social cognitive model of SRL provided the theoretical framework for this study. The social cognitive perspective emerged from Bandura’s (1977) Social Learning Theory which posited human cognitive behavior can be viewed in terms of a continuous reciprocal interaction between cognitive, behavioral, and environmental determinants. Social learning researchers suggest that SRL is a triadic reciprocal cycle comprised of personal processes which are influenced by environmental and behavioral events (Zimmerman, 1989).

According to Zimmerman’s (2000) model, SRL develops dynamically in three cyclical phases: forethought, performance, and self-reflection. These three phases allow learners to plan, practice, and evaluate respectively. Figure 1 depicts the three phases.
Forethought is the initial phase of the SRL process. This is the pre-action phase (i.e., it occurs before the effort to learn). During this phase learners might ask and answer questions such as: What are my goals? What strategies will I use to complete learning task? When will I start the task? Where will I perform the task? Who can help me if I need assistance? This type of self-questioning aids students in establishing goals for the
learning task, planning how they will approach the task, and assessing their beliefs in their ability to complete the task.

The second phase of Zimmerman's (2000) model is performance. This is the action phase (i.e., it occurs during the learning task). During this phase, learners self-regulate by managing and metacognitively monitoring the strategies or methods that they identified in the forethought phase. For example, the students might use predetermined strategies such as generating questions, rehearsing their learning, monitoring their progress, and checking their comprehension by responding to self-generated questions.

The third phase of the model is self-reflection. This is the phase in which students reflect upon their performance after they have completed the first two phases. Once again, the learners' use of metacognitive skills will assist them in mediating this phase. Learners might ask themselves: How well did I do? Did I meet my goal(s)? What strategies worked or did not work? What might I do differently to get better results the next time I have a similar learning task? Since this model is a cyclical process, the learner will use self-evaluation strategies to serve as inputs into the forethought phase in subsequent iterations of the cycle.

Winne (1995) reviewed several empirical studies on SRL to highlight the complexity of this construct. Based on his review he concluded all learners self-regulate, but there are learner differences regarding their knowledge base about SRL and their knowledge about when to transfer this knowledge into practical application. For example, student outcomes vary as a function of their declarative, procedural, and conditional knowledge of SRL (see Winne, 1995 ).
Numerous research studies have examined how the levels of self-regulation affect students' achievement. Students who have greater levels of self-regulation experience higher achievement than students who have lower levels of self-regulation (Nota, Soresi, & Zimmerman, 2004; Ruban & Reis, 2006; Zimmerman & Martinez-Pons, 1988, 1990).

Not only have researchers demonstrated the positive impact of affective self-monitoring and self-regulation on achievement, but they have also demonstrated the efficacy of SRL training on achievement. For example, Bail, Zhang, and Tachiyama (2008) compared students' who were enrolled in an SRL course with comparable students who were not enrolled in the course. They found that the treatment group had significantly higher odds of graduating, and significantly lower odds of receiving one or more failing grades in subsequent semesters. This study, in conjunction with previously reviewed studies, reinforces the efficacy of SRL strategy training.

Similar to other studies that correlated achievement level and metacognitive monitoring (e.g., Bol et al., 2005; Schraw, 1994), Nietfeld et al. (2005) found college students' metacognitive monitoring scores were highly correlated with their GPA and their test scores in an educational psychology course. Using repeated testing measures across the semester, these researchers predicted test performance would positively correlate with metacognitive judgments. Their findings were consistent with Bol and colleagues.

Researchers have provided insight into the SRL knowledge and skills of first-year college students by exploring the efficacy of SRL strategy use among high school seniors. For example, Nota et al. (2004) conducted a longitudinal self-report study which examined the relationship between SRL strategies used by high school seniors and
subsequent collegiate level achievement. The degree to which students reportedly used SRL strategies in high school predicted course grades in high school and subsequent course grades at the university.

Studies have varied in terms of the length and intensity of SRL training. Bol and Campbell (2014) investigated the effectiveness of a four-week SRL training on achievement and metacognition among community college students enrolled in a developmental math course. They found that students who received the SRL training had a significantly higher mean score on the MSLQ than students who did not receive the training. These finding demonstrate the effectiveness of even short-term strategy SRL intervention. The present study explored the effectiveness of three-week SRL training on achievement and metacognition among university students enrolled in a general education science course.

In sum, when students are metacognitively aware and self-regulate, their achievement is likely to improve (Everson & Tobias, 1998; Nordell, 2009; Schraw & Dennison, 1994). Researchers have examined how the levels of self-regulation affect students' achievement (e.g., Nota et al., 2004; Ruban & Reis, 2006; Zimmerman & Martinez-Pons, 1988, 1990). The findings support the link between students' successful use of self-regulation and their achievement (Ruban & Reis, 2006; Zimmerman & Martinez-Pons, 1988, 1990).

Learning Strategy Instruction

In order to self-regulate their learning, students must not only be metacognitively aware, but they must also have the capacity to efficiently and effectively use strategies to attain their learning goals. For decades researchers have examined the effect of learning

Although there are numerous strategies to facilitate learning, a particularly promising strategy supported by research is elaboration (Danner & Taylor, 1973; Weinstein, 1977). Questions, and other elaboration strategies such as summaries, advanced organizers, examples, paraphrases, metaphors, flow charts, tables, and alternative explanations, can be used to facilitate knowledge acquisition and transfer (Wittrock, 1974, 1989). These strategies help learners engage in deeper levels of cognitive processing which facilitate learning and application (Craik & Lockhart, 1972; Jonassen, 1985). Hence, as learners are trained to generate and use relevant elaborations, they will likely be able to self-regulate how they use these strategies for future learning tasks.

Since a significant number of college students are challenged by the demands of college reading (Adams & Mikulecky, 1989), elaboration strategies may be an effective aid to support students’ construction of knowledge. Although Weinstein (1977) investigated the effect of teaching elaboration on the academic performance of a group of high school students, the findings may be generalized to college students. Participants were randomly assigned to one of three groups: treatment, control, and posttest only. Participants in the treatment and control groups were given five weekly 1-hour cognitive strategies training sessions, which included elaboration strategies, at approximately 1-week intervals. However, the treatment group received additional strategy prompts and directions. The immediate posttest was administered one week after the last exposure to
the stimulus materials and the delayed posttest was administered one month later. The results demonstrated the treatment group’s performance surpassed the performance of the other two groups. However, the control and posttest only groups’ performance did not significantly differ from each other. These findings suggest student comprehension can be aided by elaboration training, especially when guided by prompts and directions.

Additional studies have supported the efficacy of elaboration strategies on reading comprehension which is a requisite skill for all academic studies (e.g., Johnsey, Morrison, & Ross, 1992; Mayer, 1980; Palincsar & Brown, 1984; Wittrock, 1989). In cases where elaborations did not prove effective, researchers inferred contributing factors such as subject’s inexperience with the strategies or the lack of congruence between the subject’s prior knowledge and the instructional content (e.g., Johnsey et al., 1992). Consistent with the findings of Mayer (1980), other researchers have reported results that demonstrated participants who generated elaborations outperformed participants who received no elaborations or experimenter-generated elaborations (Johnsey et al., 1992; King, 1994; Slamecka & Graf, 1978).

Question Generation

Question generation, an elaboration, is an effective comprehension-fostering and self-regulatory cognitive strategy (Palincsar & Brown, 1984; Sternberg, 1987). Generating questions encapsulates subprocesses which collectively lead to comprehension. In order to generate questions, students must not only focus their attention on the content, but they must also attend to the main idea while monitoring their comprehension of the text (Palincsar & Brown, 1984; Rosenshine, Meister, & Chapman, 1996). Comprehension monitoring is inherent to metacognitive awareness. Hence,
students who are trained to generate questions may experience greater reading comprehension of the instructional materials than students who do not use this strategy (Wong, 1985).

There is substantial empirical support for the efficacious use of question generation (Haller, Child, & Walberg, 1988; Rickards & Di Vesta, 1974; Wong, 1985). Generating questions promotes comprehension of text as well as content delivered in classroom lectures (King, 1989, 1990, 1994; Rosenshine et al., 1996; Wong, 1985).

Wong (1985) reviewed 27 studies which explored the efficacy of students' self-questioning on their processing of prose. These studies, which involved students from elementary to college levels, were categorized according to one of three theoretical perspectives: active processing, metacognition, and schema theory. Each of the perspectives guided the type of questions that were generated. For example, students were correspondingly instructed to write higher order questions, self-monitoring questions, or questions that would activate relevant prior knowledge. All of the studies, except four, demonstrated the effectiveness of training. The studies that did not promote achievement experienced one or more of the following problems: insufficient training prior to administering the criterion measure, inadequate explicit instructions on question generation, and insufficient time allotted to complete the task. Wong concluded that generating questions is an effective strategy for improving reading comprehension.

In a later review, Rosenshine et al. (1996) examined 26 studies in which question generation was used as an intervention to improve students' comprehension. Overall, the studies demonstrated gains in comprehension for students who were taught to generate questions. Although significant results were found, the sample sizes were small, ranging
from 1 to 25 students in each group. The authors recommended conducting additional studies with larger sample sizes in order to replicate these patterns of findings.

Although the benefits of question generation facilitating comprehension of both prose and lecture content have been examined in numerous studies (Foote, 1998; Frase & Schwartz, 1975; King, 1991, 1994; Kintsch & van Dijk, 1978; Rosenshine et al., 1996; Wong, 1985), the researcher found fewer studies that explored the effectiveness of question generation to aid comprehension among university students. Of the 26 studies reviewed, only 3 studies involved college students (Rosenshine et al., 1996). The present study extended this line of research by investigating the use of self-questioning strategies with college students enrolled in a general education science course.

In an exploratory study, King (1994) used generic question stems (adapted from Ryan, 1971) to guide college students in generating higher order questions to elaborate upon lecture content. Findings of this pilot study supported the prediction that students who self-generated questions would perform better than students who were provided questions; and, students who generated their own questions remembered the lecture materials and made inferences better than students who were provided questions. These findings were similar to previous research that found self-questioning strategies to significantly improve reading comprehension (e.g., Davey & McBride, 1986; Frase & Schwartz, 1975).

Since college students often experience challenges in disciplines such as the sciences (Greene, Hutchison, Costa, & Crompton, 2012), these students might experience greater academic success if they are provided self-regulated learning strategy training,
which incorporates question generation. As students learn to use these strategies, they might begin to metacognitively monitor their understanding of the content (King, 1989).

In sum, the above literature review indicates that there is substantial educational potential in self-regulated learning strategy training. Previous research studies support the efficacy of SRL and metacognitive awareness. Researchers have demonstrated the impact of SRL on students’ achievement (e.g., Azevedo & Cromley, 2004; Kitsantas & Zimmerman, 2009). Other researchers have shown that teaching learning strategies improves student achievement (e.g., Garcia & Pintrich, 1992; Weinstein, 1987; Weinstein & Meyer, 1991). Furthermore, empirical research has supported the benefits of self-generated questions on comprehension (King, 1989; Rosenshine et al., 1996; Wong, 1985).

Whereas some researchers have advocated the teaching of learning skills through generic study skills courses (Gamache, 2002; Haggis & Pouget, 2002), other researchers have advocated teaching study skills within a specific content domain (Durkin & Main, 2002; Wingate, 2006; Zimmerman, 1998). This study examined domain-specific study skills training.

Since academic disciplines such as science can pose a tremendous challenge to first-year college students (Greene et al., 2012), effective cognitive and metacognitive strategies to learn complex topics in science could promote students’ knowledge and transfer of science content (Schraw, Crippen, & Hartley, 2006).

Purpose of Research

The purpose of this research was to examine the impact of SRL training and question generation on metacognition and achievement. Researchers have demonstrated
how learners have successfully used elaboration techniques such as question generation to engage in deeper cognitive processing of reading content (Palincsar & Brown, 1984; Rosenshine et al., 1996) Since college-level courses such as the sciences are reading intensive, generating questions can be used to facilitate comprehension and retention of new and difficult content (Dansereau et al., 1979).

Since the literature supports the efficacy of SRL and question generation, one might argue the two constructs will have a positive synergistic effect on student learning. Therefore, the treatment group in the present study received SRL augmented with self-generating questions to prompt elaboration which should result in better performance outcomes. The control group only received ruse activities regarding their study habits.

Research Questions and Hypotheses

Five research questions guided this study:

1. Do students who are trained to self-regulate and generate questions have higher academic achievement than students who are not trained?

2. Do students who are trained to self-regulate and generate questions have higher metacognitive awareness than students who are not trained?

3. Does the quality of student-generated questions affect achievement?

4. Does the effectiveness of training on academic achievement vary as a function of prior achievement as measured by SAT score?

5. Does the effectiveness of training on metacognitive awareness vary as a function of prior achievement as measured by SAT score?
Since the literature supports the effectiveness of SRL training and question
generation on metacognition and achievement (e.g., Bail et al., 2008; Palincsar & Brown,
1984), the researcher made five predictions. First, training in SRL and question
generation will result in higher achievement as measured by the unit science exam score.
Second, training in SRL and question generation will result in better metacognitive
awareness as measured by the MSLQ Metacognitive Self-Regulation scale and
metacognitive judgments. Third, students who generate higher-order questions will
experience higher achievement than students who generate recall questions as measured
by the unit exam score. Fourth, the effectiveness of the training on achievement will vary
as a function of prior achievement as measured by SAT scores. Finally, the effectiveness
of the training on metacognitive awareness will vary as a function of prior achievement
as measured by SAT scores.
CHAPTER II

METHOD

Design

The study used an experimental design. The researcher randomly assigned half of the consenting students from each class to the treatment group and half to the control group. The independent variables were the training condition (treatment or control), prior achievement level as measured by SAT scores, and quality of questions (recall or application). Dependent variables were total exam scores, percentages of recall and application questions answered correctly, metacognition, and calibration accuracy. Table 1 provides a summary of the variables used in this study.

Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Type</th>
<th>Description</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
<td>IV</td>
<td>Treatment or Control</td>
<td>1 or 2</td>
</tr>
<tr>
<td>SAT</td>
<td>IV</td>
<td>Prior Achievement (grouped by median split)</td>
<td>1000-2090</td>
</tr>
<tr>
<td>Question Quality</td>
<td>IV</td>
<td>Recall or Application</td>
<td>1 or 2</td>
</tr>
<tr>
<td>Exam Score</td>
<td>DV</td>
<td>% of items answered correctly on total exam</td>
<td>0 – 100</td>
</tr>
<tr>
<td>Recall</td>
<td>DV</td>
<td>% of correctly answered recall items</td>
<td>0 – 100</td>
</tr>
<tr>
<td>Application</td>
<td>DV</td>
<td>% of correctly answered application items</td>
<td>0 - 100</td>
</tr>
<tr>
<td>Metacognition</td>
<td>DV</td>
<td>Responses on Metacognitive Self-regulation scale</td>
<td>1 – 7</td>
</tr>
<tr>
<td>Calibration Accuracy</td>
<td>DV</td>
<td>Absolute prediction accuracy on exam</td>
<td>0 – 100</td>
</tr>
<tr>
<td></td>
<td>DV</td>
<td>Absolute postdiction accuracy on exam</td>
<td>0 – 100</td>
</tr>
<tr>
<td></td>
<td>DV</td>
<td>Signed prediction accuracy on exam</td>
<td>-100 – +100</td>
</tr>
<tr>
<td></td>
<td>DV</td>
<td>Signed postdiction accuracy on exam</td>
<td>-100 – +100</td>
</tr>
</tbody>
</table>

In an effort to increase external validity and to assess the utility of the training in authentic learning environments, the study was embedded within the structure of an
existing general education science course. The study was designed in a manner to allow the treatment activities to serve as a means of learning and evaluating the regular course content.

**Participants**

Ninety-one undergraduate students enrolled in three sections of a general education biology course at a southeastern university consented to participate in the study. Fifty-one of the students persisted to the end. The three sections were taught by the same instructor, had equivalent instruction, and had the same course requirements. The mean age of the group was 20.61. The mean Scholastic Aptitude Test (SAT) combined math, verbal, and writing scores of the total group of students was 1284.39. An independent samples t-test was conducted to compare the SAT scores in the treatment and control conditions. There was not a significant difference in the scores for treatment (M = 1299.91, SD = 137.81) and control (M = 1272.62, SD = 191.44) conditions; t(49) = .57, p = .88. This suggests the groups were statistically equivalent on the prior achievement measure. The sample consisted of freshmen (n = 29), sophomores (n = 14), juniors (n = 7) and seniors (n = 1). Table 2 shows the descriptive statistics for the sample's age and SAT.

**Table 2**

Means and standard deviations of sample's ages and SAT scores

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>51</td>
<td>20.61</td>
<td>7.15</td>
</tr>
<tr>
<td>SAT -Control Group</td>
<td>29</td>
<td>1272.62</td>
<td>191.44</td>
</tr>
<tr>
<td>SAT -Treatment Group</td>
<td>22</td>
<td>1299.91</td>
<td>137.81</td>
</tr>
<tr>
<td>SAT -Total Sample</td>
<td>51</td>
<td>1284.39</td>
<td>169.37</td>
</tr>
</tbody>
</table>
Participation was voluntary. However, the instructor offered extra credit for participation, and the researcher offered gift cards in exchange for participation. Participants were informed that they had to persist to the end of the study and complete the required tasks in order to receive the incentives. The researcher monitored all responses and sent emails to students whose attempts were incomplete or appeared to have lacked appropriate attention. Table 3 provides a distribution of the participants from the three classes.

Table 3
Participant Distribution per Course

<table>
<thead>
<tr>
<th>Course</th>
<th>Enrolled (n)</th>
<th>Consented (n)</th>
<th>Completed (n)</th>
<th>% Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>32</td>
<td>31</td>
<td>16</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>31</td>
<td>31</td>
<td>22</td>
<td>71</td>
</tr>
<tr>
<td>3</td>
<td>32</td>
<td>28</td>
<td>13</td>
<td>41</td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
<td>90</td>
<td>51</td>
<td>54</td>
</tr>
</tbody>
</table>

SRL Instruction and Questioning Module

Training Module. The training was delivered through the university’s Blackboard course management system (see Appendices A and B). Students were informed of the rationale of the training to facilitate strategy maintenance (Brown & Palincsar, 1982). The module consisted of four sections. The first section emphasized the need for strategy training that prompted engagement in the learning process. The second section provided an overview of SRL incorporating Zimmerman's (2002) three cyclical phase model of SRL. The third section described elaborations in the context of its value, features, and effective strategies (e.g., summarizing, paraphrasing, outlining, and question generation). Examples of each strategy were included. The fourth section described question generation in greater detail with embedded practice exercises. The researcher
provided generic question stems to guide students in writing questions as used by King (1994) (see Appendix C).

The researcher supplied sample passages from the class textbook to model generating questions. Following the model, the participants were presented with another passage, and they had to generate questions and submit them to the researcher via Bb.

To ensure consistency of treatment, the researcher designed a self-paced instructional module based on a pilot design (Wilkins, 2012) that incorporated elements of effective programs described in the literature (Dansereau et al., 1979; Johnsey et al., 1992). The module was pilot tested using a population similar to the population in the proposed study.

Although there were no significant findings between the treatment and control groups in the pilot study, the researcher used the feedback from the study to clarify concepts and mitigate technological issues. In the pilot study, some students advanced through the online content without attending to the new information. To mitigate the temptation for participants to advance without reading, the researcher included knowledge checkpoints to provide more opportunities and cues for the participants to attend to the content. Second, the participants found the fifty-two item Metacognitive Awareness Inventory (Schraw & Dennison, 1994) to be too long and repetitive. Hence, in the present study, the research used an instrument with fewer items to measure metacognition. Third, the researcher encountered technical issues with the embedded learning object (LO) communicating with Bb. For example, some students could complete the LO with the responses reflected in Bb while other students were not successful accessing the same LO from within Bb. The researcher made additional
modifications to circumvent technical issues by developing the entire module in the Blackboard course management system instead of embedding a Shareable Content Object Reference Model (SCORM) LO.

Measures

Demographic Questionnaire. The demographic survey was used as the cover screen for the metacognition survey described below. The following data were collected: student identification number, gender, classification, and ethnicity. The identification number was used to link the metacognition surveys pre and post to the participants. All other demographic data were used to provide descriptive information for the sample (see Appendix D).

Metacognitive Self-Regulation Scale. The Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al., 1991) was used in this study. The questionnaire consisted of 12 Likert-type items. Participants were instructed to rate each item on a 7-point Likert scale, from (1) “not at all true of me” to (7) “very true of me” as it related to their specific behavior in the science class. If the statement was more or less true, the participants were instructed to “find the number between 1 and 7 that best describes you.” Although the original scale only contained labeled end points (i.e., anchor 1 “not at all true of me”, and anchor 7 “very true of me”), the researcher included additional labels to correspond with the middle anchor points: (2) “untrue of me”, (3) “somewhat untrue of me”, (4) “neutral”, (5) “somewhat true of me” and (6) “true of me”. The additional anchors were added because scales with all the response anchors clearly labeled are likely to yield higher reliability than those with only the end points labeled (Weng, 2004). Sample items from the metacognitive scale were: “If course materials are difficult to
understand, I change the way I read the material” and “When studying for this course I try to determine which concepts I don’t understand well” (see Appendix E). The participants had to complete this on-line questionnaire as the first activity included in the training module.

The researcher selected the MSLQ because it was designed to be used with post-secondary students; the original author reported good internal consistency (e.g., $\alpha = .79$ for the 12-item metacognitive scale); and, the subscale aligned well with the treatment. The Cronbach’s alphas for the 12 items on the pre and post instruments in the present study were .76 and .81 respectively. Furthermore, the instrument was used because it has shown predictive validity or strong correlation between the scale scores and achievement (Pintrich, Smith, Garcia, & McKeachie, 1993). The reported correlation between the two measures was .59 ($p < .001$).

**Calibration.** As measured by Bol et al. (2012), calibration accuracy was calculated for each participant by taking the absolute value of the difference between the predicted and postdicted scores and the unit test score. For example, if a participant predicted that he or she would receive an 80 on the exam but actually received a score of 85, the accuracy score would be 5. Hence, lower scores indicate better calibration accuracy. Participants recorded their judgments using the Prediction and Postdiction sheet attached to the front of the exam. For prediction, students were asked, “How many points (1-100) do you think you will earn on the test?” For postdiction, they were asked, “Now that you have taken the test, how many points (1-100) do you think you earned?” (See Bol et al., 2012.) Prior studies have used the absolute difference calibration accuracy
and have found postdicted scores to be more accurate than predicted scores (Hacker et al., 2000; Nietfeld et al., 2005; Schraw, 2009).

**Question Quality.** Participants in the treatment group submitted five self-generated questions to practice question generation. The sets of student-generated questions were rated for type of question (i.e., recall or application). For a question to be considered “recall,” it would have to test students’ basic understanding of facts and concepts. “Application” questions would have to require students to apply knowledge in the solution of a problem. Raters used a dichotomous scale (“A” for application and “R” for recall) to classify the question type. Two raters with expertise in cognitive psychology and qualitative analysis conducted a reliability check. The raters used two questions as practice items to calibrate the ratings. They discussed discrepancies to enhance consensus in how the item should be rated. Raters then independently rated the question sets. Interrater reliability calculated as percentage agreement was .88, indicating strong consistency in coding.

**Exam.** Achievement was measured by the score on the exam which was designed by the researcher in collaboration with the instructor to assess students’ comprehension of the assigned reading during the study. The researcher developed a test blueprint to guide the development of the 27-item multiple choice exam and enhance content validity (see Appendix F). The test items were selected from the test bank included with the textbook and consisted of recall and application type questions. The exam appears in Appendix G. An example of a recall question was:

> The science of biological classification is used to:
> a. predict an organism’s future evolution.
> b. decide when an organism died.
> c. show relationships among organisms.
d. decipher an organism’s DNA.

An example of an application question was:

Viruses
a. divide by a form of cell division known as binary fission.
b. are considered nonliving because they contain no hereditary material, such as DNA.
c. infect humans but not bacteria.
d. lack the ability to acquire energy independently.

All students took the same exam. Cronbach’s alpha for the 27 items was .67, indicating acceptable internal consistency.

**Procedure**

The experiment was conducted over a three-week period. Participants from the intact groups were randomly assigned to the treatment or control group. They were then enrolled in the respective Blackboard module. The first week, participants in both groups received the demographic survey and the Metacognitive Self-Regulation scale (pre). The treatment group received the training module with embedded knowledge-check activities and generated three practice questions. During the second week, participants in the control group completed a study habits survey as a ruse while the treatment group generated five practice questions using the textbook and provided question stems. The third week, each group received calibration instructions and completed the MSLQ (post). The unit exam was administered one week later in class. Table 4 gives an overview of weekly activities.
Table 4

Weekly Activities by Group

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time Period of Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Week 1</td>
</tr>
<tr>
<td>Demographic Survey</td>
<td>T</td>
</tr>
<tr>
<td>MSLQ M-SR Scale</td>
<td>X</td>
</tr>
<tr>
<td>Study Habits Survey</td>
<td></td>
</tr>
<tr>
<td>SRL Training and Questioning</td>
<td></td>
</tr>
<tr>
<td>Module (Self-Checks 1-5)</td>
<td></td>
</tr>
<tr>
<td>Study Time Survey</td>
<td>X</td>
</tr>
<tr>
<td>Write Questions</td>
<td></td>
</tr>
<tr>
<td>Calibration Introduction</td>
<td></td>
</tr>
<tr>
<td>MSLQ M-SR Scale</td>
<td></td>
</tr>
</tbody>
</table>

Note. T = Treatment. C = Control.

Participants were given access to weekly modules on Monday of each week. Once the study started, participants retained access to the content from the previous week(s).

The researcher sent weekly emails to encourage the treatment group to complete the activities and practice often.

Incentives were used to encourage persistence. Participants who completed all activities received extra credit points and a $10 gift card to Chick-fil-A or Panera Bread.

The participants were familiar with navigating the Bb course management system.

Therefore, no additional training was needed to navigate the module or complete the tasks.

Data Analysis

The following section will describe the data analyses for the guiding hypotheses. All data were imported into SPSS for analyses. To address the first hypothesis, the researcher conducted an analysis of variance (ANOVA) to determine the effects of condition (treatment vs. control on the unit exam score. To address the second hypothesis, the researcher conducted an analysis
of covariance (ANCOVA) to determine the effect of condition on metacognition controlling for pre-existing metacognitive awareness. Further, the researcher conducted a multivariate analysis of variance (MANOVA) to explore the effect of condition on calibration accuracy. To address the third research hypothesis, the researcher planned to conduct a one-way ANOVA to determine the effect of question quality (recall vs. application) on the unit test score. However, as described in the next chapter, the small group size precluded the use of inferential statistics to address this research hypothesis. Similarly due to the small sample size, the researcher could not perform the factorial ANOVA to explore the proposed fourth hypothesis. The researcher predicted the effects of treatment would vary as a function of achievement level. In lieu, the researcher conducted a MANOVA to observe how SAT affected calibration accuracy. Finally, to address fifth research hypothesis, the researcher planned to conduct a MANOVA to analyze the effects of condition (treatment vs. control) and prior achievement on metacognition as measured by the Metacognitive SR scale and metacognitive judgments. However, the small group size also precluded the use of inferential statistics to address this hypothesis. Instead, the researcher conducted a one-way ANOVA to assess the influence of SAT on metacognition. Table 5 provides a summary of the data analyses conducted.
### Table 5

**Data Analysis by Hypothesis**

<table>
<thead>
<tr>
<th>#</th>
<th>Hypotheses</th>
<th>Independent:</th>
<th>Statistical Tests</th>
</tr>
</thead>
</table>
| 1  | Students who receive SRL strategy training and question generation will have higher achievement than students who do not receive the training. | Condition:  
SAT  
Condition x SAT | ANOVA |
|    |                                                                           | Dependent:   |                   |
|    |                                                                           | Exam Score   |                   |
| 2  | Students who receive SRL strategy training and question generation will have higher metacognitive awareness than students who do not receive the training. | Condition (IV)  
Metacognition (DV) | ANCOVA |
|    |                                                                           | Dependent:   |                   |
|    |                                                                           | Exam Score   |                   |
| 3  | Students who generate higher-order questions will experience higher achievement than students who generate recall questions as measured by the unit exam score. | Independent:  
Question Quality | Descriptive |
|    |                                                                           | Dependent:   |                   |
|    |                                                                           | Recall  
Application |                   |
| 4R | Prior achievement will affect calibration accuracy across groups.         | SAT (IV)  
Calibration Accuracy (DV) | MANOVA |
|    |                                                                           | Dependent:   |                   |
|    |                                                                           | SAT (IV)  
Calibration Accuracy (DV) | Absolute Judgments |
| 5R | Prior achievement will affect metacognitive awareness across groups.      | SAT (IV)  
Metacognition (DV) | ANOVA |

R = Original hypothesis revised due to sample size.
CHAPTER III
RESULTS

This study examined the impact of SRL and question generation training on metacognition and achievement. The results are organized according to the research hypotheses: (1) Students who are trained to self-regulate and generate questions will have higher academic achievement than students who are not trained. (2) Students who are trained to self-regulate and generate questions will have higher metacognitive awareness than students who are not trained. (3) The quality of student-generated questions will affect achievement. (4R) Prior achievement will affect calibration accuracy across groups. And, (5R) Prior achievement will affect metacognitive awareness across groups.

Hypothesis 1 - Training and Achievement

A one-way analysis of variance (ANOVA) was conducted to examine the differences between the treatment and control groups on the dependent variable exam scores. The results of the ANOVA suggested training did not influence achievement, $F(1, 49) = .03, p = .87$. As shown in Table 6, both groups' exam scores were low. The groups' mean exam scores were less than 50 out of a possible 100 points. Surprisingly, participants in the treatment group had a slightly lower group mean score on their final exam ($M = 44.64$) than participants who did not receive the treatment ($M = 45.34$).

<table>
<thead>
<tr>
<th>Table 6</th>
<th>Group means and standard deviations of exam scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Control</td>
<td>29</td>
</tr>
<tr>
<td>Treatment</td>
<td>22</td>
</tr>
</tbody>
</table>

Note. Scores could range from 0 to 100.
Although there was no significant difference between the treatment and control groups' exam scores, additional analyses were employed to explore if there might be a difference between the groups with respect to the types of questions participants answered correctly. A multivariate analysis of variance (MANOVA) was conducted to evaluate the differences between the two groups on the dependent variable of item type (i.e., recall or application). Table 7 displays descriptive statistics on the percentage of correctly answered recall and application exam items for the two groups.

Table 7

<table>
<thead>
<tr>
<th>Question Quality</th>
<th>Recall</th>
<th></th>
<th>Application</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>29</td>
<td>49.62 (13.92)</td>
<td>37.16 (15.79)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>22</td>
<td>47.98 (16.58)</td>
<td>38.38 (18.70)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The results of the MANOVA did not show a significant difference between the treatment and control groups' percentages of correctly answered item type, $F(2, 48) = .35, p > .05$; Wilk's $\Lambda = 0.99$, partial $\eta^2 = .01$. Participants correctly answered more recall questions than application questions. This finding suggests the difficulty level of the application questions was greater than the difficulty level of the recall questions. Interestingly, the control group performed slightly better on answering the recall items than the treatment group.

Hypothesis 2 - Training and Metacognitive Awareness

An analysis of covariance (ANCOVA) was conducted to examine the differences between the treatment and control groups on the dependent variable, metacognition, as measured by the 12-item Metacognitive Self-Regulation scale (post) with the same
measure (pre) as a covariate. A mean score was computed across items. The means and standard deviations of the dependent variable for the two groups are presented in Table 8.

Table 8

<table>
<thead>
<tr>
<th>Metacognition</th>
<th>n</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>29</td>
<td>4.68</td>
<td>.78</td>
</tr>
<tr>
<td>Treatment</td>
<td>22</td>
<td>4.67</td>
<td>.86</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>4.68</td>
<td>.81</td>
</tr>
</tbody>
</table>

Note. Scores range from 1 to 7.

Results of the ANCOVA showed there was not a significant effect of treatment on metacognitive awareness after controlling for the effect of participants' metacognitive awareness prior to treatment, F (1, 48) = .15, p > .05. As shown in Table 8, the treatment and control groups' scale scores were very similar (M = 4.67 and M = 4.68, respectively). The scale data were similar to what Pintrich and colleagues (1991) reported (N = 380, M = 4.54, SD = .90). Both groups reported moderate to high levels of metacognitive awareness (i.e., almost 5 on a 7 point scale).

Although there were no significant findings relative to metacognitive awareness measure, an additional MANOVA was used to explore the differences between the two groups on the dependent variable calibration accuracy (i.e., absolute predictions and postdictions, signed predictions and postdictions). Table 9 presents the means and standard deviations of the dependent variable for the two groups’ absolute accuracies.
Table 9

*Group means and standard deviations of absolute prediction and postdiction*

<table>
<thead>
<tr>
<th></th>
<th>Calibration Accuracy</th>
<th></th>
<th></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>29</td>
<td>24.24</td>
<td>15.22</td>
<td>20.17</td>
<td>12.41</td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td>22</td>
<td>32.14</td>
<td>13.68</td>
<td>25.09</td>
<td>13.83</td>
</tr>
</tbody>
</table>

Results of the MANOVA did not show a significant difference between the groups' absolute calibration accuracies, $F(2, 48) = 1.80, p > .05; \text{Wilk's } \Lambda = .93, \text{partial } \eta^2 = .70$. In both predictive and postdictive judgments, however, the participants in the treatment group were less accurately calibrated ($M_{\text{Pre}} = 32.14, M_{\text{Post}} = 25.09$) than participants in the control group ($M_{\text{Pre}} = 24.24, M_{\text{Post}} = 20.17$). As shown in Table 10, signed calibration accuracy yielded similar results.

Table 10

*Group means and standard deviations of signed prediction and postdiction*

<table>
<thead>
<tr>
<th></th>
<th>Calibration Accuracy</th>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>29</td>
<td>23.97</td>
<td>15.66</td>
<td>14.79</td>
<td>18.68</td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td>22</td>
<td>27.05</td>
<td>22.42</td>
<td>20.00</td>
<td>20.78</td>
</tr>
</tbody>
</table>

Participants in both groups were overconfident in their predictions and postdictions. Interestingly, participants in the treatment group were more overconfident ($M_{\text{Pre}} = 27.05, M_{\text{Post}} = 20.00$) than participants in the control group ($M_{\text{Pre}} = 23.97, M_{\text{Post}} = 14.79$).

**Hypothesis 3 - Question Quality and Achievement**

Due to the small subsample size of the treatment group, inferential statistics were not performed to test this hypothesis. Instead, descriptive statistics were analyzed to
identify trends that might exist between question type and the two dependent variables: percentage of recall questions answered correctly, and percentage of application questions answered correctly. Participants generated five questions which were rated as recall or application. For each student the numbers of recall and application items were tallied. If the majority of items generated by a student classified as recall, the student was coded into the recall category. Conversely, if the majority of items generated by a student classified as application, the student was coded into the application category. An example of a recall question was: “What are the six kingdoms?” An example of an application question was: “Why are decomposers important to nutrient recycling?”

As shown in Table 11, the mean exam scores of students who generated application questions (M=51.11) was over 10 percentage points higher than students who generated recall questions (M=40.15). This trend suggests students who generate application questions have higher exam scores than students who generate recall questions.

<table>
<thead>
<tr>
<th>Question Quality</th>
<th>Recall</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N 13</td>
<td>M 40.15</td>
</tr>
<tr>
<td></td>
<td>n 9</td>
<td>M 51.11</td>
</tr>
</tbody>
</table>

Not only did students who generated application questions have a higher exam mean score than students who generated recall questions, they also scored higher on recall items. Table 12 shows that participants who generated application questions scored on average nearly 15 percentage points higher on recall items than the participants who generated recall questions. The trend suggests students who generated higher level
questions were better prepared to answer recall items than students who wrote recall level questions.

Table 12
Means and standard deviations of percentage of recall items answered correctly

<table>
<thead>
<tr>
<th>Question Quality</th>
<th>Recall</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
</tr>
<tr>
<td>Treatment</td>
<td>13</td>
<td>41.88</td>
</tr>
</tbody>
</table>

Although performance on the exam and on recall items was better for students who developed application rather than recall items, the scores between these two groups were very similar for application items. Table 13 depicts the means and standard deviations of the percentage of application items answered correctly.

Table 13
Means and standard deviations of percentage of application items answered correctly

<table>
<thead>
<tr>
<th>Question Quality</th>
<th>Recall</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td>Treatment</td>
<td>13</td>
<td>37.61</td>
</tr>
</tbody>
</table>

Hypothesis 4R- Prior Achievement and Calibration Accuracy

The researcher could not test the original Hypothesis 4 due to the small subsample size. Instead, the researcher examined the effect of prior achievement on calibration accuracy across groups. A median split was performed to divide the sample into two groups based on their SAT scores in relation to the median score of 1270. Group 1 was comprised of participants whose SAT scores were less than the median. Group 2 was comprised of participants whose scores were greater than or equal to the median score.
First, the researcher examined the monitoring accuracy by comparing low and high achievers on their absolute predictions and postdictions. The means and standard deviations by achievement group (i.e., low or high) on the dependent variables, absolute prediction and absolute postdiction, are shown in Table 14.

Table 14  
Means and standard deviations of absolute predictions and postdictions by prior achievement  
<table>
<thead>
<tr>
<th></th>
<th>Calibration Accuracy</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prediction</td>
<td>Postdiction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>1-Lower-achieving</td>
<td>24</td>
<td>30.17</td>
<td>14.21</td>
<td>23.33</td>
<td>15.18</td>
</tr>
<tr>
<td>2-Higher achieving</td>
<td>27</td>
<td>25.41</td>
<td>15.52</td>
<td>21.37</td>
<td>11.24</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>27.65</td>
<td>14.96</td>
<td>22.29</td>
<td>13.14</td>
</tr>
</tbody>
</table>

Consistent with the data shown in Table 9 which reported between group (i.e., treatment and control) differences, the descriptive statistics reported in Table 14 suggest these participants across the groups, regardless of their prior achievement, were not well calibrated. Participants in both groups were mostly inaccurate in their predictions and postdictions of exam performance (i.e., mean judgments differed by more than 20 percentage points from actual performance.) The descriptive data was confirmed by inferential testing. The researcher conducted a MANOVA to evaluate the differences in absolute prediction and postdiction. The results did not yield a statistically significant difference in absolute calibration accuracy based on achievement level, $F(2, 48) = .69, p > .05$; Wilk's $\Lambda = 0.97$, partial $\eta^2 = .028$.

Second, the researcher examined the monitoring accuracy by observing the signed predictions and postdictions to see how confident (e.g., over or under) the participants
were in their judgments. The means and standard deviations by group (i.e., low or high) on the dependent variables, signed predictions and postdictions, are shown in Table 15.

Table 15
Means and standard deviations of signed prediction and postdiction by prior achievement

<table>
<thead>
<tr>
<th></th>
<th>Calibration Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prediction</td>
</tr>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>1-Lower-achieving</td>
<td>24</td>
</tr>
<tr>
<td>2-Higher-achieving</td>
<td>27</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
</tr>
</tbody>
</table>

As shown Table 15, lower and higher-achieving participants were overconfident in their monitoring accuracy. The total group means were 25.29 and 17.04 for predictions and postdictions, respectively. Lower-achieving participants were more confident in their predictions (M=28.25) than the higher-achieving participants (M=22.67). Both groups remained overconfident in their postdictions as well. However, the postdictions revealed slightly less confidence than the predictions.

Hypothesis 5R - Prior Achievement and Metacognitive Awareness

The original Hypothesis 5 was not tested due to the small subsample size. Instead, the researcher examined the influence of prior achievement on students’ metacognitive awareness across the groups. Based on the median split on SAT scores described earlier, participants were divided into low and high achieving groups. Descriptive statistics were used to examine the mean and standard deviations of metacognitive awareness across the groups. Table 16 displays these statistics.
Table 16

<table>
<thead>
<tr>
<th></th>
<th>Metacognition Self-Regulation Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>1-Lower-achieving</td>
<td>24</td>
</tr>
<tr>
<td>2-Higher-achieving</td>
<td>27</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
</tr>
</tbody>
</table>

As shown in Table 16, the lower-achieving group (M = 4.80) reported a slightly higher level of metacognitive awareness than the higher-achieving group (M = 4.58). To test this difference, the researcher conducted a one-way ANOVA to compare the effect of achievement level on metacognition. There was no significant effect of achievement level on metacognition, F (1, 49) = .92, p > .05. The findings suggest that metacognitive awareness did not differ between high and low achieving students.
CHAPTER IV
DISCUSSION AND CONCLUSIONS

The purpose of this research was to examine the impact of SRL and question generation training on metacognition and achievement among university students enrolled in a general education science course. This chapter interprets the present findings as they relate to the literature. It concludes with a discussion of the study's limitations, implications, and recommendations for further research.

The efficacy of SRL and question generation training is supported in the literature (Bol & Campbell, 2014; Palincsar & Brown, 1984; Zimmerman, 1998; Zimmerman & Martinez-Pons, 1990). Metacognitive judgments and calibration accuracy are two measures used to assess metacognition (Hacker et al., 2000; Nietfeld et al., 2005; Schraw, 1994). In an effort to understand the efficacy of SRL training and question generation on achievement and metacognitive outcomes, the researcher investigated five research hypotheses. These hypotheses focused on the efficacy of training on achievement and metacognitive awareness; the quality of self-generated questions on achievement; and the role of prior achievement in predicting calibration accuracy and metacognition.

Does SRL training affect achievement?

Although the literature supported the effectiveness of SRL training and question generation on metacognition and achievement (e.g., Bail et al., 2008; Palincsar & Brown, 1984), the researcher's hypothesis was not supported. The researcher predicted training in SRL and question generation would result in higher achievement as measured by the exam scores. Expanding upon research that suggested such training improved achievement (e.g., Bail et al., 2008; Bol & Campbell, 2014; King, 1994), results of this
study did not support the influence of training on achievement. In contrast to previous studies, there was no significant difference between the control and treatment groups’ exam scores. Overall, the participants did not perform well on the exam. As reported earlier, the mean scores on the exam were below 50 percentage points for the sample.

Several factors might have contributed to the low scores. First, disciplines such as science can pose tremendous challenges for college students due to the multifaceted nature of complex scientific concepts (Greene et al., 2012; Nordell, 2009; Schraw et al., 2006). The content covered on this exam might have presented new and challenging concepts for the students to assimilate. Second, this was the first exam in the course. Students might not have known how to adequately prepare for this exam. Furthermore, since over 50 percent of the sample was freshmen students, they might have used strategies they previously used in high school only to discover the strategies do not work in college. Nordell (2009) contended freshmen have a difficult time transitioning from high school to collegiate level academics, especially in science courses. Third, since there may have been a floor effect associated with low exam scores, the exam items might have been too difficult for the sample. Finally, the treatment instruction might not have had adequate scaffolding that would lead participants to self-regulate. Researchers have recommended scaffolded human coaching while teaching students to self-regulate in a computer-based learning environment (e.g., Azevedo, 2005). In regards to types of questions answered correctly, participants responded correctly to more recall questions than to application questions. Application type questions are considered higher-order thinking questions, based on Bloom’s taxonomy of objectives, and require an increased level of cognitive demand (Bloom, 1956). Recall questions, on the other hand, rely on
factual knowledge and do not require elaborate thinking. Thus, it was not surprising to see the students performed better on the recall type questions.

**Does training affect metacognitive awareness?**

The second hypothesis predicted training in SRL and question generation would result in better metacognitive awareness as measured by the MSLQ Metacognitive Self-Regulation scale (Pintrich et al., 1991) and metacognitive judgments. Contrary to findings reported by Bol and Campbell (2014) that supported the efficacy of SRL training on math achievement and metacognition, the results of this study did not show a significant difference between the control and treatment groups' mean scores on the Metacognitive Self-Regulation scale. Both groups' scores were similar. However, the mean and standard deviations for this sample were consistent with the scale statistics reported by Pintrich and colleagues.

In an attempt to corroborate the self-reported measure of the metacognitive self-regulation scale, the researcher compared the self-judgment measure with the actual performance on the exam. This additional measure was performed in response to researchers call for evidence to substantiate findings based upon self-reported data to see whether these self-reported data reflect actual performance (Dinsmore et al., 2008; Schunk, 2008). Although the results of this study did not support the prediction, the results did reveal the participants were overconfident in their judgments. Participants' low exam scores along with their poor calibration skills are consistent with previous findings reported in the literature. Generally, lower performing students are poorly calibrated. Hacker et al. (2000) reported strong overconfidence among lower performing students, with increasingly exaggerated overconfidence the lower they scored.
Subsequent studies supported similar findings (e.g., Bol et al., 2005; Bol et al., 2012; Nietfeld et al., 2005).

As reported in the present study, the participants in both groups had mean exam scores less than 50 percentage points of the possible total score, and they were overconfident on average by as many as 20 points in their postdictive judgments. Researchers have found test difficulty level to affect metacognitive judgments. A vast majority of variation in overconfident judgments has been contributed to the difficulty level of the test (Schraw & Roedel, 1994). In order to mitigate the overconfidence, one might suggest administering well designed test that does not exceed the ability level of the students and offering practice in calibration accuracy. In regards to calibration practice, Hacker et al. (2000) reported lower-performing students did not improve in their prediction and postdiction accuracy across the span of a semester. In another study, these researchers found that incentives increased lower-performing students postdiction accuracy (Hacker et al., 2008). Other interventions, such as piloting the test with a similar learner population combined with incentives, might prove to be more effective.

**Does the quality of student-generated questions affect achievement?**

The third hypothesis predicted students who generated higher-order questions would experience higher achievement than students who generated recall questions as measured by the unit exam score. This prediction was based on the generative learning theory proposed by Wittrock (1974) which purports students create new knowledge by generating relations between new information and prior knowledge. Previous research has supported the hypothesis that students who generate their own elaborations, such as paraphrasing, learn more effectively than students who do not generate elaborations
(Johnsey et al., 1992). Question generation, an example of a generative strategy, might facilitate deeper processing and knowledge transfer (Craik & Lockhart, 1972; Jonassen, 1985). However, the research on the efficacy of question generation strategy on achievement is inconclusive (Redfield & Rousseau, 1981; Samson, Strykowski, Weinstein, & Walberg, 1987; Winne, 1979). In the present study, students who went beyond recall questions to application performed better on the unit exam.

The treatment group’s small sample size in the present study precluded the use of inferential statistics. However, the descriptive statistics showed participants who generated application questions scored an average of 10 percentage points higher on the exam than students who primarily wrote recall questions. Similarly, students who wrote application level questions answered on average 16 percent (i.e., two questions) more of the recall test questions (n=18) than students who wrote recall practice questions. This observation is consistent with previously reported findings that quality higher order thinking questions induce a thorough processing of the text which leads to improved comprehension (e.g., Davey & McBride, 1986).

When interpreting these results, the reader should understand previous findings in support of this prediction have been mixed. Wong (1985) and Rosenshine et al. (1996) reviewed studies that examined the effectiveness of self-questioning on comprehension and concluded that when students are adequately trained to generate questions, they will experience a gain in their comprehension of the content. To the contrary, Foote (1998), replicated procedures used in King’s (1990, 1991) studies that supported the effectiveness of questioning on students’ comprehension. However, Foote did not find
similar results. The generation questions failed to enhance students’ performance on the lecture comprehension exam.

**Does prior achievement affect calibration accuracy?**

The researcher predicted that prior achievement affected calibration accuracy. The purpose of this prediction was to substantiate previous claims that prior knowledge improves monitoring accuracy (e.g., Hacker et al., 2000; Nietfeld & Schraw, 2002). However, prior knowledge did not affect calibration accuracy in the present study. Participants in both groups were overconfident in their predictions and postdictions of exam performance. Considering the sample’s SAT scores and poor performance on the exam which suggest a lower-achieving sample, this finding is not surprising. Other researchers have reported similar findings. For example, Hacker et al. (2000) reported students who scored less than 50% on the exam exhibited gross overconfidence in their predictions and postdictions.

Some factors that diminished the effects of treatment on achievement may have also affected calibration accuracy. First, participants might have been ill-prepared to take the first exam in the course. Second, the difficulty level of the exam might have been a challenge for the majority first-semester freshman sample. Finally, participants could have had limited prior domain knowledge. These factors have been previously considered as variables that affect monitoring accuracy (Nietfeld & Schraw, 2002).

**Does prior achievement affect metacognitive awareness?**

Contrary to the researcher’s prediction, the findings did not suggest prior knowledge, as measured by SAT scores, influenced metacognitive awareness in the sample population. Participants in the lower and higher achieving groups reported similar
levels of metacognitive awareness. Although a median split was used to assess if there was a difference within the sample, the researcher would classify the entire sample as lower-achieving students since the sample’s mean SAT score more than 200 points below the national average for 2013 (The College Board, 2013a). Whereas some researchers contend the acquisition of metacognition does not depend strongly on intellectual ability (Alexander, Carr, & Schwanenflugel, 1995; Swanson, 1990), Nietfeld et al. (2005), on the other hand, argued prior achievement (e.g., GPA) correlated strongly with monitoring accuracy. In the present study, students’ overconfident judgments might be attributed to their achievement level and test difficulty as discussed earlier. In addition to the relationship of prior knowledge on metacognition, the appropriate declarative, procedural, and conditional knowledge of learning strategies might be other factors to consider when exploring this relationship.

Limitations

There were several limitations of the study. First, the relatively small sample size, due to attrition, restricted the researcher’s ability to investigate the complex relationships among the constructs. A total of 40 students (44%) withdrew from the study. The attrition rates for the treatment and control groups were 52% and 36%, respectively. Even with the use of individual incentives for participants which included extra credit points and gift cards, participants were not motivated to persist through completion of the study. Some students may have considered the requirement to write practice questions during weeks 1 and 2 excessive. On the other hand, participants in the control group who withdrew from the study might have observed no benefit of completing the ruse activities and dropped out of the study. The study consisted of primarily low-achieving students.
which might have contributed to the high attrition. Finally, the overall attrition could have resulted from students' lack of motivation to learn a new strategy (Weinstein et al., 2011).

Consequently, the attrition rate yielded little statistical power. Due to the small sample size, the researcher was restricted in the use of inferential statistics and had low power when they were employed. This limitation affected the internal and external validity of the study.

The third limitation was internal consistency reliability of the unit exam. The floor effect phenomenon suggests the test items might have been too difficult for the sample population. In a future study, the exam should be piloted with a representative sample of the population being studied.

The fourth limitation was design contamination. Since the treatment and control groups were divided within each class at a smaller university, there was greater opportunity for participants to discover what the treatment group was doing either overtly (talking with each other specifically about the study) or covertly (studying together). To discourage design contamination, participants were instructed not to discuss the weekly activities with anyone until the conclusion of the study.

The fifth limitation was social desirability. Since the MSLQ is a self-reporting instrument, students might have responded to the questions according to how they perceived their peers might respond. The researcher examined the actual exam scores to determine if students' self-reported judgments correlated with their actual performance.

Finally, there were threats to ecological and external validity. Ecological and population validity were limitations since the sample population was enrolled in one
general education science course. Furthermore, the population was not a representative sample of the undergraduate student population. Therefore, the results cannot be generalized to other content areas and other populations.

Recommendations for Further Study

A significant number of studies that explore the efficacy of SRL training and metacognitive monitoring in authentic learning environments have small sample sizes. Further study, using a larger sample size, would extend the ecological and external validity of existing studies. The following modifications are recommended for future studies: (1) Incorporate scaffolded SRL training, and (2) administer repeated measures on achievement extended over a longer time period rather than a single instance (e.g., a unit exam). Furthermore, an exploration on how to effectively incentivize this population to persist in research studies, which promise intangible benefits such as improved achievement, could mitigate high attrition in such studies. What will it take to recruit and retain these students in studies that might train them to become self-regulated and metacognitively aware learners? Researchers might consider interviews and focus groups to investigate this phenomenon.

Conclusions

As high school students transition to college students, institutions should provide resources to help students achieve academic success. Particularly, learning strategy interventions and metacognitive monitoring techniques have been shown to aid students in developing academic skills which contribute to their achievement (Hacker et al., 2008; Weinstein & Mayer, 1986; Zimmerman, 1990). With College Board classifying less than half of the students who take the SAT as meeting the college preparedness benchmark,
students will find themselves unprepared for the rigors of collegiate academics (The College Board, 2013b).

The present study sought to explore the efficacy of SRL training and question generation on metacognitive awareness and achievement. The results of this study did not lend support to the efficacy of SRL training and question generation on metacognition and achievement. Instead, descriptive statistics revealed several trends consistent with the literature. First, students who generated application questions had higher exam scores than students who generated recall questions. Second, students across groups were not well calibrated. Signed prediction and postdiction accuracy showed students were overconfident in their monitoring accuracy. Finally, lower-achieving students self-reported greater metacognitive awareness than higher-achieving students. This trend suggests lower-achieving students are less likely to accurately self-assess the metacognitive awareness than higher-achieving students. Limitations in this study could explain the lack of significant differences between the treatment and control groups’ achievement and metacognitive awareness.

In sum, training students to become self-regulated and metacognitively aware learners holds great promise for student achievement.
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After taking his first college exam, Reggie couldn't wait to see his academic advisor to tell her how well he thought he had done on the exam. He entered her office with a smile on his face. "How did you do on your exam?" she asked. "I think I did ok," he said. "I made sure I read over my notes before I took the test," he confidently added.

A few days later Reggie returned to see his advisor. She noticed he didn’t look too happy. "Reggie, what’s going on with you today?" she asked. With a disappointed look and tone Reggie exclaimed, "I don’t know how to study!" He went on to tell her that he had read over his notes as he previously did to prepare for tests in high school. However, it didn’t work this time. "I flunked that test!" he exclaimed!

When high school students transition to university freshman they are often surprised, like Reggie, when they discover their academic performance skills that yielded success in high school do not produce similar results in college. The university’s brisk instructional pace, the breadth and depth of content, the expectation for independent out-of-class learning, and the requirement of integrating new knowledge with previously acquired knowledge can present significant challenges for new college students. To minimize the challenge of this new world for college freshmen, learning strategy instruction can have a positive impact on students’ academic performance.
APPENDIX B

TRAINING MODULE

Overview

After taking his first college exam, Reggie couldn’t wait to see his academic advisor to tell her how well he thought he had done on the exam. He entered her office with a smile on his face. “How did you do on your exam?” she asked. “I think I did ok,” he said. “I made sure I read over my notes before I took the test,” he confidently added.

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In this unit of instruction, you will learn strategies that can help you regulate (or control) your learning. Upon completion of this training module, you should be able to:
1. Define metacognition.


3. Describe three phases of SRL.

4. Given an elaboration strategy, describe a learning task that might benefit from the technique.

5. Generate questions from a reading passage.

You will encounter knowledge checkpoints throughout the unit. The purpose of the checkpoints is to help you monitor how well you comprehend the materials. Be sure to complete the checkpoints before proceeding to the next section. If you have never done this before, give it a try. You just might be pleasantly surprised by the results!

Remember, college requires independent out-of-class learning. So, let’s start practicing now!

**What is Metacognition?**

When was the last time someone asked you, “What are you thinking?” or “What’s on your mind?” Better yet, when was the last time you asked yourself, “What am I thinking about?” *(Pause to reflect.)* These questions are intended to cause us to think about what we are thinking at a given moment so that we can be sure we are focusing our attention on the matter at hand. This is a very important question to ask yourself while engaging in learning activities (e.g., reading the text, listening to lectures, completing homework assignments.)

Metacognition is an academic term that directs us to think about what we are thinking. Basically, it is thinking about thinking. It is defined as self-awareness and knowledge of one’s thinking. Students who are metacognitive aware are able to:
1. Explain (or describe) how they learn, and

2. Manipulate their mental resources to facilitate learning.

When it comes to your academic success, it will be necessary for you to think about your thinking while you are reading your textbook, class notes, and this instructional unit. Students who are metacognitively aware do more than think about their thinking. They also select and use appropriate learning strategies to regulate aspects of their learning. For example, metacognitively aware students will purposefully stop to see if they can recall what they just read. If they have difficulty recalling, they might (should) re-read the paragraph before proceeding. After the re-read, they might write a sentence or two to summarize the main idea of the paragraph. (*Give it a try. Can you recall the main idea of this paragraph?*)

Recall the last time you read something and you asked yourself, “What did I just read?” Perhaps there were moments that you realized you had been looking at letters on a page, calling out words, and turning pages, but you really did not comprehend any of the content. What did you do?

**Knowledge Check**

1. **What is the definition of metacognition?**

2. **What are two things metacognitively aware students are able to do?**

**What is Self-Regulated Learning?**

Before I define self-regulated learning (SRL), let me first tell you what it is not. SRL is not an academic performance skill such as being able to write an essay or recite a
passage from memory. SRL is not determined by your mental ability. Students with different mental abilities and performance skills can, with practice, become self-regulated learners.

So then, what is SRL? Simply put, SRL is your ability to regulate (control) your learning and evaluate your progress. Regulate and evaluate! In high school others might have regulated much of your learning. For example, your teachers probably told you what to study in order to prepare for the test. Your parents or peers might have suggested that you study. However, do not expect your college professors to tell you precisely what you must learn; when you should study; or, how long you should study. They will present information or guide you to discover new information. Your professors will not regulate your learning. If it were that easy, everyone would learn everything and earn an “A”. SRL is something you do for yourself. Take charge!

What are the benefits of SRL? The fundamental benefit is improved academic performance (better grades). Self-regulated learners are more successful in achieving their academic goals than students who are not self-regulated learners. Furthermore, self-regulated learners are more metacognitively aware, motivated, and know how to apply the knowledge they learn.

Knowledge Check

1. Self-regulated learners will _____ their learning and _____ their progress.

2. How might SRL benefit you in this class?
Now, let's take a closer look at SRL. In this lesson, we will discuss three phases of SRL.

The **Forethought Phase** occurs before you begin studying. This is considered the planning phase. During this phase, you should ask yourself: What are my goals for this learning task? When will I start the task? Where will I perform the task? What conditions will help or hinder me in achieving my goal? Who can help me if I need assistance? Once you have made plans for learning, you will be ready to proceed to the next step.

The **Performance Phase** is where you practice what you planned. During this stage, you will put into practice the strategies or methods you identified in the **Forethought Phase**. The following are helpful strategies you might use during the **Performance Phase**:

- Arrange conditions that help you learn. For example, if you are easily distracted, remove clutter from your study area. If you need a quiet environment, go to the library or find an empty classroom.
• Use learning strategies that will help you study in a manner that you will actually learn the new information. We will discuss a few strategies that you can use in this course later.

• Monitor your progress. Check to see if you are moving towards achieving your goal.

• Check your understanding. Make certain you are not just staring at words on a page but you are actually learning the material.

• Seek help if you need assistance.

The next phase is the **Self-Reflection Phase**. After you have planned and practiced, you should take a moment to reflect upon your performance. You might ask questions such as the following:

• How well did I do?

• Did I achieve the goal(s) that I identified in the *Forethought Phase*?

• What learning strategies worked or didn’t work in this task?

• What might I do to get similar (if results were good) or better (if results were not the best) the next time?

Once you have completed the three phases, notice the arrow from the *Self-Reflection Phase* points towards the *Forethought Phase*. You got it! You will use the information from the reflection phase to help you plan your next learning task. Your SRL skills will become stronger the more you do this. Practice makes perfect!
Knowledge Check

1. During what phase of SRL would you self-check your understanding of the materials you are studying?
2. Should you wait until the professor announces an exam date before you study? Why?
3. If you do not understand the material while studying, what are some things you might do to facilitate your understanding of the content?

Let’s Review

So far we have discussed two concepts: metacognition and self-regulated learning. Metacognition refers to self-awareness of learners’ thinking and their ability to manipulate their mental resources to facilitate learning. When students are metacognitively aware, they are in a better position to control their learning by regulating their own study environment, setting academic goals, selecting helpful strategies, and evaluating their progress.

Learning Strategies

Learning strategies aid students in acquiring new knowledge. For example, some students have learned the Great Lakes with the aid of the mnemonic HOMES. Other students highlight or underline keywords or phrases while reading a passage to facilitate learning the main ideas or concepts.

College students are expected to process information more deeply than basic rote memorization and recall. You will be challenged to go beyond the surface of new information as you will be required to explain, analyze, compare, contrast, distinguish,
evaluate, etc. Surface processing will help you on simple learning task. However, deep processing allows you to apply the knowledge in different situations other than recall. Let’s take a look at some learning strategies that will facilitate deep processing of content.

**Elaboration strategies** are learning strategies that facilitate deeper processing of information. Elaborations will help you connect the new information with the background knowledge you already posses regarding the content. The following list contains examples elaboration techniques:

- **Examples** – Provide your own examples to illustrate concept(s).

- **Summaries** – Write a *brief* restatement, in your own words, of the content of a passage, focusing on the central idea(s). Summaries are usually shorter than the original passage. Summaries highlight the main idea of the passage.

- **Paraphrases** – Write a *precise* restatement, in your own words, of the content of a passage. Paraphrases are used to simplify or clarify a passage. Paraphrases include more detail than the summary.

- **Questions** – Self-generate and answer questions concerning the key points of a passage.

- **Flow charts**

- **Tables**

- **Alternative explanations**
Knowledge Check

1. What learning strategies do you use when studying?

2. Which of these strategies do you presently use?

3. Which of these strategies might you use in the future?

Question Generation

In the final section of this training module, you will learn how to use a specific elaboration strategy—question generation. Although you have had much practice answering questions written or asked by your teacher, you will now write your own questions to check your understanding. When you generate your own questions rather than waiting for your professor to provide questions on study guides or the exam, you gain greater control (regulation) over your learning. That’s how you become a self-regulated learner! Question generation will help you determine:

1. What you already understand;

2. What you do not yet understand; and,

3. What you need to study further.

This section is very practical. You will be asked to practice writing questions. First, you will be provided with a list of generic question stems. Use the question stems to develop questions concerning the key points of a passage. You will accomplish this by plugging in appropriate words or phrases in the spaces indicated with "…". For now, just read over the stems to become acquainted with them. Second, you will be given a brief reading passage. Carefully read the passage for understanding. Third, you will select any
three of the question stems and write three questions pertaining to the passage you just read. Finally, answer your questions. You choose the stems. You write the questions. You answer the questions. You are becoming a self-regulated learner.

Let's get started!

1. **Question Stems** – Each stem contains “…” You are to fill in these spaces with appropriate concepts or appropriate words from the reading passage. I will provide an example shortly.

   - What is a new example of...?
   - How could ... be used to...?
   - What would happen if...?
   - What are the strengths and weaknesses of...?
   - What do we already know about...?
   - How does ... tie in with what we've learned before?
   - Explain why ...
   - Explain how...
   - How does ... affect...?
   - What is the meaning of...?
   - Why is ... important?
   - What is the difference between ... and...?
   - How are ... and ... similar?
   - How does ... apply to everyday life?
   - What is the best ... and why?
   - What are some of the possible solutions for the problem of...?
   - Compare ... and ... with regard to ...
   - What conclusions can be drawn about...?
   - What do you think causes...?
   - Do you agree or disagree with this statement...? Support your answer.

**Steps to Generating Good Questions:**

1. Carefully read (and re-read) the passage for understanding. Use a dictionary to look up the meaning of words that you do not know.
2. Determine the main idea(s) or key point(s) of the passage. The section heading and the topic sentence of the paragraph are good places to look for the main idea. Highlight or underline key points. (Re-read the passage if necessary.)
3. Select three of the question stems that seem most applicable for this passage and write your questions. (Re-read the passage if necessary.)
Example:

Consider this passage from an introductory biology textbook:

Scientists use two types of systematic thought processes: deduction and induction. With deductive reasoning, we begin with supplied information, called premises, and draw conclusions on the basis of that information. Deduction proceeds from general principles to specific conclusions. For example, if you accept the premise that all birds have wings and the second premise that sparrows are birds, you can conclude deductively that sparrows have wings. Deduction helps us discover relationships known as facts. A fact is information, or knowledge, based on evidence.

Inductive reasoning is the opposite of deduction. We begin with specific observations and draw a conclusion or discover a general principle. For example, you know that sparrows have wings, can fly, and are birds. You also know that robins, eagles, pigeons, and hawks have wings, can fly, and are birds. You might induce that all birds have wings and fly.

1. I read the passage for understanding.
2. Then, I read it again. This time I highlighted and underlined what I thought were key points.
3. I selected three stems and completed the questions. Take a look.

Questions:

1. What are the strengths and weaknesses of inductive reasoning?
2. What is a new example of deductive reasoning?
3. What is the difference between deductive and inductive reasoning?
Here is another passage. This time you give it a try.

**A hypothesis is a testable statement**

Scientists make careful observations, ask critical questions, and develop hypotheses. A hypothesis is a tentative explanation for observations or phenomena. Hypotheses can be posed as “if...then...” statements. For example, if students taking introductory biology attend classes, then they will make a higher grade on the exam than students who do not attend classes.

After reading the passage, write three questions using the stems as a guide.

**Summary**

You have reached the end of this module; check your understanding to ensure you are able to:

1. Define metacognition.
3. Describe three phases of SRL.
4. Given an elaboration strategy, describe a learning task that might benefit from the technique.
5. Generate questions from an assigned passage.

After you have mastered the content presented in this lesson, you should practice what you have learned as often as possible in all of your classes. Write questions often. Put your questions aside for a little while and then see if you can answer them without looking at the passage. If you can, great! If not, determine what you do not know. Re-read the passage or visit your professor during office hours to get clarification. Be sure to
use the skills you have developed towards your academic success in this class as well as other classes where these strategies might be used.

Since this is an experiment, please do not the content of this instructional unit with anyone in the class until the study concludes. In the meantime, practice, practice, practice!
APPENDIX C

GENERIC QUESTION STEMS

1. What is a new example of...?
2. How could … be used to…?
3. What would happen if…?
4. What are the strengths and weaknesses of…?
5. What do we already know about…?
6. How does … tie in with what we’ve learned before?
7. Explain why …
8. Explain how…
9. How does … affect…?
10. What is the meaning of…?
11. Why is … important?
12. What is the difference between … and…?
13. How are … and … similar?
14. How does … apply to everyday life?
15. What is the best … and why?
16. What are some of the possible solutions for the problem of…?
17. Compare … and … with regard to …
18. What conclusions can be drawn about…?
19. What do you think causes…?
20. Do you agree or disagree with this statement…? Support your answer.
APPENDIX D

DEMOGRAPHIC SURVEY

What is your gender?

Male
Female

What is your classification?

Freshman
Sophomore
Junior
Senior

What is your ethnicity?

African American
Asian American
Caucasian
Hispanic
Two or more races

What is your Banner ID#? (Your ID# will only be used to link your pre and post survey responses.)
The following questions ask about the learning strategies and study skills you use for this class. There is no right or wrong answer. For each question rate how true or untrue this is for you. If the statement is very true of you, circle 7; if a statement is not at all true of you, circle 1. If the statement is more or less true of you, find the number between 1 and 7 that best describes you.

1. During class time I often miss important points because I'm thinking of other things.

2. When reading for this course, I make up questions to help focus my reading.

3. When I become confused about something I’m reading for this class, I go back and try to figure it out.

4. If course readings are difficult to understand, I change the way I read the material.

5. Before I study new course material thoroughly, I often skim it to see how it is organized.

6. I ask myself questions to make sure I understand the material I have been studying in this class.

7. I try to change the way I study in order to fit the course requirements and the instructor’s teaching style.

8. I often find that I have been reading for this class but don’t know what it was all about.

9. 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 this course.

10. When studying for this course I try to determine which concepts I don’t understand well.

11. When I study for this class, I set goals for myself in order to direct my activities in each study period.

12. If I get confused taking notes in class, I make sure I sort it out afterwards.
APPENDIX F

TEST BLUEPRINT

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APPENDIX G

CHAPTER EXAM

Be sure to record your predicted exam score on the cover sheet before proceeding. Then record your postdicted score after you take the exam.

Multiple Choice

Identify the choice that best completes the statement or answers the question. Record all answers on the provided answer sheet.

1. The science of biological classification is used to
   a. predict an organism's future evolution.
   b. decide when an organism died.
   c. show relationships among organisms.
   d. decipher an organism's DNA.

2. Evolutionary tree diagrams representing the relationships between various organisms can be drawn only when those organisms share a
   a. common cellular metabolism.   c. common cellular organization.
   b. distinct lineage.   d. common ancestor.

3. In order to determine relationships among different organisms scientists would examine
   a. DNA.   c. body structures.
   b. behavior.   d. all of the above

4. Which of the following pairs of kingdoms would be included exclusively in the domain Eukarya?
   a. Plantae and Bacteria    c. Animalia and Fungi
   b. Animalia and Archaea    d. Protista and Bacteria

5. Which of the following would contain the most closely related group of phyla?
   a. Class    c. Genus
   b. Order    d. Kingdom
6. *Canis latrans* is the scientific name for the coyote. The term *Canis* represents the coyotes’
   a. genus. c. order.
   b. kingdom. d. species.

7. When success is defined as the greatest number of living individuals, Earth’s most successful inhabitants are the
   a. vertebrates and birds. c. bacteria and archaea.
   b. fungi and animals. d. plants and animals.

8. A distinguishing difference between bacteria and archaeans is
   a. that bacteria are prokaryotic and archaeans are eukaryotic.
   b. the molecules used to construct their cell walls.
   c. the presence of membrane-bound organelles, which are observed only in bacteria.
   d. the greater size of the bacterial nucleus.

9. Because plants lack the ability to directly use the _____ present in the atmosphere, their abundance often depends on bacterial populations present within the soil.
   a. Nitrogen c. Water
   b. Oxygen d. carbon dioxide

10. Viruses
    a. divide by a form of cell division known as binary fission.
    b. are considered nonliving because they contain no hereditary material, such as DNA.
    c. infect humans but not bacteria.
    d. lack the ability to acquire energy independently.

11. A viral particle is very simple, consisting of a core of DNA or RNA surrounded by a
    a. microscopic cell c. Endotoxin
    b. protein coat d. host cell

12. Viral classification and biology has been challenging; presently most biologists agree that viruses
    a. should be classified as members of the kingdom Protista.
    b. are constructed from a protein wrapped around DNA or RNA.
c. use a photosynthetic process more similar to bacteria than plants.
d. should be classified as autochemotrophic.

13. The most ancient eukaryotic fossils are similar to red algae, a type of _____ abundant today.
   a. Fungi  c. Protest
   b. Bacteria d. Plant

14. Biologists hypothesize several advantages for the larger cell size typically observed in eukaryotes, including
   a. the storage of food.
   b. a larger selection of potential prey for predatory species.
   c. improved defensive capabilities against predatory species.
   d. all of the above

15. Although exceptions exist, reproduction in most eukaryotes involves
   a. two individuals combining DNA during the formation of a new organism.
   b. one individual dividing to make two identical organisms.
   c. two individuals fusing to form one organism.
   d. the cells of an individual dividing.

16. Protists may superficially resemble organisms in the other kingdoms; one exception is the kingdom _____, whose members do not resemble protists in any meaningful way.
   a. Bacteria  c. Plantae
   b. Fungi  d. Animalia

17. The single-celled protists are often mobile, moving within the environment by means of
   a. pseudopodia.  c. flagella.
   b. cilia.  d. all of the above

18. During a red tide
   a. air pollution turns the sunrise and sunset bright red, which, in turn, makes beaches appear red.
b. fish die from water pollution and bleed as they wash up on the shoreline.
c. single-celled protists become so numerous that they color the water red, brown, yellow, or other colors.
d. fish eat large quantities of red-colored food items and temporarily become red themselves.

19. What resources do plants use to produce the sugar molecules that plant cells use for fuel?
   a. carbon dioxide, water, and light energy  c. nitrogen and oxygen
   b. water and pond scum  d. water, nitrogen, and iron

20. Fertilization is the event occurring when a(n)
   a. egg and sperm unite to first form a zygote and eventually an embryo.
   b. pollen tube grows through the style and reaches the ovary.
   c. pollen grain is transported by wind or insect to the female portion of the plant.
   d. pollen grain is released from the male portion of the plant.

21. The arrival of a pollen grain on the carpel of a flower or the scale of a female cone is termed
   a. fertilization.  c. germination.
   b. pollination.  d. vascularization.

22. The primary body of a fungus is known as the
   a. mycelium.  c. mitochondrion.
   b. gymnosperm.  d. septum.

23. In comparison to the above-ground fruiting body, or mushroom, the mass of the underground mycelium is
   a. substantially smaller.  c. substantially larger.
   b. about the same.  d. larger in the basidiomycetes only.

24. Despite having cell walls like plant cells, this feature is not considered a shared derived trait between the fungi and plants because
   a. fungal cell walls are incomplete.
   b. chitin rather than cellulose is the primary structural component of a fungal cell wall.
c. digestive enzyme can be secreted through the cell wall of a hypha.
d. glycogen rather than glucose is a primary structural component of a fungal cell wall.

25. Mutualistic organisms are more commonly termed
   a. parasitic organisms   c. symbiotic partners
   b. Decomposers         d. collaborators

26. A mutualistic association between a photosynthetic microbe and a fungus is called a
   a. Protozoan            c. Mycorrhizae
   b. Lichen               d. Biosis

27. What best explains the differences in shoot weight shown in the graph below?

   ![Graph showing differences in shoot weight]

   a. Commercial fertilizers often contain harmful contaminants that can suppress growth.
   b. Sterilized growth environments remove competitive bacteria and fungi, allowing plants to experience their best possible growth.
   c. Commercial fertilizers can be tailored to meet the needs of specific plants, producing the best possible growth for that species.
   d. Mycorrhizal fungi not only increase the availability of soil nutrients but often transport them into the plant root.
VITA

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