A PEDAGOGICAL APPROACH TO IMPROVING STUDENTS' USE OF METACOGNITIVE STRATEGIES

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DEDICATION

This dissertation is dedicated to the loving memory of my late mentor,

Ann Weeman Auleb.

ABSTRACT

In higher education, there has been a push to strengthen students' critical thinking skills. Metacognition is a central component of critical thinking and research has indicated that students who use metacognitive strategies tend to become better critical thinkers and academically successful students. Though the merits of metacognition are known, relatively less research has been conducted on the effectiveness of pedagogical practices intended to improve students' metacognitive skills and abilities. The overarching agenda guiding this study is to contribute to research that improves students' critical thinking; the specific focus is on the effectiveness of metacognitive pedagogy on students' self-reported use of metacognitive strategies. In a quasi-experimental two-group research design, 392 undergraduate students received metacognitive pedagogy and worked with metacognitive strategies while completing a 16-week undergraduate course in sexuality studies. Students in Group A received metacognitive pedagogy and learning for a total of ten weeks, whereas students in Group B received metacognitive pedagogy and learning for a total of five weeks. Throughout both semesters, data about students' self-reported use of metacognitive strategies were collected using the Metacognitive Awareness Inventory (MAI; Schraw & Dennison, 1994) on four occasions, two before and two after the pedagogy was introduced. To examine the effects of metacognitive pedagogy on students' self-reported use of metacognitive strategies, I analyzed changes in students' regulation and knowledge scores from the MAI using latent growth curve modeling. The results revealed a statistically significant change in students' metacognitive strategies pertaining to regulation of cognition, whereas with knowledge of cognition, the pattern of change did not support the hypothesized growth. In addition, the amount of exposure to metacognitive pedagogy did not have an effect on students' use of metacognitive strategies. The findings suggest that metacognitive pedagogy can have a

positive effect on students' regulation of cognition but little if any effect on students' knowledge of cognition. Furthermore, more exposure does not appear to result in higher gains, though the study was constrained within a single semester and unable to measure durability or delayed changes in either regulation or cognition.

CONTENTS

TABLES

FIGURES

CHAPTER 1

INTRODUCTION

In recent years, there has been a shift within education to promote what has become known as 21st century learning. Whereas education during the previous century largely focused on the development of literacy and numeracy, today's education places additional focus on creativity, curiosity, technology, leadership, and collaboration; with a central goal to foster critical thinkers who will become more capable employees and engaged citizens. American psychologist and distinguished scholar, Diane Halpern has contributed significantly to research about critical thinking. Halpern (1998) defined critical thinking as, "the use of those cognitive skills or strategies that increase the probability of a desirable outcome…critical thinking is purposeful, reasoned, and goal-directed" (p. 450). Significant research has suggested that students with well-developed critical thinking skills are more likely to make more informed decisions and judgments in complex situations (Bennett, 2016; Dwyer, Hogan, & Stewart, 2014; Fonteyn & Cahill, 1998; Halpern, 1998; Hattie, 2009; Hattie, Gurung, & Landrum, 2015; Plumlee, Rixom, & Rosman, 2015; Reid & Anderson, 2012). Similar studies suggest that good critical thinkers are less likely to engage in biased thinking (Dwyer, Hogan, & Stewart, 2014; Facione & Facione, 2001) and are also more likely to perform better academically (Alexander, Graham, & Harris, 1998; Dwyer, Hogan, & Stewart, 2014; Halpern, 1998; Hattie, Biggs, & Purdie, 1996; Kolencik, & Hillwig, 2011; Seraphin, Philippoff, Kaupp, & Vallin, 2012; Tractenberg & FitzGerald, 2012; Tractenberg, Umans, & McCarter, 2010). The assertion is that students who use critical thinking skills possess the ability to learn quickly, process information accurately, and use necessary information in decision-making.

In today's education, there is a stronger emphasis on critical thinking as evident in the new standards being developed for K–12 education. In the Common Core State Standards and the Next Generation Science Standards, critical thinking is a central concept to both teaching and learning. A similar trend exists within higher education. Trilling, Fadel, and Partnership for 21st Century Skills (2009) suggested that the ability to think critically across disciplines is one of the most needed skills for students to be successful in post-secondary education and later in the workforce.

While mission statements and course syllabi in higher education often emphasize learner autonomy, initiative taking, critical and diverse thinking, the set-up of the classroom and the needed pedagogical support in helping students further these skills typically introduces a glaring contradiction (Hattie, Gurung, & Landrum, 2015; Reid & Anderson, 2012). There is an inherent expectation that post-secondary students have mastered the necessary prerequisites, including how to be successful learners prior to entering higher education (Reid & Anderson, 2012). Post-secondary learning environments are typically structured on the assumption that students have arrived not only with sufficient knowledge of academic content, such as in language arts, science, and mathematics, but also with sufficiently developed skills in regulating their own learning (Hattie, Gurung, & Landrum, 2015). Today's students in post-secondary education tend to be diverse (e.g., age, gender, ethnicity, employment), and as they enter college they are often not sufficient in the skills and abilities needed to regulate their learning. Their knowledge and skills in learning strategies tend to vary greatly, thus leading to incongruous expectations for success in college (Hattie, Gurung, & Landrum, 2015). Though post-secondary education should require rigorous academic standards, research has shown that many students arrive in higher-education with lower skills in self-regulated learning (SRL) than is assumed and this affects their critical thinking (Reid & Anderson, 2012).

A study by Arum and Roksa (2011) assessed 2,300 students in twenty-four institutions after they had completed their first year and a half of college. The findings reveled that 45% of the students showed no statistically significant improvement in their critical thinking skills (as cited in Fink, 2013). Findings from another large ongoing study, the Wabash National Study led by Blaich and Wise (2011), showed similar outcomes when looking at students' critical thinking abilities within liberal arts education. This longitudinal study, which involved over 17,000 students in 49 institutions was designed to better understand teaching practices, student experiences, and institutional conditions that promote student growth across multiple outcomes, including critical thinking. Some of their findings showed that after four years of college, students marginally improved in their critical thinking. Studies such as these suggest that current teaching practices in higher education are not meeting set goals for producing students with skills that societal leaders believe are necessary for navigating and improving our 21st century society.

Problem Statement

Several studies have shown that students can improve in SRL and become better critical thinkers as a result of instruction (Fonteyn & Cahill, 1998; Halpern, 1998; Hattie, 2009; Plumlee, Rixom, & Rosman, 2015; Reid & Anderson, 2012). Though there is general agreement about promoting SRL as a way to develop students' critical thinking skills in preparation for effective citizenship, there is less understanding about what constitutes best pedagogical practices to effectively teach students these necessary skills (Wilen & Phillips, 1995). Pedagogy is important, perhaps one of the most important factors in encouraging students to become self-regulated learners and good critical thinkers. It is suggested that teaching—the pedagogical aspects of teaching critical thinking—might be one of the best predictors of students developing and utilizing these important habits of mind (Halpern, 1998; Hattie, 2009, 2011, 2015).

According to Hattie (2011), the best teaching practices for teaching students to become better critical thinkers include clear learning intentions that explicitly describe student expectations. Hattie recommends that expectations, such as the skills, knowledge, attitudes, and values needed to succeed, should be explicit within any unit or lesson learned.

> What seems needed are teaching methods that allow teachers to know more about student perspectives in learning, to communicate clear learning intentions and criteria for success, to optimize metacognitive and student-regulated learning, to increase feedback that is appropriately received by students, and most critically for teachers to seek greater feedback from students to them then lead to changes in their teaching. (p. 140)

Numerous scholars have noted that to make students explicitly aware of their learning (i.e., to become better critical thinkers), a key component of this process is teaching students to be able to reflect on their thinking processes, something referred to as metacognition (Alexander, Graham, & Harris, 1998; Hattie, Biggs, & Purdie, 1996; Kolencik, & Hillwig, 2011; Seraphin, Philippoff, Kaupp, & Vallin, 2012; Tractenberg & FitzGerald, 2012; Tractenberg, Umans, & McCarter, 2010).

According to Halpern (1998), "Metacognition is the executive or 'boss' function that guides how adults use different learning strategies and make decisions about the allocation of limited cognitive resources" (p. 454). In a way, metacognition can be described as some of the tools used in the process of critical thinking, which is also part of self-regulated learning (Figure 1.1). According to Dwyer, Hogan, and Stewart (2010), "Critical thinking is a metacognitive process that, through purposeful, reflective judgement, increases the chances of producing a logical conclusion to an argument or solution to a problem" (p. 43). Thus, from a pedagogical

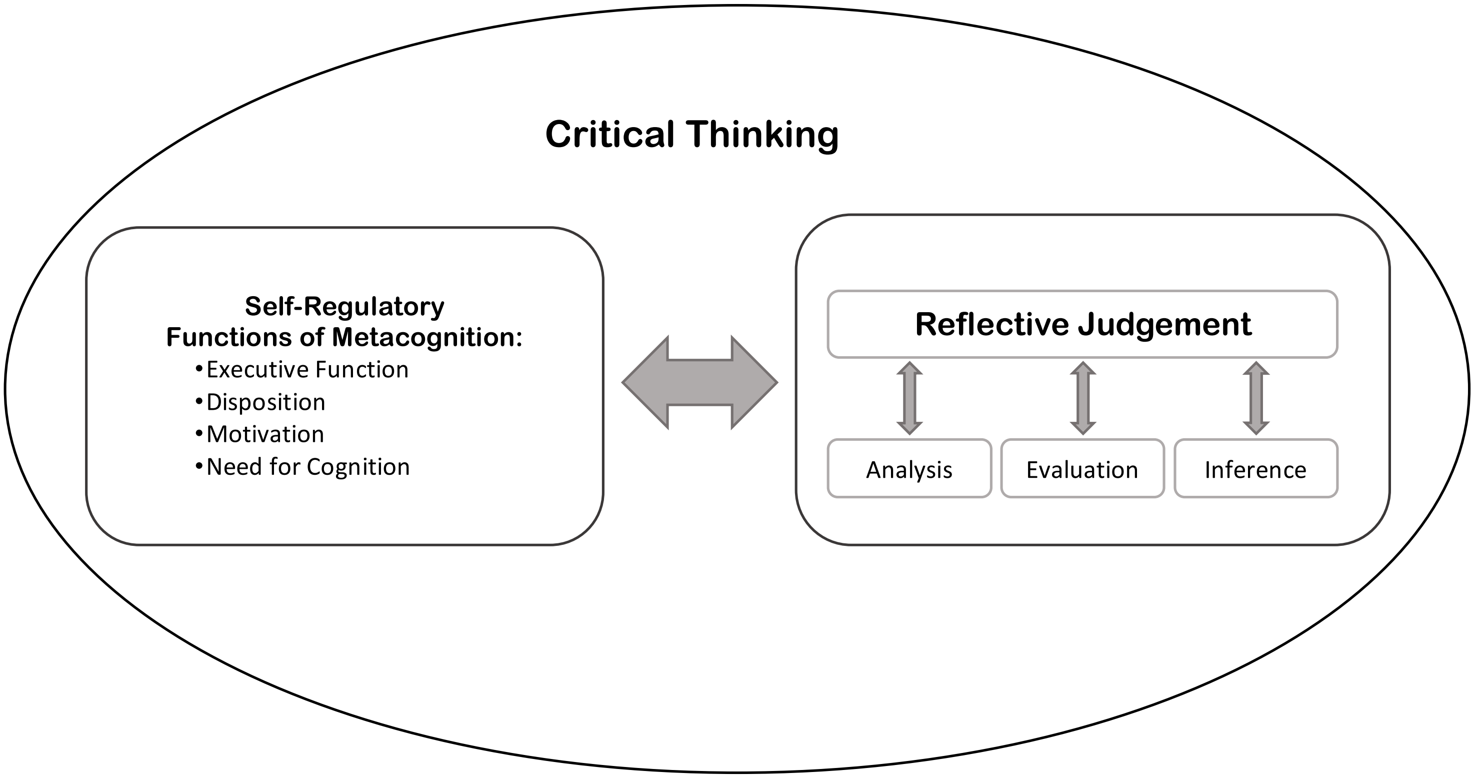

Figure 1.1. The components of critical thinking described by Dwyer, Hogan, and Stewart (2014).

perspective, teaching students how to engage in metacognition by equipping them with the knowledge and skills needed to reflect and regulate their learning will improve their academic performance and foster thoughtful decision-making skills that will extend to life beyond the classroom (Dewyer, Hogan, & Stewart, 2014).

Metacognition. Metacognition, commonly understood as "thinking about thinking", refers to the knowledge and control people have over their thinking process and is described as a crucial part of SRL (Flavell, 1979). To improve critical thinking, noted researchers (Fink, 2013; Halpern, 1998; Hattie, Gurung, & Landrum, 2015; Schraw, Crippen, & Hartley, 2006) have suggested focusing on developing students' metacognitive skills and abilities. Schraw, Crippen, and Hartley (2006) provide a useful framework for understanding the relationships between SRL, critical thinking, and metacognition (Figure 1.2). Significant research has shown that

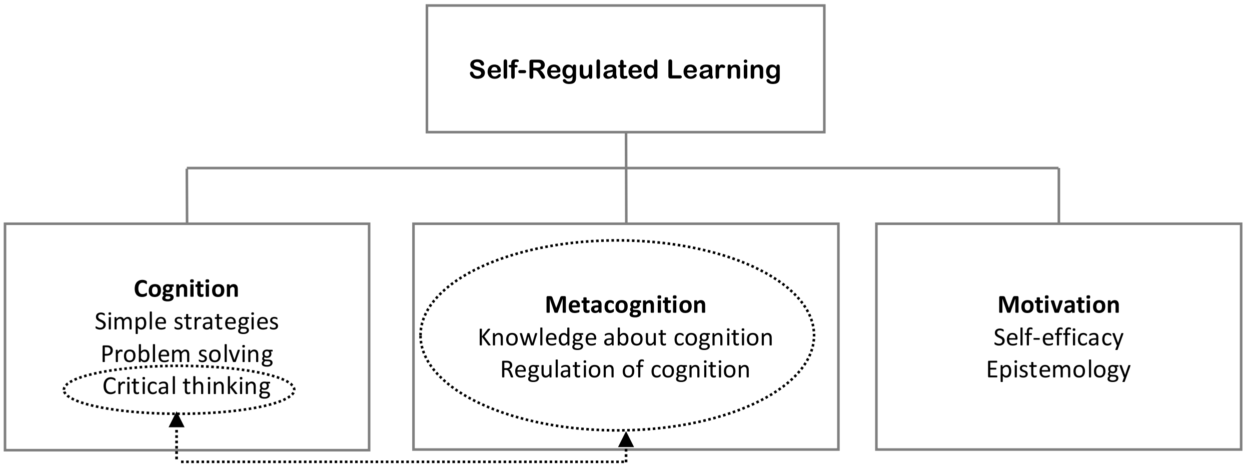

Figure 1.2. The three components of self-regulated learning defined by Schraw, Crippen, and Hartley (2006). The dashed circles represent the aspects of SRL that were of interest for my study.

students who apply metacognitive strategies in their learning tend to be better critical thinkers and, therefore, perform better academically (Bransford, Brown, & Cocking, 2000; Dewyer, Hogan, & Stewart, 2014; Halpern, 1998; Hartman, 2001; Hattie, 2009; Justice & Dornan, 2001; McCormick, 2003; Peverly, Brobst, Graham, & Shaw, 2003; Sternberg, 1998, 2003; Vrugt & Oort, 2008; Winston, Van Der Vleuten, & Scherpbier, 2010). So, in a nutshell, if metacognition can be utilized as a pedagogical tool to effect change in students' use of metacognitive strategies, this in turn might improve critical thinking and academic performance (Halpern, 1998; Hattie, Gurung, & Landrum, 2015; Schraw, Crippen, & Hartley, 2006).

Searching for existing scholarship about utilizing metacognition as a pedagogical tool, I encountered few experimental research studies. So, to contribute scholarship to this deficit in the literature, I decided to conduct a study about the effects of pedagogical practices of metacognition on students' self-reported use of metacognitive strategies in their learning.

Statement of the Purpose and Research Questions

The goal of this study is to explore if the use of metacognitive pedagogy has an effect on students' self-reported use of metacognitive strategies in their learning. If the metacognitive pedagogy is shown to have had an effect on students' self-reported use of metacognitive strategies, this would serve as an important step to further investigate its relationship to critical thinking. However, critical thinking is a much broader scope than what I address in this study. So, to accomplish this first step, focusing on the effects of metacognitive pedagogy, I conducted research that was guided by two questions. The first question addressed the extent to which metacognitive pedagogy can improve students' self-reported use of metacognitive strategies. The second question addressed the extent to which students' self-reported use of metacognitive strategies can be enhanced by greater exposure to metacognitive pedagogy.

Rationale and Significance of the Study

Though existing scholarship has helped to define what metacognition is and how it plays a significant role in critical thinking, fewer empirical studies have investigated what type of pedagogical practices are most effective in helping students to become metacognitive learners, and thus, better critical thinkers. This raises some questions: What does it mean to teach metacognition and how is it done successfully? What type of teaching strategies should be used to help promote students' understanding and application of metacognitive skills? Studies have shown that when metacognition is integrated into course content, learning is more effective (Hattie, 2009). How much integration is necessary to see an effect on students' self-reported use of metacognitive strategies in their learning? What does this pedagogy look like?

Fink (2013) made a case for integrative learning, and suggested that instructors scale down content to allow time for teaching about the effectiveness of metacognition, and then apply metacognitive strategies in the content learning process. In a study by Winston, Van Der Vleuten, and Scherpbier (2010) specific metacognitive strategies, such as goal setting, planning, and time management were explicitly taught to struggling medical students to help improve their academic performance. Students received metacognitive teaching for about 1–2 hours per week over a 14-week period, and their academic improvement was remarkable. Ninety-one percent of the 216 students in the program reached satisfactory academic achievement compared to only 58% of non-participating students. The researchers also found a positive correlation between the number of sessions attended and academic achievement. Literature findings such as these suggest that metacognition can lead to positive outcomes on academic performance when integrated into course content, thus providing the rationale for conducting a study about utilizing metacognition as a pedagogical approach.

There is a significant body of literature that suggests that students' use of metacognitive strategies enhances their academic achievement. According to Hattie (2009), specific metacognitive strategies such as goal-setting and planning, self-instruction, and self-evaluation have been identified as particularly predictive of academic success. However, much less literature exists on how these strategies are taught in a way that improves students' use of metacognition in their learning. This is the novel aspect of this dissertation study, conducting research that focuses on the pedagogical practices of teaching metacognition. A goal of the present study is to develop pedagogical practices that will affect students' understanding of metacognition and use of metacognitive strategies, which in turn have the potential to improve their critical thinking. With the underlying intent of this research, I am arguing that instructors could take greater responsibility for their students' learning process by teaching metacognition modelling and applying metacognitive strategies to better help students become more effective learners and higher academic performers.

Assumptions

Assumptions are those issues or items that are taken for granted relative to a study (Simon & Goes, 2013). This study was set up as a quasi-experimental design, and it rests on the assumption that the pedagogical practices were carried out in their intended format and that the students' responses to the questionnaire used to obtain data about their self-reported use of metacognitive strategies were answered honestly.

Limitations and Delimitations

Limitations are those factors that may affect the study and over which the researcher does not have control (Simon & Goes, 2013). These constrain generalizability of the research findings. Though the findings from this study may be generalizable to the larger population of post-secondary educators and students who were not included in this study, the findings are bound by the settings and contexts in which the study took place.

Delimitations are factors that may affect the study that are controlled by the researcher. For example, the intentional choices that were made prior to the study, such as choosing research design (Simon & Goes, 2013). The research design defines the scope of the study, which in turn restricts some of the inferences that can be made from the findings. A delimitation of the current study was the non-randomized sample of participants. To participate in this study, one had to be an enrolled student in the course in which the study took place. Limitations and delimitations are related to reliability and validity, and I further address these issues in Chapter 3.

Summary and Organization of the Study

This dissertation is organized into five chapters, a reference list, and appendices. Chapter 1 introduces the study and provides an overview of the research including a problem statement and the significance of the study. Chapter 2 presents a literature review that situates this study in a greater research context. In Chapter 3, I provide a detailed description of the research methods and rationale used in the study, and in Chapter 4, I present the research findings. In the last chapter, Chapter 5, I discuss the significance of the research findings and raise some questions for future research.

CHAPTER 2

REVIEW OF THE LITERATURE

Inquiry into how students learn best has inspired educational research for decades. The research on academic learning and performance emerged more than thirty years ago striving to answer questions about how to enable students to master their own learning process, in what is known as self-regulated learning (SRL).

SRL involves the cyclical learning process of planning for a task, monitoring the performance, and then reflecting on the outcome (Zimmerman, 1986). SRL has been and continues to be one of the most important areas of research within educational psychology. According to Pandero (2017), SRL can be thought of as an umbrella-term that describes “the cognitive, metacognitive, behavioral, motivational, and emotional/affective aspects of learning” (p. 1). The literature on SRL is vast and can broadly be divided into two categories, one that focuses primarily on the behavioral and motivational aspects (e.g., Boekaerts, 1988; Pintrich, 1989; Zimmerman, 1989), and another that focuses more on the cognitive aspects, including metacognition (e.g., Borokowski, 1992; Brown, 1978; Flavell, 1976; Winne, 1995).

Research about students’ metacognitive skills and abilities is deeply entangled in the existing body of SRL literature, and is rarely, if ever, presented as an isolated construct. Accordingly, in this chapter I locate metacognition within the broader SRL literature. I begin by first presenting a brief historical background of SRL including the origins of metacognition, followed by a section about the concept of metacognition, and another on research on metacognition.

Historical Background of Self-Regulated Learning

Numerous researchers have studied the self-regulatory processes that are part of learning. One of the most influential is renowned Canadian-American psychologist Albert Bandura. Inspired by research about behaviorism conducted in the early 1900s by famous American psychologists, John B. Watson (Watson, 1958), and then furthered by Burrhus Frederic Skinner (Skinner, 1974) in the 1930s and 1940s, Bandura in the early 1950s began to outline what would later develop into Social Learning Theory (SLT). During the 1960s, together with his first doctoral student, Richard Walters, Bandura began doing research with children about the role of modeling in observational learning (Bandura & Walters, 1963). His famous Bobo doll experiments with young children were important in providing empirical evidence for SLT that was introduced in 1977 (Bandura, 1977). The theory posits that human behavior is learned through observation and modeling of superiors. According to Bandura (1977),

> Learning would be exceedingly laborious, not to mention hazardous, if people had to rely solely on the effects of their own actions to inform them what to do. Fortunately, most human behavior is learned observationally through modeling: from observing others one forms an idea of how new behaviors are performed, and on later occasions this coded information serves as a guide for action. (p. 22)

SLT proposes that learning takes place within a social context, and that relies on a dynamic and reciprocal interaction between the person, environment, and behavior (Bandura, 1977). The purpose of SLT is to describe how people (person) regulate their behavior through control (behavior) and reinforcement (environment) to achieve goal-directed behavior that can be maintained over time. This triadic relationship is presented in Figure 2.1. SLT rests on five interrelated constructs that are presented in Table 2.1.

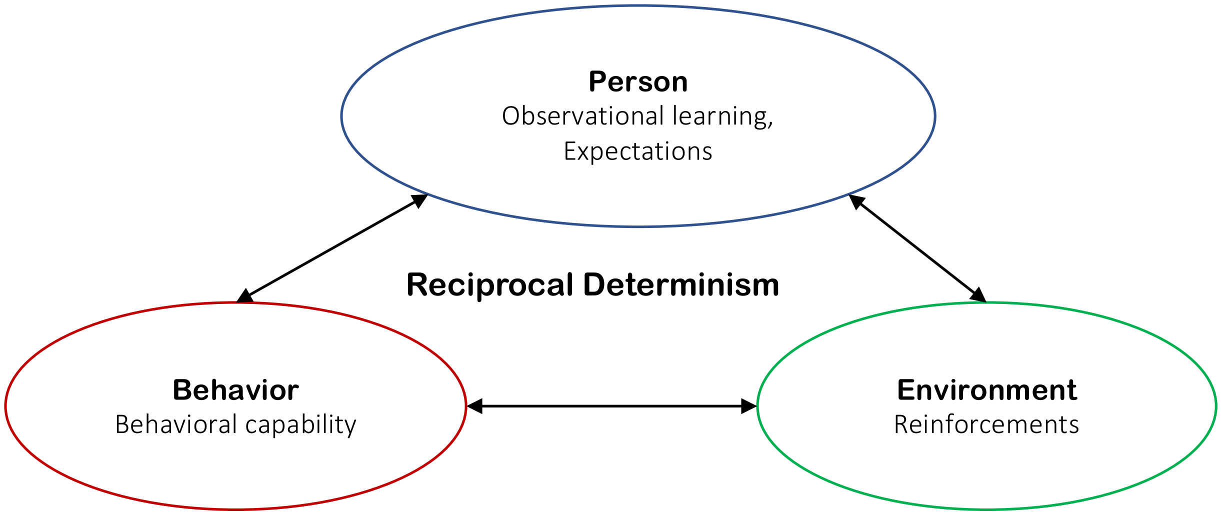

Figure 2.1. Reciprocal determinism described by the three components, person, environment, and behavior in Social Learning Theory (Bandura, 1977).

Table 2.1. The Five Constructs of Social Learning Theory, Bandura (1977).

Reciprocal determinism	The interactions between the individual (person), the environment (external social context), and the behavior (response or action to achieve goal).
Behavioral capacity	Describes the individual's ability to perform the desired behavior. Knowing what to do and how to do a specific behavior is essential for goal attainment. Behavioral consequences play a significant role in the learning process, which is related to the environment.
Observational learning	The process of the individual observing behavior then trying to reproduce the observed behavior. Reproducing observed behavior is referred to as modeling.
Reinforcements	Describes a system of rewards that refers to both internal and external responses to a behavior and can be both positive or negative. Positive reinforcement affects the likelihood of the behavior reoccurring, whereas negative reinforcement acts to minimize or prevent the behavior from reoccurring.
Expectations	The expected consequences following a behavior. This construct also includes the expectations that are anticipated prior to performing a behavior, thus previous experiences are important in forming new expectations.

Bandura continued his research about how children learn and fine-tuned his SLT by adding yet another construct called, self-efficacy. Self-efficacy describes an individual's belief about their ability to perform the behaviors needed to reach desired goals. According to Bandura, an individual's level of self-efficacy can play a significant role in how goals are approached, tasks are formed, and challenges are either undertaken or avoided. "People with high assurance in their capabilities approach difficult tasks as challenges to be mastered rather than as threats to be avoided" (Badura, 1995, p. 11). In later research, self-efficacy became a major component for understanding student motivation, self-confidence, and anxiety as they pertain to learning. With the added self-efficacy construct, Bandura (1986) renamed the now expanded theory to, Social Cognitive Theory (SCT). One of the most significant contributions of Bandura's SLT and SCT theories is that they helped bridge the behavioral and the cognitive aspects of learning; concluding that humans can monitor and control their behaviors through a process known as self-regulation (Bandura, 1991).

SRL research is often rooted in these seminal theories by Bandura, and particularly during the 1970s and 1980s, there was an influx of SRL research that focused largely on students' self-regulatory processes. American educational psychologist, Barry J. Zimmerman, heavily influenced by Bandura's theories, developed an often-cited model of self-regulation that is situated within academic learning (Zimmerman, 1986, 1989, 1995, 1998, 2002; Zimmerman & Bandura, 1994), which is represented in Figure 2.2. Zimmerman (2002) defined self-regulation as, "…the self-directed process by which learners transform their mental abilities into academic skills" (Zimmerman, p. 65). Like Bandura, Zimmerman also believed that self-regulation is a goal-driven process that includes cognitive aspects of learning, such as thoughts, feelings, and behaviors. He suggested that self-regulation is a cyclical process that involves three

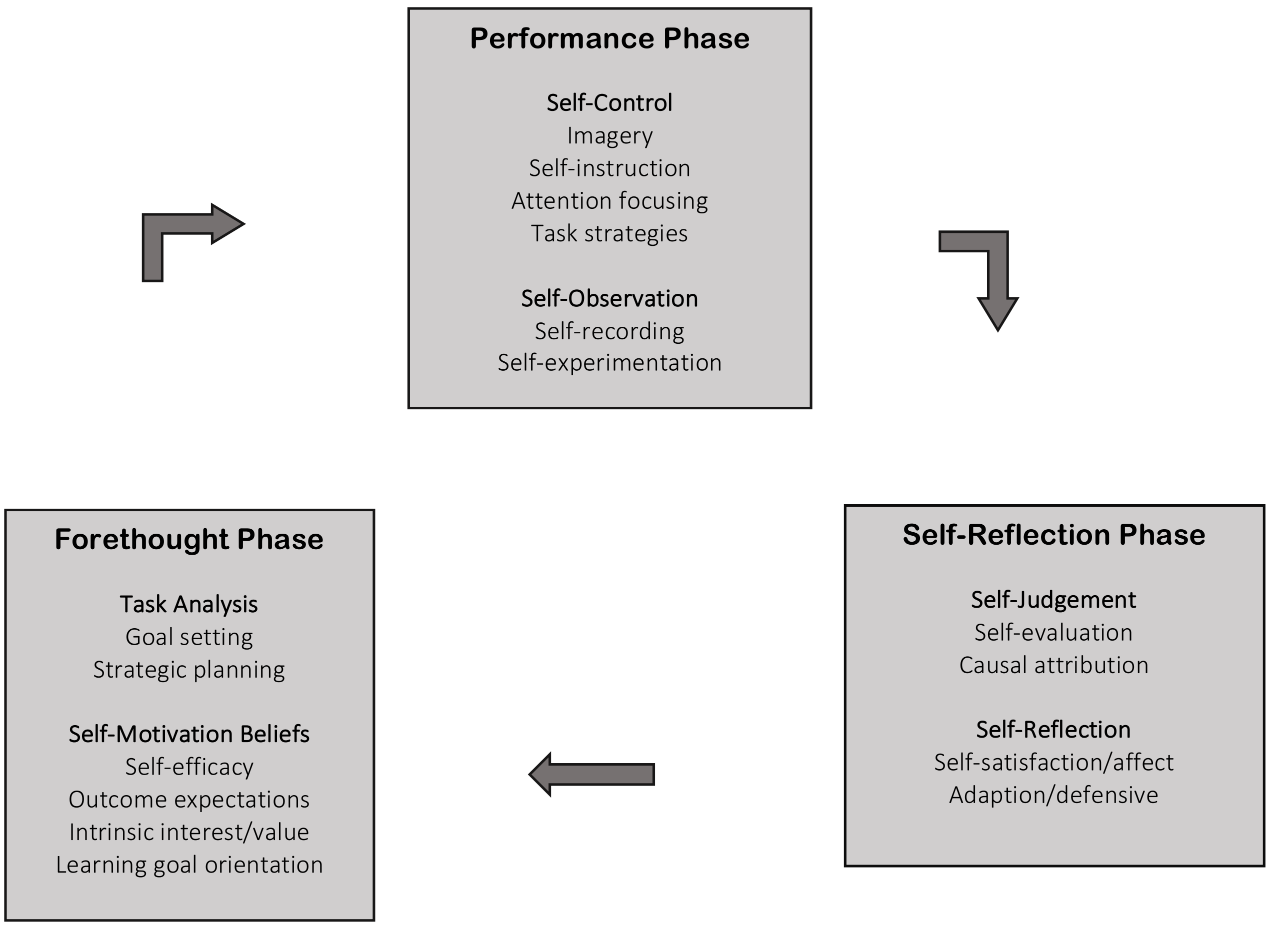

Figure 2.2. Zimmerman's (2002) tri-phasic model of self-regulated learning.

phases; forethought phase (before learning), performance phase (during learning), and self-reflection (after learning). Another similarity to Bandura's work is that Zimmerman also situated self-regulated learning within a framework of motivation. Zimmerman (2002) stated that, "what defines students as "self-regulated" is not their reliance on socially isolated methods of learning, but rather their personal initiative, perseverance, and adoptive skill" (p. 70). In both Bandura's and Zimmerman's models of SRL there is an emphasis on the awareness, monitoring, and control of learning, collectively known as metacognition.

Metacognition has always been a significant part of SRL and an important component of SRL research. Many researchers, including both Bandura and Zimmerman, acknowledge metacognitive skills and abilities to be crucial components of SRL (e.g., Boekaerts, 1988; Borokowski, 1992; Brown, 1978; Flavell, 1976; Pintrich, 1989; Winne, 1995). One researcher in particular, distinguished American developmental psychologist John H. Flavell, became very interested in the metacognitive aspects of learning (Flavell, 1971, 1976, 1979, 1985). Although Flavell supported the notion that SRL was composed of several important components, including motivation and self-efficacy, his research largely focused on the metacognitive aspects of SRL. Flavell (1976), described metacognition as a crucial part of SRL,

> In any kind of cognitive transaction with the human or non-human environment, a variety of information processing activities may go on. Metacognition refers, among other things, to the active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects or data on which they bear, usually in service of some concrete goal or objective. (p. 232)

In 1979, Flavell proposed a formal model of metacognition that included what he referred to as four classes of phenomena, (a) metacognitive knowledge, (b) metacognitive experiences, (c) tasks or goals, and (d) strategies or activities. This model is displayed in Figure 2.3. In the coming sections, I will provide a detailed description of Flavell's work on metacognition as this has significantly informed the theory underlying this study.

In university settings in which an individual educator seeks to have students practice skills that will improve their learning of the course content, Flavell's research about metacognition provides a manageable and focused framework, particularly when the topic of the course is not related to the psychology of learning. Therefore, this research is focuses on the

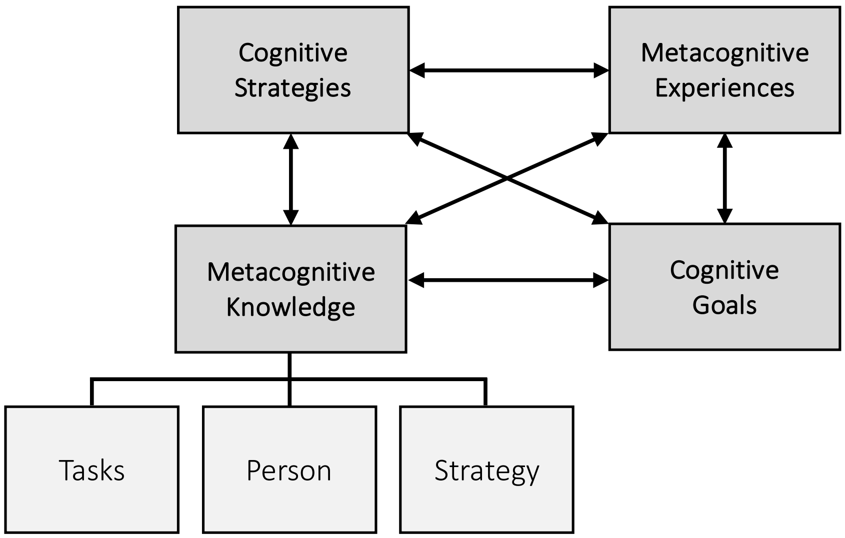

Figure 2.3. Flavell's (1979) model of metacognition, its four classes of phenomena and sub-phenomena.

metacognitive aspects of learning per se and is founded on the theoretical framework put forth by Flavell (1985) to utilize metacognition as a pedagogical approach to affect students' self-reported use of metacognitive strategies in their learning.

Alongside Bandura, Zimmerman, and Flavell, other noted education scholars including Dale Schunk, Ann Brown, Joel Levin, Michael Pressley, Scott Paris, Paul Pintrich, Gregory Schraw, and David Moshman, among others, also contributed important SRL research. Results from many of these early studies provided evidence that when prompted to engage in self-regulatory behaviors, students achieved higher academic performance (Brown, 1978). Encouraged by these positive findings, a wave of SRL research transpired in the 1980s though there was little consensus about the definition of self-regulated learning, stirring some debate about how to conceptualize the construct.

A noteworthy event in this debate occurred during the 1986 annual meeting of the American Educational Research Association, where a group of prominent researchers established guidelines intended to direct future SLR research. A key outcome of this monumental meeting was the inclusive definition of SRL as, “the degree to which students are metacognitively, motivationally, and behaviorally active participants in their own learning process” (Zimmerman, 2008, p. 167). Though the scholars agreed that the SRL construct included metacognitive, motivational, and behavioral components, they differed in their beliefs about to what extent each component contributed to SRL. Not surprisingly, the variations in how SRL research operationalizes the concept correspond with the theories driving the research. In a broad sense, SRL research has grown primarily out of two theoretical frameworks: one anchored in Bandura’s (1977, 1982) SLT and SCT; and the other in Flavell’s (1985) work on metacognition. Puustinen & Pulkkinen (2001) support this classification and suggest that SRL models can be divided into two categories, one that focuses on motivation and another that focuses on metacognition.

Origins of metacognition research. The study of cognition is central to the field of psychology, and questions about what people know about their own thinking have been studied for centuries. For instance, American psychologists John Cavanaugh and Marion Perlmutter (1982) pointed out that studies about self-awareness and problem-solving were conducted early on, in the beginning of the 1900s, both in the U.S. and abroad. Assessments of these cognitive abilities of self-awareness and problem-solving were also used during these early stages. For example, according to Cavanaugh (1982) research conducted by American psychologist, James Mark Baldwin in the early 1900s showed that academic performance of 6th and 12th Grade students was related to self-reports of study activities.

Another example is from the work of Estonian-Canadian experimental psychologist and cognitive neuroscientist, Endel Tulving—whose research on human memory has had tremendous influence in the field—who called for more experimental research into the development of models of memory (Tulving & Madigan, 1970). Tulving suggested that a better understanding about metacognitive processes might in turn further research about memory. Tulving and Madigan (1970) stated:

> We cannot help but to feel that if there is ever going to be a genuine breakthrough in the psychological study of memory…it will, among other things, relate the knowledge stored in the individual's memory to his knowledge of that knowledge. (p. 477)

Research in this area of memory—the knowledge about knowledge, can largely be attributed to Flavell. During the 1960s and 70s, Flavell conducted extensive research about children's cognitive abilities, and was particularly interested in memory development. According to Flavell (1975), memory development can be divided into four categories. The first category describes basic operations and processes of memory systems, such as, the process of object recognition. The second and third categories represent the "knowing" and the "knowing how to". To illustrate these types of categories, think about the process you go through when trying to find your lost keys. You know what your keys look like, and you try to remember when and where you might have left your keys by mentally reviewing each event since you last saw your keys. The fourth category of memory development, the "knowing about knowing", refers to an individual's knowledge and awareness of memory, and Flavell dedicated most of his research to better understanding the cognitive processes associated with this last category, something he referred to as metamemory.

Metamemory. In 1971, Flavell coined the term, *metamemory* and described metamemory as distinct from memory in that metamemory involved reflective processes of memory. For example, people utilize metamemory to assess how well they can remember certain things over others. Since metamemory involves cognition about human activity, Flavell recognized metamemory as a form of social cognition, hence the link to learning and education. Flavell worked on several memory models, attempting to explain how memory knowledge and behavior interact. One of his later versions captured both metamemorial experiences—referring to the introspective knowledge of memory, meaning knowledge about one's own mental states and memory process capabilities—and a behavior component in the form of cognitive actions—describing strategies, and the processes involving self-monitoring of memory, such as making decisions about how much study time should be allocated for the completion of various learning tasks. This distinction between knowledge and regulation of memory laid the foundation for what Flavell later would coin as metacognition.

Early work in metacognition. Flavell's work is widely recognized as the origin of metacognition. As a young scholar, Flavell was influenced by eminent Swiss psychologist Jean Piaget and his groundbreaking cognitive development theory (Piaget, 1936). Piaget was revolutionary in many ways. He was the first psychologist to conduct systematic studies about cognitive development in children, studies that significantly contributed to the understanding of the child. Prior to Piaget's work, a common assumption was that children were miniature adults, though less competent thinkers. This was an assumption that Piaget rejected. Cognitive development theory explains how children understand and form mental models of the world, and the theory includes several ideas relating to metacognition. For example, the notion of intentionality that presupposes that thinking is deliberate, goal-directed, and involves planning a sequence of actions; all important characteristics of metacognition. Flavell found much inspiration in Piaget's work, and one of his more noted accomplishments is the publication of the book, *The Developmental Psychology of Jean Piaget* that provides a detailed and comprehensive guide to Piaget's work of cognitive functioning and development (Flavell, 1963).

In 1976, Flavell wrote his often-cited article, *Metacognitive Aspects of Problem Solving*, this was the first time that he used metacognition as a part of a title. In the article, Flavell (1976) defined metacognition as follows:

> Metacognition refers to one's knowledge concerning one's own cognitive processes or anything related to them, e.g., the learning-relevant properties of information or data. For example, I am engaging in metacognition if I notice that I am having more trouble learning A than B; if it strikes me that I should double check C before accepting it as fact. (p. 232)

This early definition of metacognition focused largely on the cognition about knowledge, and in later works, Flavell (1979) improved on this definition to also describe the regulatory aspects of cognition that involves monitoring and control of learning in the form of strategies. Flavell (1979) argued that metacognition is learned and that it improves with age. In his observations with children, he noted that various tasks were completed in different ways depending on the child's age and related level of ability. As the children got older they demonstrated more awareness of their thinking processes and were also better able to judge their level of task readiness.

In 1979, Flavell prosed a model of cognitive monitoring (Figure 2.3.) that included (a) metacognitive knowledge, (b) metacognitive experiences, (c) tasks or goals, and (d) strategies or activities. He described metacognitive knowledge as stored cognitive world knowledge that he further divided into *person* (beliefs about intraindividual, interindividual, and universals of cognition), *task* (referring to the objects of a cognitive experiences), and *strategy* (describing the cognitions or behaviors used to complete the task). To assist us in understanding this model, we can reflect on our own learning process: Perhaps your belief is that you learn better with visuals than with text (intraindividual), and that to succeed on your next exam (task) you will create concept maps (strategies) to better help visualize what you are learning.

Metacognitive experiences, unlike metacognitive knowledge, represent the feelings, judgments, and estimates one embodies in the process of task completion. Metacognitive experiences can happen during an experience as it occurs, or after the experience during reflection. Flavell (1979) hypothesized that metacognitive experiences were more likely to happen in situations that require high cognitive attention, for example, while working on a job or school task, or any other activity that requires careful planning, monitoring, and evaluation. To illustrate a metacognitive experience, imagine that you are listening to your instructor teaching, and suddenly you realize that you do not understand a certain concept. This realization makes you write a note in the margin of your textbook to go back and review after class. Flavell also recognized that metacognitive experience and metacognitive knowledge overlap at times. For example, while studying later you go back to that note about the concept you were struggling with, you utilize metacognitive knowledge to assess your lack of understanding, set a goal, and decide on what strategies to use to improve comprehension. For more recent research on metacognitive experiences, see Eflkides and Petkaki (2005).

Flavell believed that metacognitive knowledge increases and improves with metacognitive experience. He understood metacognitive experiences as crucial to metacognitive knowledge and suggested that our metacognitive experiences can influence the direction of our thinking by influencing our goals with the decisions we make about revising, abandoning, or creating new goals. The more metacognitive experiences we have, the more opportunity we create for improving and furthering existing metacognitive knowledge. Flavell's perception—of making knowledge that was gained through a new experience fit with previous knowledge—reflects the

Piagetian concept of assimilation, which describes the cognitive process that manages how we take in new information and incorporate that new information into our existing knowledge (Piaget, 1976). Since metacognitive experiences influence metacognitive knowledge, Flavell envisioned his theory to be utilized as an opportunity for a more engaged form of learning, a form of learning that utilized metacognitive skills and abilities to improve comprehension and achieve academic success. He also suggested that learning about metacognition could potentially improve other aspects of student learning such as moral reasoning and ethical decision making. Flavell (1979) stated:

> In many real-life situations, the monitoring problem is not to determine how well you understand what a message means but to determine how much you ought to believe it or do what is says to do. I am thinking of the persuasive appeals the young receive from all quarters to smoke, drink, take drugs, commit aggressive or criminal acts, have causal sex without contraceptives, have or not have casual babies that often result, quit school, and become unthinking followers of this year's flaky cults, sects, and movements. (Feel free to revise this list in accordance with you own values and prejudices). Perhaps it is stretching the meanings of metacognition and cognitive monitoring too far to include the critical appraisal of message source, quality of appeal, and probable consequences needed to come with these inputs sensibly, but I do not think so. It is at least conceivable that the ideas currently brewing in this area could someday be parlayed into a method of teaching children (and adults) to make wise and thoughtful life decisions as well as comprehend and learn better in formal educational settings. (p. 910)

Flavell's suggestion here, to connect the use of metacognition to critical thinking that extends beyond the classroom—to help assess real-life situations that involve important decision-making about drug-use and sexuality pertaining to youth, deeply resonated with me in my work within sexuality education. I became very excited about the possibility to utilize metacognition as a teaching approach, to engage students to become critical learners, thus empowered about sexuality. If metacognitive pedagogy could enhance students' use of metacognitive strategies, this would produce a favorable setting for practicing and improving students' critical thinking in sexuality education.

Throughout the 1980s and into the 1990s, Flavell and other noted scholars (Brown, 1982; Jacob & Paris, 1987; Pressley, Borokowski & Schneider, 1989; Schraw & Moshman, 1995), all significantly contributed to the theorizing of metacognition. Though the construct of metacognition has been difficult to define precisely [once famously noted by Wellman (1985) as a 'fuzzy concept'], most early theorists agree that there are two components to metacognition, knowledge of cognition and regulation of cognition (Brown, Bransford, Ferrara & Champione, 1983; Flavell, 1976; Jacobs & Paris, 1978; Schraw & Moshman, 1995).

The Concept of Metacognition

Metacognition, simply translated as big (from the Greek μετά, meaning beyond or after) thinking (referring to the mental processes of acquiring or understanding knowledge), has often been described as thinking about your thinking. Metacognition involves both awareness and control of one's cognitive processes. The National Research Council (2001) described metacognition as "the process of reflecting on and directing one's own thinking" (p. 78). Nelson and Narens (1994), described this process of reflecting and directing one's own thinking as something that happens on a meta-level of awareness. This meta-level of awareness is related to cognition about knowledge via control and monitoring functions that are represented by regulation of cognition (Efkildes, 2006; Nelson, 1996; Nelson & Narens, 1994). Knowledge of cognition is informed by the regulatory aspects of cognition, the control and monitoring functions.

Our knowledge about cognition involves conscious thought processes—what we know about our memory—and regulation of cognition refers to how we control this process (Brown, 1987; Jacobs & Paris, 1987). Being able to apply metacognitive skills requires knowledge of various strategies and awareness about when to best apply them (Ambrose, 2010; Schraw, Crippen, & Hartley, 2006). The regulation of cognition involves monitoring and a continuous evaluation of what is known and what still needs to be learned (Brown, 1987; Flavell, 1976; Jacobs & Paris, 1987).

As previously stated, metacognition is an essential component of SRL (Figure 1.1) and is rarely if ever, presented as an independent phenomenon (Dinsmore, Alexander, & Loughlin, 2008; Flavell, 1976; Ormrod, 2011; Zimmerman, 2002; Zull, 2011). Students who have become self-regulated learners take ownership of their learning, they practice metacognitive skills and are often referred to as expert students (Bransford, Brown, & Cocking, 2000; Seraphin, Philippoff, Kaupp, & Vallin, 2012; Sternberg, 1998). Ambrose (2010), provides an often-cited summary of self-regulated students' use of metacognitive skills and abilities: "To become self-directed learners, students must learn to assess the demands of the task, evaluate their own knowledge and skills, plan their approach, monitor their progress, and adjust their strategies as needed" (p. 188).

Research on Metacognition

Since the mid 1970s there has been a strong focus on research on metacognition (Bruning, Schraw, & Norby, 2011). Significant research has shown that students who use metacognitive strategies in their learning tend to perform better academically (Bransford, Brown, & Cocking, 2000). Recent research (e.g., Fink, 2013; RincónGallardo, 2009; Winston, Van Der Vleuten, & Scherpbier, 2010; Young & Fry, 2008) has identified a positive correlation between the use of metacognitive strategies and student learning in both secondary and postsecondary education. Classroom research shows that students who apply metacognitive strategies are more likely to excel in problem-based learning (Hmelo-Silver, 2004; Rozencwajg, 2003), self-regulation (Butler & Winne, 1995; Narciss, Proske, & Koerndle, 2007; Pintrich, 2004; Schunk & Zimmerman, 2003), self-efficacy and motivation (Dinsmore et al., 2008; Ormrod, 2011; Wolters & Pintrich, 1998; Zull, 2011), expert learning (Bransford, Brown, & Cocking, 2000; Sternberg, 1998, 2003), and in academic achievement (Hartman, 2001; Justice & Dornan, 2001; McCormick, 2003; Peverly, Brobst, Graham, & Shaw, 2003; Vrugt & Oort, 2008; Winston, Van Der Vleuten, & Scherpbier, 2010).

Research on metacognitive learning strategies. A related body of research on students' use of metacognitive skills and abilities focused on investigating what types of learning strategies students apply in their learning (Cao & Nietfeld, 2007; Hattie, 2009; RincónGallardo, 2009; Winston, Van Der Vleuten, & Scherpbier, 2010).

Students' awareness of different approaches to learning and application of various learning strategies has been found to be closely linked to various measures of academic achievement (Hartman, 2001; Justice & Dornan, 2001; McCormick, 2003; Peverly, Brobst, Graham, & Shaw, 2003; Vrugt & Oort, 2008; Winston,Van Der Vleuten, & Scherpbier, 2010), and perceived and actual ability (Williams & Clark, 2004). For instance, Schraw and Dennison (1994) found that higher achieving students applied more learning strategies compared to lower achieving students, suggesting that higher achieving students are more aware of their learning processes and what strategies they need to apply to their learning in order to better succeed.

Metacognitive learning strategies have been defined as any thoughts or behaviors that promote encoding (Schellenberg, Negishi, & Eggen, 2011). Within this definition, encoding refers to a process in the brain where perceived items of interest are converted into a construct that can later be recalled from short-term or long-term memory. Contemporary research about students' metacognitive learning strategies suggests that these strategies are complex and that metacognition does not involve a single technique (Zimmerman, 2002). Applying metacognitive strategies involves several aspects of the learning process and may include planning an approach, evaluating the progress, and monitoring levels of comprehension (Hattie, 2009).

There has been a distinction in the literature between strategies that promote deep learning such as note-taking, reviewing and summarizing lecture notes, outlining and verbal explanations (Cao & Nietfeld, 2007; Hattie, 2009; Justice & Dornan, 2001) versus shallow rehearsal strategies such as rereading and underlining or highlighting words and sections that are never further analyzed. Shallow learning, also known as surface learning, privileges content knowledge, such as years, facts, and ideas; whereas deeper learning favors knowing the events behind the years, the connections between facts and ideas, and the ability to extend these to other contexts (Hattie, Gurung, & Landrum, 2015). Knowing the value of deep learning, many instructors and programs put forth course objectives that include wording, such as, "students should be able to understand, explain, make connections, and extend [course content] beyond the classroom" (Hattie, Gurung, & Landrum, 2015, p. 80). Yet too often this type of deep learning is not reflected in classroom practice or assessments (Halpern, 1998; Hattie, Gurung, & Landrum, 2015). And students quickly figure out that what is valued in assessment is the content, the years, the facts, and the ideas (Hattie, Gurung, & Landrum, 2015). As result, the most commonly used study strategies by students are rereading and underlining or highlighting, which do not promote lasting learning

(Cao & Nietfeld, 2007; Carrier, 2003).

Research on students' metacognitive learning strategies suggests that although students know about various strategies and believe that certain content requires different types of learning strategies for successful outcomes, most students, regardless of the content they are studying, still all too often rely on ineffective strategies such as rereading and underlining (Cao & Nietfeld, 2007; Carrier, 2003; Graham & Perin, 2007; Peverly, Brobst, Graham, & Shaw, 2003). Cao and Nietfeld (2007) found that when students reported struggling with various aspects of the course content, such as understanding difficult concepts, distinguishing concepts, comparing and contrasting relationships between concepts, and being able to fully comprehend concepts in a limited time, the most commonly applied study strategy was rereading the textbook and studying lecture notes with the intent to memorize the information. Similar findings were presented by Carrier (2003), who surveyed students in an upper-division psychology course about their study techniques while preparing for the course's two exams. Even though rehearsal strategies are known to be ineffective, in both instances, the students reported rereading the textbook (65% reported this strategy in preparing for Exam 1, and 64% reported this strategy for Exam 2) and reviewing lecture notes (42% reported this strategy in preparing for Exam 1, and 40% reported this strategy for Exam 2) as some of the most frequently used strategies (Carrier, 2003).

Despite findings from earlier research about the importance of integrating metacognition into course content (Alexander, Graham, & Harris, 1998; Fink, 2013; Hattie, Biggs, & Purdie, 1996; Wilen & Phillips, 1995), neither study, Cao and Nietfeld (2007) nor Carrier (2003) incorporated explicit metacognitive instruction that included modeling the use of and application of metacognitive strategies to the learning process. In the study by Cao and Nietfeld (2007), students were explicitly (though only briefly) exposed to a variety of study strategies in the beginning of the semester, and then simply asked to report on how they used the strategies throughout the course of the semester. And in the research conducted by Carrier (2003), students were simply asked to report on their study technique without any explicit instruction of different learning strategies. To promote deep learning, it is essential that learning about the benefits of metacognition and of metacognitive strategies be integrated into the course content and not be treated as an additive or separate piece (Fink, 2013).

These studies (Cao & Nietfeld, 2007; Carrier, 2003; Graham & Perin, 2007; Peverly, Brobst, Graham, & Shaw, 2003) suggest that university students lack metacognitive learning strategies. Thus, the need for research about using metacognition as a pedagogical approach to improve students' use of metacognitive strategies is timely and needed.

Research on Teaching Metacognition

With an increased focus on the development of skills and attitudes students will need for life-long or sustainable learning, there is a growing necessity for higher education to leave behind traditional methods focused of rote content-learning, and on a larger scale, instead utilize pedagogy that promotes transferable metacognitive thinking in conjunction with content-learning (Brooks, & Ebrary, 1999; Fink, 2013; McDaniel, Lister, Hanna, & Roy, 2007; Rovai, 2004; Tractenberg, 2013).

There is a sizeable body of literature that suggests that student use of metacognitive strategies enhances their academic achievement (Alexander, Graham, & Harris, 1998; Fink, 2013; Hattie, Biggs, & Purdie, 1996; Kolencik, & Hillwig, 2011; Seraphin, Philippoff, Kaupp, & Vallin, 2012; Tractenberg & FitzGerald, 2012; Tractenberg, Umans, & McCarter, 2010). Promoting metacognitive thinking is challenging. In the past, education was largely focused on increasing students' content-knowledge, encouraging rote learning (Hattie, Gurung, & Landrum, 2015). Although content-learning requires thinking, the teaching methods used for teaching content matter are not optimal for engaging students metacognitive thinking (Halpern, 1998; Hattie, Gurung, & Landrum, 2015). The higher-order skills and abilities that have been defined as essential characteristics of the 21st century learner are not fostered when instruction in most courses focuses on learning content knowledge (Halpern, 1998; Hattie, 2009, 2011). Metacognitive thinking does not develop in a vacuum; therefore, instruction should actively engaging students in the learning process. Effectiveness of teaching metacognition also increases when it is incorporated into the course content, meaning that metacognition should be explicitly addressed by the instructor, perhaps through modeling, then utilized by the students (Fink, 2013; Halpern, 1998; Hattie, 2009, 2011, 2015; Wilen, & Phillips, 1995). Metacognitive instruction should be clear and organized with a purpose and goal in mind. Pascarella and Blaich (2013) found that when students were exposed to clear and organized instruction it enhanced not only their general cognitive skills such as critical thinking, but also their orientation toward inquiry and continuing intellectual development. Significant research suggests that students tend to improve in both metacognitive thinking and in their knowledge of subject matter when these two are integrated (Brooks, & Ebrary, 1999; Fink, 2013; Halpern, 1998; Hattie, 2011, 2015; Wilen & Phillips, 1995).

Several studies have shown that active students who utilize metacognition—who set goals for their learning, monitor achievement, and adjust learning strategies as needed—performed better academically compared to students who instead could be described as passive learners. Even though existing scholarship has helped to define metacognition and confirmed that students who use metacognitive strategies tend to perform better academically, few empirical studies have investigated how metacognition could be utilized as a pedagogical approach to engage student learning to promote the use of metacognitive strategies in the learning process.

Integrating metacognition. Integrating metacognition into course content is widely supported as one of the most effective methods when teaching, learning, and utilizing metacognition, and certain metacognitive strategies have been found to be especially effective (Fink, 2013). Wilen and Philips (1995) were early proponents for integrating metacognition into existing course curricula. They proposed a metacognitive approach to teaching that focused on two components, awareness and action. Awareness included purpose, what one knows, what one needs to know and what facilitates learning and action. This included planning, checking, evaluating, revising, and remediating. They suggested that teachers should lead the learning by deciding what skills should be learned, then explain the benefits of the skill and model the skill to the students. The students then observe and model the skill based on their observation. Though this pedagogical approach recognizes the value of integrating metacognition with existing curricula to make the learning process explicit, it relies on a traditional authoritative structure that stresses observation rather than inspiring student initiative, inquiry and curiosity—which are valued characteristics of today's teachings. Theoretically, this interactive pedagogical approach has its roots in Bandura's (1977) well-known theory of social learning, which stresses that one of the most powerful means of teaching is to model values, attitudes, and patterns of thought and behavior. Drawing on theory from cognitive psychology, other models of human learning can also be applied to help redesign education that fosters metacognitive thinking. One way to model metacognitive thinking in instruction is to actively engage students and make the thought-process explicit throughout the learning process.

In 2009, John Hattie published his famous meta-analysis, *Visible Learning* which synthesized more than 800 meta-studies covering more than 80 million students (Hattie, 2009).

In his analysis, guided by the question, how do we maximize achievement in our schools, Hattie examined 138 different types of influences predicating various learning outcomes, and he ranked these based on their effect size (Cohen's *d*) from low to high. He found that the average effect size of all 138 influences was Cohen's $d = 0.4$, and he then used this as a cut-off point for identifying an influence as having a positive effect (Cohen's $d \geq 0.4$) or a negligible effect (Cohen's $d \leq 0.4$) on learning outcomes. Hattie originally studied six areas important to learning: the student, the home, the teacher, the curricula, and teaching and learning approaches (Hattie, 2009), and his most recent work (Hattie, Gurung, & Landrum, 2015) includes the classroom. This latest research is now based on 1,200 meta-studies and includes an updated list of 196 ranked effect sizes of various influences on learning. From his extensive research, Hattie argues that a key to making a difference in learning is to make learning visible. To make learning visible students should be actively involved in every step of the learning process: setting a goal, planning, implementing the plan, adjusting as needed, and evaluating the progress.

According to Hattie (2009), when instructors teach about metacognition as a separate course component, for example as a way to offer "study tips", it tends to only affect students' surface knowledge. In contrast, when instructors integrate metacognition into the course content and require the use of metacognitive strategies in the learning process, this tends to affect a deeper level of student understanding (Hattie, 2009). Lavery (as cited in Hattie, 2009) found that the metacognitive strategies that seemed to produce the highest effects on students' knowledge were goal-setting and planning, self-instruction, and self-evaluation. From a pedagogical perspective, when these metacognitive strategies are integrated with content, they have been shown to affect the learning cycle at various crucial phases, including (a) planning an approach, (b) monitoring the learning during the performance and focusing attention to useful strategies, and (c) self-reflecting and evaluating the performance in reaching the goal (Hattie, 2009). Hence, pedagogy integrated with metacognition—explicitly teaching about metacognition, modeling metacognitive strategies, and teaching content by involving metacognitive strategies—seems to offer the best possibilities for the development of students' metacognitive skills and abilities.

Metacognition in constructivist teaching. Constructivist ideas about teaching seem to be conducive to the development of students' metacognitive skills and abilities as they share a common view of a student-centered learning environment. Constructivist teaching assumes that all knowledge is constructed from previous knowledge, irrespective of how one is taught (Bransford, Brown, & Cocking, 2000) and through its reflective characteristics, metacognition could be an important element in how new knowledge is integrated with existing knowledge. Meeting the students where they are, meaning that teaching is based on students' prior knowledge, is one of the most successful approaches to improving student learning (Hattie, Gurung, & Landrum, 2015). Teaching in a way that creates opportunities for students to build on existing knowledge has its roots in Piagetian pedagogy and his concept of assimilation—how we incorporate new information or experiences into our existing knowledge (Piaget, 1976). Constructivist pedagogy promotes a deeper form of learning, in which learners are expected to utilize metacognitive skills, such as reflect, find, process, refine, and present information without the constraints imposed by shallow learning, such as repetition and retention (Fink, 2013). Deep learning requires higher order thinking due to its complexity, and involves cognitions such as analyzing, evaluating, creating, and judging (Halper, 1998). In contrast, lower order thinking refers to remembering, understanding, and applying, sometimes described as rote learning (Anderson, Krathwohl, & Bloom, 2001). A central goal for constructivists pedagogy is to foster critical thinking that promotes metacognitive thinking skills that help direct one's own thinking, such as performing analysis and synthesis, and making a judgment. Another essential characteristic for critical pedagogy is to promote higher order thinking that is context-sensitive yet transferable, meaning that the ability to think critically should transfer to a multitude of contexts (Halpern, 1998). Autonomy and initiative prompt students to search for the connections between different ideas and concepts. Students who frame questions about a concept are more likely to be motivated to answer the questions and thereby take responsibility for their learning. In turn, responsible learners inherently seek new knowledge regarding the problems they discover (Brooks, & Ebrary, 1999). Constructivist teachers allow students to engage in purposeful, relevant learning that encourages students to understand the interconnectedness and interrelationships between the different units of a curriculum (Brooks, & Ebrary, 1999; Fink, 2013; Rovai, 2004), and teaching is viewed as a holistic process rather than as covering important but isolated topics.

In a study by Winston, Van Der Vleuten, and Scherpbier (2010), findings from a cognitive skills program dedicated to explicitly teaching struggling medical students about effective learning techniques at a U.S. medical university in the Caribbean, were shown to increase students' academic performance with the help of metacognitive instruction. The program was designed in response to high rates of students (particularly first-year students) being on academic probation as a result of failing course work. These students were required to participate in cognitive skill sessions to improve their academic achievement. Students were required to attend at least one session (typically lasting from one to two hours) per week for 14 weeks. During these cognitive skill sessions, students learned about various metacognitive learning strategies and were then expected to apply the strategies and reflect on their progression. One strategy taught was time management, in which students were asked to plan out their week in detail and then report back how they facilitated that time management. Another example, study tips, addressed the notion that short, repeated, distributed study sessions are more beneficial for learning and memory compared to fewer and longer crunch-like study periods. A third strategy, illusion of knowing, focused on language and the importance of being able to accurately describe a situation using correct medical terminology—something students often claimed to master, but, when put to the test, struggled with their explanation (Winston, Van Der Vleuten, & Scherpbier, 2010). The outcome of these cognitive skill sessions was remarkable. Out of the 216 students participating in the program, 91% reached satisfactory academic achievement for completion of the first missed semester, compared to only 58% of the non-participating students. The researchers also found a positive correlation between the number of sessions attended and academic achievement, where 93% of the students who attended more than 15 sessions successfully completed the first missed semester, compared to 60% of the students who attended between 10–15 sessions, and 42% of the students who attended less than 10 sessions. These findings support previous claims about the benefits of teaching about metacognition by showing that (a) metacognitive skills in the context of college students can be explicitly taught, (b) it is important to teach and to model metacognitive learning strategies for student learning, and (c) longitudinal exposure to metacognitive learning strategies are likely to result in higher achieving students in terms of their academic proficiency.

Significant research has shown that self-regulated students tend to use a wide variety of metacognitive strategies, thus performing better academically (Alexander, Graham, & Harris, 1998; Fink, 2013; Hattie, 2009, 2015; Hattie, Biggs, & Purdie, 1996; Kolencik, & Hillwig, 2011; Seraphin, Philippoff, Kaupp, & Vallin, 2012; Tractenberg & FitzGerald, 2012; Tractenberg, Umans, & McCarter, 2010). Given that there is a need for research about the effects of metacognition, we need more research about teaching metacognition in higher education, and since "…nearly every intervention can show some evidence of success, we need to ask not 'What works?' but 'What works best' and seek comparisons between different ways of influencing student learning" (Hattie, 2015, p. 79). This study, using metacognition as a pedagogical approach to improve students' self-reported use of metacognitive strategies, is contributing research to fill this void. To investigate these variables, metacognitive pedagogy and students' self-reported use of metacognitive strategies, and to frame the current study, I ask the following two research questions:

1. To what extent does metacognitive pedagogy improve students' self-reported use of metacognitive strategies?
2. To what extent is students' self-reported use of metacognitive strategies enhanced by greater exposure to metacognitive pedagogy?

Specifically, for Question 1, I will look at the whether there is a statistically significant effect of metacognitive pedagogy on students' self-reported use of regulation of cognition. I will also examine whether there is a statistically significant effect of metacognitive pedagogy on students' self-reported knowledge about cognition. For each of these, my intent is to also estimate the effect size. Given the theory I have described in this chapter, I hypothesize that the metacognitive pedagogy will have a positive and statistically significant effect on both regulation and knowledge. For Question 2, I investigate if more exposure leads to higher gains. Consistent with the findings in Winston, Van Der Vleuten, and Scherpbier (2010), I hypothesize that more exposure will result in a statistically significant gain in both students' regulation and knowledge of metacognition.

CHAPTER 3

METHODS

This chapter begins by a presentation of the research design and how aspects of threats to validity were addressed. Then I provide a description of the participants and present some of their demographic data. Next, I provide an overview of the development of the metacognitive pedagogy, and this section includes a detailed description of the metacognitive strategies that were taught. In the section that follows, I present information about how to assess metacognition, this includes my reasoning for choosing the Metacognitive Awareness Inventory (MAI) by Schraw and Dennison (1994) as the instrument for data collection. I then describe the pilot test that involved the implementation of the metacognitive pedagogy and the administration of the MAI. I subsequently describe the treatment and the main data collection, including a section about how the data were prepared for analysis. And lastly, I describe the latent growth curve models that I used to analyze the scores from the MAI data.

To examine the effects of metacognitive pedagogy on students' self-reported use of metacognitive strategies, I used a two-group quasi-experimental design. The participants in each group were students enrolled in a 3-unit, 16-week undergraduate sexuality studies course at a large American public university. I served as the instructor. The treatment in the study, metacognitive pedagogy and learning, was a part of regular course instruction during both semesters. The amount of treatment differed between the two groups: students enrolled in Group A received the treatment for ten weeks, whereas students enrolled in Group B received the treatment for five weeks. The students were not recruited to participate in the study, nor were they informed about the study as it was being conducted, thus mitigating some threats to internal validity. Lastly, the data collected in the study had no bearing on the students' grades.

Design

In the process of setting up the research design for this study, I searched for a setup that would answer my research questions and mitigate threats to the validity of my study. To answer Research Question 1: To what extent does metacognitive pedagogy improve students' self-reported use of metacognitive strategies? I used a one-group pretest-posttest design with a double pretest (Shadish, Cook & Campbell, 2002). This setup: $O_1 \quad O_2 \quad X \quad O_3$, where *X* represents the treatment (metacognitive pedagogy), O_1 and O_2 represent the two pretests, and O_3 represents the posttest after intervention, provides a design setup to address Research Question 1. This design allowed me to detect whether there was a maturation effect (referring to any changes in scores that would naturally occur and would be unrelated to effects of the treatment) or any effects of testing (exposure to the test can produce a change in scores on subsequent tests that would be unrelated to the effects of the treatment), both are possible threats to internal validity (Shadish, Cook & Campbell, 2002). Specifically, the two pretests without any intervention are to identify whether any maturation or testing effect was likely occurring. Though I would not be able to disentangle maturation and testing from each other, this would allow me to detect and potentially account for any change in pre-intervention scores when examining the pre-treatment to post-treatment change. In the event that there was pre-treatment growth, I would be able to estimate the pre-to-post treatment effects after having accounted for this maturation or testing effect. If this growth did occur and was not accounted for, the treatment effect would be overestimated because it would include the maturation or testing effect. For example, if the outcome at the three time points, Time O_1 to Time O_3, showed a linear trend, where the change from Time O_2 to Time O_3 is the same in magnitude and direction as the change from Time O_1 to O_2, I would be unable to claim that any post-intervention change was due to the treatment because it could have been due to the expected trend in maturation and testing effects. Thus, this design would allow me to address Research Question 1 and mitigate threats to maturation and/or testing effect. However, there are more threats to validity, such as effects due to history, that this simple design does not account for.

In the context of validity, history (Shadish, Cook & Campbell, 2002) refers to any event that occurs simultaneously with the treatment that could produce a change in the observed outcome that is not due to the treatment, but rather is an effect of history. A one-group design does not permit detection of any effects of history because the history event can co-occur with the treatment. To mitigate this threat to validity, a two-group design could yield some information about any possible effects of history. So, to improve on the one-group design, I decided to use a two-group design with a double pretest (Shadish, Cook & Campbell, 2002):

Group A O_1 O_2 X O_3

Group B O_1 O_2 X O_3

Using two groups rather than one, I could address Research Question 1 while reducing the threat of history to internal validity. This is achievable by separating the two groups in time, so that Group A receives the treatment first, then the study would repeat with a different group once Group A finished. This two-group design is an improvement by reducing more threats to validity in comparison to the one-group design, but it did not allow me to address Research Question 2: To what extent is students' self-reported use of metacognitive strategies enhanced by a greater amount of exposure to metacognitive pedagogy?

To address the second research question, I needed to add an additional observation to both groups, and I needed to increase the amount of metacognitive pedagogy to one of the groups to be able to detect any change in students' scores from O_2 to O_3 and from O_3 to O_4. This design, a two-group quasi-experimental design with four observations and a double pretest that differed in the amount of treatment between groups provided an appropriate design to answer both research questions. Thus, this became the final research design for the study (Figure 3.1).

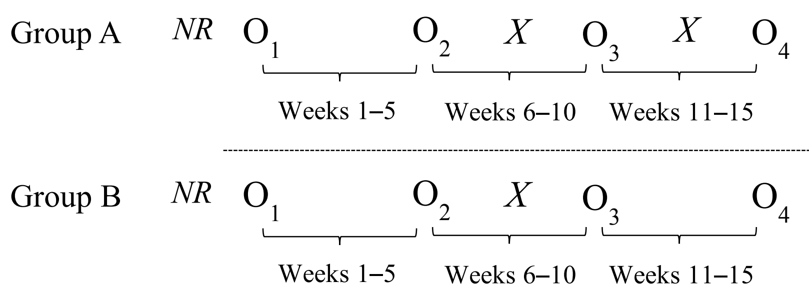

Figure 3.1. An overview of the final quasi-experimental two-group research design. Data were collected from each group over a 15-week semester. *NR* notes the non-random sample. The four observations noted as $O_{1,}$ $O_{2,}$ O_3, and O_4, represent each time point of the data collection with the MAI, and *X* represents the treatment, metacognitive pedagogy.

Participants

The participants in this study were students completing an upper undergraduate-level course in sexuality studies at a large American public university. Though the students were not randomized, they were also not recruited to the study, and therefore students' decisions to enroll in the course were very likely unrelated to the outcomes in the study; thus, selection bias into the treatment (receiving metacognitive pedagogy) was not likely a validity threat. Once enrolled in the course, students were never briefed about the study because the treatment, metacognitive pedagogy, had been integrated into the course content and was part of regular course expectations. The students' responses to the MAI had also been integrated into the course and had no bearing on their grades. This design worked to mitigate social desirability (referring to the tendency of research participants behaving or responding in a manner that is assumed to be viewed favorably by others), another threat to internal validity (King & Bruner, 2000). To position this study in the broader body of research on metacognition, I decided to collect data on three demographic variables: age, gender, and academic level. Knowing the demographic make-up of the sample may be useful to other researchers who want to connect the results of this study to their own research populations. Similarly, future research, such as meta-analyses, may benefit from this demographic information for summarizing purposes across multiple studies.

The total data collection for the main study spanned two 16-week semesters, and in total, 398 students enrolled in the course. In the fall semester of 2015, Group A enrolled 181 students, and in the spring semester of 2016, Group B enrolled 217 students. During the first data collection time point, students were asked to answer the three demographic variables. Most of the students self-identified as female; 64% (256) and about 25% (100) self-identified as male. Eight students responded that they identified outside of the gender binary, and three students identified as agenderd (without gender). Students were relatively young; 61% (243) were in the age range of 18–21, though most of them, about 45% (179) were seniors in terms of academic level. In Table 3.1, I summarize the participants' demographic data within each group and within the entire sample.

Development of Metacognitive Pedagogy

I introduced metacognition to the students in the beginning of the sixth week during both semesters, and I began the introduction by talking about common study habits. I mentioned that recent research (e.g., Cao & Nietfeld, 2007; Hattie, 2009) has shown that some of the most frequently used study techniques by college students were underlining/highlighting information and reading/re-reading, despite these shallow learning strategies being very ineffective for deep leaning. I used John Flavell's words when defining metacognition as "thinking about your thinking", being able to reflect on the learning process and identify what is known, what is not known, and what can be done to know the unknown. I used the definition of metacognition as

Table 3.1

Number of Participants in Each Band of Age, Gender Identification, Academic Level and Major

	Within each group[a]		Within entire sample[b]
Age group	Group A (n = 181)	Group B (n = 217)	(N = 398)
Ages 18-21	110 (61%)	133 (61%)	243 (61%)
Ages 22-25	55 (30%)	48 (22%)	103 (26%)
Ages 26-29	4 (2%)	8 (4%)	12 (3%)
Ages 30+	3 (2%)	4 (2%)	7 (2%)
Prefer not to answer	1 (<1%)	0 (0%)	1 (<1%)
Did not provide an answer	8 (4%)	24 (11%)	32 (8%)
Gender identification			
Female	114 (63%)	142 (65%)	256 (64%)
Male	55 (30%)	45 (21%)	100 (25%)
Outside of the gender binary	4 (2%)	4 (2%)	8 (2%)
Agender	0 (0%)	3 (1%)	3 (1%)
Prefer not to answer	1 (<1%)	0 (0%)	1 (<1%)
Did not provide an answer	7 (4%)	23 (11%)	30 (8%)
Academic Level			
Freshman	9 (5%)	15 (7%)	24 (6%)
Sophomore	34 (19%)	46 (21%)	80 (20%)
Junior	54 (30%)	55 (25%)	109 (27%)
Senior	82 (45%)	97 (45%)	179 (45%)
Graduate	2 (1%)	4 (2%)	6 (2%)

Note. [a]Percentages are out of the number within each group; Group, A n = 181 and Group B, n = 207. [b]Percentages are out of the total number of participants, N = 398.

described in the MAI (Schraw & Dennison, 1994), talked about the two components of metacognition—knowledge about cognition and regulation of cognition—and gave examples of behaviors that related to each of their subcomponents. We watched a 5-minute YouTube clip (Walker, 2012) that described metacognition and its benefits to the learning process, and I ended the introduction by letting the students know that we would learn about different metacognitive strategies and apply these to our learning both in class and in various take-home assignments to improve on our understanding of the course content. The total introduction took 20 minutes.

Theory about metacognition (Flavell, 1976) suggests that there is a strong correlation between the two components, knowledge about cognition and regulation of cognition, and most often knowledge is addressed before regulation. It stands to reason that one needs to first be able to reflect on the learning process and as second step learn how to regulate the process. At the same time, regulation of cognition can inform knowledge of cognition (Flavell, 1979). Because the two components are interconnected it was challenging to separate them for teaching purposes. I spent several weeks developing teaching materials that would address each component in an effective and comprehensible way. I struggled with how to teach about knowledge of metacognition since this component is quite abstract. These cognitive processes are being executed as a task is being completed, so I found that it was impossible to develop any class activity or assignment—given the context of my classroom—that would record these cognitive processes in action. Regulation of cognition, however, is more feasible for teaching because regulation involves specific actions or strategies that help regulate the learning process. Therefore, I decided to start teaching about regulation of cognition, and once the students had been given some opportunities to learn specific learning strategies they were then instructed to think about during what conditions these strategies could be applied, which introduced them to the knowledge about cognition component.

During the process of developing the teaching materials, I wanted to make sure that these were reflected in the MAI, the instrument for data collection. In my teaching, I was able to address seven out of the eight subcomponents of the MAI. I purposefully omitted teaching about debugging strategies because of this component's abstractness. According to Schraw and

Dennison (1994), debugging strategies are used when realizing that the current strategy is not useful for learning, therefore another strategy is applied as a debugging technique. Though this is an important part of learning—knowing how to assess learning and be able to apply different learning strategies when current strategies are not working—debugging strategies are challenging to teach since these strategies are more descriptive of cognitive rather than behavioral processes. I also found debugging strategies to be very similar to what Schraw and Dennison (1994) refer to as procedural knowledge. For example, while reading a passage in a textbook, you realize that you are not fully comprehending what is read, you stop reading and begin to look up definitions of certain words to gain more context to improve comprehension. The procedural knowledge refers to your realization that you are not comprehending and therefore decide to change your learning strategy by looking up challenging words, and the behavior of stopping to read and look up definitions of words is a type of debugging strategy. So, instead of teaching debugging strategies as a distinct component, I instead focused on teaching a variety of learning strategies—on the MAI referred to as information management strategies—and asked students to draw on their metacognitive knowledge to judge how well a strategy worked to improve their learning. If an applied strategy did not work well, I encouraged them to draw on their procedural knowledge to find a better fitting strategy. Though I did not explicitly teach about debugging strategies, I taught about the importance of procedural knowledge to assess the usefulness of strategies they used in their learning, and how to apply a different strategy if needed. In total, I developed teaching materials for seven out of the eight subcomponents of the MAI, only omitting debugging strategies.

Metacognition is complex, and to get an overview of the coherence between the different components and to ensure overall meaning and purpose of the learning, I identified logical connections between the regulation and knowledge components of metacognition. In Figure 3.2 I present an overview of metacognition and the metacognitive pedagogy I developed. I show the connections I identified between knowledge and regulation, and I also list the specific strategy I taught to address each subcomponent.

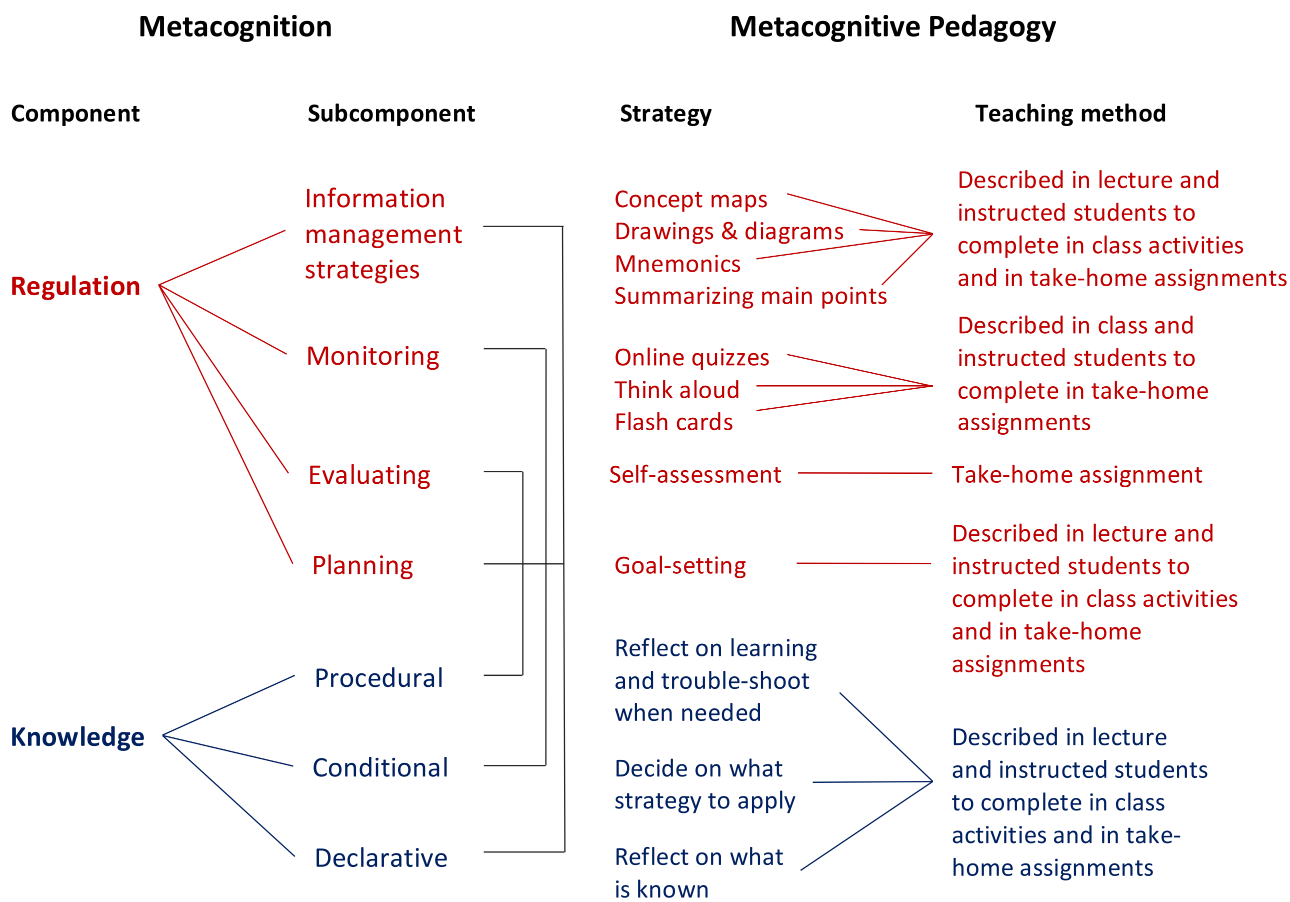

Figure 3.2. An overview of the components and subcomponents of metacognition and how the specific strategies were addressed in the metacognitive pedagogy.

Regulation of cognition. The regulation component of metacognition targets specific behaviors such as knowing how to use various learning strategies and how to apply these various strategies in the learning process. Regulation of cognition is also involved with planning your studies, knowing how to monitor your learning progress, and how to evaluate your work. During

Weeks 6–10 both Group A and Group B were taught specific learning strategies that targeted each of these four subcomponents. Students in Group A continued to utilize these metacognitive strategies for the remainder of the semester, during Weeks 11–15.

Information management strategies. Most of the metacognitive pedagogy was spent on this subcomponent of regulation; teaching about different types of learning strategies. From a teaching perspective, it was relatively easy to develop teaching materials that addressed regulatory behaviors of learning. I found that it was rewarding to have the opportunity to teach about different strategies students could use in the process of learning the content, an area I think is often overlooked in teaching as it is assumed that the responsibility to figure out how to study effectively is on the students. Thus, we spent significant time in class learning about different study strategies and how to apply these to become better at managing information. I taught four different information management strategies: concept mapping, drawings and diagrams, mnemonics, and summarizing main points.

Concept mapping was applied to complex content to help visualize components and to make explicit connections between the various components. When teaching about how to make a concept map, I asked the students to first consider what type of content would work well with this type of strategy. Once a topic had been chosen, I asked them to draw on their declarative knowledge to list important subtopics of the chosen topic. After a list of subtopics had been completed, the next challenge was to connect the subtopics so that they formed explicit connections to each other using linkage words. This is a crucial part of concept mapping, creating these connections so that each subtopic helps to explain a part of the overarching topic. Once a concept map had been completed, students were instructed to explain their map to demonstrate their comprehension.

Drawings and diagrams are useful techniques to help memorize things that are otherwise often learned via rote memorization. I offered some examples of content that was useful for a drawing or a diagram, and then I demonstrated some examples using the whiteboard in class. Students were instructed to create their own drawings and diagrams, first working in groups in class and then later in take-home assignments. Once a drawing or a diagram had been completed, students were asked to explain their work.

I taught about the usefulness of creating mnemonics to help remember certain facts, and we worked with three types of mnemonics: acronym, acrostic, and catchy phrase. In class I talked about the usefulness of mnemonics in helping to improve memorization and retention, and I gave some examples of each of the three types. Students were then instructed to come up with their own examples working in groups in class.

Summarizing main points helped the students identify key concepts from lengthier texts. Many students are used to skimming and highlighting textual information, but if this highlighted information is not further summarized, then the learning remains shallow. In class I talked about the importance of being able to summarize key concepts from a text, and how important it is to summarize text using our own words. When teaching about this, students worked in groups and were instructed to create written scenarios to help define specific concepts we were working on during that lecture. In creating their scenarios, students first had to comprehend the concepts that we were learning, then analyzing text from their course reader and identifying key terms. These terms then became the central components in their written scenarios. At the end of this class activity, student-groups were asked to share their scenarios with the rest of the class in a closing discussion.

Monitoring. Being able to monitor your learning progress is another critical component of the learning process. How do you know that your study strategy is working? And how do you know when you have studied enough? In class students worked in groups and were instructed to share some of their experiences with using some of the various study strategies we had learned in class, for example, concept mapping or summarizing main points. They were also asked to talk about what they did to check on their learning progress. Groups reported out some of the monitoring strategies they had shared amongst themselves, and I listed them on the white board to initiate a class discussion. Useful examples of monitoring the learning progress were noted as, completing the weekly online quizzes to check on comprehension, explaining certain content to a friend or family member and answering questions, making flash cards of key concepts, and creating drawings and diagrams of various content from memory.

Planning. When learning about how to plan their studying, students completed a worksheet in groups to plan their studying for the upcoming midterm exam (Group A also did this activity in planning for their final exam). They completed a worksheet that asked them to plan their time, monitor their learning progress, and evaluate their learning. To plan their studies, students were asked to look at their calendars, note the date and time of the exam, then mark what days and how much time they would dedicate to their studying leading up to the exam. To break up their studying into smaller segments, students were asked to list specific content areas they were struggling with, and to decide what study strategies they would apply to further their learning in these challenging areas. Next, they were asked to note what they would do to monitor their learning progress, and to set a deadline for when the studying for each content area should be completed. Lastly, they were instructed to set some goals for their studying by stating what score they aimed to earn on their exam and what overall final letter grade they aimed to earn in the course. Creating this timeline gave the students an opportunity to break up their studying into several segments thereby reducing the likelihood of cramming just prior to the exam. This activity also gave the students an opportunity to situate their studying for an individual exam into a larger context of reflecting on their overall learning progression towards their final course grade. A copy of this class activity is provided in Appendix A: Exam Prep.

Evaluating. Students were required to write two self-assessments during the course of the semester. The first self-assessment was completed after the midterm and a second self-assessment was turned in during the last week of class, just prior to their final exam. Some of the prompts for the first self-assessment asked the students to reflect on their preparation and satisfaction about their studying for the midterm exam. They were asked to write about how they planned their studying, what strategies that had used, how they had monitored their learning progress, and what goals they had set for their performance on the midterm. They were asked, if they had earned their desired midterm score, and if they would do anything to change their study strategies in preparing for the upcoming final exam.

Knowledge about cognition. The knowledge component of metacognition was the most challenging to teach due to its abstractness. It was difficult to create teachable strategies that addressed knowledge of metacognition since this component is so much about students' awareness of their abilities and less about specific behaviors that could be taught. To address knowledge about cognition in my teachings I decided to explicitly talk to the students about the importance of assessing metacognitive knowledge before, during and after they applied a specific learning strategy. In doing so, they would utilize all three subcomponents of knowledge of cognition: declarative, conditional, and procedural knowledge.

When teaching about the three subcomponents, I tied these into the various activities we did when learning about regulation of cognition, and I had an explicit discussion with the students about how we tend to draw on our knowledge of cognition as we are studying and how we are often unaware of this. When teaching students how to decide what learning strategy to apply to a given content area, I talked about how it is useful to first begin reflecting on what is already known about the given content area, rather than just using familiar study strategies that may be ineffective, such as simply highlighting. Then based on what is known—this is reflected in our declarative knowledge—I talked about how we can then make a decision about what type of learning strategy to apply, for example, concept mapping or summarizing main points, and that in making this decision we utilize our conditional knowledge, assessing what strategy would work best under the given conditions. I also talked about how we sometimes tend to modify our learning or even change the learning strategy while studying, and when we do that we draw on our procedural knowledge, as we realize that our learning procedures must be modified or changed. I continued to explicitly remind the students about the importance of reflecting on their metacognitive knowledge while they were studying for class as this is key to improve their learning. Each time we learned about a new learning strategy in class, before we applied the strategy to the content, we always began by reflecting on metacognitive knowledge, and I would explicitly remind the students about being mindful about their learning as they went to work on their assignments. In take-home assignments, students were required to reflect on their metacognitive knowledge and write about their experiences working with the different metacognitive strategies.

Metacognition project. As a part of the course requirements, students were expected to complete the metacognition project, which was a take-home assignment. This project was introduced shortly before the midterm in both groups. However, students in Group A continued to work on their metacognition projects until the last week of class, whereas students in Group B were required to submit their projects shortly after the completion of their midterm. The reason for this was because students in Group A continued to receive metacognitive teaching until the end of their semester, whereas students in Group B did not receive any more metacognitive teaching once their metacognitive projects had been turned in at the end of Week 10.

Students were allowed to collaborate, though all students needed to complete and submit individual projects. The purpose of the metacognition project was for the individual student to demonstrate their knowledge of and ability to apply metacognition—drawing on both knowledge and regulation of metacognition—this project served as a culminating assignment about metacognition.

Part I. The first part of the metacognition project asked the students to plan their studies leading up their final exam (for students in Group A) and their midterm exam (for students in Group B). They were asked to complete and submit the same worksheet we had worked on in class to explicitly demonstrate their abilities to create a plan for their studies. This first part of the project addressed the seven subcomponents of metacognition that I had taught in class.

The first prompt on the worksheet asked the students to reflect on what content they knew and to identify any gaps that needed more attention; this process utilized declarative knowledge. Once they had figured out what content areas needed more attention, they drew on their knowledge of various information management strategies and on their procedural knowledge to determine what strategy to apply when studying these specific content areas. They were also required to identify how they would check their level of comprehension when they utilized their monitoring strategies. During the process of completing the worksheet the students engaged in evaluating their work and if they made any changes they did so utilizing their conditional knowledge. Lastly, the students were, by default, engaged in planning while completing the worksheet. The metacognitive project assignment is provided in Appendix B: Metacognitive Project.

Part II. The second part of the project asked the students to submit artifacts from having applied two different learning strategies, a concept map and mnemonics to any of the content learned in class, and then write a reflection about their experiences of having completed the metacognition project. Previously in class I had taught the students about each of these strategies; concept mapping and three types of mnemonics, their benefits for promoting deeper learning, and what type of content that would work best for each of the strategies.

When creating the concept map, students were required to choose a main piece of content that they wanted to visualize, and then to present a minimum of 10 topics that helped to explain this content. As each topic was connected, linkage words were required to help explain the relationships between the connections and how they, all together, helped explain the chosen piece of content. Students were required to submit three different types of mnemonics, and they were free to draw on any content in the course when creating an acronym, an acrostic, and a catchy word or phrase. The last part of the metacognition project asked the students to reflect on their experiences of having completed this assignment. They were asked to write a reflection in which they answered some questions about their use and knowledge of metacognition and the different strategies that they had used in their project. They were also asked to write about whether they believed that the metacognitive strategies we had learned were useful to their learning, and if they were likely to use them again in future courses.

Assessing Metacognition

Educating students to become critical thinkers with metacognitive skills and abilities is one of the primary initiatives of 21st century learning (Partnership for 21st Century Skills, 2009). Characteristics of the 21st century learner include being able to critically assess, synthesize, and utilize knowledge across disciplines. “However, without metacognitive assessment that can provide with diagnostic information and directions for its instruction, educational initiatives seem to take students’ metacognitive development or adequacy unreliably for granted” (Ozturk, 2017, p. 134).

How to best assess metacognition has long been a question of interest. These questions stem from an earlier debate about how to assess SRL and the appropriateness of measuring SRL as a single- versus a multiple-construct. Noted scholars in the field have focused their research on different components of SRL. For example, Zimmerman (1989), Boekaerts (1988, 1996) and Pintrich (1989, 2000) emphasized the importance of student motivation as the essential drive for SRL, whereas, Brown (1978), Borkowski (1992), and Winne (1995) rather focused their efforts on the task-driven components of SRL, such as the cognitive process-oriented aspects of metacognition. Researchers, including Winne (1995) and Pressley (2002), found the metacognitive aspects of SRL to be essential for students to develop self-regulatory skills and abilities and called for more research about assessment in this area.

Measuring metacognition. Instruments to measure various metacognition models have been developed in the form of interviews, observations, think-aloud protocols, and self-report questionnaires, and a distinction has been made between on-line and off-line measurements (Saraç & Karakelle, 2017; Veenman, Van Hout-Wolters, & Afflerbach, 2006). On-line measurements are intended to measure metacognition as it is happening in real time. Systematic observations, think aloud protocols, or computer simulations are common instruments used for this type of on-line measurements (Peteranetz, 2018; Saraç & Karakelle, 2017). In contrast, off-line measurements aim at assessing general knowledge of metacognition or metacognition as related to a specific task, and these types of measurements are utilized retrospective to task performance. The most common forms of off-line measurements are self-report questionnaires, interviews, and teacher ratings (Ozturk, 2017; Saraç & Karakelle, 2017).

Measurement of metacognition is challenging because the construct is not only unobservable, it is not theorized to directly explain performance on indicators. This is different from measurement of knowledge and skills such as mathematics or language arts proficiency, which can result in measureable performance on an assessment. Given the complexity of metacognition, from a measurement perspective, it is wise to plan how to feasibly operationalize the concept. The first thing we must consider is whether to measure it as a single construct or as multiple dimensions of an overarching construct (Adams, Wilson & Wang, 1997; Briggs & Wilson, 2003; Harrison & Vallin, 2018). The second consideration is the scope, as metacognition has been measured at different levels of granularity (Berger & Karabenick, 2016; Pintrich, 2004; Veenman, Van Hout-Wolters, & Afflerbach, 2006). Depending on what aspect of metacognition—knowledge about cognition or knowledge about regulation—different types of measurements might be more suitable for use. For measuring fine-grained differences in metacognition, online measures are more appropriate than self-report instruments such as questionnaires. For example, systematic observations are good measures for obtaining online information about the regulatory aspects of cognition, but are less suited for measuring knowledge about cognition. And similarly, to measure knowledge about cognition, interviews might be a more appropriate measure in comparison to observations.

In the context of research about using metacognition as a pedagogical approach to effect students' use of metacognitive strategies, I was interested in finding a measurement that would allow me to quickly gather large quantities of data on multiple occasions to track any change. I had first considered several different methods including think-aloud protocols, interviews, and focus groups. However, these methods would require too many resources to investigate the levels of changes that you expect might occur in a large lecture-style classroom research setting. Because of the research setting, an off-line measure would suffice, and I therefore decided to use a self-report questionnaire.

Self-report questionnaires to measure metacognition. The use of self-report questionnaires is common in metacognitive research, and is the primary off-line instrument used to measure both metacognitive knowledge and regulation (Akturk & Sahin, 2011; Peteranetz, 2018). I reviewed three of the most frequently used surveys, The Learning and Study Strategies Inventory (LASSI) developed by Weinstein, Schulte and Palmer in 1987, the Motivated Strategies for Learning Questionnaire (MSLQ) developed by Pintrich, Smith, Garcia, and McKeachie in 1993, and the Metacognitive Awareness Inventory (MAI) developed by Schraw and Dennison in 1994.

The Learning and Study Strategies Inventory (LASSI). In 1987, Claire E. Weinstein, David R. Palmer, and Ann C. Schulte developed the Learning and Study Strategies Inventory (LASSI), a self-report questionnaire to assess learning strategies. The LASSI is founded on both a general model of learning and cognition (Simon, 1979) and on a strategic model of learning (Weinstein, 1994). The general model of cognition stems from cognitive psychology and presents students as active, self-determined individuals who process information and construct knowledge. The strategic model of learning also views students' as active agents in the learning process and identifies three interactive components that explain successful learning: skill, will, and self-regulation (Cano, 2006).

The LASSI is designed as a diagnostic and prescriptive instrument to measure high-school and post-secondary students' use of various learning strategies. Weinstein defined learning strategies as, "any thoughts, behaviors, beliefs, or emotions that facilitate the acquisition, understanding or alter transfer of new knowledge and skills" (Weinstein, Husman, & Dierking, 2000, p. 727). The LASSI is not context-dependent, but rather assumes a general approach to learning. The most recent third edition of the instrument consists of 60 items that are classified into 10 subcategories that belong to the three main categories: skill, will, and self-regulation (Weinstein, Palmer, & Acee, 2016). Each of the 60 items are rated on a 5-point Likert-type scale, where *a* = Not at all typical of me, *b* = Not very typical of me, *c* = Somewhat typical of me, *d* = Fairly typical of me, and *e* = Very much typical of me.

The skill category consists of three subcategories: information processing, selecting main ideas, and test strategies. These scales examine students' learning strategies, skills and thought processes related to identifying, acquiring, and constructing meaning for important new information, ideas and procedures, and how they prepare for and demonstrate their new knowledge on tests or other evaluative procedures.

The will category measures the degree to which students worry about their academic performance, their receptivity to learning new information, their attitudes and interest in college, their diligence, self-discipline, and willingness to exert the effort necessary to successfully complete academic requirements. The three subscales of the will category are called: anxiety, attitude, and motivation.

The last category, self-regulation consists of four subcategories: concentration, self-testing, time management, and using academic resources. These scales measure how students manage, self-regulate, or control the entire learning process. These processes include: using time effectively, focusing attention and maintaining concentration, checking to determine if learning demands for a class, assignment, or a test have been met, and a willingness to seek help from instructors, fellow students, tutors, academic coaches, learning centers and tutoring programs.

The LASSI was originally developed to be completed with paper and pen, but today is also offered as a web-based instrument. The LASSI has been used to assess metacognition though the instrument is not intended for this purpose (McMahon & Luca, 2001). Some of the items in two of the subcategories, the skill and the self-regulation categories, overlap with the measure of metacognition. Since the LASSI lacks a clear focus to measure metacognition I decided against using this instrument in this study.

Motivated Strategies for Learning Questionnaire (MSLQ). In 1993, Paul Pintrich, David Smith, Teresa Garcia, and Wilbert McKeachie developed the Motivated Strategies for Learning Questionnaire (MSLQ). The MSLQ was developed from a social–cognitive theoretical perspective (McKeachie, Pintrich, Lin, & Smith, 1986), and is designed to assess college students' motivational orientations and their use of different learning strategies for a college course (Pintrich, Smith, Garcia, & McKeachie, 1991). That is, the course is seen as the unit of measure, which is distinct from the LASSI, which attempts to assess students' learning strategies and attitudes toward learning in general (Artino, 2005). Though the MSLQ is designed to be course-specific, some researchers have modified the MSLQ to be course-general (Kitsantas, Winsler, & Huie, 2008).

The 1991 version of the MSLQ has a total of 81 items, and each of the 81 items is rated on a 7-point semantic-differential scale, where *1* = Not at all true of me and *7* = Very true of me. The items are divided into two sections, motivation and learning strategy. These two sections include 15 subscales, six within motivation section and nine within the learning strategies section. The motivation section consists of 31 items that assess students' goals and value beliefs for a course, their beliefs about their skill to succeed in a course, and their anxiety about tests in a course. The learning strategy section includes 31 items about students' use of different cognitive and metacognitive strategies, and 19 items about students' management of different resources. The MSLQ is developed as separate scales that can be used together or individually (Pintrich, Smith, Garcia, & McKeachie, 1991).

The MSLQ has been utilized extensively for empirical research, and especially in the areas of motivation and self-regulated learning (Artino, 2005). Though there are items on the MSLQ that measure control and regulation of metacognition (metacognitive self-regulation scale), there are no items that assess metacognitive knowledge. Since I was interested in obtaining information about students' metacognitive knowledge, I decided against using this instrument in this study.

Metacognitive Awareness Inventory (MAI). In 1994, Gregory Schraw and Rayne Sperling Dennison developed the MAI to assess adults' metacognitive awareness. Schraw (1994) had been doing research investigating the relationship between knowledge and regulation of metacognition. His research involved off-line self-report measures in the form of ratings of different metacognitive behaviors related to both knowledge and regulation of metacognition and this work is what later led to the development of the MAI.

Schraw and Dennison's work about assessing metacognition is heavily influenced by Flavell's (1976, 1979) theory about metacognition. Unlike the LASSI and the MSLQ, which are both anchored in social cognitive theories, the MAI has its theoretical roots in theories of cognition, and particularly in Flavell's theory (Flavell, 1971, 1976, 1979, 1985,) about metacognition. Theories of cognition are a subset of theories of mind that explain cognitive phenomena, such as beliefs, knowledge, emotions, desires, and intents. Similar to Flavell's model of metacognition (Figure 2.3), the MAI also consists of two major constructs, knowledge about cognition and regulation of cognition, though it lacks Flavell's two other main categories, metacognitive experiences and cognitive goals. Figure 3.3 presents the theoretical model of the MAI by Schraw and Dennison (1994).

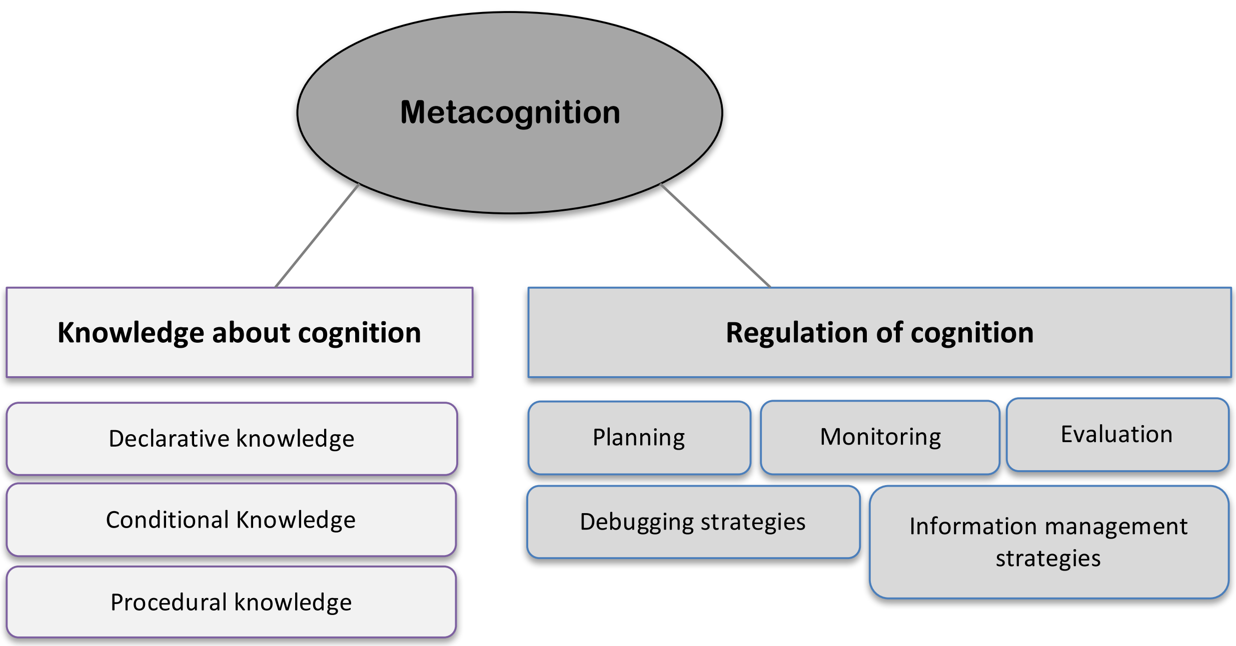

Figure 3.3. An overview of Schraw and Dennison's (1994) model of metacognition that was used as a theoretical foundation for the MAI. Metacognition is presented as a dual construct with eight subcomponents, three under knowledge about cognition and five under regulation of cognition.

Knowledge about cognition includes three subcategories that describe the reflective aspects of metacognition: declarative knowledge refers to knowledge about self and about strategies, procedural knowledge refers to knowledge about how to apply strategies, and conditional knowledge refers to knowledge about when and why to use strategies (Schraw & Dennison, 1994). Regulation of cognition describes the monitoring and control aspects of metacognition and is composed of five subcategories: planning, information management strategies, monitoring, debugging strategies, and evaluation. There are a total of 52 items on the MAI and each item was originally rated on a visual-analogue scale consisting of a 100mm bi-polar scale where *1* = false and *100* = true. Schraw and Dennison purposefully used a 100-point scale instead of a 5- or 7-point scale to increase the response variation as a way to improve the reliability of the instrument; though survey methods research has suggested there is no difference in these two types of scales in reliability and validity (Dillman, Smyth, & Christian, 2013). The MAI has since been modified to record responses to the 52 items as either dichotomous true/false, or on 5-point Likert-type scale (Harrison & Vallin, 2018; Young & Fry, 2008).

The MAI has been utilized extensively in empirical research, and is likely the most frequently used off-line measure in research about metacognition. The MAI is a well-researched and often-used instrument in metacognitive research, and has fueled theoretical discussions about metacognition (Schraw & Moshman, 1995) that have occurred in over 1,000 scholarly publications (Moshman, 2017). Due to its focus, ubiquity, and convenience, I selected the MAI as an appropriate instrument for assessing the use of metacognitive pedagogy to improve students' self-reported use of their metacognitive strategies.

Recent research on the MAI has used different approaches to calculate scores from the MAI, and the studies also tend to vary in their adherence to the intended theory (Coutinho, 2007;

Hartley and Bendixen, 2003; Hughs, 2015; Kleitman and Stankov, 2007; Magno, 2008, 2010; Pucheu, 2008; Stewart, Cooper, & Moulding, 2007; Turan, Demirel, & Sayek, 2009; Umino & Dammeyer, 2016; Young & Fry, 2008). Harrison and Vallin (2018) addressed these shortcomings and proposed modifications in calculating MAI scores while being mindful of the intended theory. Through the use of confirmatory factor analysis (CFA) and multidimensional random coefficients multinomial logit (MRCML) item-response modeling, data from 622 undergraduate students were examined to see how well they fit the intended functioning of the MAI. The results supported scoring the MAI as a two-dimensional construct—knowledge about cognition and regulation of cognition—but the findings indicated that the 52-item measure had a poor fit. Using iterative CFA and MRCML models, subsets of items from each of the eight subcategories were tested to stay true to the theory and 19 items were found to have a good fit. Follow-up tests with between-group and time invariance supported the use of a 19-item subset for between-group comparisons, with provisional evidence for its use in longitudinal studies (Harrison & Vallin, 2018). Based on the findings from Harrison and Vallin (2018), I decided to use this 19-item measure to operationalize metacognition for the analyses, even though the full 52-item MAI had been administered as part of the course expectations.

Pilot Test

Due to the experimental design of the current study, I wanted to test the treatment and the instrument before carrying out the main study. The purpose was to identify and address any issues that could be resolved before the start of the main study.

Pilot testing of metacognitive pedagogy and class activities. I tried out the metacognitive pedagogy for the first time with 11 students while teaching the course during a summer session in 2015. Due to the smaller class size, I was able to get continuous feedback through various class discussions about how the students experienced learning about metacognition. We engaged in evaluative discussions as a part of completing each of the metacognitive class activities, thus allowing me to get instant feedback about how the students experienced the learning. Overall, the students responded well to the metacognitive pedagogy, and all students found the use of metacognitive strategies helpful to their learning. Based on their feedback, I added a class activity that addressed regulation of metacognition in terms of learning how to plan, set goals, and evaluate their performance when preparing for the midterm and final exams.

To get additional information about my teaching performance, I arranged to be observed by an experienced educator, who also teaches about metacognition in a different line of work. I was observed on two different occasions for a total of two hours. Based on the feedback from the observations, I revised some of the content that explained metacognition to be more succinct. I also revise the prompts and instructions for the major take-home assignment about metacognition.

After final revisions, the course included a 20-minute introduction to metacognition, and explicit teachings about the usefulness of metacognition for the learning process which included modeling of metacognitive strategies such as drawing diagrams, concept mapping, summarizing main points, performing think alouds, and discussing how to plan studies. Metacognition was also integrated into student assignments, including class activities, online quizzes, written self-assessments, and a metacognition project.

Pilot testing of administering the MAI. Though the MAI has been well-researched and established as a useful instrument to collect data about the use of metacognition (Coutinho, 2007; Hartley & Bendixen, 2003; Hughs, 2015; Kleitman & Stankov, 2007; Magno, 2008, 2010; Pucheu, 2008; Stewart, Cooper, & Moulding, 2007; Turan, Demirel, & Sayek, 2009; Umino &

Dammeyer, 2016; Young & Fry, 2008), I decided it would be important to gather some information about how the instrument would work in the context of the current study. I thought it would be important to get a better understanding of the process of administering the MAI to the students. I wanted to make sure that I was well-prepared to administer and collect the data, and I was also curious about how students would experience the process of completing the MAI.

The MAI was originally developed as a pen and paper instrument (Schraw & Dennison, 1994). However, transferring data from paper to electronic formats is cumbersome, and more importantly creates an opportunity for error in the transfer process. So, to eliminate this step of transferring the data, I instead decided to collect the data via a classroom response system (CRS) known as iClicker. I have used various CRSs in my classrooms since the beginning of my teaching career, and I very much appreciate the ability to collect participation data, check comprehension, and to ask anonymous questions with the use of clickers. One of the advantages of using iClicker is that students' responses are automatically recorded as CSV files, thus eliminating the possibility of making an error when transferring paper-based data to electronic versions. CSV files are also easily formatted for later statistical analyses. Since my students were already well-versed with using iClicker as a part of their regular classroom experience, I decided to utilize iClicker to collect the MAI data. I pilot-tested the administration of the MAI with iClickers in the spring semester of 2015 with 153 students.

To collect the data, I created a PowerPoint presentation that listed each of the 52 prompts from the MAI. Figure 3.4 shows an example of how a prompt was presented to the students on a slide. On each slide, before each prompt it was stated: "In this class, and while studying for this class:", to remind students that while responding to the prompts, they should only think about their studies pertaining to our class and not in other courses. Student used their clickers to respond to each of the 52 prompts and data were collected on a five-point Likert-type scale where, *A* = Not at all typical of me, *B* = Not very typical of me, *C* = Somewhat typical of me, *D* = Fairly typical of me, and *E* = Very typical of me.

In this class and while studying for this class:

3. I try to use strategies that have worked in the past.

A. ***Not at all*** typical of me
B. ***Not very*** typical of me
C. ***Somewhat*** typical of me
D. ***Fairly*** typical of me
E. ***Very*** typical of me

Figure 3.4. A sample item from the MAI presented to the students via PowerPoint. The students used their iClickers to respond to each prompt.

Students who did not have their clickers at the time of data collection completed the MAI via pen and paper. The paper version of the MAI listed each of the 52 items, and underneath each item was the 5-point scale ranging from *not at all typical of me* to *very typical of me*. In Figure 3.5 I provide a sample item from the paper-based version of the MAI.

3. I try to use strategies that have worked in the past.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

Figure 3.5. A sample item from the paper-based version of the MAI that was completed by students who did not have their iClicker at the time of data collection.

Think aloud sessions. To get information about how students experienced answering the MAI using iClicker, I conducted three think-aloud sessions following guidelines developed by Ericson and Simon (1993). In each session, the students verbalized their thoughts as they completed the MAI using an iClicker. During the time they completed the MAI, I sat silently observing and taking notes. I noted how long it took them to respond to each of the 52 prompts and the total assessment. I also noted any questions they voiced about any specific prompts. After they had completed the MAI, we discussed their experiences and any questions they had. None of the three students experienced any issues or challenges when completing the MAI, though they all noted that the process felt lengthy and at times boring. They responded to each prompt in less than 10 seconds, and the entire assessment was completed within 10 minutes. This, however did not hold true when completing the MAI with the rest of the class. Data collection in class took much longer; each prompt sometimes took up to 45–60 seconds to complete, and the completion of the entire MAI varied from 20–25 minutes. Knowing about the significant time it took to administer the MAI became a crucial component when planning how to spend class-time in the main study since I had to assume that close to two full class meetings would be dedicated to collecting MAI data.

Treatment

After making final revisions based on findings from the pilot test about metacognitive pedagogy and of the administration of the MAI, I integrated the metacognitive pedagogy and the use of the MAI into the course, and was ready to begin the main study. Using the two-group quasi-experimental design, I prepared to teach metacognitive pedagogy in the two sections of the same course that were offered back-to-back in subsequent semesters, Group A in the fall of 2015 and Group B in the spring of 2016. The students in Group A received a total of ten weeks (Weeks 6–15) of metacognitive pedagogy, and the students in Group B received a total of five weeks (Weeks 6–10). Nearly all of the 398 students, about 95% (379), completed the metacognition project (nine from Group A, and ten from Group B did not make a submission), and over 80% of students in both groups responded to the MAI at each of the four Time Points.

Group A. The 181 students enrolled in Group A began to receive treatment in Week 6, starting with the 20-minute introduction that defined metacognition and justified why metacognitive strategies are useful to learning. From Week 6 until the end of the semester, the students received weekly metacognitive pedagogy as a part of regular classroom practice. I taught explicitly about both knowledge of metacognition (declarative, procedural, and conditional) and regulation of metacognition (planning, evaluating, monitoring, and information management strategies). Specific information management strategies such as concept mapping, summarizing key points, drawing diagrams, and developing mnemonics were explicitly taught in class and students also got the opportunity to apply these various strategies in class activities and take-home assignments. The metacognition project was introduced in the beginning of week six and the metacognitive strategies that were required to be used in this project were taught and applied to content twice before it was due at the end of the semester.

Group B. The 217 students enrolled in Group B received a total of five weeks of metacognitive teaching and learning. And just like the students in Group A, students in Group B started to receive the treatment in the beginning of Week 6 with the same introduction to metacognition. For the following five weeks, we engaged in metacognitive teaching and learning, and though students in Group B only received the treatment for a total of five weeks in the middle of the semester, metacognition was addressed in the exact same way, and the same metacognitive strategies were taught with the same content as students in Group A. However, because the students in Group B received less treatment, each of the metacognitive strategies, such as concept mapping, summarizing key points, drawing diagrams, and developing mnemonics, were only taught and applied to content in class once during the five weeks.

Data Collection

The metacognitive pedagogy and students' completion of the MAI had been integrated into the course as part of the course expectations. To meet ethical requirements, the data were analyzed as existing data with all identifiers removed and after the courses had been completed. Permission was granted for the analysis of these data by the institutional review board of the university in which the study was conducted.

Most students completed the MAI using their iClicker at each of the four data collection Time Points. This number ranged from about 37–60% at each Time Point. If students did not have their clicker at time of data collection, they instead completed the MAI with paper and pen, and this number ranged from 7–10% at each Time Point. The paper and pen version of the MAI is presented in Appendix C.

iClicker raw data. The original data collected via iClicker were stored as CSV files and I converted them to Excel files for ease in formatting. Each student's iClicker had an ID code that tied the student's first and last name to their iClicker making it possible to track the data. To strip the data of this iClicker ID code, I created a new ID code that replaced the original, so that it was no longer possible to match any data with student names. The Excel file containing the original iClicker ID code and the new ID code was kept in a separate file for verification.

Pen and paper raw data. I manually entered students' responses to the paper version of the MAI into Excel. The students' names were replaced with new ID codes and their responses to each of the 52 items were entered numerically, where Not at all typically of me = *0*, Not very typical of me = *1*, Somewhat typically of me = *2*, Fairly typical of me = *3*, and Very typical of me = *4*, and any missing responses were coded as NA. The completed paper versions of the MAI were kept in a locked file cabinet in case they were needed for future verification.

To verify the manually entered Excel data, all responses to the paper version of the MAI were entered into a separate Excel file a second time by a colleague who had previous data-entry experience. The two files were cross-checked with 100% agreement. Next, the cross-checked Excel data were appended to the iClicker data set to constitute the complete dataset containing each of the four time points of the data collection. Lastly, I merged the two Excel files containing the raw student MAI data from each group into a master Excel dataset, with a group identifier variable, that contained all data from the 398 students.

Preparation of the Data for Analysis

To prepare the raw data for analysis, I calculated the students' scores on the 19-Item MAI subscale that were later used in the latent growth curve model analysis.

Scoring of the MAI 19-Item subset. Though I collected data using the original 52 items of the MAI, I analyzed the 19-Item subscale as defined by Harrison and Vallin (2018) that operationalized metacognition as a dual construct consisting of knowledge (defined by eight items) and regulation (defined by eleven items), which is in Figure 3.6. I entered this 19-item subset of data into R 3.51 (R Core Team, 2018).

Calculating regulation and cognition scores. I calculated the students' scores on the two variables, knowledge and regulation, for each of the four time points. Instead of calculating the sum of the Likert-type responses across the items, as is commonly done with the MAI (Harrison & Vallin, 2018), I calculated factor scores using a confirmatory factor analysis model following Kline's (2015) effects coding method, which places the factor scores on a scale that is similar in range to the 0-to-4 Likert-type scale of the items. This approach of using factor scores to estimate students' levels of regulation and cognition was also used in Harrison and Vallin (2018). For this procedure, I used the lavaan package (Rosseel, 2012) in R.

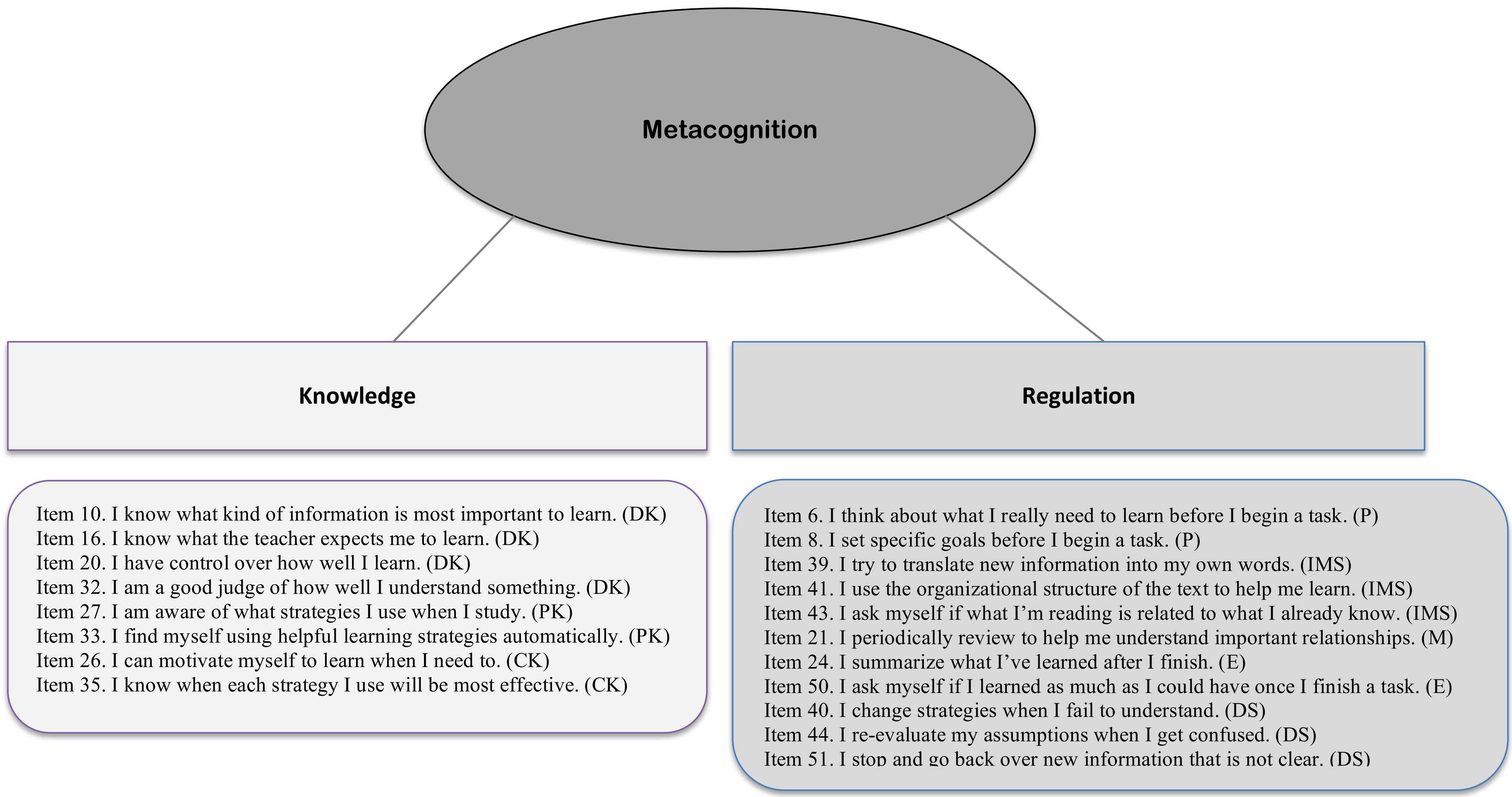

Figure 3.6. A representation of the MAI 19-item subset. The knowledge scale (knowledge about cognition) represented by eight items, and the regulation scale (regulation of cognition) represented by eleven items as defined in Harrison and Vallin (2018).
DK = declarative knowledge, PK = procedural knowledge, CK = conditional knowledge, P = planning, IMS = information management strategies, M = monitoring, DS = debugging strategies, E = evaluation.

Missing data, which were coded as NA in R, were included so that a person's score could be estimated even if they had not answered the complete set of items at a particular time point. One of the benefits of running models in lavaan is that the program can estimate missing data using maximum likelihood estimation. However, if there is too many missing data, the model cannot be estimated. For six participants, there was missing data on all of the 19 items across the four time points, which prohibited any estimation of their scores. After removing these participants, there were 392 observations. I calculated the percentage of the data that were missing for the regulation items and the knowledge items separately. Of the total number of person-by-item cells, 392 x (11x4) = 17,248 in the regulation data, 1,960 (11%) were missing. Nearly the same proportion was missing in the knowledge items, with 392 x (8x4) = 12,544 total possible responses and 1,397 (11%) missing. I proceeded to analyze the data using the lavaan package with robust maximum likelihood estimation, which permits missing data and which is appropriate when we cannot assume multivariate normality, as is often the case with five-point Likert-type data (Kline, 2015).

To make sure the scores retained their meaning across the four time points, I tested for invariance over the four time points by comparing the fit of the configural, metric, and scalar models, as had been done in Harrison and Vallin (2018) with only two time points. The scalar model is ideal for subsequent use in analyzing whether there is a change in scores across time because it means that the items retain their same level of difficulty of endorsement across the four time points. In other words, the students' changes in the factor scores can be attributed to differences in the student rather than changes in the difficulty of the individual items.

For the regulation item scores, the scalar model had reasonably good fit, with chi-square = 1404.13, *df* = 881, the comparative fit index (CFI) = .90, and the root mean square error of approximation index (RMSEA) = .04. The scalar model was also not statistically significantly worse than the metric model (chi-square = 51.99, *df* = 21, *p* > .05), which was in turn not worse than the configural model (chi-square = 4.05, *df* = 51, *p* > .05). In other words, the scalar model for the regulation scores was acceptable for use in my subsequent analysis.

For the knowledge items, the scalar model had good fit, with chi-square = 682.58, *df* = 452, CFI = .93, and RMSEA = .04. The scalar model was, however, statistically significantly worse than the metric model (chi-square = 83.49, *df* = 21, *p* < .05), suggesting that the items were not equally difficult to endorse across the time points. The metric model was better than the configural model (chi-square = 15.86, *df* = 21, *p* > .05), though, which is good because it suggests that the items relate to the model-estimated latent factor, knowledge, in the same strength across the time points. Even though the scalar model was not supported, I used it to calculate the knowledge scores because it had good fit. But, I interpreted the knowledge scores with caution, the scores might include some variability due to the way the items function differently across time.

Reliability of the MAI 19-item subset. Because there were missing item-level data, I estimated internal consistency reliability using omega reliability coefficients from the fitted model in lavaan, which had accounted for missing data, using the reliability function from the semtools package (Jorgensen, Pornprasertmanit, Schoemann, & Rosseel, 2018) in R. Omega coefficients are more appropriate than coefficient alpha in models containing items that are assumed to reflect a latent variable (DeVellis, 2017). In Table 3.2, I provide the omega reliability estimates of knowledge and regulation for each of the four time points.

With the Factor scores, I also estimated test-retest reliability by calculating the Pearson correlation coefficient between the scores at Time Points 1 and 2 for each of the two variables,

Table 3.2

Omega Reliabilities of Knowledge and Regulation for Each Time Point for Both Groups

Scale	Time 1	Time 2	Time 3	Time 4
Knowledge	0.76	0.81	0.85	0.87
Regulation	0.80	0.84	0.84	0.86

knowledge and regulation, which were .80 and .69 respectively. Although the internal consistency reliability estimates were reasonable, the .69 estimate of the test-retest reliability of the regulation scores suggests that the results of the study should be taken with caution because the stability of regulation scores is slightly lower than is typically desired, where a .75 or .80 would constitute high reliability.

Assumption of multivariate normality. For latent growth modeling, the assumption of multivariate normality is important. I tested this with the MVN package in R (Korkmaz, Goksuluk, & Zararsiz, 2014) with both the set of regulation scores and the set of knowledge scores. The assumption was not met for the regulation scores (Mardia skewness = 96.72, $p < .001$ & Mardia Kurtosis = 14.54, $p < .001$) nor for the knowledge scores (Mardia skewness = 174.60, $p < .001$ & Mardia Kurtosis = 20.85, $p < .001$). Because this assumption was not met, the results of the latent growth curve models with both outcomes should be taken with caution.

Tests of existing group differences on demographic variables. To test whether the two groups differed in their demographic makeup, I conducted Fisher's exact tests. On the three variables, age, gender, and academic level, there were no statistically significant differences between the two groups (group by age, $p = .384$; group by gender, $p = .107$; group by academic level, $p = .758$). This suggests that if there is any differential growth between the groups, such growth is not likely attributable to these demographic variables. However, this does not rule out the presence of other unmeasured covariates that might contribute to differences in the way groups respond to more exposure to the pedagogy.

Analysis for Research Question 1. In the first step of the analysis, I was interested in knowing whether there was a testing or maturation effect. To account for this possibility, I examined the scores from the two pretests administered at O_1 and O_2 (Figure 3.7). If there was any change in scores, I would examine whether this change was of the same magnitude and direction as the change between Time Points O_2 to O_3, in which case I would have been unable to disentangle any effect of the metacognitive pedagogy from testing or maturation effects. In the event that there was no detectable change from the first to second time point, I would assume that there was no maturation or testing effect, which would allow me to examine the pre-to-post intervention change as likely being due to the metacognitive pedagogy.

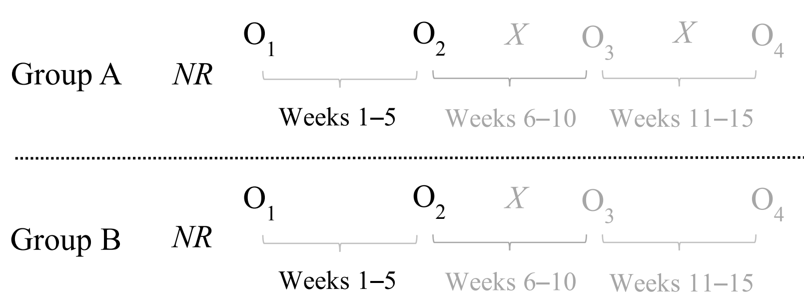

Figure 3.7. To explore any effects of testing or maturation I investigated any change in students' scores on the two pretests represented as O_1 and O_2 in the figure.

To address Research Question 1, which was about the extent to which metacognitive pedagogy improves students' self-reported use of metacognitive strategies, I combined both groups and analyzed any change in students' scores from $O_{2,}$ to O_3 as a single group (Group AB) because both groups received the same sequence and amount of treatment (Figure 3.8). I also

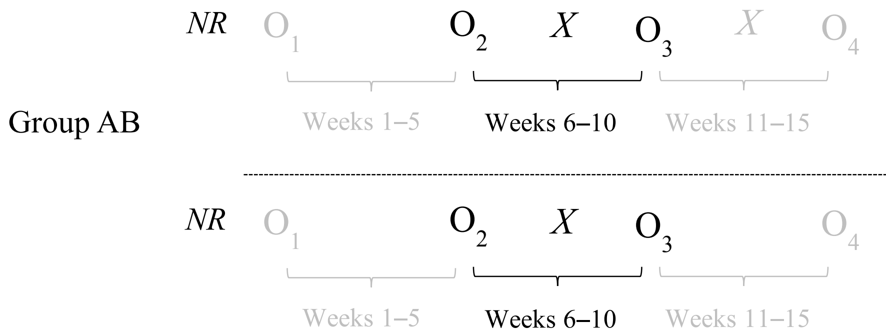

Figure 3.8. To answer Research Question 1, I collapsed both groups into one and investigated any change in students' scores between O_2 and O_3 to estimate any effects of the treatment.

examined any change from $O_{2,}$ to O_4 to account for growth that might not have been immediately detectable.

Analysis for Research Question 2. To answer Research Question 2, which was about the extent to which students' self-reported use of metacognitive strategies was enhanced by greater exposure to metacognitive pedagogy, I examined whether there was any change in scores from O_3 to O_4 for each group to see if there was a significant difference between the two groups, as is displayed in Figure 3.9.

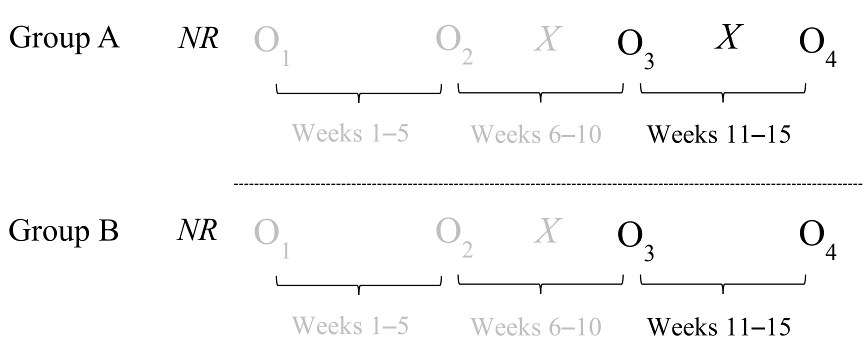

Figure 3.9. To answer Research Question 2, I tested whether there was a statistically significant difference between the two groups in their change from O_3 to O_4.

Analytic Methods for Answering the Research Questions

The remainder of this chapter is a description of latent growth curve (LGC) modeling analysis, which I used to analyze the knowledge and regulation scores. This aligns with the double pretest design, which I described in the beginning of this chapter, and which can include the effect of group for the second research question.

Latent Growth Curve Modeling. A number of statistical approaches can be applied to examine change in a variable or variables (Duncan, 1999). One of the most basic approaches to accomplish this is by examining any change in scores from Time 1 to Time 2 using pretest-posttest analysis. Though this is a common research-design within the field of education, the pretest-posttest design will not yield sufficient information about change over time. To examine growth trajectories with longitudinal data over time, a more sophisticated approach is needed (Duncan, 1999; Preacher, 2008).

LGC modeling is an approach based on structural equation modeling (SEM), and is widely considered to be a powerful technique to analyze longitudinal data (Byrne, 2013; Duncan, 2009; Preacher, 2008). Because LGC modeling is rooted in SEM methodology, they share many strengths and weaknesses. For example, one of the strengths of using a LGC modeling approach is the ability to examine intraindividual (within-person) as well as interindividual (between-person) variability in change over time (Preacher, 2008). A limitation of LGC modeling as with other SEM approaches is that they require relatively large sample sizes to run. LGC modeling also requires a variable or variables to be measured in the same way on at least two time points (Duncan, 1999). LGC modeling is useful to model change over time, which is considered as a latent unobserved process. Another unique feature of LGC modeling is that it also permits investigations into the antecedents (first half of a hypothetical proposition) and consequents (second half of a hypothetical proposition) of change, making it an appropriate approach to estimate any effects of a treatment that is expected to grow over time (Duncan, 1999; Preacher, 2008). LGC models make it possible to observe change in the form of trajectories that can be described in both direction and functional form by examining the levels and the shapes (Preacher, 2008). Functional form is another way to label the change in the double-pretest model, where any pre-intervention functional form represents the maturation and testing validity threats.

When defining, and later analyzing LGC models, it is important to anchor this process in theory. In developing a model to be fit to observed data, it is crucial that the specified model accurately reflect the predictions or implication of substantive theory of growth (Preacher, 2008). It follows then, given a theoretically sound model, hypotheses in LGC models can be tested by examining the model fit based on the significance of model parameters. Important model parameters include the means of the level (intercept) and shape (slope) factors, and the variances and covariances among aspects of change over time (Hertzog & Nesselroade, 2003). The level is the estimated baseline of the participants; the shape is the change over time.

LGC models are most often not an exact fit of the population, and because of this, good models are sometimes rejected due to assumed poor chi-square fit of the observed data (Duncan, 2009; Preacher, 2008). Therefore, to evaluate the fit of a model, it is essential to examine the global comparative fit index (CFI) and the Tucker-Lewis Index (TLI). Models that fit the observed data well typically have CFI and TLI estimates that are greater than .95 on the 0 to 1 scale, where 1.00 represents perfect fit. Adequate models typically have model fit estimates greater than .90 (Hu & Bentler, 1999). Adequate-fitting models can then be used for comparison to identify the model that best fit the observed data. To compare models, it is appropriate to use maximum likelihood estimation and compare the Akaike’s information criterion (AIC) and the

Bayesian information criterion (BIC). The model with the lowest AIC and BIC estimates are presumed to be the better fit for the observed data. An additional measure to determine model fit when comparing models, is examining the root mean square error of approximation (RMSEA), which represents estimated population model error per degree of freedom (Preacher, 2008). A smaller RMSEA on the 0 to 1 scale indicates better model fit. Hu and Bentler's (1999) criterion of less than 0.06 is often used as a criterion for good fit.

Specifying the Model. Following Heck and Thomas (2015), I specified the latent growth curve model as

$$\boldsymbol{Y}_{it} = \boldsymbol{\Lambda}\boldsymbol{\eta}_{it} + \boldsymbol{\varepsilon_{it}} \,, \qquad (1)$$

where $\boldsymbol{Y}_{it}$ is the score of Person *i* at Time *t*; $\boldsymbol{\eta}_i$ is a vector of latent curve factors, η_{Li} and η_{Si}, representing the two factors, level and shape, of each person; $\boldsymbol{\Lambda}$ is the specified change process that is pre-determined by the model design but which can also be estimated in the model, and $\boldsymbol{\varepsilon_i}$ represents the error in predicting the score of Person *i* at Time *t*.

For example, with regulation as the outcome (*Y*), each person may have a regulation score at each of the four time points ($\boldsymbol{Y}_{it}$), which is predicted by that person's location on the level factor (η_{Li}) and their location on the shape factor (η_{Si}). The level factor represents the person's baseline regulation, before any change is expected to occur; the shape factor represents the person's change in regulation above (or below, if they worsened) the baseline. In a matrix format, the equation with a linear trend, with Time 1 as the baseline, can look like this:

$$\begin{bmatrix} Y_{i1} \\ Y_{i2} \\ Y_{i3} \\ Y_{i4} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \\ 1 & 2 \\ 1 & 3 \end{bmatrix} \begin{bmatrix} \eta_{Li} & \eta_{Si} \end{bmatrix} + \begin{bmatrix} \varepsilon_{i1} \\ \varepsilon_{i2} \\ \varepsilon_{i3} \\ \varepsilon_{i4} \end{bmatrix}, \qquad (2)$$

where the level factor is constant within person across time and the shape factor specifies the change as linear, from baseline, which excludes any effect of the shape factor because its coefficient is zero, to the last time point, with the shape fixed to be three. Figure 3.10 represents the specification in Equation 2. The figure also shows arrows that represent estimations of the covariance between level and shape, and the error variances of the *Y* variable at the four time points.

With the model in which no change was expected to occur before the strategies were introduced, the specification might be this:

$$\begin{bmatrix} Y_{i1} \\ Y_{i2} \\ Y_{i3} \\ Y_{i4} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 0 \\ 1 & 1 \\ 1 & 2 \end{bmatrix} [\eta_{Li} \quad \eta_{Si}] + \begin{bmatrix} \varepsilon_{i1} \\ \varepsilon_{i2} \\ \varepsilon_{i3} \\ \varepsilon_{i4} \end{bmatrix}, \tag{3}$$

where the first two time points are fixed to zero to impose no change from Time 1 to Time 2, but where the change is specified as linear from Time 2 to 4. LGC modeling can also be used to estimate the amount of change between two time points. For instance, to estimate any pattern of growth after the intervention was introduced, I could use this model (Figure 3.10), in which the change from Time 2 to Time 3 is estimated, symbolized by the asterisk, and in which the total change is in one unit on the η_{Si} scale. Because each person's latent level (η_{Li}) and shape (η_{Si}) is estimated, I can estimate the mean level (η_L) and the mean shape (η_S) across all the persons. The mean level represents the expected mean score on Y before any intervention was introduced, which in this model is fixed to be the same value at Time 1 and Time 2. Because I fixed the final time point to be one, the mean on the shape factor represents the mean growth of my sample on the outcome.

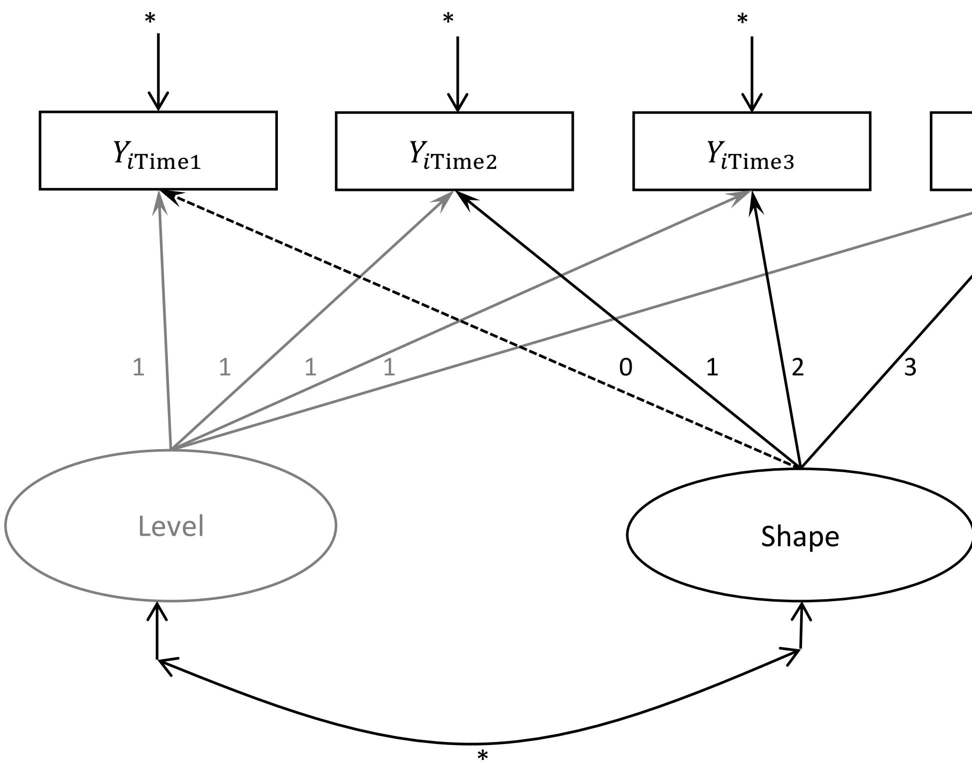

Figure 3.10. An example of a latent growth curve model with growth specified as linear. The dashed line represents a coefficient of zero to show that the shape has zero contribution to the estimation of the person's score on Y at that time point.

$$\begin{bmatrix} Y_{i1} \\ Y_{i2} \\ Y_{i3} \\ Y_{i4} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 0 \\ 1 & * \\ 1 & 1 \end{bmatrix} [\eta_{Li} \quad \eta_{Si}] + \begin{bmatrix} \varepsilon_{i1} \\ \varepsilon_{i2} \\ \varepsilon_{i3} \\ \varepsilon_{i4} \end{bmatrix}, \tag{4}$$

Ideal model for Research Question 1. Finally, I can investigate a piecewise latent growth curve model (Heck & Thomas, 2015), in which the specification includes two shape factors:

$$\begin{bmatrix} Y_{i1} \\ Y_{i2} \\ Y_{i3} \\ Y_{i4} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 1 & 0 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \end{bmatrix} [\eta_{Li} \quad \eta_{S1i} \quad \eta_{S2i}] + \begin{bmatrix} \varepsilon_{i1} \\ \varepsilon_{i2} \\ \varepsilon_{i3} \\ \varepsilon_{i4} \end{bmatrix}, \tag{5}$$

where the first shape factor, η_{S1i}, represents person i's latent change from Time 2 to Time 3, which represents the change between the time just before the strategies were introduced and the time four weeks later. The second shape factor, η_{S2i}, represents the person's change from Time 3 to Time 4. This model is valuable because it allows us to see where the change, if any occurs. It can reveal whether any change levels off (if $\eta_{S2} = 0$), stays about the same (if $\eta_{S2} = \eta_{S1}$), or increases (if $\eta_{S2} > \eta_{S1}$) or decreases.

Model comparisons. To determine whether I could use the ideal model for Research Question 1, I conducted model comparisons using the chi-square difference tests between models to determine which one fit better, or more accurately whether a more desirable model did not fit significantly worse.

My first important comparison addressed whether there was any growth. This will compare a model with zero growth across all four time points to a model that permits growth but does not specify the functional form. In other words, I compared a model that excluded the shape factor (because all coefficients would be set to zero) to one that freely estimated the shape factor's coefficient on Time 2 and Time 3.

My second important concern was whether a model that specified zero growth from Time 1 to Time 2 had better fit than a model that freely estimated growth from Time 1 to Time 2. If the zero pre-test growth model fit better, I could claim that there was no evidence of maturation or testing.

In addition, I examined whether the covariance between level and shape factors was zero or whether the parameter should be estimated. This has implications because growth might depend on the person's baseline. For example, if students who have a low pre-intervention regulation score grow at a steeper rate than students who have a high pre-intervention score, there would be evidence for a threat to validity known as regression to the mean (Shadish, Cook, & Campbell). If a model with zero between-factor covariance fit better than one with that interaction effect being freely estimated, I could eliminate this threat to validity.

My third important comparison was whether a piecewise model was as good as a zero pretest-growth model. If this fit well, I could use the mean of the first shape factor, η_{S1}, to address my first research question.

If the piecewise model (Figure 3.11) fit well and if the estimated mean of the first shape factor, η_{S1}, is statistically different from zero, I would have reason to support the alternative hypothesis that the immediate change in students' regulation scores was not by chance, but probably because of the metacognitive pedagogy. I intended to use this model specification to address the first research question if the model fits better than a model specified to have zero growth or free growth. Lavaan provides both the mean and the variance of the latent variables in its output, along with an estimate of the standard error of these parameters, a *z*-statistic, *p*-values, and confidence intervals.

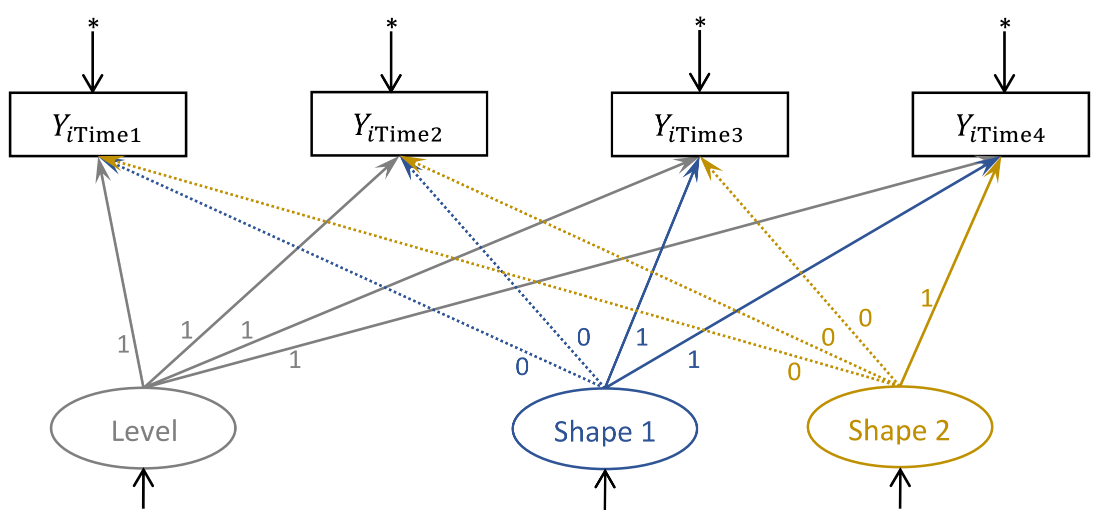

Figure 3.11. An example of a piecewise model. The dashed line represents a coefficient of zero, signifying that the growth factor has no effect on the observed scores at that particular time point.

To estimate the effect size, I estimated Cohen's *d* by dividing the estimated immediate effect, η_{S1}, by the estimated standard deviation of the level, $\sqrt{var(\eta_L)}$. I also investigated the total effect size as $(\eta_{S1} + \eta_{S2}) / \sqrt{var(\eta_L)}$. This placed the estimated change in the units of the pre-intervention standard deviation.

Ideal model for Research Question 2. To address the second research question, I used the piecewise model, but added a dichotomous group variable (Figure 3.12), where Group A, which received 10 weeks of the strategy training is coded as 1 and Group B, which received 5 weeks of the strategy training, was coded as 0. To determine whether more metacognitive pedagogy predicted differences in the second shape, which represented the change from Time 3 to Time 4, I examined the effect of the group variable in predicting η_{S2}. Statistical significance would suggest that extra treatment had an effect on the change in scores on Y from Time 3 to 4.

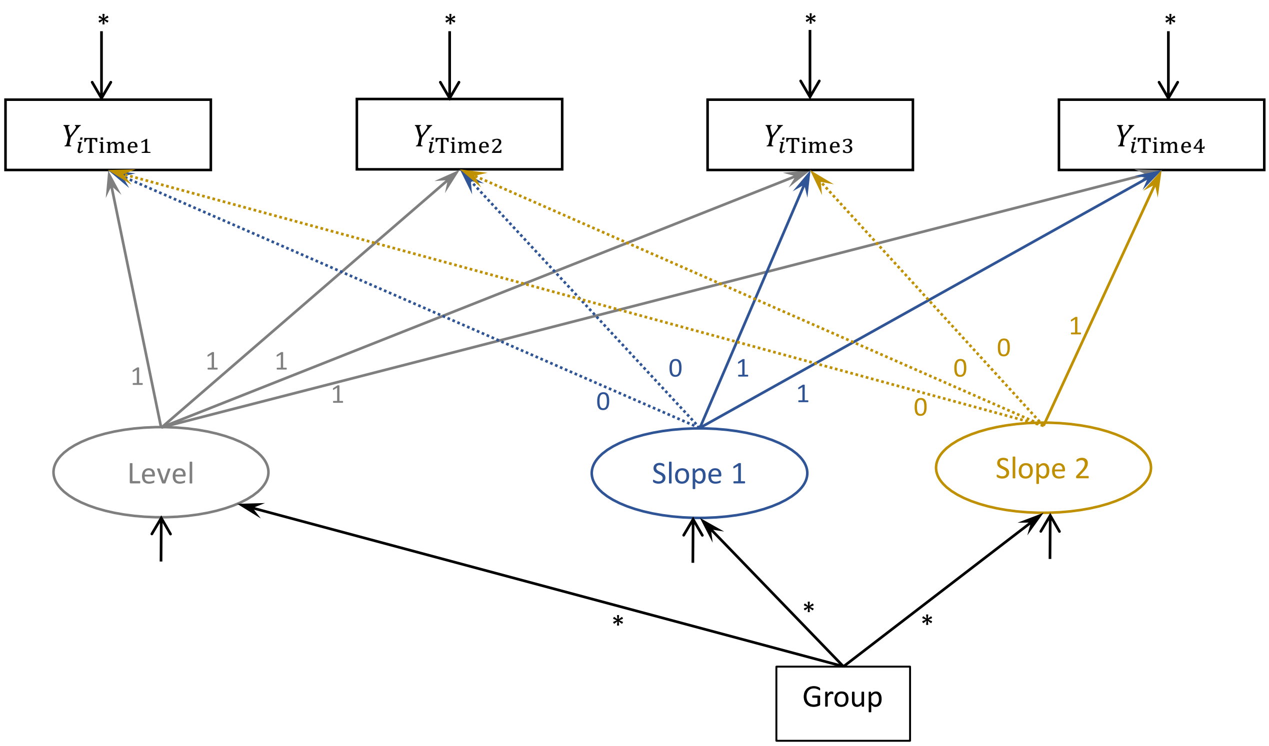

Figure 3.12. An example of a piecewise model with a dichotomous group variable. The dashed line represents a coefficient of zero. The asterisk represents a parameter the model will estimate.

CHAPTER 4

RESULTS

With the data set of factor scores that were calculated from the scalar models described in Chapter 3, I conducted latent growth curve model analyses to assess model fit and address the research questions. In this chapter, I present the descriptive statistics, conduct model comparisons to determine if the piecewise model is appropriate for the LGC modeling, and estimate LGC model parameters for regulation and for knowledge.

Descriptive Statistics

Tables 4.1–4.6 present the descriptive statistics for the knowledge and regulation scores by group. The range of scores can be roughly interpreted as interval scale values corresponding to the 5-point Likert-type scale. For example, the mean knowledge score at Time 1 was 2.48, which

Table 4.1.

Descriptive Statistics of the 11-Item Regulation Subscale Factor Scores for Group AB

	N	Min	Median	*M*	Max	*SD*	se_m
Time 1	392	0.65	2.51	2.50	3.78	0.45	0.02
Time 2	392	1.13	2.50	2.50	3.88	0.46	0.02
Time 3	392	1.16	2.55	2.55	3.86	0.48	0.02
Time 4	392	0.64	2.66	2.64	3.87	0.49	0.02

Table 4.2.

Descriptive Statistics of the 11-Item Regulation Subscale Factor Scores for Group A

	N	Min	Median	*M*	Max	*SD*	se_m
Time 1	178	0.65	2.53	2.48	3.69	0.46	0.03
Time 2	178	1.19	2.52	2.52	3.79	0.45	0.03
Time 3	178	1.16	2.58	2.59	3.62	0.46	0.03
Time 4	178	0.64	2.68	2.67	3.79	0.49	0.04

Table 4.3.

Descriptive Statistics of the 11-Item Regulation Subscale Factor Scores for Group B

	N	Min	Median	*M*	Max	*SD*	se_m
Time 1	214	1.32	2.49	2.51	3.78	0.44	0.03
Time 2	214	1.13	2.48	2.48	3.88	0.47	0.03
Time 3	214	1.20	2.52	2.53	3.86	0.49	0.03
Time 4	214	1.28	2.59	2.61	3.87	0.50	0.03

Table 4.4.

Descriptive Statistics of the 8-Item Knowledge Subscale Factor Scores for Group AB

	N	Min	Median	*M*	Max	*SD*	se_m
Time 1	392	1.05	2.66	2.64	3.81	0.42	0.02
Time 2	392	1.25	2.75	2.73	3.89	0.44	0.02
Time 3	392	0.81	2.79	2.76	3.92	0.48	0.02
Time 4	392	0.53	2.82	2.78	3.91	0.49	0.02

Table 4.5.

Descriptive Statistics of the 8-Item Knowledge Subscale Factor Scores for Group A

	N	Min	Median	*M*	Max	*SD*	se_m
Time 1	178	1.05	2.62	2.61	3.58	0.42	0.03
Time 2	178	1.43	2.81	2.76	3.73	0.44	0.03
Time 3	178	1.01	2.83	2.79	3.9	0.48	0.04
Time 4	178	0.53	2.83	2.78	3.89	0.50	0.04

Table 4.6.

Descriptive Statistics of the 8-Item Knowledge Subscale Factor Scores for Group B

	N	Min	Median	*M*	Max	*SD*	se_m
Time 1	214	1.32	2.70	2.66	3.81	0.42	0.03
Time 2	214	1.25	2.73	2.70	3.89	0.44	0.03
Time 3	214	0.81	2.75	2.74	3.92	0.49	0.03
Time 4	214	1.08	2.79	2.78	3.91	0.49	0.03

is about half way between the somewhat-typical-of-me response category and the fairly-typical–of-me response category in degree to which the students report themselves as having knowledge of their cognition.

LGC Model Comparisons of the Regulation Scores

The regulation scores were composed of students' responses to the 11 items on the MAI, as defined by Harrison and Vallin (2018), over Time Points 1–4. I labeled the models and the model comparisons with an R (for regulation) to distinguish them from models for knowledge (which begin with K). The models are alphabetical, from Model R.A through Model R.G; the model comparisons are numeric, from R1 through R5.

Model comparison R1: No growth versus freely estimated growth. As a first step in the analysis, I created Model R.A, a no growth base model (null model) to fit the data under the null hypothesis, which is that there is no effect of the treatment (Figure 4.1). If this, Model R.A, were to fit the data better than a model that would permit growth, it would support a hypothesis of zero growth across the four time points. The level coefficients for Model R.A were specified to be one across all four time points (i.e., 1, 1, 1, 1). To assume no growth in this model, the shape factor was absent from the model, which effectively specifies the shape to be zero across all four time points, (i.e., 0, 0, 0, 0) and removes any estimate of the mean of the shape factor and any covariance with the level factor. In this, and in all models, the error variance was set to 0.022 for Time 4 because the model did not converge in my earlier attempt to fit the model when this error is freely estimated.

Model R.B, the freely estimated growth model, was specified to permit any shape of growth across the four time points (i.e., 0, *, *, 1), where the asterisks represent free estimation of the shape; Figure 4.2). The results are presented in Tables 4.7 and 4.8.

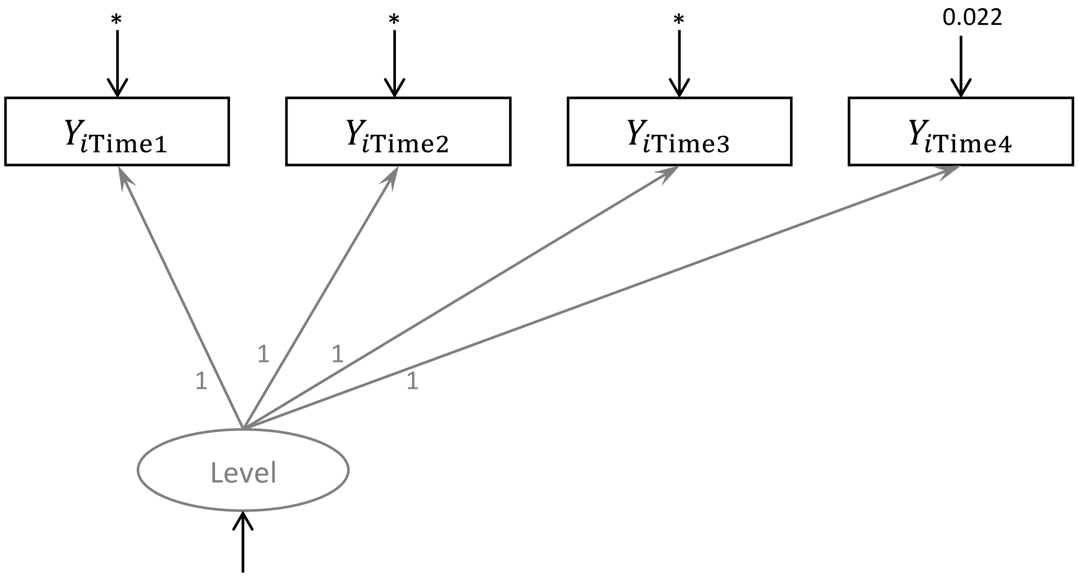

Figure 4.1. The no growth based model used to fit the data under the null hypothesis.

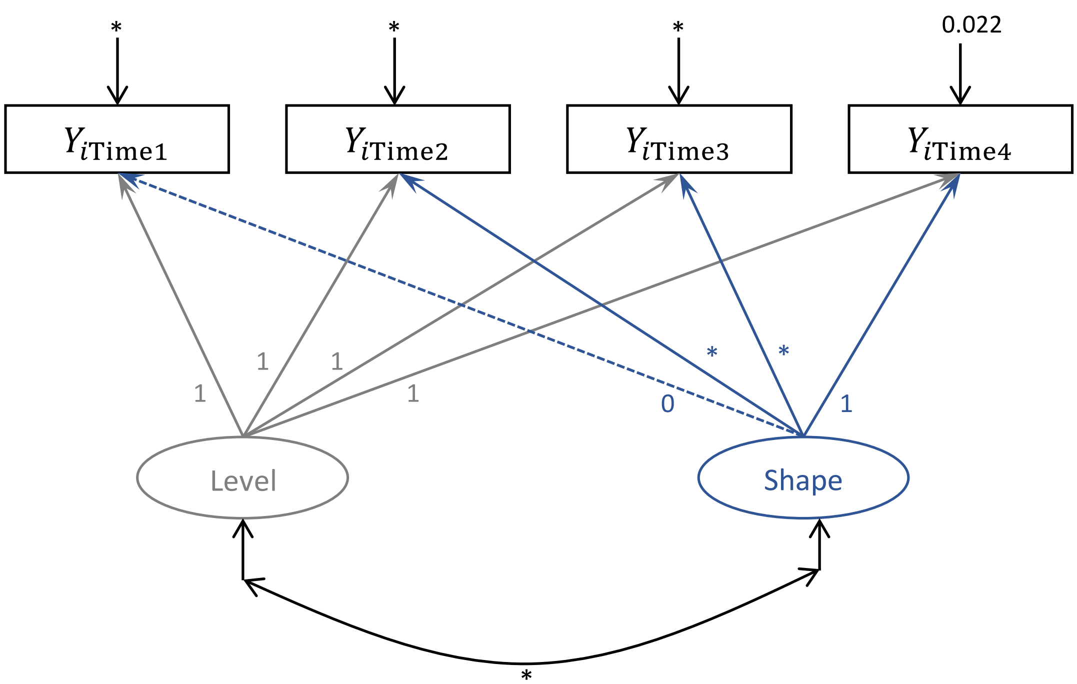

Figure 4.2. The freely estimated growth model.

Table 4.7

R1: Fit Estimates of The No Growth and the Freely Estimated Growth Models

Model Comparison R1	Chi-square (*df*)	*p*	CFI	TLI	RMSEA
Model R.A: No growth	97.50 (6)	< .01	.909	.909	.197
Model R.B: Free growth	39.41 (6)	< .01	.965	.947	.150

Note. CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation.

Table 4.8

R1: Chi-square Difference Test of the No Growth and the Freely Estimated Growth Models

Model Comparison R1	AIC	BIC	Chi-square	*df*	*p*	Decision
Model R.A: No growth	1187.33	1219.10				Reject
Model R.B: Free growth	1133.23	1172.95	58.09	2	< .01	Retain

Note. AIC = Akaike information criterion, and BIC = Bayesian information criterion.

Model R.B (the freely estimated growth model) fit the data well and was a statistically significant improvement over Model R.A (the no growth model) based on the chi-square difference test and the lower AIC and BIC values (where lower is better). This first model comparison rejected the null hypothesis of no growth, suggesting that there was some growth. Therefore, I rejected Model R.A and retained Model R.B for the next comparison.

Model comparison R2: Free growth pretests versus flat pretests. To investigate any effects maturation or testing, I created Model R.C (Figure 4.3), a flat pretest model (i.e., 0, 0, *, 1), to examine if there was any change in scores in between Time Point 1 and Time Point 2. If Model R.B (the free growth model) were to fit the data better than Model R.C, it would suggest that there was a change in scores before the start of the intervention, which could indicate a maturation or testing effect. If there is no statistically significant improvement by adding this one constraint to the model (i.e., imposing zero shape at Time Point 2), Model R.C would be retained as the better model. The results are presented in Tables 4.9 and 4.10.

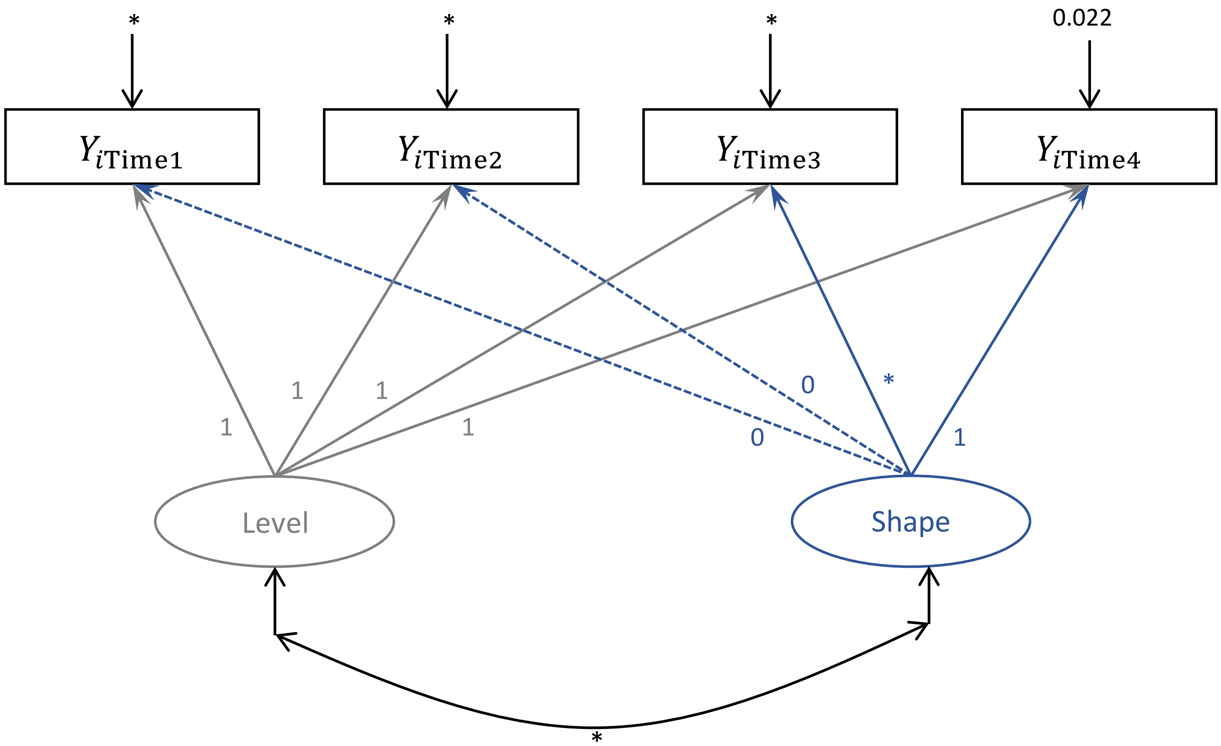

Figure 4.3. Model R.C: The flat pretests model, with post-intervention growth freely estimated.

Table 4.9

R2: Fit Estimates of the Free Growth Pretests and the Flat Pretests Models

Model Comparison R2	Chi-square (*df*)	*p*	CFI	TLI	RMSEA
Model R.B: Free growth pretests	39.41 (6)	< .01	.965	.947	.150
Model R.C: Flat pretests	39.94 (5)	< .01	.965	.958	.134

Note. CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation.

Table 4.10

R2: Chi-square Difference Test of the Free Growth Pretests and the Flat Pretests Models

Model Comparison R2	AIC	BIC	Chi-square	*df*	*p*	Decision
Model R.B: Free growth pretests	1133.2	1173.0				Reject
Model R.C: Flat pretests	1131.8	1167.5	0.530	1	.467	Retain

Note. AIC = Akaike information criterion, and BIC = Bayesian information criterion.

This second model comparison suggested that the flat pretest model was a better for the data. Therefore, I rejected Model R.B, the free growth model, and retained Model R.C for the next comparison.

Model comparison R3: Flat pretests versus flat pretests with zero level–shape interaction. Model R.C (the flat pretests model) permitted growth from Time Point 2 to Time Point 3. To determine whether that growth depended on the students' levels on the pre-tests, I compared the flat pretest model with Model R.D, a flat pretests model (Figure 4.4) that constrained the interaction (or covariance) between the level and shapes to be zero.

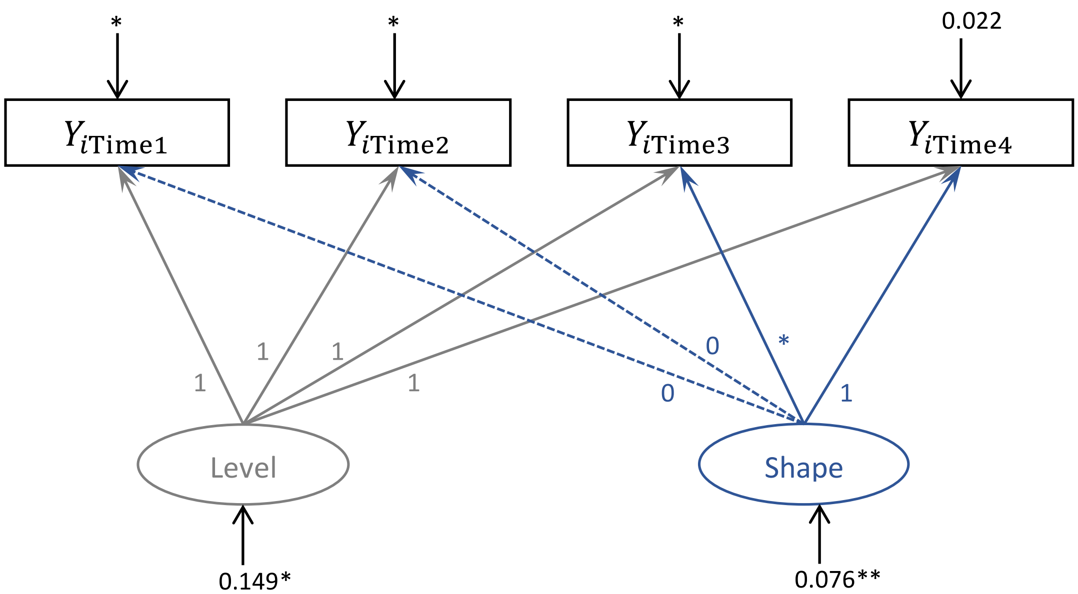

Figure 4.4. Model R.D: The flat pretests with zero level-shape interaction.
$^{**}p < 0.01$.

Model R.D permits one more degree of freedom. If this extra constraint is not statistically significantly worse than Model R.C (the flat pretests model), I would retain this more parsimonious model. The benefit of this would be that any detected change could be attributed to time rather than to the level of regulation the students had upon arrival in the class (i.e., prior to the intervention). The results are presented in Tables 4.11 and 4.12.

Table 4.11

R3: Fit Estimates of the Flat Pretests and the Flat Pretests with Zero Level-Shape Interaction Models

Model Comparison R3	Chi-square (*df*)	*p*	CFI	TLI	RMSEA
Model R.C: Flat pretests	39.94 (5)	< .01	.965	.958	.134
Model R.D: Flat pretests with zero level-shape interaction	40.04	< .01	.966	.966	.120

Note. CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation.

Table 4.12

R3: Chi-square Difference Test of the Flat Pretests and the Flat Pretests with Zero Level-Shape Interaction Models

Model Comparison R3	AIC	BIC	Chi-square	*df*	*p*	Decision
Model R.C: Flat pretests	1131.76	1167.51				Reject
Model R.D: Flat pretests with zero level-shape interaction	1129.86	1161.63	0.10	1	.754	Retain

Note. AIC = Akaike information criterion, and BIC = Bayesian information criterion.

This third model comparison suggested that the flat pretests with zero level-shape interaction was a better fit to the data. Therefore, I rejected Model R.C, the flat pretests model, and retained Model R.D, for the next comparison.

Model comparison R4: Flat pretests with zero level-shape interaction versus piecewise. To answer Research Question 1, which asked about the extent to which metacognitive pedagogy would improve students' self-reported use of metacognitive strategies, I created Model R.E, a piecewise model to statistically test the growth from Time 2 to Time 3 and from Time 3 to Time 4 (Figure 4.5). Model R.E has two shapes, where Shape 1 is (0, 0, 1, 1), which tests the difference from Time 2 to 3 and Shape 2 is (0, 0, 0, 1) which tests the additional change from Time 3 to Time 4. Tables 4.13 and 4.14 presents the results.

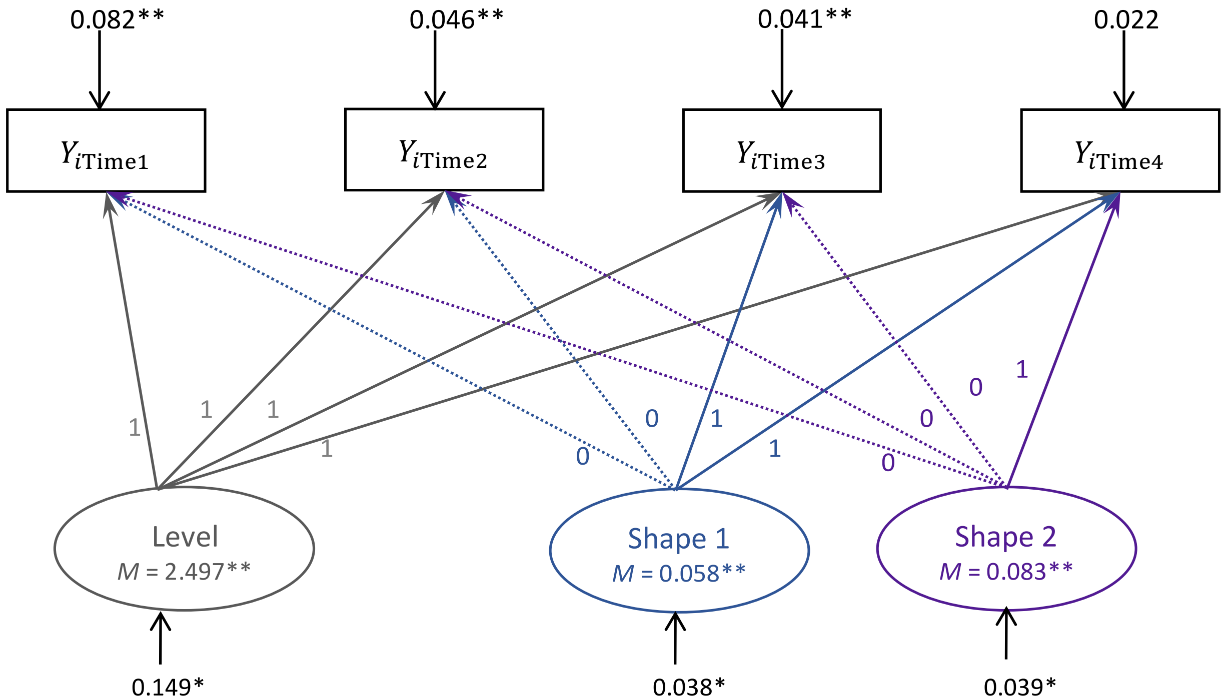

Figure 4.5. Model R.E: The piecewise model used to address Research Question 1 for regulation. $^{**}p < 0.01$.

Table 4.13

R4: Fit Estimates of the Piecewise and Flat Pretests with Zero Level-Shape Interaction Models

Model Comparison R4	Chi-square (*df*)	*p*	CFI	TLI	RMSEA
Model R.D: Flat pretests with zero level-shape interaction	40.04	< .01	.966	.966	.120
Model R.E: Piecewise	39.51 (5)	< .01	.966	.959	.133

Note. CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation.

Table 4.14

R4: Chi-square Difference Test of the Piecewise and the Flat Pretests with Zero Level-Shape Interaction Models

Model Comparison R4	AIC	BIC	Chi-square	*df*	*p*	Decision
Model R.D: Flat pretests with zero level-shape interaction	1129.86	1161.63				Reject
Model R.E: Piecewise	1131.34	1167.08	0.519	1	.471	Retain

Note. AIC = Akaike information criterion, and BIC = Bayesian information criterion.

This fourth model comparison suggested that the piecewise model was a better fit for the data. Therefore, I rejected Model R.D, the flat pretests with zero level-shape interaction and retained Model R.E, to address Research Question 1 for regulation.

Results to address Research Question 1 with regulation. The mean estimated change in Slope 1, which represents the change between Time Points 2 to 3, was positive and statistically significant. The estimate was 0.058 units on the factor-score scale, with a standard error of 0.017, resulting in a z-value of 3.48 ($p < .01$). In terms of the scale, however, the effect was weak; the 0.058 gain in factor-score units, which had the same possible range as the 0-to-4 Likert-type scales, was roughly the same as a 6% gain from one scale point to the next. The variance of the intercept was 0.149, and the standard deviation of the intercept ($\sqrt{0.149}$) was 0.386. Thus, the effect size of the immediate change from the pretests baseline to Time Point 3 was small, with Cohen's $d = 0.058/0.386 = 0.15$.

To further investigate the effects of the treatment, I examined the mean estimated change in Slope 2, which was 0.083. The mean estimated change in Slope 2 was higher compared to the change in Slope 1. This indicates that students' self-reports of regulation of cognition increased more later in the study (between Weeks 11–15) in comparison to right after the intervention (in the end of Week 15). The effect of the treatment by the end of the study, from Time Point 2 to Time Point 4, was 0.058 + 0.083 = 0.141, or about 14% of a gain in the Likert-type scale. When divided by the standard deviation of the intercept (0.386), this resulted in an effect size of Cohen's $d = 0.36$. Table 4.15 presents the statistics. Figure 4.6 displays the plot of the observed regulation scores, as calculated from the scalar invariant model described in Chapter 3, across the four time points. This shows the zero pre-intervention slope and that there was growth after the intervention, which was found to be statistically significant and of moderate effect size overall.

Table 4.15

Estimated Means of the Latent Factors in the Piecewise Model to Address Research Question 1 with Regulation

Factor	*Estimate*	*SE*	*z*	*p*	*LB*	*UB*
Level	2.497	0.021	116.95	< .01	2.455	2.539
Shape 1	0.058	0.017	3.483	< .01	0.025	0.090
Shape 2	0.083	0.016	5.140	< .01	0.051	0.114

Note. *LB* and *UB* are lower bound and upper bound of the 95% confidence interval.

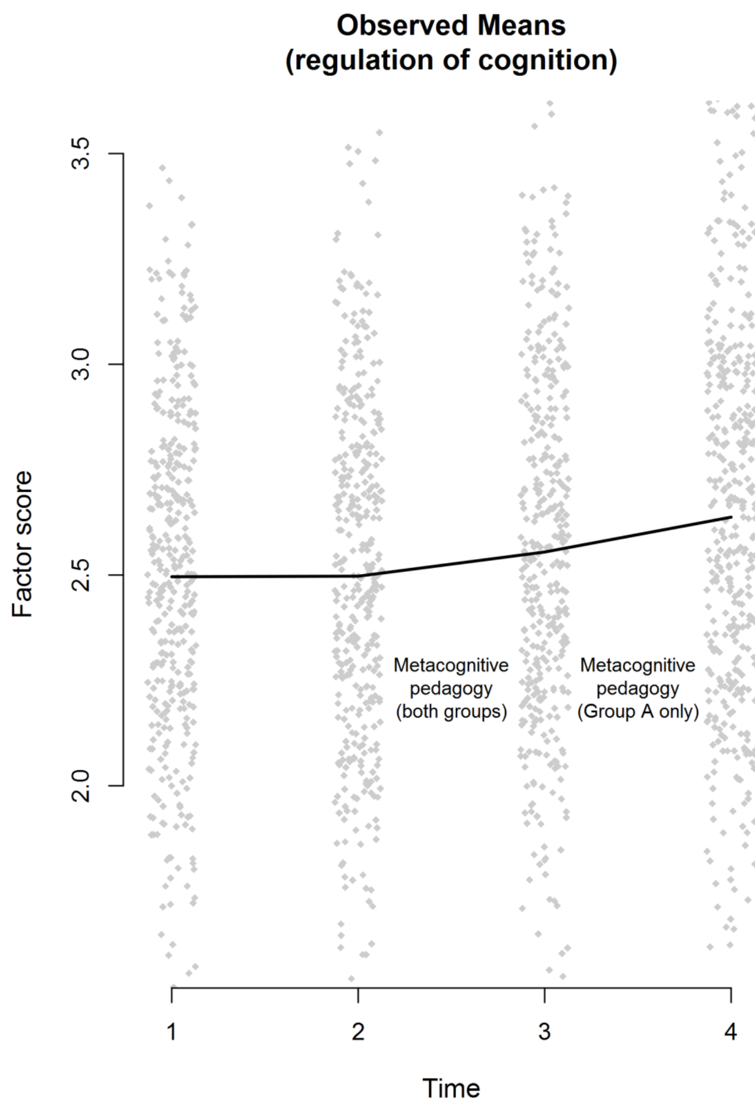

Figure 4.6. Plot of observed regulation scores.

Model comparison R5: Piecewise model with group. To answer Research Question 2, which asked about the extent to which students' self-reported use of metacognitive strategies is enhanced by greater exposure to metacognitive pedagogy, I added the group variable to the piecewise model to test whether group was a statistically significant predictor of the second shape (Figure 4.7).

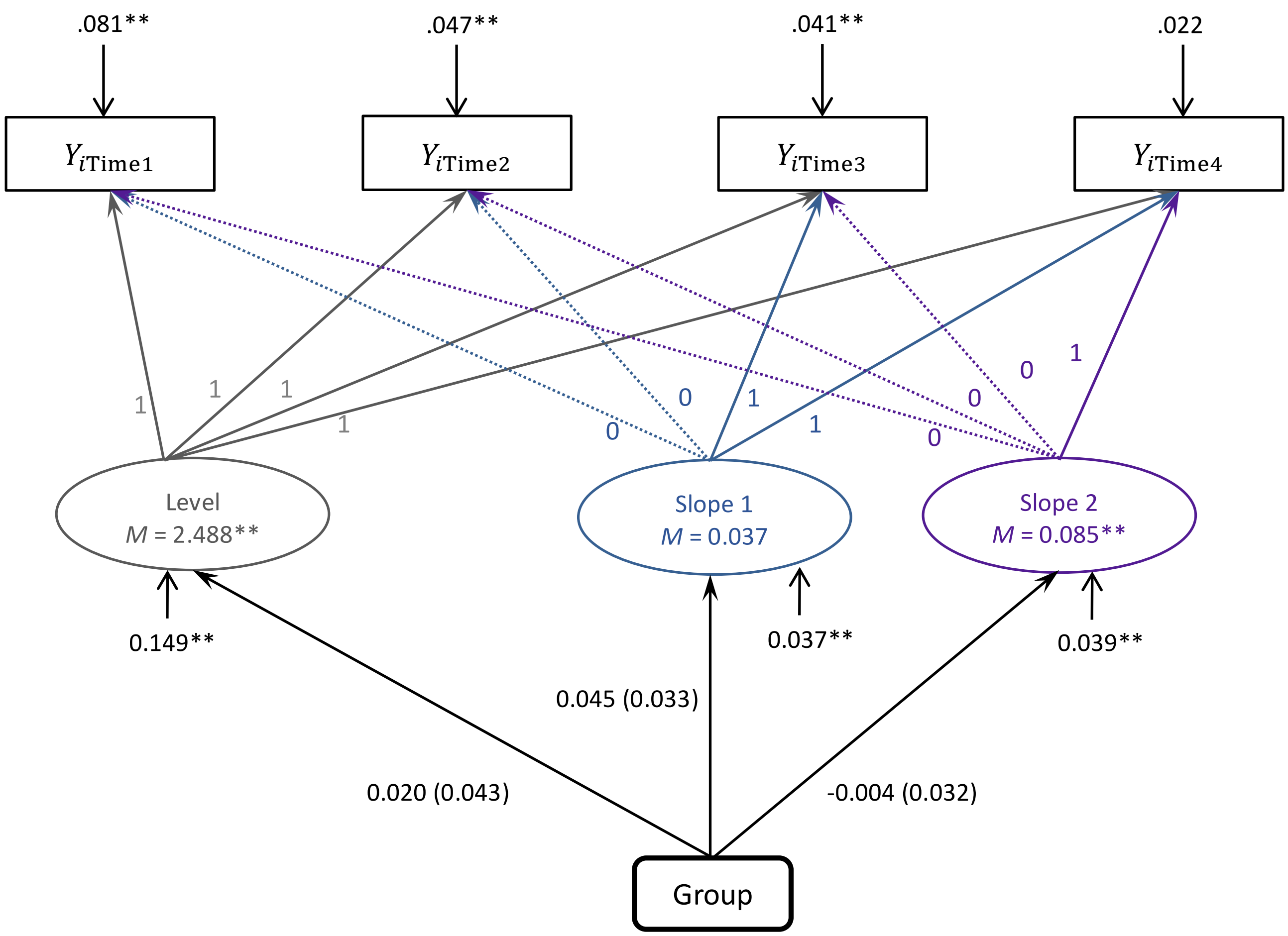

Figure 4.7. Model R.F: The piecewise model with group added to address Research Question 2 with regulation. Shape 1 estimates the growth from Time 2 to Time 3 and Shape 2 estimates the growth from Time 3 to Time 4. The effect of group membership on Shape 2 was close to zero, with a large standard error and no statistical significance.
**$p < 0.01$.

Results to address Research Question 2 with regulation. I had hypothesized that more exposure to metacognitive pedagogy would result in students reporting a more frequent use of metacognitive strategies in their learning, as consistent with Winston, Van Der Vleuten, and Scherpbier (2010). However, the results did not support this as there was no evidence showing that more exposure lead to more frequent strategy use. The students in both groups experienced a similar growth trajectory despite being exposed to a different amount of the treatment. Students in Group A received ten weeks of metacognitive pedagogy whereas students in Group B only received five weeks of metacognitive pedagogy.

Table 4.16 displays the statistical tests. The confidence interval and *p*-value of group on Shape 2 provide no evidence to suggest that being in the group with more exposure had any effect on self-reported regulation. This near-zero effect is also evidenced in the descriptive statistics (Tables 4.2 and 4.3), which are represented in Figure 4.8. The two groups' slopes from Time Point 3 to 4 are nearly parallel with each other. If there had been an effect due to more exposure, the slope of Group A would have been steeper than that of Group B.

Table 4.16

Estimates of the Flat Pretests and the Flat Pretests with Zero Level-Shape Interaction Models

Interaction	*Estimate*	*SE*	*z*	*p*	*LB*	*UB*
Group by level	0.032	0.042	0.770	0.441	-0.050	0.114
Group by Shape 2	0.013	0.030	0.429	0.668	-0.046	0.071

Note. LB and *UB* are lower bound and upper bound of the 95% confidence interval.

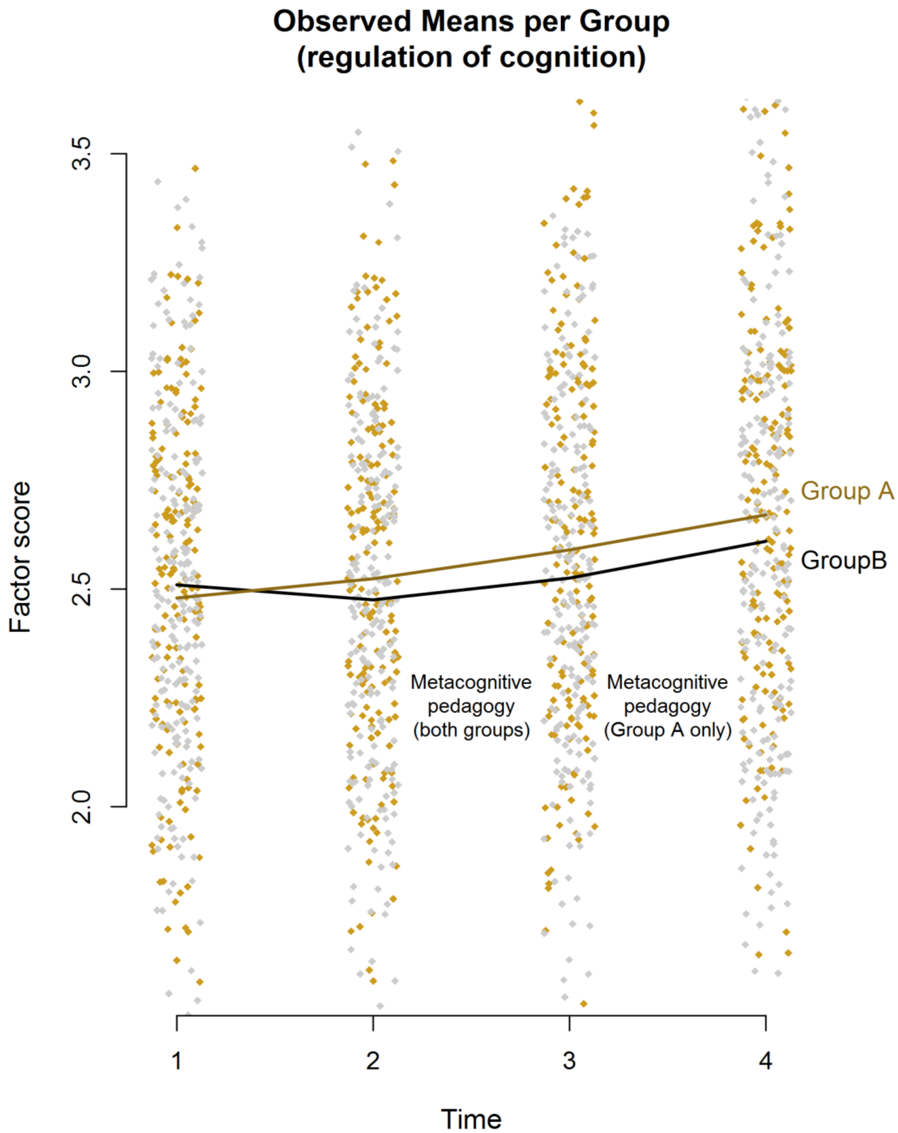

Figure 4.8. Plot of observed regulation scores for both groups.

LGC Model Comparisons of the Knowledge Scores

The knowledge scores were composed of students' responses to the 8-items on the MAI as defined by Harrison and Vallin (2018). I used the students' knowledge scores from each of the four time points and followed the same sequence of LGC model analysis as I had done with the regulation scores. I label the model comparisons with a K (for knowledge) and a number to indicate the sequence of model comparisons; there are three model comparisons, K1 through K3.

Model comparison K1: No growth versus freely estimated growth. To start the analysis of the knowledge scores, I compared Model K.A, the no growth model, with Model K.B, the free growth model, to determine which model would be a better fit for the data. The results, are presented in Tables 4.17 and 4.18.

Table 4.17

K1: Fit Estimates of the No Growth and the Freely Estimated Growth Models

Model Comparison K1	Chi-square (*df*)	*p*	CFI	TLI	RMSEA
Model K.A: No growth	218.57 (9)	< .01	.810	.873	.244
Model K.B: Free growth	35.90 (4)	< .01	.971	.957	.143

Note. CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation.

Table 4.18

K1: Chi-square Difference Test of the No Growth and the Freely Estimated Growth Models

Model Comparison K1	AIC	BIC	Chi-square	*df*	*p*	Decision
Model K.A: No growth	1128.51	1148.36				Reject
Model K.B: Free growth	955.84	995.55	182.67	5	< .01	Retain

Note. AIC = Akaike information criterion, and BIC = Bayesian information criterion.

This first model comparison rejected the null hypothesis of no growth, suggesting that there was some growth. Therefore, I rejected Model K.A and retained Model K.B, the free growth model for the next comparison.

Model comparison K2: Free growth pretests versus flat pretests. To investigate any effects of testing or maturation, I used Model K.C, the flat pretest model to determine if there was any change in scores in between Time Point 1 and Time Point 2. If Model K.B, the free growth model (Figure 4.2) fits the data better than Model K.C, it would suggest that there was a change in scores before the intervention, which could indicate a possible maturation or testing effect. The results are presented in Tables 4.19 and 4.20.

Table 4.19

K2: Fit Estimates of the Free Growth Pretests and the Flat Pretests Models

Model Comparison K2	Chi-square (*df*)	*p*	CFI	TLI	RMSEA
Model K.B: Free growth pretests	35.90 (4)	< .01	.971	.957	.143
Model K.C: Flat pretests	51.59 (5)	< .01	.958	.949	.154

Note. CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation.

Table 4.20

K2: Chi-square Difference Test of the Free Growth Pretests and the Flat Pretests Models

Model Comparison K2	AIC	BIC	Chi-square	*df*	*p*	Decision
Model K.B: Free growth pretests	955.84	995.55				Retain
Model K.C: Flat pretests	969.53	1005.27	15.69	1	< .01	Reject

Note. AIC = Akaike information criterion, and BIC = Bayesian information criterion.

The results indicate that there was a change in scores between Time Point 1 and Time Point 2, and therefore effects of maturation or testing cannot be ruled out. I therefore retained Model K.B, the free growth model, and rejected Model K.C, the flat pretest model.

Model comparison K3: Free growth pretests versus linear growth. To further investigate the trajectory of this growth trend that started pre-intervention, I examined whether the data fit a linear model. Model K.F, a linear model, specifies the growth to be the same across each time point transition (i.e., 0, 1, 2, 3). If this model were to fit the data better than the free growth model, it would suggest, under the assumption that maturation and testing effects remain constant over time, that the effects from the maturation or testing could not be disentangled from any effects of the treatment. Tables 4.21 and 4.22 presents the results. The results suggest that the linear growth model should not be retained. The next step is to examine a piecewise model to understand the shape of the growth.

Table 4.21

K3: Fit Estimates of the Freely Estimated Growth and the Linear Growth Models

Model Comparison K3	Chi-square (*df*)	*p*	CFI	TLI	RMSEA
Model K.B: Free growth	35.90 (4)	< .01	.971	.957	.143
Model K.F: Linear growth	51.44 (6)	< .01	.959	.959	.139

Note. CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation.

Table 4.22

K3: Chi-square Difference Test of the Freely Estimated Growth and the Linear Growth Models

Model Comparison K3	AIC	BIC	Chi-square	*df*	*p*	Decision
Model K.B: Free growth	955.84	995.55				Retain
Model K.F: Linear growth	967.38	999.15	15.540	2	< .01	Reject

Note. AIC = Akaike information criterion, and BIC = Bayesian information criterion.

Model comparison K4: Free growth pretests versus piecewise pre-treatment. To further investigate the shape of the pre- and post-intervention growth, I examined whether the data fit a piecewise model that estimated the growth from Time Point 1 to Time Point 2 and from Time Point 2 to the average of Time Points 3 and 4. Model K.F specifies Shape Factor 1 (i.e., 0, 1, 1, 1) and Shape Factor 2 (i.e., 0, 0, 1, 1) to estimate the mean growth at these two intervals. It also specifies zero covariance among the three factors. This model fit the data better than the free growth model (Tables 4.23 and 4.24), suggesting it is more parsimonious than the free growth model and permitting me to interpret the results in terms of the effect of the growth that might be due to maturation and testing effects.

Table 4.23

K4: Fit Estimates of the Freely Estimated Growth and the Piecewise Pre-treatment Models

Model Comparison K4	Chi-square (*df*)	*p*	CFI	TLI	RMSEA
Model K.B: Free growth	35.90 (4)	< .01	.971	.957	.143
Model K.G: Piecewise pre-treatment growth	19.87 (5)	< .01	.986	.984	.087

Note. CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation.

Table 4.24

K4: Chi-square Difference Test of the Freely Estimated Growth and the Piecewise Pre-treatment Models

Model Comparison K3	AIC	BIC	Chi-square	*df*	*p*	Decision
Model K.B: Free growth	955.84	995.55				Reject
Model K.G: Piecewise pre-treatment growth	937.82	937.56	16.03	1	< .01	Retain

Note. AIC = Akaike information criterion, and BIC = Bayesian information criterion.

Results to address Research Question 1 with knowledge. The piecewise pre-treatment growth model, which modeled post-intervention growth separately from the pre-to-post intervention growth indicated that both estimates of growth were statistically significant and positive (Table 4.25 and Figure 4.9). The growth before any metacognitive instruction (0.086) was estimated to be twice that as the growth due to the metacognitive instruction (0.043).

Table 4.25

Estimated Means of the Latent Factors in the Pre-Treatment Piecewise Model

Factor	*Estimate*	*SE*	*z*	*p*	*LB*	*UB*
Level	2.640	0.022	118.383	< .01	2.596	2.683
Shape 1 (Pre-treatment)	0.086	0.015	5.911	< .01	0.058	0.115
Shape 2 (Pre- to post-treatment)	0.043	0.017	2.525	.012	0.010	0.076

Note. *LB* and *UB* are lower bound and upper bound of the 95% confidence interval.

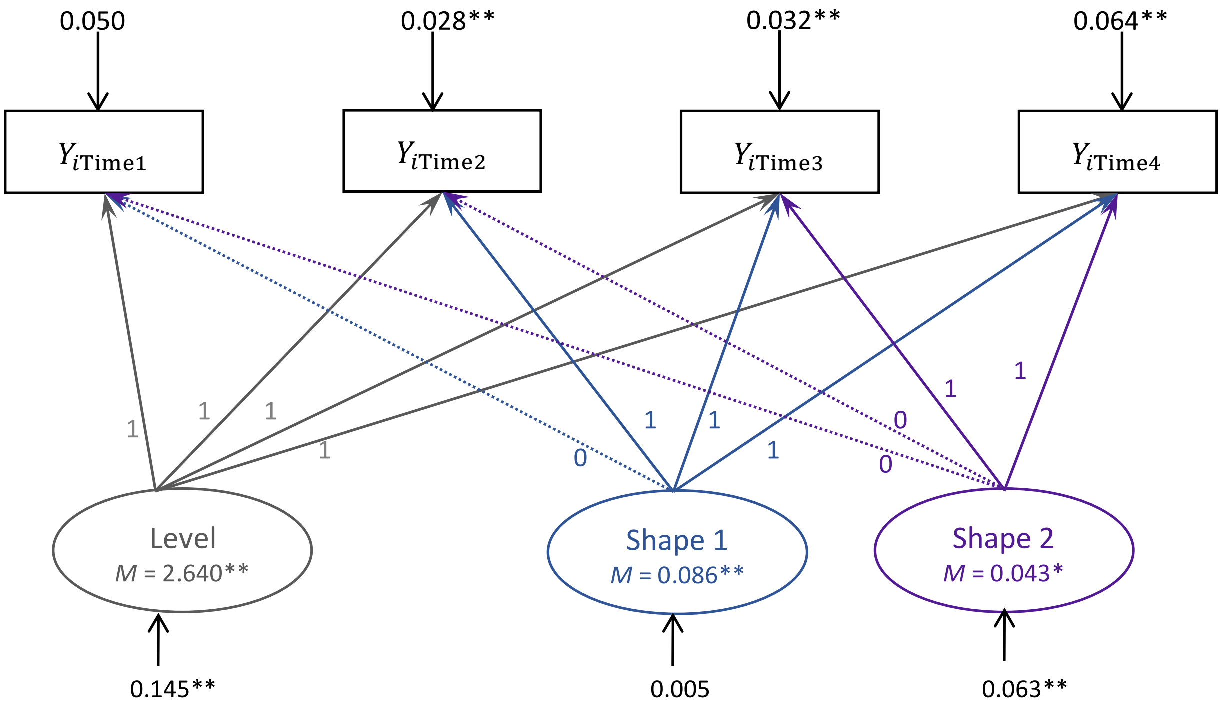

Figure 4.9. Model K.G: The piecewise model with pre-intervention and pre-to-post-intervention growth for knowledge. The mean of Shape 1 represents the growth that occurred before any metacognitive pedagogy was introduced. The mean of Shape 2 represents the growth from before to after the pedagogy.
$*p < 0.05$
$**p < 0.01$

Because maturation and testing effects can continue across the time points, and because the growth due to treatment was lower than the growth occurring before the treatment, there is arguably no additional effect that can be explained by the treatment. Therefore, with regard to Research Question 1, which asked about the extent to which metacognitive pedagogy improves students' self-reported knowledge of their cognition, there was no evidence to reject the null hypothesis of zero effect. The descriptive statistics (Table 4.4) and the plot of the mean knowledge scores time (Figure 4.10) are consistent with this result. Most of the observed growth clearly occurred between Time Points 1 and 2, before any metacognitive pedagogy was introduced. Because the piecewise model fit best and the observed trend suggested lower post-intervention growth, I decided to not investigate the effect size, since it would be impossible to disentangle any effects of the treatment from effects of maturation or testing.

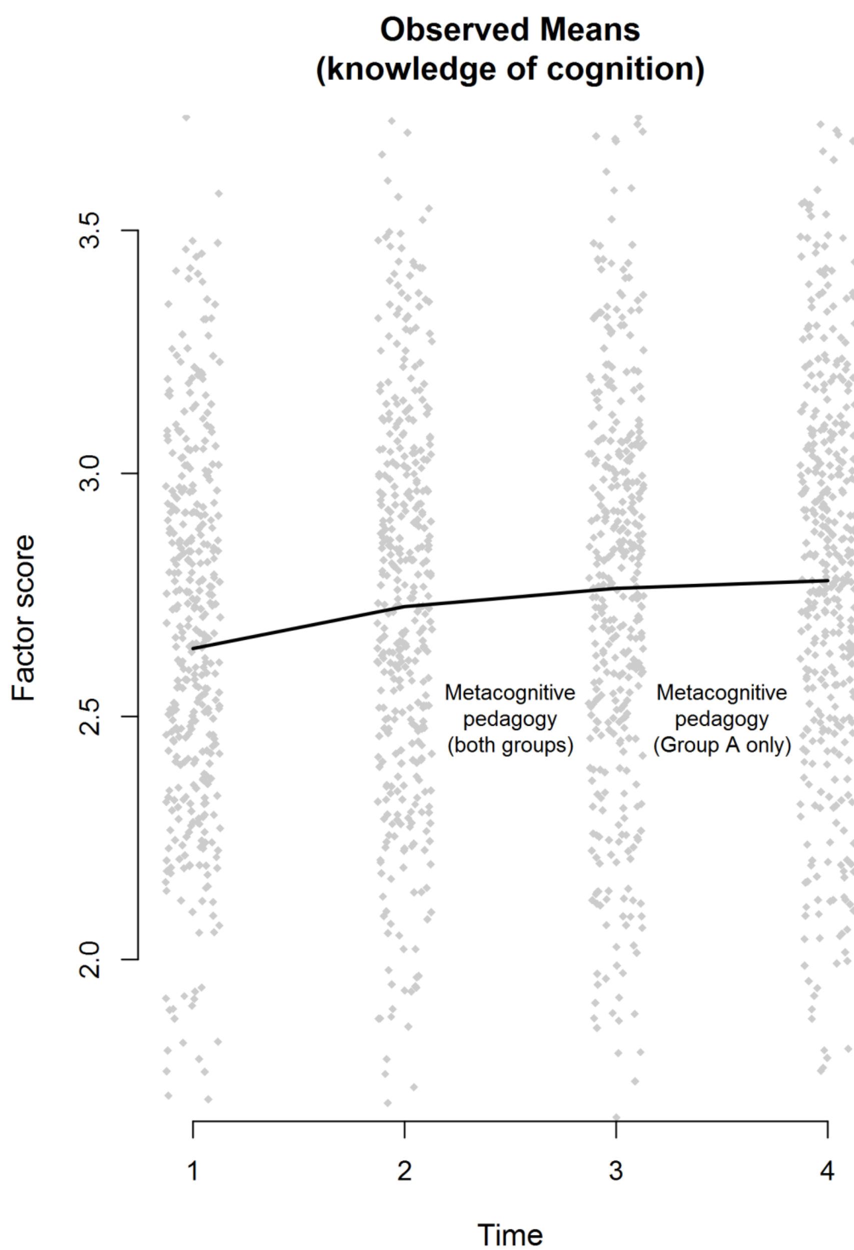

Figure 4.10. Plot of observed knowledge scores.

Results to address Research Question 2 with knowledge. I had hypothesized that more exposure to metacognitive pedagogy would result in students reporting higher levels on their metacognitive knowledge. However, the results did not support this. Figure 4.11 and Tables 4.5 and 4.6 show that Group A worsened in knowledge scores from Time Point 3 to 4 (from 2.79 to 2.78) compared to Group B (from 2.74 to 2.78). Therefore, it is safe to conclude that the extra exposure to metacognitive pedagogy did not result in any increase in knowledge.

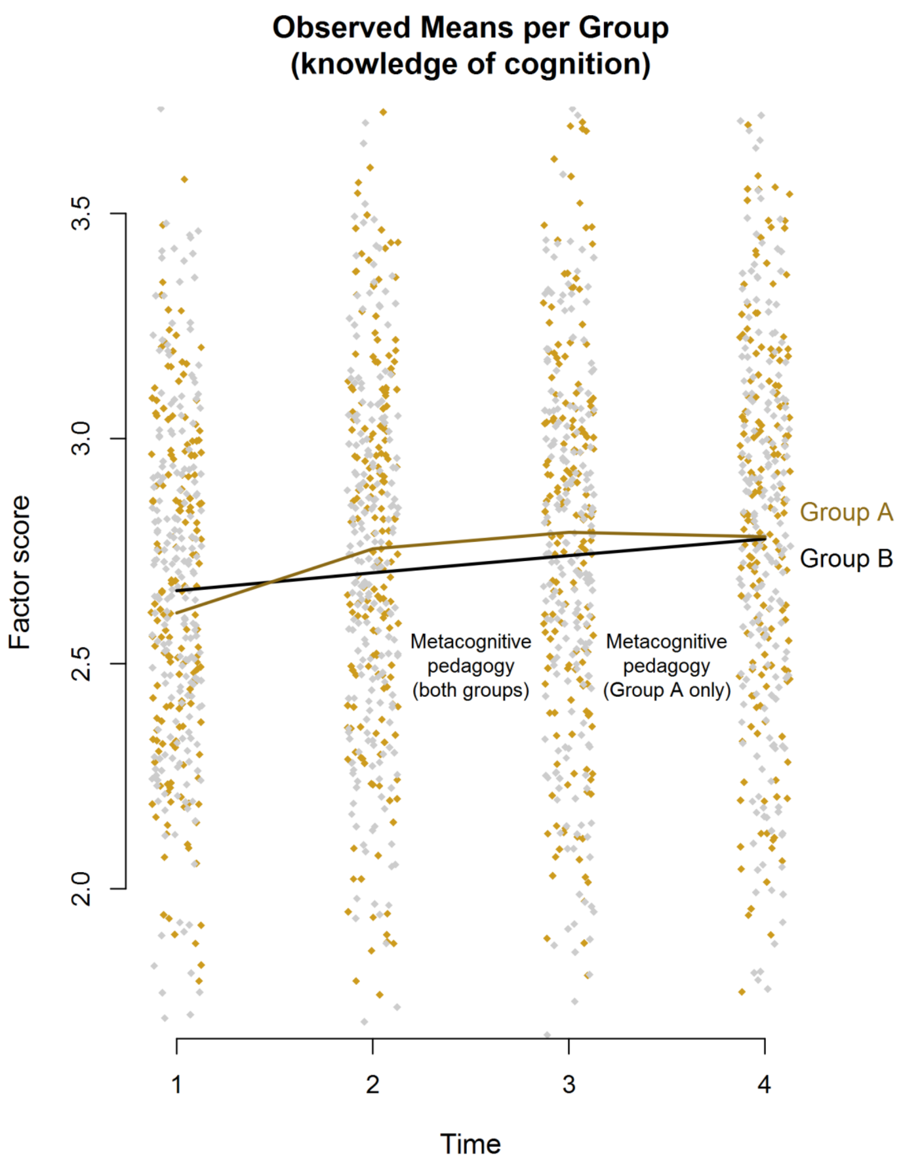

Figure 4.11. Plot of observed knowledge scores for both groups.

CHAPTER 5

DISCUSSION

The purpose of this study was to investigate the effects of metacognitive pedagogy on students' self-reported use of metacognitive strategies in their learning. The immediate focus of the study was to improve students' metacognition, which has the potential to, in turn, improve students' critical thinking. The study results suggest that metacognitive pedagogy has a positive effect on students' regulation of cognition but no effect on students' knowledge about cognition. The results also show that more exposure to metacognitive pedagogy did not seem to have an effect on students' self-reported use of metacognitive strategies. These results provide useful information for researchers and teachers who are interested in pedagogical aspects of teaching metacognition as a means to improve students' metacognitive skills and abilities. Moreover, the results yield important details about the type of pedagogy and metacognitive strategies used to positively affect students' regulation of cognition.

Effects of Metacognitive Pedagogy

The first research question called for an investigation into the effects of metacognitive pedagogy on students' self-reported use of metacognitive strategies. In other words, if metacognition was integrated into the course content, and metacognitive strategies were modeled by the teacher and utilized in class assignments, would this have an effect on the students' use of metacognitive strategies in their learning? Guided by existing research (Fink, 2013; Hattie, 2009, 2015; Wilen & Philips, 1995), the findings of the study suggest that it is possible to integrate metacognitive pedagogy into an existing 16-week college-level course, and have positive effects on students' use of metacognitive strategies in their learning, insofar as their self-reports reflect their actual use. Though the intent was to improve both knowledge about cognition and regulation of cognition, students' knowledge about cognition did not improve as a result of the metacognitive pedagogy.

The results from the latent growth curve (LGC) modeling analysis did not support the hypothesis that metacognitive pedagogy had an effect on students' knowledge about cognition. Most of the growth in the students' knowledge scores occurred between Time Point 1 and 2, before any metacognitive pedagogy had been introduced (Figure 4.10). Moreover, the results also did not support the hypothesis that more exposure to the metacognitive pedagogy would result in higher gains in knowledge about cognition. Students in Group A, who received ten weeks of metacognitive pedagogy, slightly improved in their scores between Time Point 2 and 3, but their scores declined between Time Point 3 and 4. In contrast, students in Group B, who received five weeks of metacognitive pedagogy increased in their scores between Time Point 2 and 3, and then again between Time Point 3 and 4 (Figure 4.11).

Though it was disappointing to find out that the metacognitive pedagogy did not have an effect on students' knowledge about cognition, it was also not surprising. Knowledge about cognition is a complex construct, which makes measurement a challenge. It is difficult to develop measurements that accurately assess knowledge of cognition (Ozturk, 2017). On-line instruments, for example interviews or computer simulations, have been used to measure knowledge about cognition as it is happening in real time (Saraç & Karakelle, 2017; Veenman, Van Hout-Wolters, & Afflerbach, 2006). However, when attempting to tap into knowledge about cognition, the natural process is interrupted as the participant is prompted to reveal their immediate thinking about cognition, and this non-authentic interruption may affect the accuracy of the measure. Moreover, reporting about the knowledge of cognition in an off-line instrument, such as in a survey, is also a challenging task as the participant is prompted to retrieve a memory that is reflective of knowledge about cognition that was used in a specific learning context that happened in the past. Despite questions such as these about the accuracy of measures, assessment about metacognition is worthwhile, as it has the potential to provide diagnostic information that can be used to inform educational initiatives and pedagogical practices.

A second challenge in researching effects on knowledge about cognition was addressed in Chapter 3. This had to do with the difficulty in developing pedagogical practices and learning assignments that help improve students' knowledge about cognition. I struggled with how to create explicit learning about something so abstract; to be reflective of thinking while learning. Therefore, the metacognitive pedagogy focused firstly on regulation of cognition, the behavioral aspects involving different learning strategies, and knowledge about cognition was taught in addition to these more concrete strategies. Teaching about the regulation of cognition was much more feasible for both teaching and learning, thus the positive effects metacognitive pedagogy seemed to have on students' regulation of cognition is promising.

Knowledge about cognition. According to Flavell (1979), knowledge about cognition precedes regulation of cognition. This seems logical; to regulate cognition, you first need to know about cognition. Knowledge about cognition is being activated during the process of completing a task, so this became a challenging task to teach. Though I did define knowledge about cognition and gave explicit examples of the three subcomponents, declarative, conditional, and procedural knowledge in both instruction and in assignments, this component was always taught in conjunction with regulation of cognition. During instruction, I reminded the students of the importance of being mindful when studying. In class during various class activities, as well as in some of their take-home assignments, students were prompted to reflect on the progress of their learning. However, being prompted to reflect on past learning is not equivalent to reflecting on learning as it is occurring in real-time. This predicament is something researchers have labored over extensively (Ozturk, 2017; Peteranetz, 2018; Saraç & Karakelle, 2017; Veenman, Van Hout-Wolters, & Afflerbach, 2006). The lack of effect of metacognitive pedagogy on students' knowledge about cognition warrants further research into this area.

Regulation of cognition. The results from the LGC modeling analysis suggest that the metacognitive pedagogy had a positive effect on students' regulation of their cognition. From Time Point 2 to Time Point 3, the mean estimated change in Slope 1 was about a 6% gain from one Likert-type scale to the next, and from Time Point 3 to Time Point 4 the mean estimated change in Slope 2 was about an 8% gain; both were statistically significant, indicating that students improved in their use of regulation of cognition beyond the amount they would improve by chance. The effects size, however, was not strong; Cohen's d was estimated as 0.36. According to Hattie's criteria, influences with an effect size less than 0.40 are not as successful in improving learning compared to influences with an effect size greater than 0.40 (Hattie, 2009, 2015). Though the total effect size for this study was, $d = 0.36$ which is slightly below Hattie's suggested cutoff of $d = 0.40$, several of the strategies taught in this study, such as concept mapping and study skills have been found to be associated with higher effect sizes, $d = 0.63$, and $d = 0.60$ respectively (Hattie, Gurung, & Landrum, 2015). I am not sure why the effect size of the current study showed a lower Cohen's d in comparison to the effect sizes of similar treatments reported by Hattie (2015). Perhaps the outcomes of this study would have shown a greater effect had I measured students' regulation of cognition over more time points. Because there was a greater change in the students' regulation scores between Time Points 3 and 4 in comparison to the change between Time Points 2 and 3, perhaps the change in scores would have continued to increase at Time Points 5 and 6. As indicated by the results from this study, there seems to be a delayed effect of metacognitive pedagogy on students' use of metacognitive strategies, therefore, future research could benefit from observing possible effects for a longer time after the initial treatment.

When integrating the regulatory aspects of metacognition into the course-content, I had to develop several new class activities and assignments. This process offered me new perspectives of how to teach some of the content and I believe it significantly enhanced my teaching. For example, in previous courses in which I had taught the human hypothalamic–pituitary–gonadal axis (HPGA) I had relied heavily on lecturing that included a short class activity in form of a worksheet. Utilizing metacognitive pedagogy, in the present study I started this section with a lecture, but instead of just using the worksheet, I modeled the making of a concept map. While creating the concept map in class in front of the students, I was able to verbally and visually highlight essential parts of HPGA, which I had previously hoped students would learn on their own when completing the worksheet. Also, when drawing the concept map, I noticed that several students began to draw their own concept maps as they were taking notes, thus modeling this useful metacognitive strategy.

I had a similar positive experience when integrating metacognitive pedagogy into another part of the content that covers sexual violence and abuse. This section is controversial in several ways, especially since many of the students have experienced some form of sexual abuse. Thus, this learning can be triggering and, at times, can hinder participation. Being mindful about the delicate aspects of this section, I invited guest speakers to come to class who were professionally trained and who worked with students who have experienced sexual violence and abuse. As a part of their talk they shared five definitions of sexual violence; stalking, sexual harassment, sexual assault, domestic violence, and rape. In past courses with this activity, students had been expected to learn these definitions by absorbing the information from the guest speakers and from the textbook. However, by integrating metacognitive pedagogy into this section, I developed an activity that created an opportunity for students to actively participate in class. Students were asked to form groups and were tasked with defining each of the five definitions of sexual abuse provided by the guest speakers. To model the expectations for this class activity, I had written a scenario that described stalking as an example. Reviewing their lecture notes and their textbook, they first summarized key points about each definition, and then, in collaboration, they wrote thoughtful scenarios describing stalking, sexual harassment, sexual assault, domestic violence, and rape using their own words. During this class activity, I experienced the atmosphere in class to be humble and respectful, and the students seemed engaged with the learning while creating. They worked together to write up the scenarios that defined the terms. There is often a lot of stigma, guilt, and shame surrounding sexual violence and abuse, and I believe that this class activity helped students engage despite these emotional barriers. By giving the students an explicit task and instructions about how to engage with the material, I was hoping that this metacognitive strategy of summarizing key points contributed to a more meaningful learning about this challenging topic of sexual violence and abuse.

Though the results indicate a moderate change in students' self-reported use of metacognitive strategies, the process of integrating metacognitive pedagogy into the course-content offered me several possibilities to carefully reflect on my teaching practices, something I felt invigorated my teaching. It was refreshing to review the content and my existing teaching practices, and reflect on how I could improve the teaching and learning. Prior to integrating metacognition into the course-content I had worried about having to cut significant portions of the content to accommodate teaching about metacognition, but found that my worries were unfounded. Though I certainly had to make some changes to my existing teaching practices, I found that by integrating metacognition I was able to teach the content more efficiently, and so in the end I believe that I gained in effective learning what I had cut out in content. Moreover, the results of this study showed that there was essentially no difference between groups in terms of students' regulation of cognition, thus suggesting that five weeks of metacognitive pedagogy is sufficient to see an improvement in students' use of metacognitive strategies.

Limitations

A limitation in this study was the lack of random selection of participants into the study and the lack of random assignment to groups. In a true experimental study, the random selection and assignment of participants into groups ensures that the participants in the study reflect true representation of the larger population (Shadish, Cook, & Campbell, 2002). Though students were not recruited to the study, they were also not randomly assigned to the two groups. Therefore, the findings in this study should not be taken out of context as they are reflective of a specific population, students enrolled at larger public university.

A second limitation in this study is revealed by the slight change in students' regulation scores on the two pretests (Figure 4.8). Students' observed regulation scores in Group A improved by 0.04 units of a factor score (Pretest 1 $M = 2.48$ and Pretest 2 $M = 2.52$). In contrast, students' regulation scores in Group B declined by 0.03 units of a factor score (Pretest 1 M =2.51 and Pretest 2 $M = 2.48$). The slightly low test-retest reliability confirms this delimitation. It is possible that this change in pre-treatment scores might have been related to some kind of maturation or testing effect, but that overall there was a washout. The mean for all students on both Pretest 1 and on Pretest 2 was $M = 2.50$.

A third limitation to this study was a possible interaction effect of the repeated testing, which posed a threat to external validity (Shadish, Cook, & Campbell, 2002). Repeatedly testing the students using same instrument that prompted them to reflect on metacognition may have created an awareness about metacognition, thus making them more sensitive to the treatment, which in turn may have influenced their scores. In other words, although the testing effect did not appear to be present in the pre-treatment time points for regulation, it may have become active after the treatment was introduced.

A fourth limitation of the study might have been related to the measurement. Because there were only four data-collection time points, I was not able to track any delayed effects due to the treatment. Perhaps improvement in metacognition, especially as it pertains to knowledge about cognition, is associated with a delayed effect, thus this growth might have been detectable later, at a Time Point 5 or a Time Point 6. Logically, it would make sense that an improvement in knowledge about cognition may result in more awareness, which in turn might result in students' rating themselves lower on the items on the MAI that asked about their use of knowledge about cognition. It is also worth noting that the accuracy of reporting one's knowledge about cognition is more challenging in comparison to reporting regulation of cognition. Therefore, it is possible that the students were not able to report an accurate assessment of themselves to the questions on the MAI that asked about their knowledge about cognition. Or perhaps the students had already developed sufficient knowledge about metacognition and just did not apply this in their learning.

A fifth limitation of the study is related to the validity threat of social desirability. When collecting the data via the MAI, I worked under the assumption that the students would provide truthful responses. However, self-report measures are often associated with social desirability, meaning that there is a tendency for participants to answer in a way that presents a favorable image of themselves. Because the participants in this study were students, I have more reason to believe that social desirability affected the accuracy of the data. Although, the data collection had been integrated into the required course expectations, and the students were not graded on their performance on the MAI, the fact that they were students who were presented repeatedly with a questionnaire that asked them about their study strategies, may have resulted in scores that included some degree of positive self-presentation in a manner that is similar to a subject-expectancy effect. However, I do not have any data that could statistically support this claim.

Related to this, a delimitation of the study was the decision to appoint myself as the instructor for the course in which the treatment was implemented. I debated this decision for quite some time, reflecting on the pros and cons of serving as both the researcher and the instructor. Arguably the biggest potential threat is the researcher expectancy effect that I may have had regarding students' responses on the MAI. That is, I may have unconsciously persuaded them to answer in a particular manner because I expected them to report an effect due to the metacognitive pedagogy. I considered an alternative, asking another instructor to implement the metacognitive pedagogy into a different course. However, this option turned out to be unreasonable due to the demanding time-commitment. The instructor would have had to be willing to first pilot test the metacognitive pedagogy, then commit to implement the metacognitive pedagogy for two consecutive semesters while I interrupted the instruction at four different time points to collect data. Therefore, the most reasonable and cost-effective option was for me to serve as the instructor. Because the metacognitive pedagogy was integrated into the course-content and the analyses of the data was done after the end of both semesters, I felt comfortable with this set-up, of serving as both the instructor and the researcher.

Lastly, although I had hoped to further explore the relationship between metacognitive pedagogy and students' critical thinking (particularly as it pertains to a sexuality studies classroom) I was not able to address this in the present study. I was, and still am, curious about if the use of metacognitive pedagogy creates avenues for students to engage in critical thinking about sexuality. Learning about sexuality can be challenging due to the controversy and taboo that surrounds the topic, and I wonder if the explicit learning strategies, such as concept mapping, summarizing key points, think alouds, mnemonics, and so forth, helped students more actively engage with learning despite the delicate content. Did these metacognitive strategies help structure the learning, thus creating a more favorable opportunity for critical thinking to occur? And if metacognitive pedagogy helped increase critical thinking about sexuality, would this contribute to a greater awareness, support, and compassion for variations in sexuality? This study was not able to address this, but in the future I hope to further investigate these important questions in the pursuit of finding evidence for using a sexuality studies classroom as a platform that contributes to social justice.

Conclusion

With the recent push from both researchers and educators to develop 21st century learners, there is a new commitment to teach about critical thinking and how to apply critical thinking to content-learning to better prepare students for life beyond the classroom. "Critical thinking skills are vital in educational settings because they allow individuals to go beyond simply retaining information, to actually gaining a more complex understanding of the information being presented to them" (Dwyer, Hogan, & Stewart, 2014). Because metacognition is an essential component of critical thinking, focusing instruction on teaching about metacognition then can provide an entry to explicitly teaching about important parts of critical thinking. The results of this study suggest, that integrating metacognitive pedagogy into course-content in as little as five weeks (out of a 16-week course) can positively influence students' regulation of cognition. The results showed no effect on students' knowledge about cognition, thus more research about effect metacognitive pedagogy is needed to further examine this relationship. Informed by the results from this study, future research can also note that metacognitive pedagogy seems to have a delayed effect on students' self-reported use of metacognitive strategies, thus it is advisable to include a sufficient number of time points to be able to analyze growth trajectories over a longer period of time. With more time points beyond the scope of the semester, researchers may find that more exposure does indeed result in higher gains in metacognition.

APPENDIX A

EXAM PREP

Our exam is up this week, so if you haven't already, it is high time to set some goals and plan your studies! In this class activity, we will focus on planning our studies by breaking it up into smaller more manageable pieces. You will reflect on your knowledge to date and note some areas you are still struggling with. You will come up with some strategies for how to study these areas effectively, and how you will monitor and evaluate your learning progress. So, within your group, discuss the following questions and complete the chart on the back of this paper.

1. First discuss what content areas you want to focus your studying on, list them.
2. What strategies will you use when you are studying these areas? List them.
3. How you will check your learning progress? List what strategies you will apply to check your level of comprehension.
4. Look at your calendar and your schedule leading up to the exam due date. Note how many hours you can dedicate to your studies, and give yourself individual deadlines for when each content area should be completed.
5. Once you have mapped out your game-plan, set some goals for your performance.
    a. By what date will you have completed the exam?
    b. What score do you hope to earn on the exam?

List content areas you will focus studying on	**List study strategies for each content area**	**How will you check your learning progress?**	**Due date for completion of content area**
Sexual anatomy	Drawings of internal and external genitalia and label each part	Search the internet for empty diagrams and complete without notes	Saturday, March 3rd (I have work on Saturday, so I can only study for 2 hours)
HPGA	Create concept maps that illustrates XX and XY HPGA	I will explain my concept maps to my roommate or via FaceTime to my sister	Sunday, March 4th
STDs	Create flash cards with key information about each disease.	First practice on my own, then ask a friend to quiz me.	Sunday, March 4th

Date and time, I will completion the exam: ________________________________

Score are I am aiming to earn: __________ out of 75 points

APPENDIX B

METACOGNITIVE PROJECT

This project is about making your learning process more explicit while preparing for the exam. The first part of this project is to plan out your studying. Next you will apply three metacognitive strategies to your learning.

The three strategies you will use in this project are, (1) a concept map, (2) mnemonics, and (3) a reflection. You need to create an individual project, but are more than welcome to work with someone or in a group as you are working on your project.

All parts except the concept map must be typed (there is no minimum number of pages, just make sure you are satisfied with your work and that you sufficiently answer all of the questions). If you wish to create your concept map by hand you need to hand it in to me in class before the due date.

Part I

Planning

Take a moment to look at your course reader and your notes, what areas do you believe you want to focus your studying on? What strategies are you planning to use when studying these areas? And by when do you hope to complete your studying? What score do you aim to earn on this exam, and how does your performance on this exam contribute to your overall course grade? (This is a part of the project so you need to submit this table with your project).

List areas of focus for studying	List strategies you are going to use when studying	How are you going to know check on your learning progress?	Target date for completion of studying
Target score for the exam (max point 75): Final letter grade you are working towards in this course:			

Part II

Concept Map

The first part of this project is to create a concept map. The purpose of a concept map is to visualize the relationships between different key concepts. You are free to create a concept map that covers any content in class. Your concept map has to include the following:

- Make sure that you include a minimum of 10 concepts in any given content area. Concepts are generally, but not always, nouns.
- Each concept has to link to at least one other concept, but should not necessarily link to all other concepts. It will not be as useful of a metacognitive tool if everything links to everything.
- Each concept needs to be linked to another using arrows and linkage words. The linkage words should form a sentence. This is the most important aspect of the concept map as these words explicitly describe the relationship between the concepts. This can be challenging, so do not be surprised if this takes some serious thinking!
- You can choose to create your map by hand or create it using a computer software. Your finished product should be visually pleasing; it should be apparent that you put some time and effort into the aesthetics, including spelling and grammar! Think about how shapes and colors can be used to enhance concepts and relationships.
- If you can fit the finished map on a regular sized paper (8.5″ by 11″) that works fine, but feel free to use a bigger format if you wish.

Mnemonics

The second part of this project is to create some useful mnemonics to help you organize and remember certain factual information. This does not have to be related to your concept map, you can choose a different content area. There are several different types of mnemonics and you will focus on three, (1) acronym, (2) acrostic, (3) catchy word or phrase. **Be sure to create one of each, 1 acronym, 1 acrostic, and 1 catchy word or phrase.**

An **acronym** is a word that is composed by using the first letter of each word you need to remember, for example, PEN = **p**roton, **e**lectron, **n**eutron, which are all parts of the atom. It can also be an abbreviation formed by initial letters, for example, Seven Up = seminiferous tubules, epididymis, vas deferens, ejaculatory ducts, (the “n” does not stand for anything, just helps to remember the word!) urethra, and penis.

Acrostics are sentences in which the first letter of each word connects the intended-to be-recalled information, for example, “Mom visits every Monday, just stays until noon” = Mercury, Venus, Earth, Jupiter, Saturn, Uranus, and Neptune.

A **catchy word or phrase**, these are often very individualistic since we may have different ideas of what we think of as catchy. You are free to create any word or phrase that helps you remember some important information. Here is an example, PETA 5D to help you remember, progesterone, estrogen, testosterone, aromatase, 5-alpa reductase and dihydrotestosterone.

Reflection

The last part of the metacognitive project is to write a reflection about your work and how you experienced the process of working with the different strategies in preparing for the exam. Take a few minutes and reflect on what you did then answer the following questions, and please make sure you explain your answer well for each question:

- **Metacognition** is about **becoming aware of your knowledge and knowing how to regulate this knowledge**, do you think these strategies were useful in helping you learn? Please explain your answer, don't simply answer yes or no.
- Do you have any previous experiences working with learning strategies, such as, concepts mapping and mnemonics? If so, please explain how you learned about them and how you use them in your learning.
- Do you have any previous experiences working with other types of metacognitive strategies? If so, please explain how you learned about them and how you use them in your learning.

In the context of the concept map:

- What do you think you did really well; what do you want to draw attention to?
- What concepts did you spend most time to link together (particular examples) and why do you think these concepts took the most time?
- How did you experience the process of creating linking words between the concepts? Please explain.
- What are some things you are less satisfied with, and why?

In the context of creating mnemonics:

- Which type of mnemonic did you find most useful, acronyms, acrostics, or a catchy word or phrase and why?
- Did you find it easy or challenging to work with mnemonics? Please explain your answer.
- Do you think mnemonics are useful tools to help us remember factual information, why or why not?

Some closing thoughts:

- What is your overall experience with creating a metacognitive project?
- Do you think it's been helpful to learn about metacognition and applying some metacognitive strategies in the context of preparing for the exam?
- Do you think you will continue to use what you have learned about metacognition in your further studies?

APPENDIX C

THE PAPER-BASED METACOGNITIVE AWARENESS INVENTORY

Please circle the answer option (*Not at all typical of me, Not very typical of me, Somewhat typical of me, Fairly typical of me, Very typical of me*) that best describes your behavior to each of the following 52 statements.

In this class, and when studying for this class:

1. I ask myself periodically if I am meeting my goals.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

2. I consider several alternatives to a problem before I answer.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

3. I try to use strategies that have worked in the past.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

4. I pace myself while learning in order to have enough time.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

5. I understand my intellectual strengths and weaknesses.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

6. I think about what I really need to learn before I begin a task.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

—Go to the next page—

In this class, and when studying for this class:

7. I know how well I did once I finish a test.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

8. I set specific goals before I begin a task.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

9. I slow down when I encounter important information.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

10. I know what kind of information is most important to learn.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

11. I ask myself if I have considered all options when solving a problem.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

12. I am good at organizing information.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

13. I consciously focus my attention on important information.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

14. I have a specific purpose for each strategy I use.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

—Go to the next page—

In this class, and when studying for this class:

15. I learn best when I know something about the topic.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

16. I know what the teacher expects me to learn.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

17. I am good at remembering information.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

18. I use different learning strategies depending on the situation.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

19. I ask myself if there was an easier way to do things after I finish a task.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

20. I have control over how well I learn.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

21. I periodically review to help me understand important relationships.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

22. I ask myself questions about the material before I begin.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

—Go to the next page—

In this class, and when studying for this class:

23. I think of several ways to solve a problem and choose the best one.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

24. I summarize what I've learned after I finish.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

25. I ask others for help when I don't understand something.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

26. I can motivate myself to learn when I need to.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

27. I am aware of what strategies I use when I study.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

28. I find myself analyzing the usefulness of strategies while I study.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

29. I use my intellectual strength to compensate for my weaknesses.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

30. I focus on the meaning and significance of new information.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

—Go to the next page—

In this class, and when studying for this class:

31. I create my own examples to make information more meaningful.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

32. I am a good judge of how well I understand something.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

33. I find myself using helpful learning strategies automatically.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

34. I find myself pausing regularly to check my comprehension.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

35. I know when each strategy I use will be most effective.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

36. I ask myself how well I accomplished my goals once I’m finished.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

37. I draw pictures or diagrams to help me understand while learning.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

38. I ask myself if I have considered all options after I solve a problem.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

—Go to the next page—

In this class, and when studying for this class:

39. I try to translate new information into my own words.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

40. I change strategies when I fail to understand.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

41. I use the organizational structure of the text to help me learn.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

42. I read instructions carefully before I begin a task.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

43. I ask myself if what I'm reading is related to what I already know.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

44. I reevaluate my assumptions when I get confused.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

45. I organize my time to best accomplish my goals.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

46. I learn more when I am interested in the topic.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

—Go to the next page—

In this class, and when studying for this class:

47. I try to break studying down into smaller steps.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

48. I focus on overall meaning rather than specifics.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

49. I ask myself questions about how well I am doing while I am learning something new.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

50. I ask myself if I learned as much as I could have once I finished a task.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

51. I stop and go back over new information that is not clear.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

In this class, and when studying for this class:

52. I stop and reread when I get confused.

Not at all typical of me	*Not very* typical of me	*Somewhat* typical of me	*Fairly* typical of me	*Very* typical of me

— **Thank you for your participation!** —

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