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Examining Self-Regulation Of Learning Among Community College Students In Developmental Mathematics Courses

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EXAMINING SELF-REGULATION OF LEARNING AMONG COMMUNITY COLLEGE STUDENTS IN DEVELOPMENTAL MATHEMATICS COURSES

by

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This dissertation, submitted by Katrina M. Eberhart in partial fulfillment of the requirements for the Degree of Doctor of Philosophy from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

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PERMISSION

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Katrina M. Eberhart
April 16, 2019

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May you always have a breeze to shoot, a tractor to drive,
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ABSTRACT

The ability to self-regulate one's learning is crucial to the success of all college students, but is particularly important to those who are considered to be underprepared; it puts students on a path towards successful course completion, subsequent course enrollment, and eventual graduation from a postsecondary institution. Those enrolled in remedial coursework are a large portion of students labeled as underprepared. Remedial education is a contentious topic in higher education. Thus, it is critical to investigate the use of classroom strategies to foster a self-regulated environment to support student success in these early classes and move onto the classes needed for their majors. The purpose of this study was to examine if multiple direct instruction, self-regulation interventions had an effect on students' reported self-regulatory strategy use, students' reported mathematics self-efficacy, and successful course completion in a developmental mathematics course.

Using Hunter's (1982) method of direct instruction, a set of interventions focused on self-regulatory skill improvement were embedded into two sections of a community college developmental mathematics course. Interventions addressed time management, exam preparation, exam error analysis, and recognition of maladaptive behaviors. To gauge the impact of the interventions, a web-based survey regarding self-regulatory tendencies and mathematics self-efficacy was distributed twice during the course. Students in the intervention sections as well as students in two other sections not receiving the intervention, which served as a control, completed the survey. Ultimately,

12 participants from each group were included in the main analyses to determine if there was a statistical difference between those who received the set of interventions and those who did not.

Results indicated no statistical differences between the control and intervention groups in regards to metacognitive self-regulation, mastery self-talk, regulating time and study environment, avoiding needed help, and mathematics self-efficacy. There was an interaction between the groups regarding effort regulation. There was a decrease in effort regulation over time in the intervention group, but no change in the control group. There was also a between-groups difference in seeking needed help, as the intervention group had higher mean values both prior to and after the set of interventions.

CHAPTER I

INTRODUCTION

There is a presumption in higher education that when students arrive at postsecondary institutions, they have already acquired the readiness skills needed to be effective and successful learners (Karabenick & Dembo, 2011). College students are expected to be more independent, are assigned more out-of-class work, and must be able to manage assignments from multiple instructors. To meet these expectations, students must have access to and ultimately utilize a variety of study and self-regulation strategies such as goal setting, self-monitoring, and task analysis, to name just a few. However, students must not only be able to select and utilize a strategy, but they must also evaluate its effectiveness and make adjustments to faulty strategies. The capacity to achieve a high level of self-regulated learning may derive either from a student's willingness or ability to learn: willingness to learn stems from achievement motivation, whereas ability to learn stems from pre-existing knowledge, domain-specific aptitude, general intelligence, and finally, self-regulatory tendencies (Jones & Byrnes, 2006).

The ability to self-regulate one's learning is crucial to the success of all college students, but is particularly important to those who are considered to be underprepared because it puts students on a path towards successful course completion, subsequent course enrollment, and eventual graduation from a postsecondary institution. According to the National Center for Education Statistics (NCES, 2018), approximately 40% of students in the United States who enroll in a postsecondary institution drop out before earning a degree. Developmental mathematics courses (courses below college-level mathematics) serve as stepping stones, and developmental mathematics students comprise nearly one-fifth of the national postsecondary student population (NCES, 2016). Retention of these students is an issue for both faculty and administration. Accordingly, it is critical to investigate the use of classroom strategies to foster a self-regulated environment so that more students can succeed in these early classes and move onto the classes needed for their majors.

Statement of the Problem

Developmental (remedial) education is a controversial topic in the world of higher education. Remediation is viewed by some as a way to equalize attainment by reducing disparities between the haves and have-nots. It is argued by others that remediation forces taxpayers to pay for the same learning opportunities twice, once in high school and once in college at an estimated annual cost of $17 billion (Bahr, 2008).

Others contend the benefits of remediation are unclear. Approximately 59% of students beginning at public two-year institutions take developmental mathematics courses (NCES, 2016). A study of over 60,000 students in 57 community colleges found that only 11% of students entering the lowest of three levels of developmental mathematics ever successfully completed a college-level mathematics course, suggesting that the traditional system of developmental education is not achieving its intended purpose of improving collegiate outcomes for underprepared students (Jaggars, 2014).

Although the demographic characteristics (i.e., ethnicity and socioeconomic status) and external demands (i.e., employment and family) of students entering developmental courses are well documented, knowledge of community college students and their attitudes toward learning is sorely lacking. There has been little effort to understand how developmental students think about their education (Grubb & Cox, 2005). Enter the concept of self-regulated learning: is it possible that teaching self-regulation skills as a part of the curriculum, instead of assuming students pick it up on their own or come to college with a skill set, could improve successful completion of developmental mathematics courses?

At the mid-western institution where the study was conducted, developmental courses in mathematics have a prefix of “academic skills course”, implying academic skills will be taught in addition to the subject area content. Currently, those skills necessary for student success are not highlighted; instead, there is a focus on the mathematical skills students need to be successful in a college algebra course. Incorporating academic skills into coursework by teaching strategies to help students become better learners is thought to foster the development of self-regulation (Butler, 1995). Bailey et al (2016) recommended teaching underprepared students how to become self-regulated learners, yet recognized a potential roadblock of scarcity of both time and resources in the classroom.

Students’ use of some self-regulation strategies can be increased through well-designed instructional interventions (Wolters, 2003). An intervention is an intentional program or set of steps taken to help a student improve in an area of need (Wright, 2012), designed to help struggling students and measure progress. It is not just a strategy, as progress is reviewed at specific time intervals. An intervention can also be thought of as “a set of actions that, when taken, have demonstrated ability to change a fixed educational trajectory” (Methe & Riley-Tillman, 2008, p. 37). Interventions can be designed to help students improve in areas such as students' self-theories and use of learning strategies (Zientek, Ozel, Fong, & Griffin, 2013).

Theoretical Framework

This study draws upon the established theory of self-regulated learning. Self-regulation (SR) of learning is defined as self-generated thoughts, feelings, and behaviors that are planned and cyclically adapted based on performance feedback to attain self-set goals (Zimmerman, 1989). Learners are viewed as active participants in the learning process who must know how to set goals, what is needed to achieve those goals, and how to actually attain those goals (Cleary, 2006; Dabbagh & Kitsantas, 2012; Pintrich, 2004; Wolters, 2003; Zimmerman & Kitsantas, 2007). Furthermore, the capacity to self-regulate is central to our assumptions about learning, decision making, problem solving, and resource management in education (Cubukcu, 2009). Essentially, SR involves student accountability and acceptance of responsibility in the learning process.

The study also draws from Bandura's (1997) theory of self-efficacy. "Perceived self-efficacy refers to the beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments." (Bandura, 1997, p. 3) The effects of self-efficacy in education are many: among others, self-efficacy can influence how much effort is put forth, how long a student perseveres, and whether thoughts are self-aiding or self-hindering.

Need for the Study

To date, there is research on one-time SR interventions in varying areas of academics. Specific research in the field of interventions in developmental mathematics is limited to tutoring services (see Butcher & Visher, 2013 and Gallard, Albritton, &

Morgan, 2010) and either shortening a course or offering a co-requisite study skills course (see Weisburst, Daugherty, Miller, Martorell, & Cossairt, 2017). This study offers much needed insight into the art of facilitating the process used by students when discovering how to learn. This study also contributes to the body of classroom practices research by defining a way to increase the use of self-regulatory strategies. Finally, it adds to research on developmental education, specifically in the area of course-based aspects impacting student success.

Purpose of the Study

As previously stated, the ability to self-regulate is crucial to the success of underprepared developmental mathematics students. Traditional remediation is designed to address academic weaknesses in math and/or English, yet many underprepared students struggle due to weaknesses in a multitude of other SR skills such as help-seeking behavior and time management, which may be more serious barriers to student success (Bailey & Jaggars, 2016). Remediation reform has paid little attention to improving SR skills; thus, the purpose of this study was to examine if multiple direct instruction, SR interventions had an effect on students' reported self-regulatory strategy use, students' reported mathematics self-efficacy, and successful course completion in a developmental mathematics course.

Research Questions

The primary research questions for this study of students' ability to self-regulate their learning were as follows:

1. What impact does structuring a developmental mathematics course with multiple direct instruction, SR interventions have on the level of student use of self-regulatory strategies?

2. What impact does structuring a developmental mathematics course with multiple direct instruction, SR interventions have on mathematics self-efficacy?

3. Does structuring a developmental mathematics course with multiple direct instruction, SR interventions lead to a higher percentage of students successfully completing the course, as compared to sections without an intervention component?

Significance of the Study

Student success, particularly in developmental classes, is important to educators and administrators and becoming an effective learner is at the heart of student success. As developmental education reform continues to plague higher education, creating a learning environment that increases the probability that students will succeed first in their coursework and then in their chosen degree program is essential.

To the researcher, this study was seen as a way to improve how developmental mathematics is taught, and ideally, improve instruction in other courses as well. At the mid-western institution where the study was conducted, developmental mathematics courses average a 52% pass rate. Furthermore, only 26% of developmental mathematics students continue on to a higher level mathematics course and graduate.

The study provided a way for the participants to “learn to learn”, a skill transferable to other areas of academia and life in general. Regular SR interventions are a way to empower students to navigate the world after the completion of their education—they will be judged by their capacity to learn in the future. College graduates entering the workforce are expected to have a set of soft skills including time management, planning and preparation, and analytical behavior, which were all addressed in this study.

In fiscally strained times, it is also important to college administration to maintain financial stability. Retention initiatives are often campus-wide and focused on at-risk student populations, as it is more cost-effective to maintain the current student population than recruit a new student body (Hanover Research, 2014). If students do not succeed in the classroom, they will not succeed in college; therefore, it was important to focus on these students at the classroom level in order to keep them in college.

Delimitations

The scope of this study is restricted to developmental mathematics students at a small Midwestern community college; however, it is important to become a successful learner in any type of course. The decision to focus on students in developmental mathematics comes from the researcher's personal, vested interest in this type of student.

Assumptions

1. Each participant will be honest in their self-reported responses and will complete all survey items.
2. Participants previous experiences with SR learning techniques were similar across sections.
3. The SR intervention will positively impact students' academic experience.

Definitions

For the purposes of this study, the key terms are defined as follows:

Developmental mathematics: Any basic mathematics skills course designed to prepare students to enter in to college-level degree credit courses;

content is equivalent to elementary and junior high mathematics. Typically college credit is not earned. Also called *remedial mathematics*.

Underprepared students: Students who enter college needing at least one developmental course.

Successful course completion: The act of a student earning a grade of "C" or better in a single, credit-hour based course.

Summary

The self-regulation of learning is important to all college students, but particularly to those who enter as underprepared students. This study sought to determine if students can improve their ability to self-regulate throughout a developmental mathematics course. Using elements of SR, this study assessed the effectiveness of direct instruction, SR interventions to increase student use of SR strategies.

This chapter provided an introduction to the research problem as well as a brief outline of self-regulated learning and self-efficacy, which served as the theoretical frameworks for this research. A need for this study was established based on current literature, a study purpose statement was provided to explain intent, and the study delimitations and assumptions were also presented. This chapter concluded with a list of terms that define and support the current study. A comprehensive review of the relative literature is presented in the next chapter.

CHAPTER II

LITERATURE REVIEW

Students entering the post-secondary classroom come with varying levels of academic abilities and study skills. Each class of students is different and brings with it an assortment of opportunities and challenges for the instructor. This chapter is structured around the major ideas that collectively support the need to determine if students could improve their ability to self-regulate throughout a developmental mathematics course.

Self-Regulated Learning

Self-regulated (SR) learning is defined as self-generated thoughts, feelings, and behaviors that are planned and cyclically adapted based on performance feedback to attain self-set goals (Zimmerman, 1989). SR learning involves the active, goal-directed, self-control of behavior, motivation, and cognition for academic tasks by an individual student (Pintrich, 1995). Learners are viewed as active participants in the learning process who must know how to set goals, what is needed to achieve those goals, and how to actually attain those goals (Cleary, 2006; Dabbagh & Kitsantas, 2012; Pintrich, 2004; Wolters, 2003; Zimmerman & Kitsantas, 2007). Wolters (2003) expanded on SR, stating that these learners are believed to have adaptive beliefs and outlooks that initiate their willingness to engage and carry on with academic tasks. Furthermore, the capacity to self-regulate is central to our assumptions about learning, decision making, problem solving, and resource management in education (Cubukcu, 2009).

Zimmerman and Kitsantas (2007) defined the cyclical self-regulation process as one using three self-oriented feedback loops: behavioral self-regulation, environmental self-regulation, and covert self-regulation. Learners develop plans that involve all three components to optimize effectiveness. SR of behavior involves actively adjusting performance processes after self-observation, such as altering one's method of learning or performing. Environmental SR includes observing and adjusting environmental conditions, like one's place for studying. Finally, covert SR involves monitoring and adjusting cognitive and affective states (e.g. strategies for deep processing, remembering, or relaxing).

Within those loops, SR processes can further be broken down into task, imagery, self-instruction, time management, self-monitoring, self-evaluation, and help-seeking strategies. These processes would be used to achieve peak academic performance; however, the need to use any one of these strategies may only be triggered when learners experience problems with their ongoing level of motivation, learning, or performance (Wolters, 2003).

Different SR phases are triggered as learners access these processes (Zimmerman & Kitsantas, 2007). The first, forethought (or planning), involves breaking a larger task into smaller tasks, allowing the learner to set sub-goals for future achievement. Moving into the performance phase, learners focus on the task at hand while also concentrating on the aspects of the task the learner performs. Finally, in the self-reflection (or self-monitoring) phase, causal attributions are placed on the success or failure of the learning effort with a conclusion about how to change a learning approach, leading back to the forethought phase for the next learning event.

To acquire self-regulatory competence, learners must use the three-phase cycle properly and meet a set of four skill requirements (Zimmerman & Kitsantas, 2007). While developing an academic skill, careful observation comes first, followed by emulation of the skill. Learners in the self-controlled level of skill development practice the skill outside of the presence of models. In this period, the goal is reaching automaticity (i.e., the skill becomes second-nature). The fourth skill level is a self-regulated level, where the learner makes adjustments based on self-observations.

It is important to recognize that the SR perspective assumes all learners can potentially monitor, control, and regulate certain aspects of their own cognition, motivation, behavior and environments, but that does not mean they are capable of or willing to do so (Pintrich, 2004). In order for students to actually self-regulate, there must be a goal, standard, or criterion against which to compare their progress (Pintrich, 1999). Highly SR learners approach learning tasks in a mindful, confident manner, proactively set goals, and develop a plan for attaining those goals. After engaging in a learning situation, SR learners will evaluate their performance relative to self-standards, attribute poor performance to faulty strategies, and will make strategic adjustments before the next situation (Cleary & Zimmerman, 2004). For example, a SR learner would look at previous test scores, evaluate the study strategy used, and make changes based on reflection.

SR learners are thought to hold a collection of adaptive beliefs and attitudes that drive their dedication to engaging and persisting in academic tasks (Wolters, 2003). These students personally initiate and direct their own efforts to learn and acquire skills rather than relying on instructors or parents (Zimmerman, 1989). Success in high school and beyond is believed to be highly dependent on students regulating themselves, particularly in disorganized settings where studying frequently occurs (Zimmerman & Martinez-Pons, 1986), and SR has been identified as one of the major factors that influences completion of a degree in community college education (Hu & Driscoll, 2013).

Cognitive and Metacognitive SR Strategies

Cognitive strategies are the ways in which learners process information required by instructional tasks (Karabenick & Collins-Eaglin, 1995). These strategies include, but are not limited to, rehearsal, organization, elaboration, and critical thinking. Metacognitive skills fall into three categories: control activities such as planning, monitoring activities such as self-testing, and activities which precede controlling such as reflecting (Masui & De Corte, 2005). The ability to regulate cognitive strategies hinges on the use of metacognitive strategies. Basically, cognition is knowing how to reach a goal and metacognition is making sure the goal was reached successfully.

Karabenick and Dembo (2011) stated that instructional methods can improve metacognitive skills. First, students can be asked to set goals to monitor performance, as accurate self-monitoring leads to more specific help seeking. This helps learners pinpoint what is yet to be mastered. By next asking what students need to do and what is needed to do it, instructors can communicate the necessary knowledge or sequence needed to complete a task. Students can then perform task analysis by asking if steps or items are completed. Lastly, ask students to analyze errors. This important step allows learners to process the help that was received. Students can describe what went wrong and instructors can give feedback by requesting the student attempt a new problem and explain the correct procedure to arrive at a solution.

Zimmerman and Martinez-Pons (1986) found that high-achieving students used a variety of cognitive and metacognitive regulatory strategies in contrast to low-achieving students. They later found that students' reports of organizing, transforming, seeking information, and seeking assistance were most highly correlated to teachers' ratings of student use of SR strategies (Zimmerman & Martinez-Pons, 1988), making it appear that SR students are not passive learners and actively seek out information and assistance when needed. Nota, Soresi, and Zimmerman (2004) found that among already high achieving students, use of self-consequenting behaviors (i.e., reward for success, reevaluation for failure) was a significant predictor of high school grades and the intention to continue on with education.

Students need not be high achieving when metacognitive skills are presented in the classroom, though. White and Frederiksen (1998) found in classes where a metacognitive skill of reflective assessment was introduced, low achieving students were brought to the level of high achieving students on post-knowledge tests and that the reflective assessment effects were greatest for students who used the assessment criteria to accurately reflect on the quality of their work. However, VanderStoep, Pintrich, and Fagerlin (1996) suggested that the components of knowledge, motivation, and self-regulation distinguished high from low achievers in social and natural science courses, but not in humanities courses.

SR Strategy Use

Use of ineffective strategies and poor SR are key factors contributing to low academic achievement (Gettinger & Seibert, 2002); thus, an essential goal of teaching students both cognitive and metacognitive strategies is to foster the development of SR (Butler, 1995). Training students to use these strategies should be carried out in a metacognitive, SR context, in connection with specific content rather than generalized skills for positive results (Hattie, Biggs, & Purdie, 1996). The use of SR strategies depends on both knowing certain strategies exist and how to properly execute them (Zimmerman, 1989); however, the need to use a strategy may only be triggered when students experience problems with their current approach (Wolters, 2003). Along with content-specific knowledge, VanderStoep, Pintrich, and Fagerlin (1996) found strategy use is important for academic performance.

Zimmerman (1989) stated that students must also distinguish between procedural and conditional knowledge of strategy use: procedural refers to knowledge of how to use strategies, whereas conditional refers to knowing when and why strategies are helpful. It is important to note that unless students understand planning is necessary to implement learning strategies, they may not make the effort to try (McMillan, 2010). Once a student makes the attempt to learn via SR, motivation can improve, and increased motivation can lead back to students applying more SR strategies (Ning & Downing, 2010). Both teachers and students need the opportunity to practice use of SR strategies in curricular activities. If activities are designed to require the use of strategies, "students will be more likely to develop thoughtful approaches to learning than if they are limited to situations where strategy use is coerced or directed." (Paris & Paris, 2001, p. 93)

Attribution. "Students should accept responsibility for their own learning and realize that they have the potential to control their own learning" (Pintrich, 1995, p. 8). The use of SR strategies can impact attribution of successes and failures. Students who attribute success and failure in a constructive way concentrate on causes over which they have control (Masui & De Corte, 2005). If students believe that strategy use is the reason for success or if students believe not using a strategy leads to failure, rather than attributing to ability or luck, they are more likely to utilize effective strategies (Paris & Paris, 2001).

Necessity of strategy use. A student who desires to exhibit competence in the classroom may be apt to use cognitive SR strategies to do so (Bartels, Magun-Jackson, & Ryan, 2010). Tuckman (2003) found that training in learning and motivation strategy use contributed to GPA improvements both in the term the training was given as well as the term directly after. Hu and Driscoll (2013) found that SR strategy training could assist learners with academic achievement, self-satisfaction, and persistence. Zimmerman and Kitsantas (2014) suggest it is of greater importance to teach SR strategies than self-discipline, as they found that SR was more predictive of students' GPA and performance on a standardized assessment than self-discipline was.

The use of such strategies as higher elaboration, organization, and rehearsal skills has been shown to lead to more positive attitudes towards coursework. Strategies like the regulation of time and study environment appear to reduce anxiety (Kesici, Baloğlu, & Deniz, 2011). To accomplish necessary academic tasks, SR students exhibited extensive help-seeking behavior (Zimmerman & Martinez-Pons, 1986).

Achievement and failure. Bartels and Magun-Jackson (2009) found the need for achievement was positively associated with an awareness of SR strategy use and also proficiency at both analyzing and modifying the use of strategies. Furthermore, they asserted fear of failure was associated with a failure to metacognitively self-regulate. Later research suggested those who fear failure may also fail to utilize cognitive SR strategies such as elaboration, organization, and critical thinking (Bartels, Magun-Jackson, & Ryan, 2010).

Use of self-monitoring. The systematic practice of monitoring one's learning enhances both learning and performance (Lan, Repman, & Chyung, 1998; Zimmerman, 1989). Informal self-monitoring is done on a regular basis, whether consciously or not (i.e., monitoring productivity, procrastination, time on social media, etc.). Informal self-monitoring may suffice, but it must be accurate and students must know when it is insufficient (Zimmerman & Paulsen, 1995). Formal self-monitoring is not necessary when tasks are easy or routine, but when a student faces a difficult task or assignment, formal self-monitoring can guide personal modification. It involves methodical observations and judgments that reflect on both the present activity and events leading up to said activity (Zimmerman & Paulsen, 1995).

When students are involved in a self-monitoring process, they become aware of the effectiveness of their learning strategies and the appropriateness of their learning environment (Lan, 1996). Students who cannot accurately monitor themselves academically on a daily basis are disadvantaged. With limited preparation for independent learning, many students find it difficult to survive in college; thus, self-monitoring can provide the incentive to change a learning strategy and the basis for choosing and assessing potential actions (Zimmerman & Paulsen, 1995). Lan, Repman, and Chyung (1998) found that a step-by-step monitoring process for students to follow during their learning activities could overcome any self-monitoring deficiencies and enhance learning.

Fabriz, Dignath-van Ewijk, Poarch, and Büttner (2014) found that students simply keeping a learning journal did not improve students' SR; instead, a journal plus receiving additional information about SR showed increases in both their use of SR strategies as well as self-efficacy. The study found no improvements for students' academic performance even with the increase in strategy use; however, the researchers proposed that "students have to automatize their use of newly learned strategies before this can have an effect on their achievement." (Fabriz et al, 2014, p. 251)

Barriers to strategy use. "We know that a moderate level of concern is essential to an individual's putting forth effort. If you are satisfied with your appearance, job, or where you live, you will not put forth effort to change it. It is only when you become concerned that you will "do something"" (Hunter, 1982, p. 11). Agentic learners and students 'set in their ways' may be resistant to using SR strategies. Agentic learners are learners who assume no responsibility for their learning, actions, or consequences, and simply follow the orders of someone in authority. They would be considered the opposite of SR learners. They can be trained to use new methods and strategies for learning, but may choose old strategies over new ones or even adapt old strategies to new situations during learning activities (Winne, 2010). Hattie, Biggs, and Purdie (1996) claimed that students' study behaviors are developed and maintained at a young age, as study skills training becomes relatively ineffective at upper secondary and college levels.

Although there are academic support programs offered at many colleges, students in those programs often fail to benefit because they do not change their academic behavior (Dembo & Seli, 2004).

Orange (1999) found that students began a term with good intentions of studying and high expectations of themselves, but as the term progressed, were overwhelmed; thus, SR behaviors and attitudes diminished. Still others do not realize until far in to a term that many of the learning and study strategies that have been used in the past are not sufficient for academic success in college. Even though they know they need to improve, they tend to stick with familiar, ineffective strategies that do not achieve the best results (Dembo & Seli, 2004).

Self-handicapping. Examples of self-handicapping behavior in academic settings include procrastination, avoidance, and staying up late before an important exam. Self-handicapping allows students to attribute poor performance to factors other than low ability or lack of strategy use while still maintaining a feeling of self-worth. It is considered maladaptive because it works to hinder students' ability to complete at task and establishes a clear excuse for not performing well even before beginning it. It is still debated if students are consciously aware of and purposefully engage in self-handicapping behaviors or if it is done without forethought (Wolters, 2003).

Perry, Phillips, and Dowler (2004) found that students motivated by extrinsic factors such as grades or social comparisons instead of personal progress and deep understanding of material try to avoid failure and damage to self-esteem by seeking out only easy tasks, procrastinating, or avoiding work altogether. They further stated these self-handicapping tactics curtail students' academic development and use of SR strategies.

Lack of help seeking. Dembo and Seli (2004) found there was a divide between knowing what to do and actually doing it. Knowing when to ask for help is absolutely essential to SR learners. Students themselves must know when to ask for assistance, be willing to ask for it, and finally accept it (Orange, 1999), yet Dembo and Seli (2004) found that the majority of students who seemingly needed help failed to seek it. Kesici, Baloğlu, and Deniz (2011) found students with lower levels of either test or class anxiety do not engage in help seeking, suggesting those that are either comfortably confident or comfortably insecure are those less likely to engage in that activity. When students meet a learning block or are faced with undesirable levels of academic performance, they must grow accustomed to asking for and accepting assistance (Karabenick & Dembo, 2011).

Failing to seek needed help and not asking questions should not be confused. On one hand, not asking questions may mean that students already comprehend the material, but on the other, it may mean students understand very little but cannot formulate a reasonable question, are embarrassed to ask, or perceive the instructor as unreceptive to questioning (Karabenick & Dembo, 2011). Thus, instructors cannot assume the degree of need for help from the lack of help seeking.

Overconfidence. "When students are left to their own devices, many of them use ineffective methods to monitor their learning, which can produce overconfidence and underachievement" (Dunlosky & Rawson, 2012, p. 278). Overconfidence may present itself as self-beliefs that are too positive or unrealistic, which can promote a casual approach to studying (Zimmerman & Paulsen, 1995). High self-perceived competence can turn into overconfidence if not accompanied by the motivation to understand the learning material at an even deeper level (Ferla, Valcke, & Schuyten, 2010). Pajares and Kranzler (1995) found that students demonstrated a strong confidence in their ability to solve mathematics problems that was not matched by competence. They discovered overconfidence was prominent, suggesting that individuals appraising their own ability are more accurate when they have more experience. Those with less experience were less accurate yet overconfident in ability.

Dunlosky and Rawson (2012) stated that being overconfident while learning can pose major risks to student learning and achievement. They found that students' inaccurate assessment of preparedness led them to stop studying early, which yielded lower levels of learning during practice, which then translated to lower levels of retention. Students of all ages appeared to struggle with accurately evaluating how well they have learned or understood materials. Similarly, Langendyk (2006) found that low-achieving students do not know what they do not know and are not able to judge their own competence accurately. Without that accuracy, students may not be able to set appropriate goals, adopt strategies for attaining those goals, nor evaluate the attainment of those goals.

Being a Millennial. The two overlapping generations currently attending colleges now are Millennials and Gen Z (also called Post-Millennials). Although generational cutoff points are not set in stone, the year 1996 is believed by some to be the defining break between the two generations (Dimock, 2019), but the U.S. Census Bureau (2015) puts the break at the year 2000 and Rickes (2009) pushes the year to 2002. Thus, the majority of information about those currently attending college is about Millennials.

Howe and Strauss (2000) identified seven key characteristics of Millennials. They are special, sheltered, confident, team-oriented, conventional, pressured, and achieving. Colleges and universities should know the Millennial student is not the only one coming to school: the parent is, as well, and is expected to be more intrusive and more likely to speak on behalf of the student at the first sign of an academic or personal issue (Lowery, 2004). Accordingly, many of these students expect faculty, staff, and administrators to be always accessible and available (Turner & Thompson, 2014).

Monaco and Martin (2007) stated that Millennials need assistance in developing both independent thinking and decision-making skills. Although they have immediate access to nearly infinite amounts of information, Millennials often do not have the tools to extract the needed information to develop their skills. As their high school success was found with little effort or time on task, there is an impractical confidence about academic skills that often make these students painfully unaware of their actual academic capabilities (Lowery, 2004). In a 2014 study of Millennials, Turner and Thompson found that the development of effective study skills was viewed by 65% of their participants as the greatest obstacle faced by freshmen students transitioning to the college environment.

Opportunities for strategy use. The SR of students depends on if they are given enough opportunities to do so (Butler, 2002). Typical college students have not had many opportunities to become SR in their earlier schooling, and as a result have few, if any, SR strategies (Orange, 1999). If students are going to learn how to think and behave in a SR manner, they need numerous opportunities to participate in the cyclical SR process (Cleary & Zimmerman, 2004).

As motivation increases, so does the capacity for use of SR strategies. Students may then continue appropriate SR behaviors until the goal that was set is attained. By observing peers, whether they are successful or unsuccessful, students can become more aware of their academic shortcomings and may be more willing to change their behavior to achieve their academic goals (Orange, 1999); however, there still may be a need to show students the SR process. Teacher support depends on the state of the learner: in terms of SR ability, beginning SR learners may need stronger guidance as opposed to expert learners who need less or even no guidance at all (Ifenthaler, 2012).

Educator Role in Fostering SR

Pintrich (1999) stated, "Self-regulated learning is neither easy nor automatic" (p. 467), yet students can learn to become SR learners with support from faculty (Pintrich, 1995). It is then on the educator to promote SR, as the traditional academic environment rarely encourages the use or development of SR skills (Orange, 1999). Thus, to help students to use SR processes in their learning, instructors must create opportunities for students to practice them (Lan, 1996). Rather than teaching study skills in a counseling or remediation center as a set of general skills, making a shift in instructional practice to incorporate SR strategy use in the teaching of content and creating an environment where effective learning can occur contributes significantly to the academic success of all learners (Hattie, Biggs, & Purdie, 1996; McMillan, 2010; Perry, VandeKamp, Mercer, & Nordby, 2001).

Educators who decide to teach SR as part of their regular class should focus on promoting effective learning (Ning & Downing, 2010). They need to share specific information about how, when, and why to apply certain strategies (Paris & Paris, 2001).

They need to use nonthreatening assessment practices that encourage students to focus on personal academic growth and view errors as opportunities to learn (Perry, Phillips, & Dowler, 2004). They need to model specific SR techniques, describe their form, and provide feedback to learners (Zimmerman, 2000).

Educators must also be supportive of students. Students in classes where teachers are perceived as more supportive are more likely to exhibit help-seeking behaviors (Karabenick & Dembo, 2011). Furthermore, the learning environment must have built-in opportunities for students to support each other, as students will then demonstrate attitudes and actions that are aligned with independent, academically effective learners (Perry et al. 2001).

Finally, educators must be cognizant of how their courses are delivered. In the online environment, Tsai, Shen, and Tsai (2011) found that lack of on-the spot teacher monitoring makes it difficult for students to concentrate on their learning. Furthermore, students who are considered dependent learners are less SR in their learning and will need frequent direction and reinforcement from their instructors.

Educator how-to. What a teacher does has the potential for affecting students' achievement (Hunter, 1979). "Just as students can learn to become SR learners, teachers can teach in ways that help students become SR learners" (Pintrich, 1995, p. 9). Teaching students to be SR learners requires a level of awareness regarding the needs of students and knowledge and effective use of some very complex instructional strategies (Perry, Phillips, & Dowler, 2004). Ley and Young (2001) suggest four principles for embedding SR support in instruction to facilitate regulation in less expert learners, derived from six SR components: goal setting, study environment, organization, monitoring learning, evaluating progress and effectiveness, and exam review. The principles attempt to represent both effective and flexible guidance for incorporating SR into instruction.

1. Guide learners to prepare and structure an effective learning environment. Before learners can concentrate, they must have an environment that allows them to focus on the task at hand. A successful SR learner arranges an instructional environment where learning goals are a priority. Instruction should embed suggestions for creating a study area that is quiet, comfortable, and without distractions. Providing a list of strategies could help students plan effective strategies, as less SR learners often use familiar but ineffective strategies.

2. Organize instruction and activities to facilitate cognitive and metacognitive processes. Organizational strategies, such as outlining, connecting content, and concept mapping are among the cognitive processes that boost achievement. Although learner-generated visual organizations of material are considered more effective than instructionally provided ones, students may not be able to create them due to time, knowledge, or willingness to do so. Previews of content may be coupled with an organizational activity, like a partial concept map or incomplete outline, to engage SR in learners.

3. Use instructional goals and feedback to present student monitoring opportunities. Successful learners monitor progress and recognize how to correct errors. Instruction that supports SR may be prompting all learners to actually monitor learning activity by observing and recording if something has been done or if performance has

meet a set benchmark. Instructors may require learners to submit the record of activity and thus provide external feedback to further encourage monitoring.

4. Provide learners with continuous evaluation information and occasions to self-evaluate. Monitoring is simply the recording of what has gone on: there is no evaluation of effectiveness. However, monitoring may stimulate self-evaluation. Self-evaluation involves a comparison between some component of performance and a set standard, so SR learners evaluate their strategies to determine if those selected are effectively assisting in reaching a goal. Guiding students through tasks, delivering constructive, corrective feedback, and providing hints on how to correct errors can all be beneficial in helping students become SR learners.

The four-step instructional process from Hunter's (1982) comprehensive method of lesson design, often called direct instruction, pairs nicely with the introduction of SR strategies. The steps are 1) watch how I do it (i.e., modeling); 2) you help me do it (i.e., together); 3) I'll watch you do it or praise, prompt, and leave (guided practice); and 4) you do it alone (independent practice). This is similar to the method of Zimmerman and Kitsantas (2007) presented earlier in this chapter regarding the development of self-regulatory competence.

The Role of Self-Efficacy in SR

"Efficacy beliefs are concerned not only with the exercise of control over action but also with the self-regulation of thought processes, motivation, and affective and psychological states" (Bandura, 1997, p. 36). Self-efficacy is defined as personal judgments of one's capabilities to succeed or accomplish designated goals (Zimmerman, 2000). What students actually believe they can accomplish has a huge impact on academic performance (Pajares & Kranzler, 1995). Students with high self-efficacy tend to work longer and harder than those with low self-efficacy, even when faced with difficult tasks (Hagen & Weinstein, 1995). Furthermore, people who are adept at regulating their own motivation will, under the same circumstances, have superior means to make things happen for themselves than those who have an inadequate sense of personal agency (Bandura, 1997).

A student's sense of self-efficacy is a key variable affecting SR. Zimmerman (1989) found students' self-efficacy perceptions to be related to two key aspects of the proposed reciprocal feedback loop: the use of learning strategies and self-monitoring. Ferla, Valcke, and Schuyten (2010) found that self-efficacy beliefs for SR learning better predicted academic performance than other judgments of self-perceived competence. Furthermore, the greater SR of learning of self-efficacious students produces higher academic achievement, plus, efficacious students are better at monitoring their study time and more persistent than inefficacious students of equal ability (Zimmerman, 2000). Specific to predicting mathematics achievement, research has shown self-efficacy has the largest role (Altun & Erden, 2013; Koshkouei, Shahvarani, Behzadi, & Rostamy-Malkhalifeh, 2016; Ozturk, Bulut, & Koc, 2007).

There is, however, a marked difference between simply having the necessary subskills and being able to execute them well under difficult circumstances. Even though students may know exactly what to do and possess the skills to do so, they often fail to perform optimally (Bandura, 1997). To aid in the use of skills, Zientek et al (2013) stated it would be beneficial for community college instructors to address student self-efficacy beliefs in multiple aspects of academic engagement, especially SR strategies.

Once students utilize effective habits of managing common situations, they act on their perceived self-efficacy automatically. After the skill is routinized, provided the belief in ability is present, people will consistently act on that belief without having to keep reminding themselves of it (Bandura, 1997). Self-efficacy beliefs have been studied as indicators of change during instructional interventions but can also be an indicator of individual differences (Zimmerman, 2000).

College Readiness

College readiness is known to be the level of preparation a student needs to gain entrance to and then succeed in a college program without requiring remediation (Venezia and Jaeger, 2013). According to American College Testing (ACT, 2018), an estimated 55% of the 2018 U.S. high school graduating class took the ACT. Of those tested, 60% met the benchmark in English; 46% met the benchmark in reading, 40% met the benchmark in math, and 36% met the benchmark in science. Only 27% met the benchmark in all four subjects, and 38% met the benchmark in three of four subjects, which ACT considers ready for college coursework. Students meeting the ACT benchmark have a 50% chance of earning a B or higher grade and a 75% chance of earning a C or higher in the corresponding college courses. Klasik and Strayhorn (2018) point out ACT's benchmarks are easy to calculate but only capture the likelihood a student earns passing grades in core college classes, thus may not align with a true interpretation of college readiness.

Venezia and Jaeger (2013) stated that students are underprepared for postsecondary coursework for a variety of reasons, including disparities between what secondary schools teach and what colleges expect, instructional differences between high schools with a high concentration of students with low socioeconomic status and high schools with more fortunate students, parental expectations, and peer influences. Using the Educational Longitudinal Study of 2002, which is nationally representative data, Klasik and Strayhorn (2018) found substantial variation in the predictions of college readiness of students from different races/ethnicities attending different colleges when using high school GPA as a predictor rather than SAT/ACT benchmarks. In the California State University system, which is the largest public system in the U.S., students considered college ready had a GPA that was 0.2 points higher and were 8.7 percentage points more likely to complete a four-year degree than those deemed unprepared (Jackson and Kurlaender, 2014).

Francis, Duke, Brigham, and Demetro (2018) reported that approximately half of students with disabilities, including autism, ADD/ADHD, and mental health needs among others, felt prepared for college, but a majority cited time management, organization, and study skills as areas marked for improvement. Many of their study participants reported there would have been a benefit from specific instruction on how to be a college student (i.e., select and register for courses, communicate appropriately with instructors, make financial decisions). Rosenbaum et al. (2004) stated that high school seniors report to have little understanding of what it takes to succeed in higher education, perhaps indicating all incoming students can gain value from pre-college instruction.

At-Risk Populations

In addition to academic preparedness, students fail to complete courses and do not ultimately earn a degree for reasons such as time management, financial literacy, and campus engagement (Tierney & Sablan, 2014). The academically underprepared are automatically assumed to be a group of at-risk students. Ender and Wilkie (2000) further broke down characteristics of the academically underprepared, citing students with low academic self-concept, unrealistic grade and career expectations, unfocused career objectives, extrinsic motivation, external locus of control, low self-efficacy, inadequate study skills for college success, a belief that learning is memorizing, and a history of passive learning as at-risk individuals. Finally, Maxwell (1997) defines more groups including economically disadvantaged students, returning adults, probationary students, disadvantaged minority students, first generation college students, international students, and ESL students.

Horton (2015) described key factors impacting student learning and success in college are in the areas of perseverance, academic mindset, learning strategies, and social skills. Educators are urged to identify these at-risk behaviors in students to become effective facilitators of student learning and success. Most colleges have student success centers or academic support programs all students may use, which can significantly boost the GPA of at-risk students (Flynn, 2015).

Developmental Education

The concept of developmental education is straightforward: bring unprepared students up to an adequate level. It is designed to provide students who enter college lacking the academic skills necessary to be successful the opportunity to strengthen those skills enough for them to be ready for college-level coursework (Bailey, Jeong, & Cho, 2008). There is much debate on the effects and benefits of developmental college courses. While there is no way of precisely gauging how many students are in need of developmental education, it is estimated that “68% of community college students and

40% of students at open-access four-year colleges *take* at least one remedial course." (Jaggars, 2014, p. 1)

Supporters say developmental education allows poorly prepared students access to higher education, while opponents argue the financial burden outweighs the benefits (Melguizo, Bos, & Prather, 2011). Over 20 years ago, Breneman and Haarlow (1998) estimated the cost of remediation at over $1 billion per year. Ten years later the estimate nearly doubled to between $1.9 and $2.3 billion for community colleges (Strong American Schools, 2008). More recently, the nationwide estimate of providing remediation to community college students annually is approximately $7 billion (Jaggars, 2014).

Colleges put resources into modifying the curriculum of remedial courses, but there is less focus on removing the need for remedial courses in the first place (Bonner & Thomas, 2017), as remedial courses rarely cost institutions more than they generate in revenue (Saxon & Boylan, 2001). However, the financial cost burdens not only taxpayers but also the students taking remedial courses. They accumulate debt and spend time and money on courses that do no not count towards their ultimate degree (Bailey, Jeong, & Cho, 2008). Barry and Dannenberg (2016) further estimated students pay an extra $3000 for each year they need remedial coursework. These students also incur psychological costs, as students are both surprised and discouraged to find that after graduating from high school, they feel they are prepared for college; however, by being placed on a remedial track, they become frustrated, causing them to give up and leave college (Rosenbaum, 2001).

Developmental mathematics. At many institutions, students not immediately placing into the college-level mathematics coursework must first pass through developmental mathematics courses. Depending on the institution, this may consist of one to a series of many courses. The developmental course(s) must be successfully completed to gain entry into a college-level course such as college algebra. In recent years, there has been an increase in students enrolling in developmental courses, supporting the notion that a large percentage of high school graduates are underprepared to meet college expectations (Zientek et al, 2013).

In a study of 57 community colleges, Bailey, Jeong, and Cho (2008) found that only 15 percent of all students referred to math remediation pass a college-level course within three years. Comparatively, in a 2008 study of California community colleges, Bahr found three out of four students placed into remedial mathematics do not remediate successfully; however, it was also found when mathematics remediation works, it works quite well. Students remediating successfully were found to experience outcomes (such as GPA and retention) equivalent to those of students not needing remediation. Similarly, Fike and Fike (2012) found if a developmental course is necessary, students who do not delay entry into the course also experience outcomes comparable to college-ready students.

Bailey, Jeong, and Cho (2008) elaborated upon further differences in remediation based on demographic group. They found female students tended to have significantly higher odds of progressing through developmental math education than their male counterparts. Similar differences were found between younger students and older students, full-time students and part-time students, and students attending a smaller college rather than a larger college. Finally, students with a demonstrated need for developmental reading have lower odds of progressing through developmental mathematics.

Barrier to success. Noel-Levitz (as cited in Bonham & Boylan, 2011) reported that in all of higher education, there is no harder course to pass than one in developmental mathematics. Students seeking a bachelor's degree who take a developmental course during their first year in college are 74% more likely to drop out than students who did not need remedial education (Barry & Dannenberg, 2016). Placing into developmental mathematics can be detrimental to a large number of students, as they can be prevented from achieving their educational goals because courses are simply not completed. "Developmental mathematics as a barrier to educational opportunity represents a serious concern for the students as well as higher education policy makers." (Bonham & Boylan, 2011, p. 2)

SR and Mathematics

SR strategies, including both cognitive and metacognitive learning strategies, are subtly present in mathematics classrooms. Zimmerman, Moylan, Hudesman, White, and Flugman (2011) found that developmental mathematics students receiving self-reflection training focused on error correction outperformed students not receiving the training on course examinations; furthermore, students were better able to judge their task-specific self-efficacy beliefs before solving problems and were more accurate in their self-evaluative judgments after solving problems. Self-reflection training also increased students' pass rate on a national gateway examination in mathematics by 25% in comparison to that of control students, demonstrating the effectiveness of SR intervention designed to improve at-risk students' success in collegiate mathematics.

Ahmed, van der Werf, Kuyper, and Minnaert (2013) discussed SR in relation to the role of emotions concerning mathematics. They found that while students' enjoyment and pride in mathematics declined over the span of a school term, boredom increased. Any changes in the positive emotions of enjoyment and pride were associated with changes in SR and achievement, as when students are in a positive affective state, they are more adept at using SR strategies than those in a negative or neutral state.

Berger and Karabenick (2011) found students' self-efficacy in mathematics and value predicted more frequent use of SR deep-processing strategies such as elaboration and metacognition. It seems being confident in one's ability to learn leads to the use of deeper, more sophisticated SR strategies, but valuing mathematics does not lead to the same outcome. Similar to Ahmed et al. (2013), Berger and Karabenick (2011) also found students became less self-regulated during the term, as a decrease in metacognition, help seeking, and time and study management was observed in these areas.

De Corte, Depaepe, Op't Eynde, and Verschaffel (2011) investigated the task-focusing and emotion-focusing coping strategies of high school mathematics students. Students believed they knew how to make use of several coping strategies in school-related mathematical activities, but low achieving students were less focused on the kind of SR strategies used. If students were faced more often with a difficult situation and thus more familiar with it, they were more likely to use a less appropriate coping strategy, such as denial. This indicated students do not automatically develop means to face complex learning situations in an effective way (De Corte et al, 2011). Other studies relating SR and mathematics found positive relationships between use of SR strategies and mathematics achievement, regardless of the nature of the student (Altun & Erden, 2013; Koshkouei et al, 2016).

Homework Completion

Completion of practice problems and application to real-life scenarios are integral parts of all mathematics courses. Self-regulation is an important part of the problem solving process (Garofalo & Lester, 1985; Schoenfeld, 1982; Stillman & Galbraith, 1998). When considering the manner in which students approach solving problems, which typically consists of deciphering given information, planning a strategy, translating information into a mathematical sentence/equation, solving said equation, and reviewing the solution for significance, it is similar to the three-phase process of SR: forethought, performance, and self-reflection. The forethought phase is the planning and organizational stages of solving problems; performance consists of writing and solving an equation; self-reflection is determining if the solution actually makes sense—if it does not, students would return to the forethought phase. Because of this alignment between the two processes, SR and solving mathematics problems are a natural fit.

Unfortunately, when solving problems, students do not always plan a course of action. Instead, methods are tested one by one until a "correct" method is found, and time is spent on futile attempts to find information that likely will not help solve the problems. Solutions are deemed correct because they "look right" (Schoenfeld, 1982). Furthermore, Lester and Garofalo (1987) found that of students that do not plan a strategy, all four arithmetic operations would be used and an answer was chosen again because it "looked right". The belief that performing a series of computations could solve all math problems shows a lack of metacognitive behavior. Finally, students who believed problems can be solved only in this manner spent no time assessing whether or not their answers made sense. If the focus in the classroom is on answers rather than solution strategies, students are not as motivated to learn—they are simply motivated to be correct (Jones & Byrnes, 2006). Both Schoenfeld (1982) and Muis (2008) found that those more interested in the result than the approach were novice non-mathematics majors with lower self-efficacy and little prior knowledge.

In regards to student setbacks while attempting to solve application problems, Stillman and Galbraith (1998) found students were equally defeated through a lack of conceptual understanding and lack of essential mathematical skills. Muis (2008) found when students do not succeed in mathematics problem solving, the failure is typically due to a lack of reflection on their cognitive processes before or during problem solving. Veenman, Kerseboom, and Imthorn (2000) discussed failure on two levels: ability deficiency and production deficiency. Ability deficiency is considered a lack of metacognitive skills, whereas production deficiency causes students to experience task irrelevant thoughts, which leads to cognitive interference with metacognitive skills a student has available. Ifenthaler (2012) stated, "If learners manage to generate information about the efficiency of their problem-solving strategies and successfully implement these findings in the ongoing problem-solving process, they are able to control and regulate their cognitive activities" (p. 40). Perels, Dignath, & Schmitz (2009), though, found there was too much emphasis on the cognitive aspect of problem solving and not enough placed on metacognitive strategies. This literature shows both cognitive and metacognitive strategies impeding (or helping) problem solving skills.

Garofalo and Lester (1985) developed a cognitive-metacognitive framework for mathematical task completion. There are four categories of activities involved, including orientation, organization, execution, and verification; similar to not only a problem solving strategy, but the phases of SR. Stillman and Galbraith (1998) found that metacognitive activities were involved in all phases of the task completion process, with the most time spent on orientation and execution. However, it was felt that reducing time spent on orientation by developing cognitive skills that facilitate more effective problem representation and by promoting the development of metacognitive strategy knowledge.

It is important to note the positive effects of homework, as many problems would be assigned to students as homework exercises. Bembenutty (2009) stated homework enhances retention and increasing understanding of course material, sharpens study skills, and shows the importance of learning outside of the classroom. Effective self-regulated learners engage in goal setting to pursue intended outcomes and identify effective methods for attaining homework goals, such as completing problems. Bembenutty (2009) also found the amount of time dedicated to study was positively related to SR.

Dunlosky and Rawson (2012) stated students who are overconfident are not expected to learn as much during homework practice as compared to students who are better attuned to their abilities; also, students of all ages appear to struggle with accurately evaluating how well they have learned or understood materials. This suggests students attempting homework problems are not properly gauging their mathematical ability, which may lead to future decreased math self-efficacy if students were overconfident in their skill level.

To offset some of the difficulties in simply working problems, Samuelsson (2008) suggested that in order to develop aspects of SR, students would need a problem solving curriculum (not an independent learning environment) and found that a problem solving curriculum increased internal motivation of students in that environment. This seems to imply that even with a problem solving curriculum, problems attempted in an independent learning environment (such as one where homework would take place) may not lead students to acquire SR strategies. Marchis (2011) found that in a problem solving scenario, two-thirds of teachers promote SR methods of understanding the problem to develop students' self-efficacy and self-control, but only one-third continue to prompt the use of students' SR strategies when students are unable to solve a problem.

SR and Developmental Education

Students with academic or learning deficiencies were more likely to also have SR deficiencies (Butler, 1998; Ley & Young, 1998; Young & Ley, 2003). As such, Bailey et al (2016) recommended teaching developmental students how to become SR learners. Furthermore, Conley and French (2014) discussed the role and importance of ownership of learning, stating that those SR elements can and should be taught to all students, most importantly in settings where an achievement gap exists. There is no definitive measure regarding how much SR support is needed to benefit developmental students nor what kind of support is most beneficial (Young & Ley, 2003), but Ley and Young (1998) stated that self-evaluation had the strongest relationship to SR.

Students placing into developmental mathematics may differ from those who do not in the way they plan, organize, monitor, evaluate, and think about the learning process and may require more external support from their learning environment (Ley &

Young, 1998; Young & Ley, 2003). As this implies there may be a deficiency in SR, educators should consider integrating SR strategies into the developmental classroom. Instruction which supports SR improves learning outcomes, which is beneficial to all students facing remediation (Young & Ley, 2003).

For improvements in test scores to be actualized, metacognitive skills must be developed at the same time as content knowledge is gained (Conley & French, 2014). Using an action-research method to merge theory and practice, Cynthia Smith chose to embed SR strategies into a developmental mathematics course throughout the term (see Pape and Smith, 2002). The original assumption for student failure was lack of effort but in actuality the problem was students did not know how to study mathematics. Data indicated students from the strategy-embedded developmental mathematics course continued to own both their successes and failures and displayed control over their learning in subsequent college-level mathematics courses.

Intervention

One goal of higher education is to create lifelong learners, yet few students show signs of being intentional, independent, self-directed learners who can acquire, retain, and retrieve new knowledge on their own (Nilson, 2013). Entering college students have difficulty balancing the social and educational demands of the higher education experience (Ley & Young, 1998). It is important to recognize SR is not a response to a requirement by a teacher: that is learning regulated by others (Pintrich, 1995). But, it has been hypothesized that SR learning is possible only when individuals monitor their learning activities (Lan, 1996), and students' use of SR strategies can be increased through well-designed instructional interventions (Cleary & Zimmerman, 2004; Wolters, 2003).

Hattie, Biggs, and Purdie defined three styles of interventions.

> Interventions may be broadly classified as cognitive, metacognitive, and affective in nature. *Cognitive interventions* are those that focus on developing or enhancing particular task-related skills, such as underlining, note taking, and summarizing. Specific skills taught directly are seen as *tactics*, which can be grouped and used purposefully as a *strategy*. These strategies are the collection of mental tactics employed by an individual in a particular learning situation to facilitate acquisition of knowledge or skill. *Metacognitive interventions* are those that focus on the self-management of learning, that is, on planning, implementing, and monitoring one's learning efforts, and on the conditional knowledge of when, where, why, and how to use particular tactics and strategies in their appropriate contexts. *Affective interventions* are those that focus on such noncognitive aspects of learning as motivation and self-concept. (1996, p. 100)

Classroom practices can be adopted to promote the use of SR strategies, but since SR strategies are not easily developed or learned, there is a need for all types of interventions to improve students' motivation, cognition, learning, and SR (Pintrich, 1999).

"Learning depends on assessment of both product and process to know what is known, what requires additional effort, and what skills are effective" (Paris & Paris, 2001, p. 95). To help students towards the path of SR learning, there are many different types of SR interventions instructors may use that fall into one of the three aforementioned SR phases (forethought, performance, self-reflection): as an example, something as simple as training students to have a pencil placed on the desk upon settling in to the classroom would be a forethought intervention; an instructor reviewing exam solutions with the class would be a performance intervention; and finally, reflective writing exercises would be a self-reflection intervention. Multiple regular classroom activities could be considered SR interventions; as such, educators should attempt to introduce proper strategies where students would most benefit from their use, and the behavior intended to be produced must be observed in context (Ness & Middleton, 2012; Paris & Paris, 2001). Furthermore, simply introducing a SR strategy via an intervention activity is not enough to yield a significant difference: students must know why the strategy is important and useful (Fabriz et al, 2014).

Program Interventions

Flynn (2015) studied the effect of a semester-long, intense academic support program intervention on a group of urban minority community college students. Those in the program were required to attend a mandatory three hours of tutoring time per week and were not allowed to miss any classes or they would be removed from student housing. The participants in the program showed a significant improvement in GPA.

Rather than targeting at-risk students, supplemental instruction in the form of residence hall study groups was created for at-risk courses (courses with 15% or more of the class having a grade below a 60%) with the goal of enhancing student performance and reduce attrition (Terrion & Daoust, 2011-2012). This intervention did not make a difference on final grades based on participation vs. non-participation the study group, but did positively impact retention at the university.

Classroom Interventions

Within literature, there is a contradiction when looking at the connection between SR and both performance and achievement in the classroom. Hu and Driscoll (2013) and Perels, Dignath, and Schmitz (2009) found performance increases with the use of SR strategies introduced in the classroom; however, multiple studies have found SR does not impact academic performance (see Fabriz et al., 2014; Ramdass & Zimmerman, 2008; & Shores & Shannon, 2010). Furthermore, Camahalan (2006) observed that with SR intervention techniques, low-achieving students could significantly improve their achievement on a standardized test, but had no effect on the final course grade.

Masui and De Corte (2005) showed that with a set of repeated interventions focused on reflection and attribution, students receiving the interventions improved their SR behavior as well as obtained better examination results in not only the intervention courses but for all other courses in which they were enrolled as compared to the control group. Cleary and Zimmerman (2004) used a pointed discussion intervention where students were told that even though strategies were being used, it was possible that what was being used was not working or helping test scores improve. The intervention helped foster the belief that poor test grades were not fixed and could be improved by learning new strategies or modifying existing ones. In using a feedback-style intervention, Labuhn, Zimmerman, and Hasselhorn (2010) caution that external feedback will not have any effects on learners' behavior and performance unless they process and interpret the information provided, reinforcing SR aspects. Similarly, Hodges and Kim (2010) found email messages containing SR prompts did not lead to any positive change in students SR tendencies.

Clearly and Zimmerman (2004) developed a SR empowerment program for middle school students where students' SR beliefs and study strategies are first assessed, then students are trained to use SR strategies and ultimately learned how to set goals, select and monitor strategy effectiveness, make strategic attributions, and adjust goals and strategies. As multiple interventions were geared towards specific students, this type of program would be hard to implement in large classes, but the researchers recommended teachers create a SR classroom by incorporating the principles of the program into daily activities. Cleary, Velardi, and Schnaidman (2017) expanded the study of the SR empowerment program, finding mixed results: on the self-report questionnaires, group differences in student SR learning were not observed but differences were observed across other measures of strategic and SR thinking.

In a 2016 study by Lai and Hwang of elementary mathematics students in a flipped classroom environment, a group required to set learning goals, reflect upon what was learned, and set the next goal, performed significantly higher on exams than their non-SR counterparts. It was also shown integrating SR strategies into flipped learning can improve students' self-efficacy as well as planning and time management strategies.

Reflective, self-assessment interventions. There are multiple studies using self-assessment interventions in different ways. Semana and Santos (2018) found in a year-long teacher intervention with written self-assessments that middle school mathematics students showed an increased accuracy to self-assess as they received regular feedback from their teacher. They suggested developing SR skills empowered students to be the main agents of their learning.

In another study of middle school students, DiGiacomo and Chen (2016) found self-monitoring and self-reflection predicted significantly higher math performance. Elementary students receiving feedback about performance were more accurate in their self-evaluative judgments than students who did not, and feedback involving social comparative information was more supportive than individual progress over time (Labuhn, Zimmerman, and Hasselhorn, 2010).

Beumann and Wegner (2018) performed two experiments with self-assessment of homework in higher education mathematics courses. Students were asked to assess the quality of some homework exercises. They found first-year students overrated themselves with self-assessed tasks and in particular, the very weak students overrated themselves excessively, but third-year students assessed honestly or even too cautiously.

Lizzio and Wilson (2013) designed a two-part intervention for students failing the first exam in a course. Participants independently completed a reflective workbook designed to guide error analysis, then had a structured consultation with a tutor to identify improvement goals and strategies. Those taking part in the intervention achieved higher pass rates for the second assessed item as well as for the course overall than a comparative group of students who did not participate.

Developmental mathematics interventions. Gallard, Albritton, and Morgan (2010) studied the cost benefit of retaining developmental mathematics students at a community college through an intervention that showcased increased tutoring for students. Data indicated pass rates of students taking advantage of tutoring services were significantly higher than students who did not seek tutoring, and that there was a positive impact upon student retention. Instead of focusing on individuals, Butcher and Visher

(2013) randomly selected entire classes for someone to come speak about services offered. The intervention led to increased use of tutoring services and decreased withdrawal rates; however, pass rates of developmental courses remained unchanged.

Weisburst et al (2017) discussed two different interventions in community colleges in Texas. One intervention compared a traditional semester-long course to a shortened course. Students enrolled in shortened courses were 12% more likely to successfully complete the course. The second intervention was a study skills course taken as a co-requisite to a course in developmental mathematics. Students enrolled in this type of class were 4% more likely to pass than those enrolled in courses without a study skills component.

Summary

The literature in this section, separated into four main sections, comprise a rich body of information guiding this study. The first section discussed what SR learning is and why it is important to use SR strategies. The second section detailed college readiness and who is considered to enter college underprepared. The third section presented literature regarding SR in mathematics, and the fourth section synthesized research regarding SR interventions.

Together, these sections raised the following research questions for this study.

1. What impact does structuring a developmental mathematics course with multiple direct instruction, SR interventions have on the level of student use of self-regulatory strategies?

2. What impact does structuring a developmental mathematics course with multiple direct instruction, SR interventions have on mathematics self-efficacy?

3. Does structuring a developmental mathematics course with multiple direct instruction, SR interventions lead to a higher percentage of students successfully completing the course, as compared to sections without an intervention component?

The methods, research design, and procedures used to conduct this study are presented in the next chapter.

CHAPTER III

METHODOLOGY

With this study, the researcher sought to examine if multiple direct instruction, SR interventions had an effect on students' reported self-regulatory strategy use, students' reported mathematics self-efficacy, and successful course completion in a developmental mathematics course. In particular, this study used quantitative methods to address the following research questions:

1. What impact does structuring a developmental mathematics course with multiple direct instruction, SR interventions have on the level of student use of self-regulatory strategies?

2. What impact does structuring a developmental mathematics course with multiple direct instruction, SR interventions have on mathematics self-efficacy?

3. Does structuring a developmental mathematics course with multiple direct instruction, SR interventions lead to a higher percentage of students successfully completing the course, as compared to sections without an intervention component?

This chapter describes the study in terms of the participants, procedures, measures, reliability and validity, and methods for data analysis.

Research Setting

The researcher conducted this study within the mathematics department of an accredited community college that is part of a U.S. Midwestern public university system. The community college has approximately 4,000 students. The college offers diploma and certificate programs, associate degrees, and two bachelor's degrees; as such, its Carnegie classification is Baccalaureate/Associate's, Associate's dominant. Students may also choose to stay on campus to earn a four-year degree through cooperative degree programs with other institutions in the university system.

Fifty-seven percent of the students attending this college are male, 56% are full-time students, 87% identify as white, and 67% are 24 years old or younger. As the college offers programs both online and on campus, it is noted that 43% of students are strictly online students, 19% take courses both online and on campus, and 38% are strictly on campus students. There are 121 full-time faculty employed as well as 224 adjunct faculty, with a 15:1 student to faculty ratio across campus and an average class size of 16.

There are eight full-time instructors in the mathematics department, teaching a wide variety of courses, both developmental and college-level, on campus and online. There are three developmental courses offered for students not immediately placing into college level mathematics: Algebra Prep I, Algebra Prep II, and Algebra Prep III. Students entering into the first or second level of the sequence must earn a "C" or better in the course, or score high enough on a placement test, to move on in the sequence. Likewise, a student must either earn a "C" or better in Algebra Prep III or score high enough on a placement test to earn entrance into college-level mathematics. These courses are offered in eight-week blocks with the exception of one Algebra Prep III section each semester offered as a 16-week class. As many students attending this college either place into Algebra Prep II or Algebra Prep III, a student has the opportunity to finish remediation in as little as one semester. Students are not awarded college credit for taking these courses nor does the grade received affect students' GPAs, but the credit hours do count towards full-time student status. All three courses are available both face-to-face and online each semester. All three courses are guaranteed to run online during the summer session, and if demand is sufficient, on campus as well.

All Algebra Prep courses use the web-based software platform My Math Lab © (Pearson Education, 2018). Students across all sections of all courses are required to submit weekly discussion posts (usually focused on study skills), complete section quizzes, and take four unit exams. Unit exams are written by the individual instructor of the course; however, weekly discussion prompts and section quizzes are the same for all students in a particular course, across all sections. In order to attempt a section quiz, a student must earn a minimum score of 50% on a set of practice problems. These practice problems do not count towards a student's overall grade. To move on to a subsequent section quiz, a student must successfully achieve a 70% proficiency level on a quiz. Students may attempt quizzes as many times as necessary to earn a 70%, and are encouraged to aim for a higher score. No matter the number of attempts at a quiz, the highest score is the recorded grade.

Participants

All students in four sections of Algebra Prep III were invited to participate in the study. Two sections taught by the researcher received four direct instruction, SR interventions, regardless of if the enrolled students chose to take the survey and participate in the study. Two sections taught by another instructor in the mathematics department were considered the control group. The control sections were chosen as such because that instructor was the only other instructor during that time frame to have multiple sections of Algebra Prep III. In total, there were 81 potential survey participants. Refer to table 1 for response rates.

Table 1. Response Rates per Group.

	Control	Response Rate	Intervention	Response Rate
Initial enrollment	49		32	
Responses at Time 1	25	51.0%	17	53.1%
Enrollment after withdrawal date	49		29	
Responses at Time 2	20	40.8%	15	51.7%
Identifier match	12		12	

As described later in this chapter, preliminary analysis resulted in some responses being rejected because the self-chosen digital identifier did not match from survey Time 1 to survey Time 2. Ultimately, the final sample consisted of 24 participants, 12 from each the control group and the intervention group, the majority of whom were female, 18-19 years old, White/Caucasian, and freshmen. Furthermore, no participants were repeating the course and a majority had passed the prerequisite course Algebra Prep II. See Table 2 for a complete listing of participants' demographic information.

Table 2. Demographic Information for Study Participants (n = 24).

Demographic Information	Valid *n* (control)		Valid %	Valid *n* (intervention)		Valid %
Gender	12			12		
Male		3	25.0		4	33.6
Female		9	75.0		8	66.7
Age	12			12		
18		7	58.3		4	33.3
19		2	16.7		5	42
≥ 20		3	25.0		3	25
Ethnicity	12			12		
White/Caucasian		9	75.0		11	91.7
American Indian		2	16.7		1	8.3
Other		1	8.3		0	0

Table 2. cont.

Demographic Information	Valid *n* (control)	Valid %	Valid *n* (intervention)	Valid %
Class Level	12		12	
Freshman	11	91.7	10	83.3
Sophomore	1	8.3	1	8.3
Other	0	0	1	8.3
Repeating Algebra Prep III	12		12	
Yes	0	0	0	0
No	12	100	12	100
Prerequisite	12		12	
Passed Algebra Prep II	10	83.3	11	91.7
Did not pass Algebra Prep II; entry via placement test	0	0	0	0
Did not need Algebra Prep II	2	16.7	1	8.3

Procedures

The procedure for this study included distributing a survey instrument to four sections of Algebra Prep III students. As the researcher was a student at a research institution, permission to conduct the research was granted by that university's Institutional Review Board (IRB) as well as the IRB of the community college at which the research took place.

An electronic version of the questionnaire was created using the Qualtrics™ online survey software. A link to the online survey was distributed to the participants via the online learning management system during the first week of the course. The survey included informed consent information along with the introductory overview and explanations, therefore participants gave their electronic consent to participate in the study. Participants were asked to create a unique identifier code to include on the survey. The survey was given again at the end of the course (in week eight), and participants were to complete the survey using their same unique identifier. Participants were told participation was voluntary and full completion of the survey was not required. To incentivize participation, one randomly selected participant received a $25 gift card to the school bookstore at each of the two survey distribution times. Although survey results were reported anonymously in aggregate, any participant wanting to be included in the random prize drawing needed to provide contact information. The final survey question was linked to a separate survey created solely to collect that information, maintaining anonymity.

At the end of each data collection period, the researcher closed the online survey. Data was downloaded from Qualtrics™ into Microsoft Excel spreadsheets. Separate from survey data, personal contact information for participants choosing to enter the random drawing was listed in order of completion and assigned a number. A random number generator was used to select the winner, who was then notified via email. Participation incentives cost the researcher a total of $50.

Interventions

Using Hunter's (1982) method of direct instruction, there were four interventions regarding SR strategies in the researcher's two sections of Algebra Prep III.

Intervention 1: Where does my time go? During the first week of the course, the topic of time management was tackled. The researcher brought in a blank weekly schedule in spreadsheet form and proceeded to detail the previous day from wake-up to bedtime, discussing how much time was spent on each recorded item (see figure 1). The importance of recording all activities was stressed, as a complete picture of a day could then be seen. Students were then directed to begin filling in the current day along with the researcher starting with the present time, and if memories were fresh, the earlier happenings of their day. The researcher began to move about the classroom to encourage further completion. Students were instructed to fill in the schedule for the remainder of the day and bring it back to class the following day. Students were encouraged to pay particular attention to what they needed to accomplish for the next school day, including any studying, reading, assignments, etc. The following day, the topic was revisited and students were instructed to continue filling in the schedule for a full week. An informal class discussion was held at the end of the week about observations students made once the schedule was complete in order to help them prioritize, project, and plan their weeks.

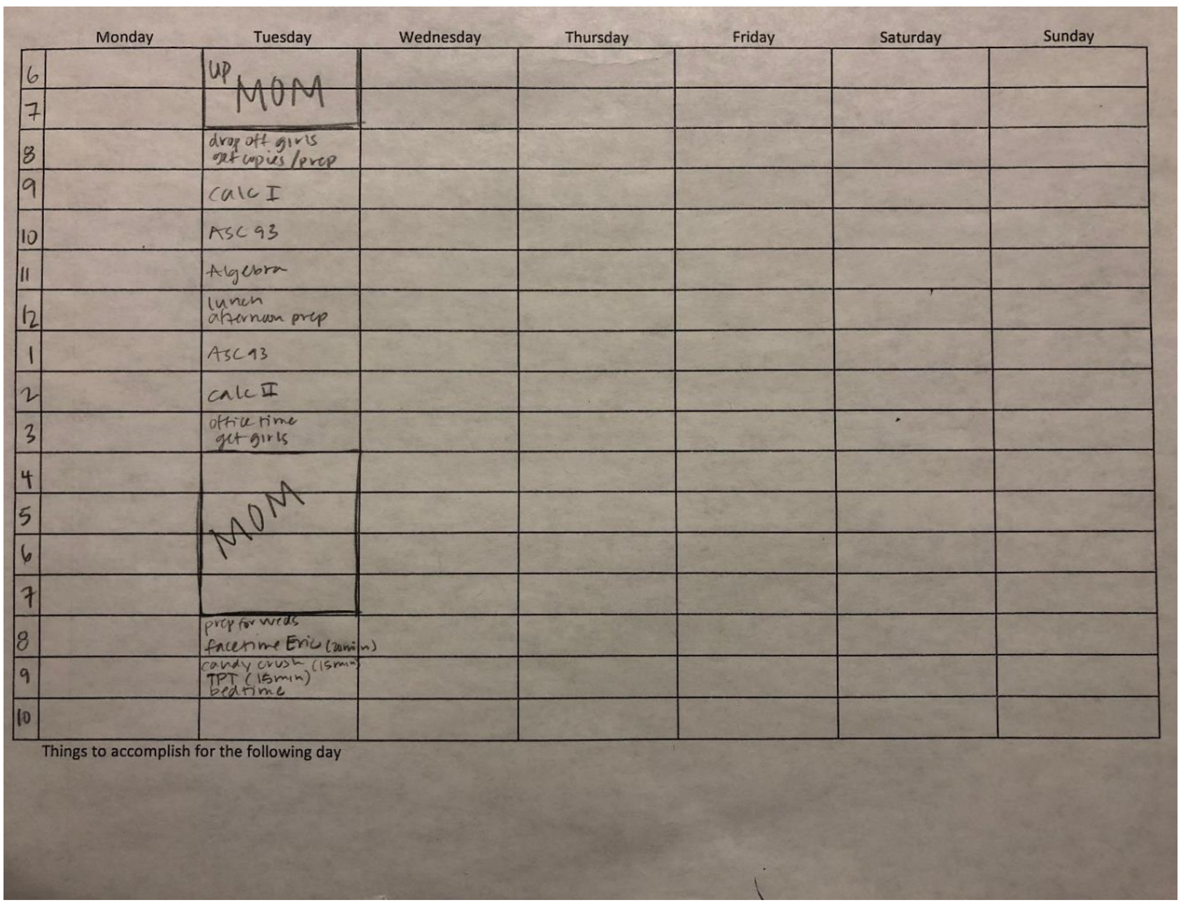
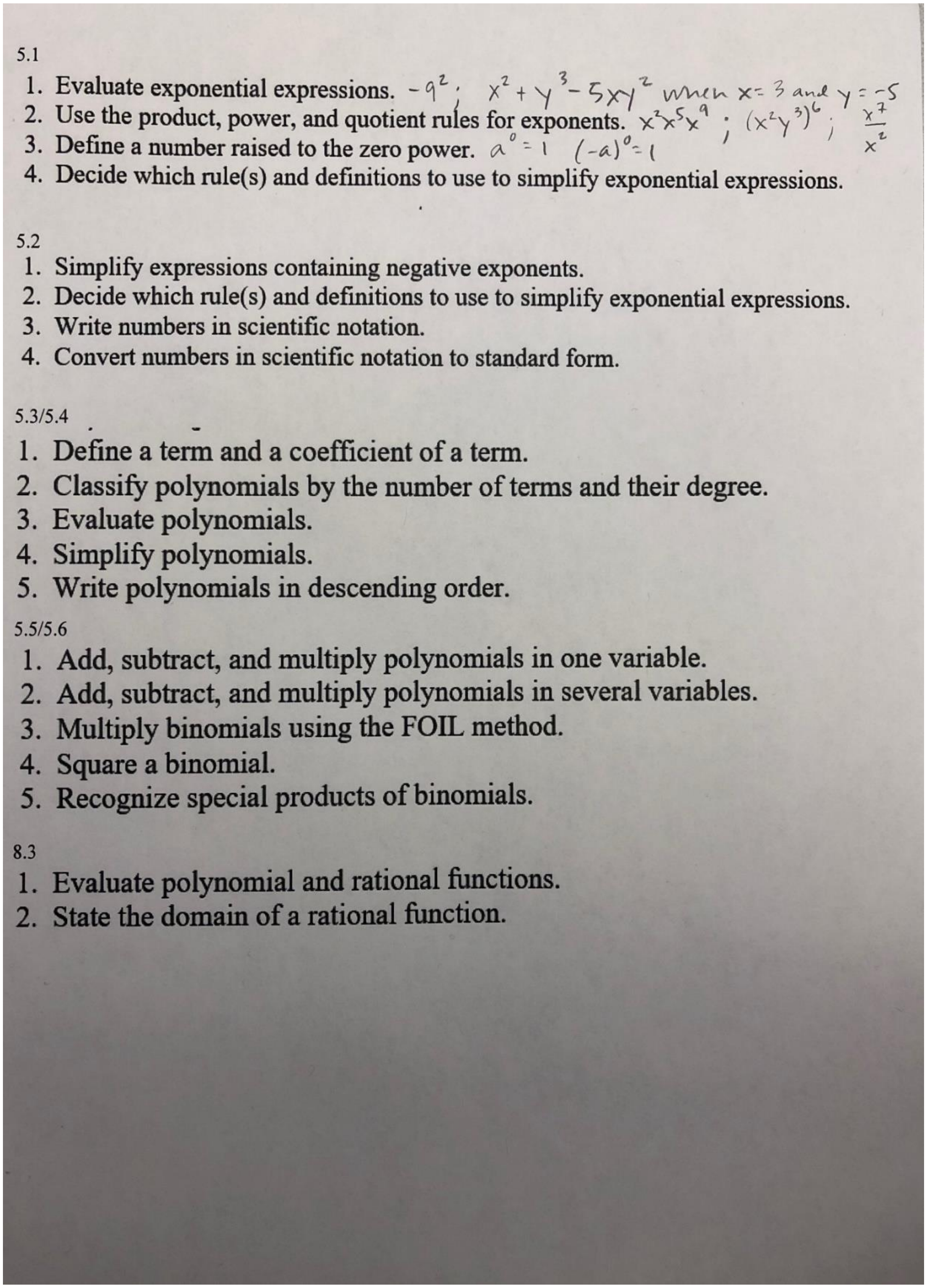


Figure 1. Researcher sample daily schedule, detailed during intervention one.



5.1

1. Evaluate exponential expressions. -9^2; $x^2+y^3-5xy^2$ when $x=3$ and $y=-5$
2. Use the product, power, and quotient rules for exponents. $x^2x^5x^9$; $(x^2y^3)^6$; $\frac{x^7}{x^2}$
3. Define a number raised to the zero power. $a^0=1$ $(-a)^0=1$
4. Decide which rule(s) and definitions to use to simplify exponential expressions.

5.2

1. Simplify expressions containing negative exponents.
2. Decide which rule(s) and definitions to use to simplify exponential expressions.
3. Write numbers in scientific notation.
4. Convert numbers in scientific notation to standard form.

5.3/5.4

1. Define a term and a coefficient of a term.
2. Classify polynomials by the number of terms and their degree.
3. Evaluate polynomials.
4. Simplify polynomials.
5. Write polynomials in descending order.

5.5/5.6

1. Add, subtract, and multiply polynomials in one variable.
2. Add, subtract, and multiply polynomials in several variables.
3. Multiply binomials using the FOIL method.
4. Square a binomial.
5. Recognize special products of binomials.

8.3

1. Evaluate polynomial and rational functions.
2. State the domain of a rational function.

Figure 2. Exam topic list built for intervention two.

Intervention 2: How do I prepare for a test? The first exam in the course occurs at the end of the second week; as such, a strategy for test preparation was addressed. Students in the researcher's sections were required to complete a class preparation assignment each day a new section was to be covered. On each assignment, the section objectives were listed. The researcher showed students how to create an exam topic list with those objectives and then illustrated how to create a practice test based on the topic list (see figure 2 above). The researcher began by detailing a problem aligned to a given objective, found either in handouts given in class or practice problems in My Math Lab © (Pearson Education, 2018). Then, the researcher opened it up to the class to continue to suggest problems for the next few objectives and finally allowed students to work either independently or in pairs for approximately 10 minutes. As the researcher moved about the classroom, any questions regarding whether or not a particular problem chosen appropriately reflected an objective were answered and assistance was given if requested.

Intervention 3: How do I reflect on a test? While returning exam one to students, a handout regarding error analysis was given (see Appendix A for handout). The researcher gave students five minutes to peruse the test on their own before speaking about it. The beginning of the handout was described, giving a synopsis of the types of errors rather than reading the descriptions verbatim. The researcher then went through the exam, giving specific examples of errors made on the exam that would classified as either conceptual or careless, as underprepared errors are more self-explanatory. Once the exam had been discussed, students were instructed to go back through their exams and classify the errors they had made. As the researcher moved around the classroom, students asking for clarification regarding which type of error was made were assisted.

Once all errors were classified by students, the rest of the handout was explained. Students were instructed to tally points lost for each type of error and write down which type of error cost them the most on the exam. They then needed to write what that told them about themselves and select one or two strategies to try moving in to the second unit and subsequent unit exam. Finally, students were encouraged (but not required) to correct all errors and visit further with the researcher privately for other test preparation and test taking strategies.

To keep the strategies students selected to compensate for the types of errors made on exam one on their minds, the researcher mentioned the reflection twice more in class prior to exam two. No other additional class time was taken to directly address exam reflection, but the researcher urged students to complete error classification after exams two and three were returned to students.

Intervention 4: Can I change my behavior? On the Monday of the second to last week of the course, students were given an article on perseverance (see appendix B) and given a chance to read through it. The researcher noted that the end of the semester was not the time to be on cruise control—it was necessary to finish strong. One line in the handout was underlined by the researcher in class. The researcher then told students to ask themselves, "How will I persevere?" To compliment that question, another handout was given (see appendix C). Students were asked to answer yes or no for each statement presented, all regarding maladaptive student behavior. During the first class period, a student comment led to the first statement to be changed from “I let my friends interrupt me when I am studying.” to “I let my phone interrupt me when I am studying.”

Once students finished, the researcher then suggested multiple solutions for modifying the behavior presented in the first statement. Students were then instructed to choose at least one of the behaviors they stated yes to and propose at least one way the behavior could be altered, plus a strategy for implementation of the proposal in the immediate future. Throughout the week, the researcher reminded students of their work regarding behavior modification to prompt students to think about their selected strategy and if or how it was being applied.

Measures

The survey instrument used for this study was compiled by the researcher. It was a combination of independent variables (demographics) used to describe the sample and dependent variables consisting of select items adapted from previously validated scales. The 49 item survey described below includes source information for previously established measures and reliability coefficients for all scales. The scales can be found in Appendix D.

Demographics. Participants were asked to complete a section of demographic and background information that included questions regarding their gender, age, ethnicity, course class level (freshman/sophomore), if the course is being repeated, and which prerequisite was met to gain entry into the course.

Establishing subscale focus. Participants were asked to rate the extent to which they agree to each of the following subscale’s statements on a 6-point Likert-type scale ranging from 1 (*strongly disagree*) to 6 (*strongly agree*).

Strategies for the regulation of academic cognition, academic motivation, and academic behavior. Developed as a way to assess academic self-regulated learning, the scales for regulation of academic cognition, academic motivation, and academic behavior (Wolters, Pintrich, & Karabenick, 2005) are established scales. Subscales used that were pertinent to the study are as follows.

Metacognitive self-regulation. The 12 items in this subscale address strategies students may use when thinking about their learning processes. Questions 1 through 12 on the survey dealt with (q. 1) wandering thoughts, (q. 2) questioning readings, (q. 3) rereading, (q. 4) changing reading strategies, (q. 5) material organization, (q. 6) questioning material, (q. 7) changing study style, (q. 8) reading comprehension, (q. 9) determining importance, (q. 10) determining what is unclear, (q. 11) study goals, and (q. 12) clarification. Cronbach's alpha for the 12 items in this subscale was .78 at Time 1 and .88 at Time 2.

Mastery self-talk. The six items in this subscale are reflective of strategies students may use to build themselves up. Questions 13 through 18 on the survey addressed (q. 13) working to learn, (q. 14) self-persuasion, (q. 15) self-challenge, (q. 16) learning for the sake of learning, (q. 17) learning as much as possible, and (q. 18) mastering material. The Cronbach alpha value for the six items in this subscale was .87 at Time 1 and .94 at Time 2.

Regulating time and study environment. This subscale dealt with study behaviors inside and outside of the classroom. Questions 19 through 26 on the survey focused on (q. 19) managing distraction, (q. 20) making use of study time, (q. 21) study schedule, (q. 22) place for studying, (q. 23) timeliness, (q. 24) class attendance, (q. 25) time on task, and (q. 26) exam preparation. Cronbach's alpha for this subscale was .84 at Time 1 and .78 at Time 2.

Effort regulation. The four items in this subscale looked at regulation of effort when course material did not necessarily appeal to participants; thus questions pertained to (q. 27) boredom with material, (q. 28) lack of enjoyment of material, (q. 29) difficulty of material, and (q. 30) uninteresting material. The Cronbach alpha value for this subscale was .84 at Time 1 and .78 at Time 2.

General intention to seek needed help. Three items dealt with help seeking behavior including (q. 31) asking for assistance, (q. 32) help with understanding lecture, and (q. 33) help with understanding readings. The Cronbach alpha value for this subscale was .90 at Time 1 and .94 at Time 2.

General intention to avoid needed help. Similar to seeking help, the subscale regarding avoidance of needed help also had three items. Questions dealt with (q. 34) guessing rather than asking, (q. 35) underperforming rather than asking, and (q. 36) difficulty of material. Although the Cronbach alpha value at Time 1 was slightly low at .69, the scale was already only three items and thus led to the decision to keep all items. At Time 2, the Cronbach alpha value was .89, further validating the decision to keep all items in the subscale.

Mathematics self-efficacy and anxiety questionnaire (MSEAQ). The MSEAQ (May, 2009) is a self-report measure designed to assess students' mathematics self-efficacy and anxiety. Only items from the MSEAQ pertaining to self-efficacy only were included in the survey instrument. These items concentrated on (q. 37) being good at math, (q. 38) ability to do math, (q. 39) ability to learn math, (q. 40) do well in future math courses, (q. 41) understand math, (q. 42) ability to earn a high math grade, and (q. 43) do the math in future math courses. Cronbach's alpha for this subscale was .96 at Time 1 and .95 at Time 2.

Data Analysis

Data analysis consisted of a preliminary analysis and main analysis. During preliminary analysis, the collected data was first manually reviewed for obvious missing values, then loaded into Statistical Package for the Social Science (SPSS) version 25, for subsequent evaluation of reliability and validity. During main analysis, specific analytical techniques were performed on the resulting data set in order to address the research questions.

Preliminary Analysis

Data Screening. In order to ensure reliability of the reported results, collected data was reviewed to check for errors, outliers, and missing data. Due to the small data set, the researcher was able to manually identify those responses that were obviously unusable. As the survey required participants to create a digital identifier known only to themselves, first, identifiers listed in the survey responses from Time 1 and Time 2 were matched. In the intervention group, there were 17 responses at Time 1, 15 at Time 2, and of those, 12 were found to have matching identifiers. In the control group, there were 25 responses at Time 1, 20 at Time 2, and 12 of those were found to have matching identifiers.

Next, the data was imported into SPSS 25. Upon further review, one response was found to be missing two subscale items and one response was found to be missing one subscale item. The decision to include these responses in the main analyses was twofold. First, the responses did contain a majority of the information being collected and thus was deemed beneficial for the descriptive statistics result. Second, the sample size was already very low and excluding an additional two responses would have negatively impacted the results. A complete listing of the variable names and values used in survey data analyses is presented in Appendix E.

Data normality. Once data screening was complete, descriptive statistics, including skewness and kurtosis values, were examined to determine normality. Skewness values greater than ±2.3 are severely non-normal, values between ±1 – 2.3 are considered moderately non-normal, and values less than ±1.0 are normal (Lei & Lomax, 2005). Kurtosis values greater than ±7.0 are considered non-normal (Byrne, 2010).

Using these guidelines, kurtosis values were all found to be normal but skewness values were moderately non-normal at Time 1 for items one, three, seven, and ten of the metacognitive self-regulation scale, item six of the regulating time and study environment scale, item four of the effort regulation scale, all items on the general intention to seek needed help scale, and item five of the self-efficacy scale. Skewness values moderately non-normal at Time 2 were item six of the regulating time and study environment scale and items one and two on the general intention to seek needed help scale. Upon further investigation, these deviations are assumed to be caused by a combination of high means scores on those items and the small sample size. Because the purpose of the study was to determine the impact of direct instruction, SR interventions in these areas, these moderately non-normal items were retained for analysis.

Lastly, the assumption of sphericity in a repeated measures ANOVA is that the variances of the differences between data from the same participant are equal, but only applies when there are more than two points of data from the same participant (Field, 2013). As there are only two levels of time for within-subjects testing in this study, sphericity is not an issue.

Principal component analysis. Although initially factor analysis was proposed to confirm the construct validity of the multiple item scales, the small sample size caused the researcher to abandon this strategy. As all scales used were established, the decision was made to continue analysis based on the previously extracted factors.

Reliability. Cronbach's alpha reliability coefficients were calculated as an estimate of data reliability. As described within the subscale, the alpha values for subscales of metacognitive self-regulation, mastery self-talk, regulating time and study environment, effort regulation, general intention to seek needed help, general intention to avoid needed help, and mathematics self-efficacy were .78, .87, .84, .84, .90, .69, and .96 respectively at Time 1; .89, .94, .78, .78, .94, .89, and .95 respectively at Time 2. Alpha values within the .70 - .95 range indicate consistency of measurement, thus provide evidence that the items are measuring the same concept (Warner, 2013). Therefore, the Cronbach's alpha values indicate the subscales are reliable.

Validity. Warner (2013) states that validity is more difficult to determine than reliability. To ensure content validity in this study, established scales to measure SR strategy use (Wolters, Pintrich, & Karabenick, 2005) and mathematics self-efficacy (May, 2009) were used. The scales were carefully reviewed by the researcher to ensure items represented the constructs being measured.

Main Analyses

After completing preliminary data analyses, additional analytical techniques were applied in order to address the research questions. The main analyses procedures are described in greater detail below, and the results are presented in chapter IV.

Question 1. The first research question sought to determine the impact of structuring a developmental mathematics course with multiple direct instruction, SR interventions on student use of self-regulatory strategies. Participant's responses regarding use of SR strategies were described using descriptive analyses including mean scores, standard deviations, and the calculated percentage of some form of agreement with each question on the SR subscales. A mixed ANOVA tested the effects of the intervention on use of SR strategies as compared to sections without an intervention component. Additionally, Pearson correlations were calculated to illustrate the degree of association among each of the subscale constructs.

Question 2. The second research question examined the impact of structuring a developmental mathematics course with multiple direct instruction, SR interventions on mathematics self-efficacy. Participant's responses regarding mathematics self-efficacy were described using descriptive analyses including mean scores, standard deviations, and the calculated percentage of some form of agreement with each question on the SR subscales. A mixed ANOVA tested the effects of the intervention on mathematics self-efficacy as compared to sections without an intervention component. Additionally, Pearson correlations were calculated to illustrate the degree of association among each of the subscale constructs.

Question 3. The third research question investigated the successful completion rate of developmental courses with multiple direct instruction, SR interventions as compared to sections without an intervention component. A two-proportion *z*-test was used to compare the completion rates from the sections invited to participate in the study.

Summary

This chapter described the methods that were used to determine the impact of structuring a developmental mathematics course with a direct instruction, SR intervention at multiple times have on the level of student use of self-regulatory strategies, on mathematics self-efficacy, and on successful course completion. The research setting and participants selected for the study were described. The research design and procedures were outlined along with a detailed explanation of the instrument used. Finally, preliminary and main analyses of data was described. The results produced using the methodology described in this chapter are presented in Chapter IV.

CHAPTER IV

RESULTS

The purpose of this study was to determine if students could improve their ability to self-regulate throughout a developmental mathematics course. Upon completion of preliminary analyses, responses from 24 participants (12 control; 12 intervention) were included in the main analyses. The results of those analyses are described here, using a statistical significance level of $p < .05$ to indicate any significant group differences are based on an attributable cause and are not due to random chance. Collectively, the results will indicate if participants receiving multiple direct instruction, SR interventions differed from participants who did not.

Research Questions

Question 1: What impact does structuring a developmental mathematics course with multiple direct instruction, SR interventions have on the level of student use of self-regulatory strategies?

The first research question sought to determine the impact of structuring a developmental mathematics course with multiple direct instruction, SR interventions on student use of self-regulatory strategies. Descriptive statistics, a mixed ANOVA, and Pearson correlations were used to answer this question. The results of those analyses are described and presented in table format here.

Metacognitive self-regulation. Table 3 shows the specific questions related to metacognitive self-regulation strategy use for participants in the control section at times one and two. At Time 1 the majority of participants agreed with 11 of 12 items, the exception being question 2. Questions 1, 3, 4, 7, 8, and 10 had mean levels at 4.2, with question 3 having the highest percentage of agreement (100%) and three other questions (Q1, Q7, and Q10) at 91.7% agreement. At Time 2 the majority of participants agreed with the same 11 of 12 items. Furthermore, questions 1, 3, 5, 7, 9, 10, and 11 had mean levels of 4.0 and above.

Table 3. Control Group Reported Metacognitive Self-Regulation Strategy Usage

		Time 1				Time 2			
Question Number	Metacognitive Self-Regulation Questions	% Some Form of Agreement	*N*	*M*	*SD*	% Some Form of Agreement	*n*	*M*	*SD*
Q1	During class time I often miss important points because I'm thinking of other things. (REVERSED)	91.7	12	5.1	.8	83.3	12	4.4	1.1
Q2	When reading for this course, I make up questions to help focus my reading.	33.3	12	2.7	1.1	41.7	12	3.3	1.4
Q3	When I become confused about something I'm reading for this class, I go back and try to figure it out.	100	12	5.0	.6	66.7	12	4.3	1.4
Q4	If course materials are difficult to understand, I change the way I read the material.	66.7	12	4.2	1.2	58.3	12	3.9	1.3
Q5	Before I study new course material thoroughly, I often skim it to see how it is organized.	75.0	12	3.8	1.3	83.3	12	4.6	1.0
Q6	I ask myself questions to make sure I understand the material I have been studying in this class.	58.3	12	3.5	1.7	75	12	3.9	1.4
Q7	I try to change the way I study in order to fit the course requirements and instructor's teaching style.	91.7	12	4.5	1.2	58.3	12	4.0	1.3

Table 3. cont.

Question Number	Metacognitive Self-Regulation Questions	Time 1 % Some Form of Agreement	*N*	*M*	*SD*	Time 2 % Some Form of Agreement	*n*	*M*	*SD*
Q8	I often find that I have been reading for class but don't know what it was all about. (REVERSED)	83.3	12	4.3	1.1	66.7	12	3.9	1.4
Q9	I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying.	66.7	12	3.8	1.2	75.0	12	4.3	1.0
Q10	When studying for a course I try to determine which concepts I don't understand well.	91.7	12	4.7	1.2	66.7	12	4.3	1.2
Q11	When I study for this class, I set goals for myself in order to direct my activities in each study period.	66.7	12	3.8	1.6	58.3	12	4.2	1.5
Q12	If I get confused taking notes in class, I make sure I sort it out afterwards.	66.7	12	3.8	1.7	58.3	12	3.9	1.5

Table 4 shows specific questions related to metacognitive self-regulation strategy use for participants in the intervention section at times one and two. Like the control group, agreement was found for a majority of participants on a majority of items, but not for questions 2 or 5 at Time 1. Seven of the 12 items had mean values of 4.0 or above (Q1, Q3, Q7, Q9, Q10, Q11, and Q12). At Time 2, disagreement was present for questions 2 and 8. Again seven items had mean values of 4.0 or above (Q1, Q3, Q6, Q7, Q10, Q11, and Q12).

Table 4. Intervention Group Reported Metacognitive Self-Regulation Strategy Usage

		Time 1				Time 2			
Question Number	Metacognitive Self-Regulation Questions	% Some Form of Agreement	*N*	*M*	*SD*	% Some Form of Agreement	*n*	*M*	*SD*
Q1	During class time I often miss important points because I'm thinking of other things. (REVERSED)	83.3	12	4.6	1.2	75.0	12	4.9	1.2
Q2	When reading for this course, I make up questions to help focus my reading.	41.7	12	2.9	1.0	33.3	12	2.9	1.2
Q3	When I become confused about something I'm reading for this class, I go back and try to figure it out.	91.7	12	5.1	1.1	91.7	12	4.6	.8
Q4	If course materials are difficult to understand, I change the way I read the material.	58.3	12	3.8	1.2	58.3	12	3.8	1.0
Q5	Before I study new course material thoroughly, I often skim it to see how it is organized.	41.7	12	3.3	1.2	66.7	12	3.6	.9
Q6	I ask myself questions to make sure I understand the material I have been studying in this class.	66.7	12	3.9	1.4	66.7	12	4.0	1.1
Q7	I try to change the way I study in order to fit the course requirements and instructor's teaching style.	91.7	12	4.3	.9	91.7	12	4.6	.9
Q8	I often find that I have been reading for class but don't know what it was all about. (REVERSED)	58.3	12	3.8	1.5	33.3	12	3.1	1.1
Q9	I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying.	83.3	12	4.0	.6	58.3	12	3.7	1.0
Q10	When studying for a course I try to determine which concepts I don't understand well.	91.7	12	4.5	.7	91.7	12	4.9	1.0
Q11	When I study for this class, I set goals for myself in order to direct my activities in each study period.	91.7	12	4.3	1.2	91.7	12	4.7	1.0
Q12	If I get confused taking notes in class, I make sure I sort it out afterwards.	75.0	12	4.3	1.1	83.3	12	4.4	.9

Mixed ANOVA results. Figure 3 gives a visual representation of the results from the mixed ANOVA. Means for both groups were nearly equal at both times one and two, and as time went by, all participants rated their metacognitive self-regulation similarly. Because of nonsignificance both within and between groups, the individual groups are not perceived to be different at two different times, and are not different from each other.

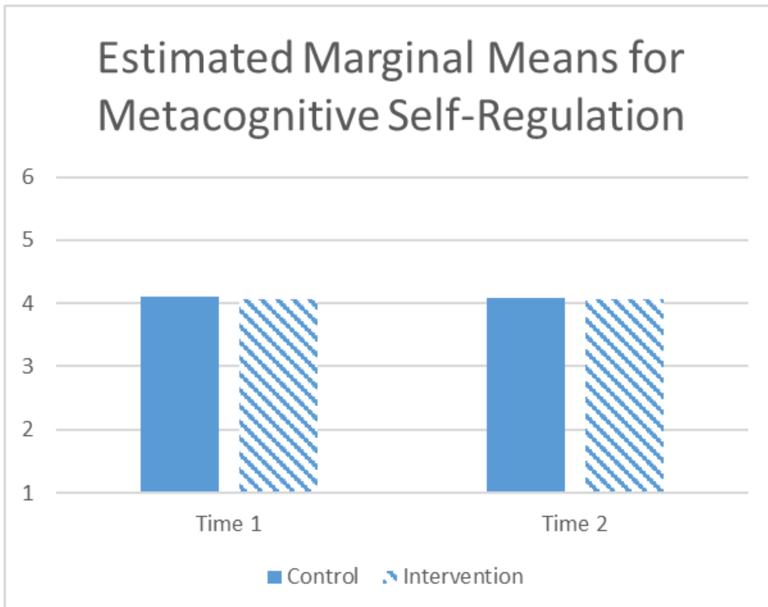


Figure 3. Estimated marginal means for the construct of metacognitive self-regulation, control vs. intervention, Time 1 vs. Time 2.

Mastery self-talk. Table 5 shows specific questions related to mastery-self talk strategy use for the control group at both times one and two. Participants reported mean levels ranging from 4.3 – 4.8 at Time 1 and from 4.1 – 4.5 at Time 2. Three questions (Q14, Q15, and Q18) had 91.7% agreement at Time 1, with the lowest percentage of agreement at 66.7% on question 16. At Time 2, the percentage of agreement dropped for four out of the six items, with Q13 and Q15 staying the same. Mean values also dropped for five of six items from Time 1 to Time 2, with Q16 remaining the same.

Table 5. Control Group Reported Mastery Self-Talk Strategy Usage

		Time 1				Time 2			
Question Number	Mastery Self-Talk Questions	% Some Form of Agreement	*N*	*M*	*SD*	% Some Form of Agreement	*n*	*M*	*SD*
Q13	I tell myself that I should keep working just to learn as much as I can.	83.3	12	4.5	1.1	83.3	12	4.3	1.2
Q14	I persuade myself to keep at it just to see how much I can learn.	91.7	12	4.6	1.0	66.7	12	4.2	1.2
Q15	I challenge myself to complete the work and learn as much as possible.	91.7	12	4.8	1.1	91.7	12	4.5	1.0
Q16	I convince myself to work hard just for the sake of learning.	66.7	12	4.3	1.2	83.3	12	4.3	1.1
Q17	I tell myself that I should study just to learn as much as I can.	83.3	12	4.3	1.1	75.0	12	4.2	1.1
Q18	I think about trying to become good at what we are learning or doing.	91.7	12	4.4	1.0	75.0	12	4.1	1.2

Shown in table 6 are results for the intervention group reported mastery self-talk strategy use. All mean levels at both times were 4.3 or above and the lowest percentage of agreement was 83.3%. Changes in means and percentages of agreement were quite varied.

Table 6. Intervention Group Reported Mastery Self-Talk Strategy Usage

		Time 1				Time 2			
Question Number	Mastery Self-Talk Questions	% Some Form of Agreement	*N*	*M*	*SD*	% Some Form of Agreement	*n*	*M*	*SD*
Q13	I tell myself that I should keep working just to learn as much as I can.	100	12	4.6	.7	83.3	12	4.4	1.0
Q14	I persuade myself to keep at it just to see how much I can learn.	91.7	12	4.5	1.1	91.7	12	4.3	.8
Q15	I challenge myself to complete the work and learn as much as possible.	83.3	12	4.7	1.3	100	12	4.8	.9

Table 6. cont.

Question Number	Mastery Self-Talk Questions	Time 1 % Some Form of Agreement	*N*	*M*	*SD*	Time 2 % Some Form of Agreement	*n*	*M*	*SD*
Q16	I convince myself to work hard just for the sake of learning.	100	12	4.7	.8	91.7	12	4.7	.8
Q17	I tell myself that I should study just to learn as much as I can.	83.3	12	4.6	1.0	91.7	12	4.8	1.0
Q18	I think about trying to become good at what we are learning or doing.	91.7	12	5.0	.9	100	12	5.1	.8

Mixed ANOVA results. Figure 4 gives the visual results of a mixed ANOVA. Although participants in the intervention group rated their levels of mastery self-talk higher than participants in the control section at both times, there was not a significant between-groups interaction nor a significant within-groups outcome. Participants in the intervention were consistent over time in their reported use of self-talk strategies, whereas control participants rated their use as slightly lower.

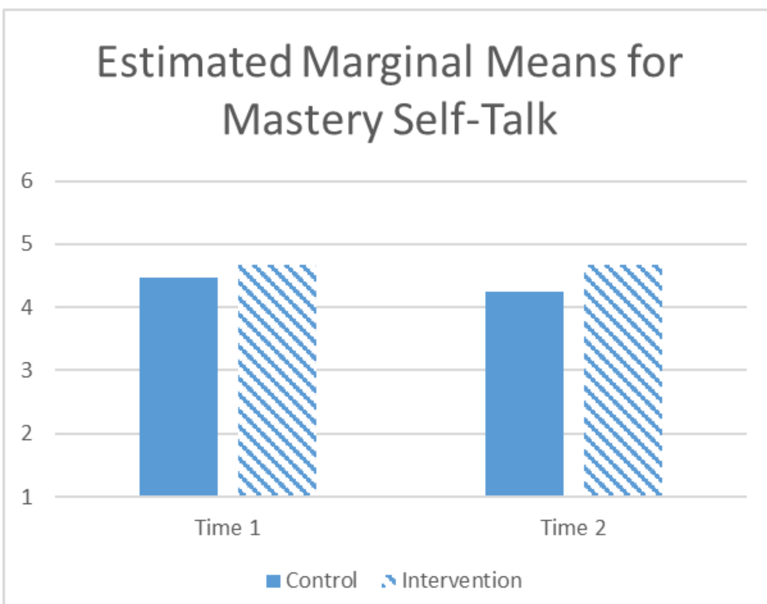


Figure 4. Estimated marginal means for the construct of mastery self-talk, control vs. intervention, Time 1 vs. Time 2.

Regulating time and study environment. Table 7 shows the results of the control group use of specific strategies to regulate time and study environment questions. Two reversed items regarding time spent on the course (Q25 and Q26) had the lowest percentage of agreement at Time 1; however, both the means and percentage of agreement increased at Time 2 for these items. At Time 2, the other reversed item (Q21) had only one-third of respondents agreeing with the reversal. This was a drop from Time 1. All other items at times one and two had a majority of participants voicing some form of agreement and changes in mean and percentage of agreement were varied.

Table 7. Control Group Reported Regulating Time and Study Environment Strategy Usage

		Time 1				Time 2			
Question Number	Regulating Time and Study Environment Questions	% Some Form of Agreement	*N*	*M*	*SD*	% Some Form of Agreement	*n*	*M*	*SD*
Q19	I usually study in a place where I can concentrate on my course work.	91.7	12	4.7	1.2	100	12	5.2	.7
Q20	I make good use of my study time for this course.	66.7	12	4.1	1.4	83.3	12	4.5	1.2
Q21	I find it hard to stick to a study schedule. (REVERSED)	63.6	11	3.6	1.3	33.3	12	3.2	1.4
Q22	I have a regular place set aside for studying.	58.3	12	3.8	1.5	75.0	12	4.0	1.6
Q23	I make sure I keep up with the weekly readings and assignments for this course.	100	12	5.2	.7	91.7	12	4.8	1.2
Q24	I attend class regularly.	91.7	12	5.3	1.0	91.7	12	5.1	1.0
Q25	I often find that I don't spend very much time on this course because of other activities. (REVERSED)	41.7	12	3.6	1.4	58.3	12	4.0	1.3
Q26	I rarely find time to review my notes or readings before an exam. (REVERSED)	50.0	12	3.7	1.2	58.3	12	4.0	1.4

Intervention participants were optimistic in reporting their use of specific strategies for the regulation of time and study environment with 100% agreement on four items at Time 1 (Q19, Q20, Q24, and Q26) and one item at Time 2 (Q24) as shown in table 8. Furthermore, all items at both times show a majority of participants agreeing with the statements; however, many of the mean values dropped from Time 1 to Time 2.

Table 8. Intervention Group Reported Regulating Time and Study Environment Strategy Usage

		Time 1				Time 2			
Question Number	Regulating Time and Study Environment Questions	% Some Form of Agreement	*N*	*M*	*SD*	% Some Form of Agreement	*n*	*M*	*SD*
Q19	I usually study in a place where I can concentrate on my course work.	100	12	5.3	.8	83.3	12	4.9	1.1
Q20	I make good use of my study time for this course.	100	12	4.9	.7	75.0	12	4.4	1.4
Q21	I find it hard to stick to a study schedule. (REVERSED)	66.7	12	4.0	1.3	58.3	12	3.6	1.2
Q22	I have a regular place set aside for studying.	83.3	12	4.6	1.2	90.9	11	4.9	.9
Q23	I make sure I keep up with the weekly readings and assignments for this course.	91.7	12	5.0	1.0	83.3	12	4.8	1.1
Q24	I attend class regularly.	100	12	5.8	.6	100	12	5.5	.5
Q25	I often find that I don't spend very much time on this course because of other activities. (REVERSED)	91.7	12	4.7	.9	66.7	12	4.5	1.5
Q26	I rarely find time to review my notes or readings before an exam. (REVERSED)	100	12	4.8	.8	75.0	12	4.5	1.1

Mixed ANOVA results. As with the previous two constructs, there were no significant results neither within-groups nor between-groups when considering the use of strategies to regulate time and study environment. Although participants in the intervention group rated their levels of regulating time and study environment higher than participants in the control section at both times, there was a decrease in mean values for the intervention group and slight increase in mean values for the control group as shown in figure 5.

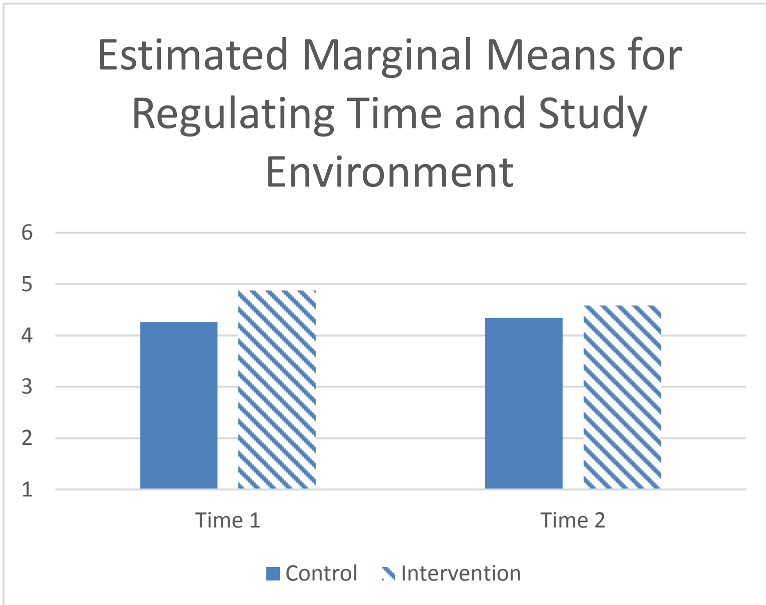


Figure 5. Estimated marginal means for the construct of regulating time and study environment, control vs. intervention, Time 1 vs. Time 2.

Effort regulation. Table 9 contains information for the reported effort regulation of the control group participants. All items at both times show a majority of participant agreement. Furthermore, the percentage of agreement stayed the same for three of four items, with Q27 increasing from Time 1 to Time 2.

Table 9. Control Group Reported Effort Regulation

		Time 1				Time 2			
Question Number	Effort Regulation Questions	% Some Form of Agreement	*N*	*M*	*SD*	% Some Form of Agreement	*n*	*M*	*SD*
Q27	I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do. (REVERSED)	66.7	12	4.1	1.4	75.0	12	4.2	1.5
Q28	I work hard to do well in this class even if I don’t like what we are doing.	83.3	12	4.7	1.0	83.3	12	4.5	1.2
Q29	When course work is difficult, I give up or study only the easy parts. (REVERSED)	75.0	12	4.3	1.1	75.0	12	4.3	1.2
Q30	Even when course materials are dull and uninteresting, I manage to keep working until I finish.	83.3	12	4.6	1.2	83.3	12	4.6	1.2

At Time 1, the participants in the intervention group rated all items very favorably with the lowest percentage of agreement being 91.7%, but at Time 2, means and percentage of some form of agreement drop for every item. Results are shown in table 10.

Table 10. Intervention Group Reported Effort Regulation

		Time 1				Time 2			
Question Number	Effort Regulation Questions	% Some Form of Agreement	*N*	*M*	*SD*	% Some Form of Agreement	*n*	*M*	*SD*
Q27	I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do. (REVERSED)	91.7	12	4.6	1.3	66.7	12	3.7	1.4
Q28	I work hard to do well in this class even if I don't like what we are doing.	100	12	4.9	.7	91.7	12	4.8	1.1
Q29	When course work is difficult, I give up or study only the easy parts. (REVERSED)	91.7	12	4.8	1.1	58.3	12	3.9	1.4
Q30	Even when course materials are dull and uninteresting, I manage to keep working until I finish.	91.7	12	4.8	.7	83.3	12	4.4	.9

Mixed ANOVA results. There was a significant interaction between the groups with respect to time, $F(1, 22) = 4.675$, $p = .042$, $r = .454$. For the intervention group, time led to a decrease in effort regulation. For the control group, time had no effect. There was no significant effect of time on the control group, nor was there a between-groups difference. A visual representation is shown in figure 6.

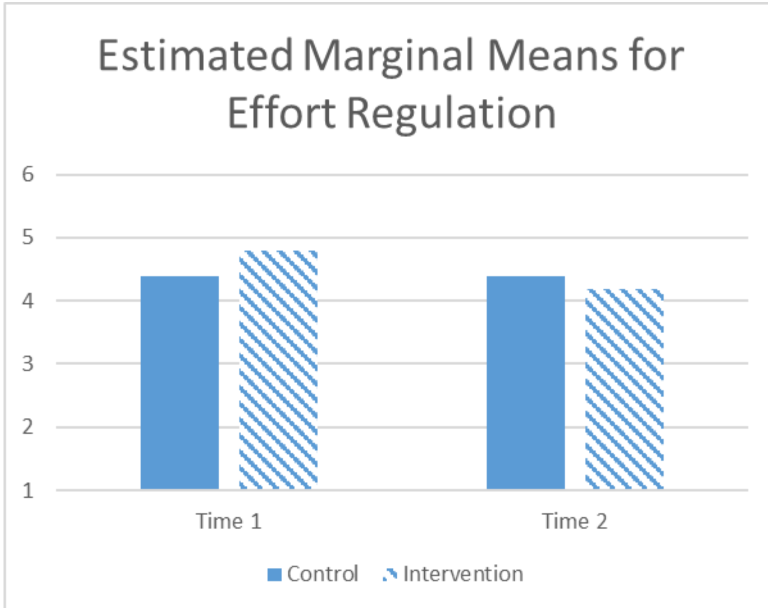


Figure 6. Estimated marginal means for the construct of effort regulation, control vs. intervention, Time 1 vs. Time 2.

Seeking needed help. Reported help-seeking behaviors for the control group are shown in table 11. Overall, a majority of participants assert help is sought when it is needed: three-fourths of participants at Time 1 and two-thirds at Time 2. Means, however, for two of three items went down, with Q32 remaining the same from Time 1 to Time 2.

Table 11. Control Group Reported Seeking Needed Help Behavior

		Time 1				Time 2			
Question Number	Seeking Needed Help and Avoiding Needed Help Questions	% Some Form of Agreement	*n*	*M*	*SD*	% Some Form of Agreement	*n*	*M*	*SD*
Q31	If I needed help in this class I would ask someone for assistance.	75.0	12	4.1	1.9	66.7	12	3.9	1.8
Q32	If I needed help understanding the lectures in this class I would ask for help.	75.0	12	4.2	1.8	66.7	12	4.2	1.6
Q33	If I needed help with the readings in this class I would ask for help.	75.0	12	4.2	1.7	66.7	12	4.0	1.7

Like the control group, the intervention group also reported high levels of seeking help when needed (91.7% agreement at minimum) both at Time 1 and Time 2. The three items had means ranging from 5.0 – 5.3 at both times. See table 12 for reported values.

Table 12: Intervention Group Reported Seeking Needed Help Behavior

		Time 1				Time 2			
Question Number	Seeking Needed Help and Avoiding Needed Help Questions	% Some Form of Agreement	*n*	*M*	*SD*	% Some Form of Agreement	*n*	*M*	*SD*
Q31	If I needed help in this class I would ask someone for assistance.	91.7	12	5.0	1.4	91.7	12	5.3	.8
Q32	If I needed help understanding the lectures in this class I would ask for help.	91.7	12	5.2	1.2	91.7	12	5.2	.9
Q33	If I needed help with the readings in this class I would ask for help.	100	12	5.3	.7	91.7	12	5.0	1.0

Mixed ANOVA results. There was a significant, medium-sized, between-groups effect; $F(1, 22) = 5.020$, $p = .035$, $r = .457$, indicating there is a statistical difference between the control and intervention groups in regards to reported help-seeking behaviors. Participants in the intervention group reported similar levels of exhibiting help-seeking behavior, whereas control participants reported deceasing levels over time. As shown in figure 7, the reported mean level for participants in the intervention group was always higher than the level reported for the control group.

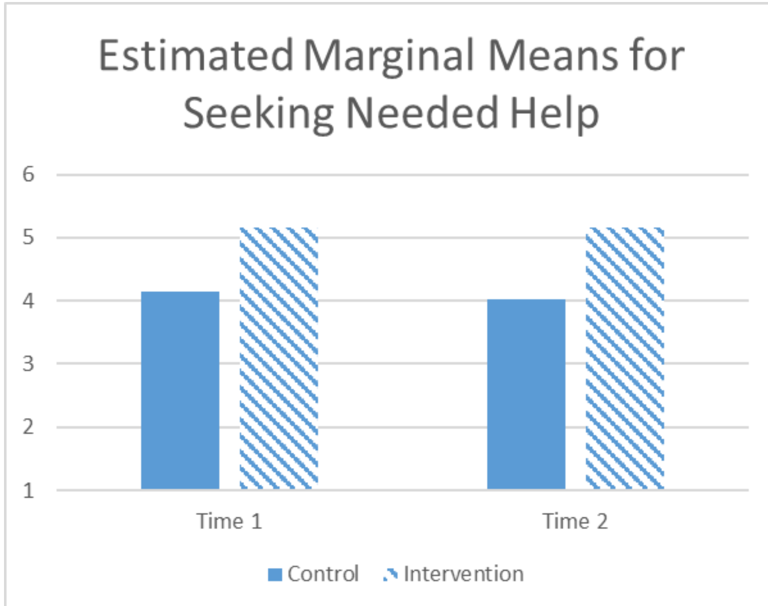


Figure 7. Estimated marginal means for the construct of seeking needed help, control vs. intervention, Time 1 vs. Time 2.

Avoiding needed help. Table 13 shows the specific questions related to behaviors associated with avoiding asking for needed help in the control group at times one and two. Mean values range from 2.3 – 2.9 at Time 1 and from 2.3 – 2.8 at Time 2. In general, the majority of participants disagreed with items in this construct.

Table 13. Control Group Reported Avoiding Needed Help Behavior

		Time 1				Time 2			
Question Number	Avoiding Needed Help Questions	% Some Form of Agreement	*n*	*M*	*SD*	% Some Form of Agreement	*n*	*M*	*SD*
Q34	If I didn't understand something in this class I would guess rather than ask someone for assistance.	33.3	12	2.9	1.4	16.7	12	2.7	1.1
Q35	I would rather do worse on an assignment I couldn't finish than ask for help.	16.7	12	2.3	1.2	25.0	12	2.3	1.1
Q36	Even if the work was too hard to do on my own, I wouldn't ask for help with this class.	25.0	12	2.8	1.4	33.3	12	2.8	1.1

Like the control group, the intervention group also reported a similar disagreement with avoiding asking for needed help. Table 14 shows the reported results. A majority of participants responded with general disagreement for the items in this construct. Means at Time 1 ranged from 1.8 – 3.0 and from 2.4 – 2.7 at Time 2.

Table 14. Intervention Group Reported Avoiding Needed Help Behavior

		Time 1				Time 2			
Question Number	Seeking Needed Help and Avoiding Needed Help Questions	% Some Form of Agreement	*n*	*M*	*SD*	% Some Form of Agreement	*n*	*M*	*SD*
Q34	If I didn't understand something in this class I would guess rather than ask someone for assistance.	33.3	12	3.0	1.6	50	12	2.4	1.7
Q35	I would rather do worse on an assignment I couldn't finish than ask for help.	0	12	1.8	.9	16.7	12	2.7	1.8
Q36	Even if the work was too hard to do on my own, I wouldn't ask for help with this class.	16.7	12	1.8	1.2	25.0	12	2.5	1.7

Mixed ANOVA results. There were no significant results neither within-groups nor between-groups when considering the avoidance of asking for needed help. Participants in the intervention group rated their levels of avoidance as increasing from Time 1 to Time 2 and there was a slight decrease in mean values for the control group as shown in figure 8.

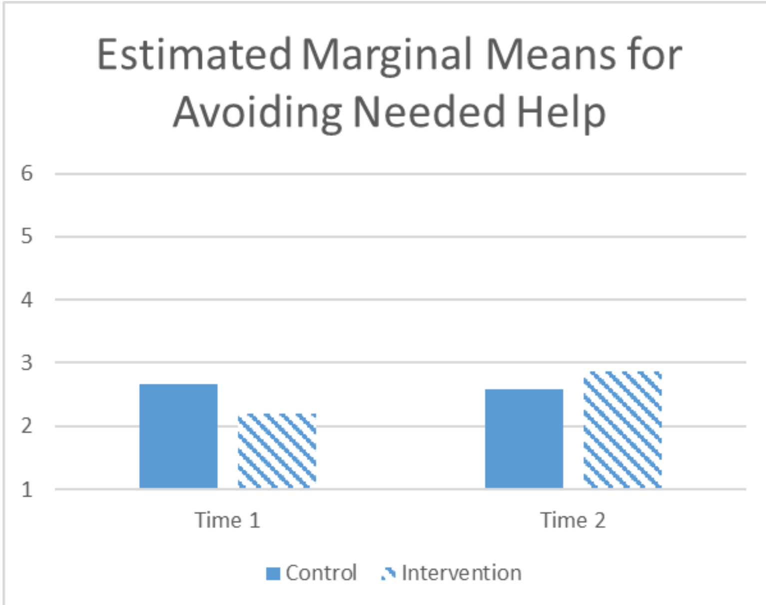


Figure 8. Estimated marginal means for the construct of avoiding needed help, control vs. intervention, Time 1 vs. Time 2.

Pearson Correlations. To delve further into research questions one and two, Pearson correlations were conducted among all constructs at both times one and two. This analysis was not done separately for the two groups. As seen in table 15, there were many significant correlations at Time 1. In fact, of the 21 possible correlations, only two were found to be nonsignificant. Using standard values for effect size of ± .1 to represent a small effect, ± .3 for a medium effect, and ± .5 for a large effect (Field, 2013), the majority of significant correlations are also quite strong.

Table 15. Correlation of Subscale Constructs and Measure of Internal Consistency for Student Use of SR Strategies and Mathematics Self-Efficacy, Time 1

Construct	Items	Subscale	C1.	C2.	C3.	C4.	C5.	C6.	Cronbach's alpha
C1.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	Metacognitive Self-Regulation	…						.78
C2.	13, 14, 15, 16, 17, 18	Mastery Self-Talk	.72*	…					.87
C3.	19, 20, 21, 22, 23, 24, 25, 26	Regulating Time & Study Environment	.61*	.62*	…				.84

Table 15. cont.

Construct	Items	Subscale	C1.	C2.	C3.	C4.	C5.	C6.	Cronbach's alpha
C4.	27, 28, 29, 30	Effort Regulation	.68*	.71*	.84*	…			.84
C5.	31, 32, 33	Intent to Seek Needed Help	.51*	.50*	.58*	.56*	…		.90
C6.	34, 35, 36	Intent to Avoided Needed Help	-.45*	-.21	-.46*	-.52*	-.60*	…	.69
C7.	37, 38, 39, 40, 41, 42, 43	Self-Efficacy	.45*	.49*	.53*	.55*	.45*	-.10	.96

*Correlation is significant at $p < .05$

At Time 2 there were also many significant correlations, as shown in table 16. The general intention to avoid needed help was still negatively correlated with five of the other constructs (two significantly versus four at Time 1), but its correlation to mathematics self-efficacy went from a weak negative at Time 1 to very slightly positive; almost zero—indicating no association at Time 2. The remaining significant correlations among other constructs remained significant at Time 2, with some correlations becoming even stronger.

Table 16. Correlation of Subscale Constructs and Measure of Internal Consistency for Student Use of SR Strategies and Mathematics Self-Efficacy, Time 2

Construct	Items	Subscale	C1.	C2.	C3.	C4.	C5.	C6.	Cronbach's alpha
C1.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	Metacognitive Self-Regulation	…						.88
C2.	13, 14, 15, 16, 17, 18	Mastery Self-Talk	.80*	…					.94
C3.	19, 20, 21, 22, 23, 24, 25, 26	Regulating Time & Study Environment	.59*	.63*	…				.78
C4.	27, 28, 29, 30	Effort Regulation	.82*	.66*	.71*	…			.78
C5.	31, 32, 33	Intent to Seek Needed Help	.67*	.73*	.63*	.48*	…		.94
C6.	34, 35, 36	Intent to Avoided Needed Help	-.35	-.23	-.57*	-.67*	-.28	…	.89
C7.	37, 38, 39, 40, 41, 42, 43	Self-Efficacy	.35	.48*	.27	.31	.32	.04	.95

*Correlation is significant at $p < .05$

Question 2: What impact does structuring a developmental mathematics course with multiple direct instruction, SR interventions have on mathematics self-efficacy?

The second research question examined the impact of structuring a developmental mathematics course with multiple direct instruction, SR interventions on mathematics self-efficacy. Descriptive statistics, a mixed ANOVA, and Pearson correlations were used to answer this question. The results of those analyses are described and presented in table format here.

As shown in table 17, the control group seemed rather neutral on the topic of self-efficacy. Although a majority of participants reported some form of agreement on six of seven items, the mean values hovered between 2.8 and 4.1. The lowest percentage of agreement and smallest mean value was for question 37 (41.7%; *M* = 2.8/3.0). Change in means from Time 1 to Time 2 was varied.

Table 17. Control Group Reported Mathematics Self-Efficacy

		Time 1				Time 2			
Question Number	Mathematics Self-Efficacy Questions	% Some Form of Agreement	*n*	*M*	*SD*	% Some Form of Agreement	*n*	*M*	*SD*
Q37	I believe I am the kind of person who is good at mathematics.	41.7	12	2.8	1.2	41.7	12	3.0	1.4
Q38	I believe I am the kind of person who can do mathematics.	66.7	12	3.3	1.3	66.7	12	3.6	1.4
Q39	I believe I can learn well in a mathematics course.	66.7	12	3.4	1.5	58.3	12	3.7	1.4
Q40	I feel that I will be able to do well in future mathematics courses.	66.7	12	3.7	1.4	66.7	12	3.8	1.2
Q41	I believe I can understand the content in a mathematics course.	83.3	12	4.1	1.3	75.0	12	4.1	1.3
Q42	I believe I can get an "A" when I am in a mathematics course.	75.0	12	3.8	1.2	75.0	12	3.4	1.5
Q43	I believe I can do the mathematics in a mathematics course.	75.0	12	3.8	1.1	91.7	12	4.2	1.1

As was the case in the control group, the intervention group's lowest mean value was for question 37 at both times one and two. All mean values went down from Time 1 to Time 2. See table 19 for reported values.

Table 18. Intervention Group Reported Mathematics Self-Efficacy

		Time 1				Time 2			
Question Number	Mathematics Self-Efficacy Questions	% Some Form of Agreement	*n*	*M*	*SD*	% Some Form of Agreement	*n*	*M*	*SD*
Q37	I believe I am the kind of person who is good at mathematics.	66.7	12	3.7	1.8	58.3	12	3.5	1.3
Q38	I believe I am the kind of person who can do mathematics.	75.0	12	4.3	1.4	75.0	12	4.2	1.2
Q39	I believe I can learn well in a mathematics course.	75.0	12	4.5	1.3	66.7	12	4.2	1.4
Q40	I feel that I will be able to do well in future mathematics courses.	91.7	12	4.3	1.0	75.0	12	4.2	1.2
Q41	I believe I can understand the content in a mathematics course.	91.7	12	4.8	1.0	66.7	12	4.2	1.1
Q42	I believe I can get an "A" when I am in a mathematics course.	75.0	12	4.1	1.7	66.7	12	3.8	1.8
Q43	I believe I can do the mathematics in a mathematics course.	83.3	12	4.5	1.0	75.0	12	4.3	1.1

Mixed ANOVA results. As seen in figure 9, the change in mean values for the intervention group did go down from Time 1 to Time 2 whereas the control group exhibited a slight increase in mean values over time, and the intervention group did have higher mean values at both times. Because of nonsignificance both within and between groups, the individual groups are not perceived to be different at two different times, and are not statistically different from each other.

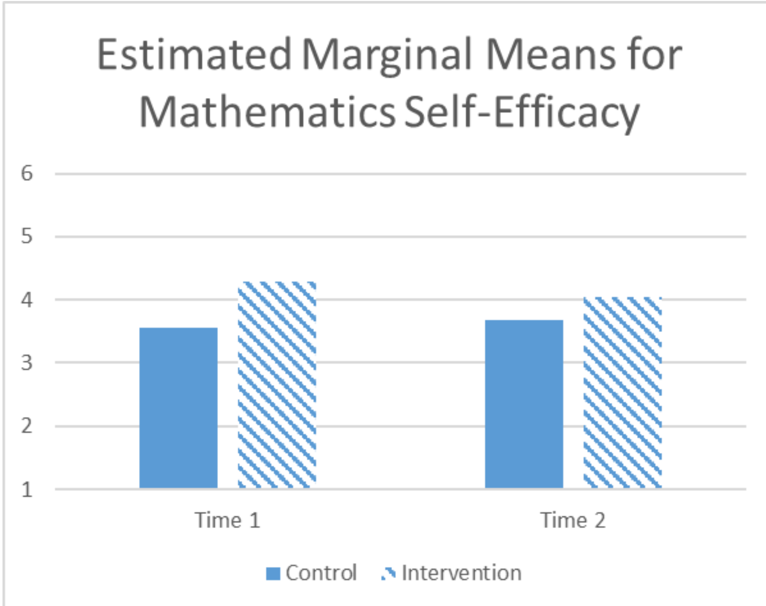


Figure 9. Estimated marginal means for the construct of mathematics self-efficacy, control vs. intervention, Time 1 vs. Time 2.

Once again, looking at Pearson correlations at Time 1 (refer back to table 15), mathematics self-efficacy was significantly, positively, strongly correlated with metacognitive self-regulation, mastery self-talk, regulating time and study environment, effort regulation, general intention to seek needed help. It was weakly negatively correlated with the general intention to avoid needed help. At Time 2, it was only significantly positively correlated with use of mastery self-talk strategies (see table 16).

Question 3: Does structuring a developmental mathematics course with multiple direct instruction, SR interventions lead to a higher percentage of students successfully completing the course, as compared to sections without an intervention component?

To investigate the last research question, successful completion numbers for the two sections were compared. Of the 29 remaining students in the intervention group after the withdraw date, 19 completed the course with a letter grade of C or better (66%) as compared to 39 of 49 students in the control group (80%). As the outcome variable is dichotomous (i.e., either a student successfully completes or does not), a *z*-test for proportions was used. A statistical difference between the two groups was not found (z = 1.893, p = .169, two-tailed). Comparing the proportions to institutional data for the pass rates of Algebra Prep III through Fall of 2017 (956 of 1834 students successfully completed the course), the intervention group did not have a statistically higher rate of completion (z = 2.052, p = .152, two-tailed).

Summary

This study investigated the impact of multiple direct instruction, SR interventions in a developmental mathematics course compared to one without an intervention component. Chapter IV included the results of descriptive statistics as well as inferential statistics tests.

Significance was found within two subscales. A significant main effect of time was found within-groups in the effort regulation subscale, and a significant main effect was found between-groups in the general intention to seek needed help subscale. Additionally, significant, strong, positive correlations were found among use of metacognitive self-regulation strategies, mastery self-talk, regulating time and study environment, effort regulation, and general intention to seek needed help; plus, a significant, strong, negative correlation was discovered between metacognitive self-regulation strategies and avoiding needed help. Chapter V will interpret and discuss the results.

CHAPTER V

DISCUSSION

The self-regulation of learning is important to all college students, but particularly to those who enter as underprepared students. This study sought to determine if students can improve their ability to self-regulate throughout a developmental mathematics course. Using elements of SR, this study assessed the effectiveness of multiple direct instruction, SR interventions to increase student use of SR strategies.

Chapter I broadly defined the research problem. Students are entering higher education underprepared with weaknesses not just in traditional academic subjects of math and English, but also in multitude of other study skills areas. Without academic success in the classroom, students cannot succeed in college. It is especially important to address this research problem given the current state of developmental education.

Chapter II described the theoretical context that grounded this study, Zimmerman's (1989) theory of self-regulated learning, as it addresses many important characteristics of becoming a successful learner in the realm of higher education. This chapter also provided a synthesis of the literature regarding college readiness, self-regulatory behavior and mathematics, and finally academic interventions.

Chapter III described the quantitative research methods used to investigate the impact of SR interventions on developmental mathematics students. Approximately 80 students in four sections of Algebra Prep III were invited to participate in the study by completing a web-based survey at two times during an eight-week course. There were a total of 12 participants each in a control group and an intervention group who had matching identifiers; their data was paired from Time 1 and Time 2 and used to conduct the main analyses.

Chapter IV contained results of the analyses, including descriptive statistics and numerous tests conducted on the data. No statistical differences were found in the subscales of metacognitive self-regulation, mastery self-talk, regulating time and study environment, avoiding needed help, and mathematics self-efficacy; however, there was a significant within-group main effect of time on effort regulation and a significant between-groups effect on the general intention to seek needed help. Furthermore, significant correlations were found nearly across the board among all subscales used in the study.

This chapter includes a summary for each research question to address the major conclusions, discussion, and implication of the findings. Chapter V concludes with implications for practice, limitations of the study, and recommendations for future research.

Research Question Summary

Three research questions, each exploratory in nature, guided the study of SR strategy use in developmental mathematics.

Question 1: What impact does structuring a developmental mathematics course with multiple direct instruction, SR interventions have on the level of student use of self-regulatory strategies?

The first research question sought to determine the impact of structuring a developmental mathematics course with multiple direct instruction, SR interventions on student use of self-regulatory strategies. The results disclosed no statistical differences between the control group and the group receiving these interventions in many facets; however, the results do advance previous research. Interpretations of the data follow.

There was almost no change in overall mean from Time 1 to Time 2 for both groups on the metacognitive self-regulation subscale. The overall subscale means suggest participants are aware of and use metacognitive self-regulation strategies, but based on item means, some strategies far more than others. The lack of change could imply that students have already selected strategies they think work best for them and continue to utilize only those approaches to studying. Likewise, on the mastery self-talk subscale, both groups reported general usage of self-talk strategies.

Overall means for the intervention group on the regulating time and study environment subscale were higher than means for the control group at both times, but since mean values decreased over time, the use of these strategies was lessened, perhaps due to end-of-term burnout. It was interesting to the researcher based on general disagreement with a few items that the control group reported finding time to devote to the class was initially an issue for participants and that sticking to a study schedule was difficult later in the term. Although the reason for this group's positive change in finding time to work would be speculation only, it is encouraging to the researcher's department to see that students without an intervention regarding time management can be disciplined enough to change that behavior.

To summarize, the lack of change from Time 1 to Time 2 for both groups in the subscales of use of metacognitive self-regulation, mastery self-talk, and regulating time and study environment could imply participants do not have issues with their current approaches and use of such strategies were not triggered, advancing Wolters' (2003) work. Furthermore, Cleary, Velardi, and Schnaidman (2017) found no observed differences after SR intervention when using self-reported questionnaires, yet there may be differences that go unnoticed. Perhaps tracking the participants in this study in a way other than the questionnaire would have unearthed differences in SR strategy use. It may also be that an intervention, no matter how well planned, has no effect. If so, the results of this study support findings of Hattie, Biggs, and Purdie (1996), who found students' study behaviors are developed and maintained at a young age and trying to change them at the collegiate level is ineffective.

In regards to the effort regulation subscale, it seems because of the percentages of agreement on all items that these students believe to possess a sense of putting forth a strong effort in the course. While the control group was consistent in its reported effort regulation, participants in the intervention group rated their effort as decreasing over time. This supports results from Orange (1999), who found students had good intentions at the start of a term, but SR behaviors and attitudes diminished.

Along with Orange (1999), Ahmed et al (2013) and Berger and Karabenick (2011) found students decreased their use of metacognitive SR strategies throughout a term. Findings in this study contradict that research, as reported metacognitive strategy use stayed constant across the two groups. As results indicated use of these strategies increased as effort regulation increased, it may be that as long as effort regulation remains relatively constant, use of metacognitive SR strategies will not decrease.

The significant results between the intervention and control groups on the general intention to seek help subscale both support and contradict past research, although it should be noted that because the difference was a between-groups difference and the majority of participants were in the instructors' classrooms for the first eight weeks of the semester, it may have been due to variances in instruction. Zimmerman and Martinez-Pons (1986) found that SR students exhibited extensive help-seeking behavior, which results of this study support. Furthermore, Orange (1999) ascertained students must know when to seek help and actively do so, also supported by the results of this study. However, results contradict both Ahmed et al (2013) and Berger and Karabenick (2011) who found a decrease in help-seeking behavior over time, as well as Dembo and Seli (2004) who found those who needed help failed to seek it. Students in developmental mathematics classes need to take the initiative to seek necessary help, and it is promising that the participants in the intervention group continued to demonstrate that behavior throughout the entire course and not let it taper off as the course ended.

The results for the general intention to avoid needed help were actually very confusing to the researcher. Participants in both groups generally disagreed with the items in this subscale, indicating they would not avoid asking for needed help, yet the intervention group mean value unexpectedly rose from Time 1 to Time 2. Upon further investigation, one participant in the intervention group strongly agreed to every item on the seeking help scale, and subsequently strongly agreed to every item on the avoiding help scale at Time 2. One other participant in the intervention group agreed to every item on both scales as well. While the two constructs are not mutually exclusive (for example, a student could willingly seek help when it is readily available, like in the classroom, but the same student may avoid seeking help otherwise, like not going to tutoring after class), it may be that those participants were not truly reading what the items on the avoiding needed help scale were asking. With the small sample size, it was thus very easy for responses from two participants to slant the results in that fashion.

There were many significant Pearson correlations found. Results show both at Time 1 and Time 2 that as use of metacognitive self-regulatory strategies increases, so does the use of mastery self-talk, regulation of time and study environment strategies, effort regulation, and help-seeking behaviors. As use of metacognitive self-regulatory strategies increases, there is a decrease in avoiding needed help.

Furthermore, this study also showed that at both Time 1 and Time 2, as use of mastery self-talk increases, so does regulation of time and study environment, effort regulation, and help-seeking behaviors. Similarly, as the regulation of time and study environment increases, so does effort regulation and help-seeking behaviors; and as effort regulation increases, so do help-seeking behaviors. Lastly, as the general intention to avoid needed help decreases, all other factors increase. The direction of all correlations found was expected because all subscales except avoiding needed help were worded positively.

Question 2: What impact does structuring a developmental mathematics course with multiple direct instruction, SR interventions have on mathematics self-efficacy?

The second research question examined the impact of structuring a developmental mathematics course with multiple direct instruction, SR interventions on mathematics self-efficacy. Although results of a mixed ANOVA again returned no statistical significance between the control and intervention groups on mathematics self-efficacy, it was noticed that the mean values for the control group essentially show a general disbelief in being good at mathematics and the mean values for the intervention participants show they believed in their mathematical abilities at both times, but less so at Time 2. Near the end of a course, a student's grade is essentially unmoving. As overconfidence can promote a casual approach to studying and lead to underachievement (Dunlosky & Rawson, 2012; Zimmerman & Paulsen, 1995), it could be that this result is a correction in confidence to a more realistic level, leading to a drop in self-efficacy.

As this study showed, an increase in mathematics self-efficacy was strongly correlated with an increase in effort regulation, regulating time and study environment, and metacognitive self-regulation. These results further research by Hagen and Weinstein (1995), who found that students with high self-efficacy tended to work longer and harder than those with low self-efficacy; by Zimmerman (2000), who found that higher self-efficacy led to better monitoring of study time; and by Berger and Karabenick (2011), who found that mathematics self-efficacy predicated more frequent use of metacognitive SR strategies.

Question 3: Does structuring a developmental mathematics course with multiple direct instruction, SR interventions lead to a higher percentage of students successfully completing the course, as compared to sections without an intervention component?

One cannot choose the students who enter the class—nor would one want to, because each class is a unique blend of abilities and personalities, creating plenty of challenges and opportunities for the instructor. The control sections had a nonsignificant higher percentage of student completion: sometimes, it is about who is in the class. While it cannot be shown the interventions helped any of the students in the researcher's courses be more successful at regulating their own learning, it also cannot be shown that the interventions hurt any of them. Although not significant, the intervention group did have a higher success rate (66%) than the current institutional average of 52% for

Algebra Prep III. As the researcher typically has sections of developmental mathematics either online or on campus every semester, that result alone is encouragement enough to continue implementing SR interventions into developmental mathematics courses.

The lower percentage of success by the students in the intervention group as compared to the control group can be linked back to studies by Fabriz et al (2014), Ramdass and Zimmerman (2008), and Shores and Shannon (2010), all who found SR does not impact academic performance.

Implications for Practice

The existing research on interventions in developmental mathematics has focused on tutoring (Butcher & Visher, 2013 and Gallard, Albritton, & Morgan, 2010) and either shortening a course or offering a co-requisite study skills course (Weisburst et al, 2017). This study looked at the teaching of specific SR skills directly implemented in to the course, not as an outside component. The results revealed developmental mathematics students do have an awareness of SR strategies and do use them, but may not modify their use of these strategies over time. This study adds to the research and practice knowledge of SR in developmental mathematics.

Learning how to learn is crucial to the success of every college student, not just those who enter underprepared. Among other things, students must understand how to manage time effectively, adapt to varied learning environments, juggle different expectations from each instructor, and complete work independently with less guidance. It seems there is a fine line for many students between holding it all together and completely falling apart. Empowering developmental mathematics students to take charge of their learning may not be “the” solution for students to stay on the right side of that line, but possibly a step in the positive direction.

If a set of interventions is determined to be applicable in a developmental classroom, it is important to realize one major obstacle: time required. Instructors are compelled to deliver curriculum-specific content while with students. As such, many may struggle to find the time to also teach SR skills in a way that is meaningful, beneficial, and transferable. Still, Bailey et al (2016) recommended teaching developmental students how to be SR learners, thus instructors need to be aware of effective ways to do so.

With a lack of significant findings when comparing the intervention group to the control group, this study cannot definitively impact practice without overstating implications. That being said, it is believed teaching SR skills still has merit. Take the time to teach the skills. Conditions are never the same from one class to the next: what falls flat at 10 a.m. may be a home run at noon; what works in the fall semester may be irrelevant in the spring. If even just one student bettered his SR skills and makes an effort to continue using the strategies presented during the interventions, he is one student moving further down the path of collegiate success.

Limitations

First and foremost, a huge limitation of this study is the sample size. To protect anonymity and not make students in the researcher’s classes to feel pressured to complete the survey, a link was placed in the learning management system for students to access on their own. In retrospect, a better choice would have been to simply have another person come into the classroom and either distribute a paper and pencil survey or bring in a mobile tablet lab to have students access the link during class time. Though not a guarantee, it is likely either of those approaches would have led to higher participation rates and perhaps more meaningful results. Helpful hints on choosing an identifier would have also been beneficial to participants, as remembering what was used from Time 1 to Time 2 was an issue.

Furthermore, the instrument used relied on self-reported data. If students were only vaguely aware of their own learning processes, when prompted with a statement of a potential study behavior, they may have believed it was something done more frequently than it was in actuality and responded accordingly (Ley & Young, 1998).

It is difficult even to compare and contrast one's own course sections to each other within a semester or a year, let alone complicating the design by introducing an element of two different instructors for two different conditions. As the control sections were taught by a different instructor, instruction and instructional design differences could also have influenced outcomes. Although the style of interventions were unique to the researcher's classes, the other instructor does go back through exams upon returning them to students, so those students are exposed to SR in that respect.

This study was also limited by a time constraint, as the sample came from a set of eight-week developmental classes. With only a short time available, it was not possible to observe any long-term effects direct instruction, SR interventions may have had on participants. Since the study took place in the second eight-week block of a semester, it may also be that results were not a true indicator of student progress because the majority of participants had already been in an Algebra Prep course during the first eight-week session.

A final limitation is the possibility of personal bias. The researcher teaches both developmental and college-level mathematics courses and makes an effort to incorporate SR skills into all classes taught. The likelihood of not mentioning any SR strategies or tips for using SR strategies in the first eight-week block would have been quite low; as such, it may be that participants in the intervention sections were already exposed to things that changed their study habits prior to an experimental classroom intervention. Having participants do an initial survey before being fully engaged in an instructor's classroom, seeing an instructor's style, or knowing how to meet an instructor's expectations may have shown different results.

Recommendations for Future Research

There are many directions to extend the research on SR interventions in developmental mathematics, first and foremost in the researcher's classroom. Assessing the use of SR strategies as students enter the developmental mathematics sequence and again at the end of each course attempted, whether it be successfully completed or not, would give a much better picture of the journey a student takes. There would be natural comparisons to make between those who successfully complete on the first try to those try multiple times: were their baselines different? Did they change over time? What happens when they complete the sequence? Do they successfully complete a college-level mathematics course? Do they graduate? Answers to these questions would provide evidence to either further incorporate SR skills in to developmental classes or discard the idea because the impact is minimal.

As the required weekly discussions in the Algebra Prep sequence are usually focused on study skills, there is a wealth of qualitative data in those discussion posts. It would be very interesting to look at that data in conjunction with the quantitative data gathered from survey responses and perhaps there would be some light shed upon the attitudes students bring in to learning.

Just as all students do not learn the same way, SR strategies deemed useful will vary from student to student. It would be worth investigating a structured intervention that is tailored to best fit an individual student, pinpointing what SR skills would be most beneficial to focus on improving. Such a study would provide an excellent opportunity for educators to find an intervention accounting for students' individual differences.

Ultimately, our goal as educators is to promote student success. We design elements of our courses to guide students down the path we feel best directs them towards their goals—finishing a course, earning a degree, getting a job—but we need to realize it is not always the discipline-specific content that is most necessary for a developmental student to gain from us.

APPENDICES

Appendix A

Test Analysis Document

Have you ever thought of your graded test as a learning experience? There is a lot you can learn about yourself, your study habits, and your test-taking skills by examining your graded test after you get it back. Did you do as well as you thought you could? Or is there room for improvement? You may think, 'the test was too hard" or "the teacher didn't give us enough time", but, chances are, your instructor has been giving a similar test under similar conditions to many student before you. So let's see what **you** can do to earn a higher score on your next test.

Look at your graded test and analyze if each point loss was due to your having been **unprepared** for that problem, a **concept error**, or a **careless error**.

- Being **underprepared** for a problem means you didn't know how to do the problem because you hadn't done the homework that would have prepared you for it. Often an error made is considered an underprepared error if you look at the problem and have no idea where to begin.
- A **concept error** is one where you really didn't understand the concept behind the problem. No matter how much time was available for a problem like this, you wouldn't have been able to do it correctly because you have no conceptual understanding of the problem. *This is not a procedural error: you can apply a procedure and still not understand the concept.* Students demonstrate conceptual understanding in mathematics when they provide evidence that they can recognize, label, and generate examples of concepts; use and interrelate models, diagrams, manipulatives, and varied representations of concepts; identify and apply principles; know and apply facts and definitions; compare, contrast, and integrate related concepts and principles; recognize, interpret, and apply the signs, symbols, and terms used to represent concepts. Conceptual understanding reflects a student's ability to reason in settings involving the careful application of concept definitions, relations, or representations of either.
- A **careless error** is one where you understood the problem and knew how to solve it, but you made a mistake that could have been avoided. Maybe you copied the problem or your handwriting incorrectly, made a relatively minor mistake in calculation, or some similar error.

1. Make a chart like the one below with one line for each problem on the test. Put the number of points you missed on each problem under the correct heading and then find the total in each column.

Problem	unprepared	concept error	careless error
1			
2			
…			
	Total points	**Total points**	**Total points**

2. In which column did you have the most missed points? What does that tell you about yourself?

3. What can you learn from this exercise?

Being Unprepared
Consider the points you lost because you were **unprepared**.

Why did you take a test without being fully prepared? Oftentimes, activities and responsibilities in life interfere with good intentions about being diligent in attending class, reading the textbook, and doing all the assignments. It may be time to:

- **re-examine your weekly schedule** and make sure you are devoting a sufficient amount of time to this class. Lay out a time management grid of your schedule making sure to schedule your math study time.
- **re-commit yourself to succeeding in this class**. Think about your college and career goals and remind yourself of how this course helps you get one step closer to achieving them.

4. List two steps you will take to remedy being unprepared.

Concept Errors
Now consider the **concept error** point loss.

A high total in this column tells you that you didn't understand the concepts very well. As you do your work day-to-day you might think you "get it", but you don't always make sure you completely understand each problem in the homework; possibly because you don't do enough homework either. You may understand a math concept for the hour you're working on problems, but forget it by the next day.

- **Review earlier sections**. Regularly review earlier sections, instead of saving all the review for test time.
- **Get the help you need immediately!** Math concepts build on each other. Each new idea is based on many previous concepts. Make sure you get the help you need immediately, as soon as you find yourself beginning to feel lost, so that the confusion doesn't compound itself—otherwise it can become like a snowball, getting bigger and bigger as it rolls through the snow.

If your total loss due to concept errors is fairly large, find out where you can get the help you need. Your school has places available just for you to get help with your math. A high concept error total is cause for concern and must be addressed immediately to guarantee success.

5. List places you can go to get help with your math.

Careless Errors

Next, look at the **careless error** point loss.

Careless errors are often caused by hurrying during a test or by lack of concentration due to test anxiety or over-confidence. Here are some strategies that have worked for other students:

- **Do the easiest problems first.** When you first start a test, look it over from beginning to end and note which problems will be easiest for you. Do all those problems first to ensure you don't leave an easy problem blank just because it is at the end of the test. Finishing problems you find easy will help build your confidence! Then go through the rest of the test from beginning to end.
- **Work carefully and neatly.** As you do each problem, try to focus on one step at a time.
- **Review each problem to look for careless errors** when you finish the test. Find and correct common careless error like arithmetic mistakes and sign errors before you turn in your test.
- Whenever possible, **check your answer**.

A lot of points can be gained by slowing down and being careful.

6. What are things you will do next time to prevent careless errors?

7. Now take half of your careless errors point total and add it back to your test total. What could your test grade have been? Would it have changed the letter grade?

Appendix B

Perseverance Handout

From *Perseverance and Grit Can Be Taught* (Slade & Hoerr, 2014; retrieved from https://www.parenttoolkit.com/social-and-emotional-development/news/resilience-and-perserverance/perseverance-and-grit-can-be-taught)

“Years ago, I remember talking to a classmate before a test and hearing how much longer he’d studied for it than I had," says Tom Hoerr, head of the New City School in St. Louis. “I didn’t think much about it until the tests were returned a week later and I noticed the disparity in our scores. Mine was not higher. What I learned from that experience about the differences in how we had studied helped me understand why his grade was so much better. The idea that you can succeed by increasing effort caused me to step back and focus my energies. People might be smarter than I am, but they weren’t going to outwork me, I decided. I would persevere.”

As illustrated in Tom’s story, the ability to persevere is necessary to develop a mind-set for success because no one, no matter how talented, achieves everything every time. Perseverance is a necessary skill for discovering new ideas, and experiencing setbacks or failures, redrafting, and re-planning are all necessary steps toward developing it. Perseverance enables us to take risks, learn from our failures, and forge ahead with new and better information.

Typically, when we read a perseverance or grit success story, it often involves overcoming unbeatable odds or surviving dire circumstances. While these stories are compelling, they are not always relatable to the average person. It’s important that perseverance and grit are understood in more common circumstances because everyone, regardless of his situation, needs to develop these skills.

Perseverance is a skill that can be taught. Although most of us learn it through trial and error, it can and should be taught, just like any other key skill or competency. Perseverance is the quality that allows someone to continue trying even in the face of difficulty, adversity, or impossibility. Grit is another important skill aligned with perseverance.

Hoerr and his colleagues at the New City School have been working to incorporate grit in the classroom. To nobody’s surprise, Hoerr says, that’s not easy to do.

“But if the focus is on preparing students to succeed in life, not just in school, it becomes clear that we need to be sure students learn to respond to adversity,” he adds. “The first step is being transparent about the need for grit. It should be part of the common vocabulary and readily discussed by teachers, students, and parents.”

Appendix C

Maladaptive Behaviors Handout

Answer yes or no for each statement.

1. I let my ~~friends~~ phone interrupt me when I am studying.

2. I lose or throw away materials from my class.

3. I work on handouts from class only when I'm in class.

4. I give up or quit when I do not understand something.

5. I avoid asking questions in class about things I don't understand.

6. I avoid going to the tutor or to my instructor for extra help.

7. I try to forget about the topics I have trouble with.

8. I wait until the last minute to do my required quizzes.

9. I wait until the last minute to study for my exams.

Appendix D

Survey Items

Strategies for the Regulation of Academic Cognition, Academic Motivation, and Academic Behavior (Wolters, Pintrich, & Karabenick, 2005)

Metacognitive Self-Regulation

1. During class time I often miss important points because I'm thinking of other things. (REVERSED)
2. When reading for this course, I make up questions to help focus my reading.
3. When I become confused about something I'm reading for this class, I go back and try to figure it out.
4. If course materials are difficult to understand, I change the way I read the material.
5. Before I study new course material thoroughly, I often skim it to see how it is organized.
6. I ask myself questions to make sure I understand the material I have been studying in this class.
7. I try to change the way I study in order to fit the course requirements and instructor's teaching style.
8. I often find that I have been reading for class but don't know what it was all about. (REVERSED)
9. I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying.
10. When studying for a course I try to determine which concepts I don't understand well.
11. When I study for this class, I set goals for myself in order to direct my activities in each study period.
12. If I get confused taking notes in class, I make sure I sort it out afterwards.

Mastery Self-Talk

13. I tell myself that I should keep working just to learn as much as I can.
14. I persuade myself to keep at it just to see how much I can learn.
15. I challenge myself to complete the work and learn as much as possible.
16. I convince myself to work hard just for the sake of learning.
17. I tell myself that I should study just to learn as much as I can.
18. I think about trying to become good at what we are learning or doing.

Regulating Time and Study Environment

19. I usually study in a place where I can concentrate on my course work.
20. I make good use of my study time for this course.

21. I find it hard to stick to a study schedule. (REVERSED)
22. I have a regular place set aside for studying.
23. I make sure I keep up with the weekly readings and assignments for this course.
24. I attend class regularly.
25. I often find that I don't spend very much time on this course because of other activities. (REVERSED)
26. I rarely find time to review my notes or readings before an exam. (REVERSED)

Effort Regulation

27. I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do. (REVERSED)
28. I work hard to do well in this class even if I don't like what we are doing.
29. When course work is difficult, I give up or study only the easy parts. (REVERSED)
30. Even when course materials are dull and uninteresting, I manage to keep working until I finish.

General Intention to Seek Needed Help

31. If I needed help in this class I would ask someone for assistance.
32. If I needed help understanding the lectures in this class I would ask for help.
33. If I needed help with the readings in this class I would ask for help.

General Intention to Avoid Needed Help

34. If I didn't understand something in this class I would guess rather than ask someone for assistance.
35. I would rather do worse on an assignment I couldn't finish than ask for help.
36. Even if the work was too hard to do on my own, I wouldn't ask for help with this class.

Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ; May, 2009)

Mathematics Self-Efficacy

37. I believe I am the kind of person who is good at mathematics.
38. I believe I am the kind of person who can do mathematics.
39. I believe I can learn well in a mathematics course.
40. I feel that I will be able to do well in future mathematics courses.
41. I believe I can understand the content in a mathematics course.
42. I believe I can get an "A" when I am in a mathematics course.
43. I believe I can do the mathematics in a mathematics course.

Appendix E

Variable Names and Values used in Survey Data Analyses

Variable Name	**Variable Description and Values**
gender	(1) male, or (2) female
age	age in years
ethnicity	(1) White/Caucasian (2) African American/Black (3) American Indian (4) Asian American/Asian (5) Mexican American/Chicano (6) Puerto Rican American (7) Other Latino (8) Other
class level	(1) freshman, (2) sophomore, or (3) other
repeat course	(1) yes, or (2) no
prereq	(1) pass algebra prep II, (2) fail algebra prep II but place with placement, or (3) didn't need algebra prep II
The values for the following are (1) strongly disagree, (2) disagree, (3) slightly disagree, (4) slightly agree, (5) agree, or (6) strongly agree	
TIME 1	
msr1_1rev	During class time I often miss important points because I'm thinking of other things. (REVERSED)
msr2_1	When reading for this course, I make up questions to help focus my reading.
msr3_1	When I become confused about something I'm reading for this class, I go back and try to figure it out.
msr4_1	If course materials are difficult to understand, I change the way I read the material.
msr5_1	Before I study new course material thoroughly, I often skim it to see how it is organized.
msr6_1	I ask myself questions to make sure I understand the material I have been studying in this class.
msr7_1	I try to change the way I study in order to fit the course requirements and instructor's teaching style.
msr8_1rev	I often find that I have been reading for class but don't know what it was all about. (REVERSED)
msr9_1	I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying.

msr10_1	When studying for a course I try to determine which concepts I don’t understand well.
msr11_1	When I study for this class, I set goals for myself in order to direct my activities in each study period.
msr12_1	If I get confused taking notes in class, I make sure I sort it out afterwards.
mst1_1	I tell myself that I should keep working just to learn as much as I can.
mst2_1	I persuade myself to keep at it just to see how much I can learn.
mst3_1	I challenge myself to complete the work and learn as much as possible.
mst4_1	I convince myself to work hard just for the sake of learning.
mst5_1	I tell myself that I should study just to learn as much as I can.
mst6_1	I think about trying to become good at what we are learning or doing.
rtse1_1	I usually study in a place where I can concentrate on my course work.
rtse2_1	I make good use of my study time for this course.
rtse3_1rev	I find it hard to stick to a study schedule. (REVERSED)
rtse4_1	I have a regular place set aside for studying.
rtse5_1	I make sure I keep up with the weekly readings and assignments for this course.
rtse6_1	I attend class regularly.
rtse7_1rev	I often find that I don’t spend very much time on this course because of other activities. (REVERSED)
rtse8_1rev	I rarely find time to review my notes or readings before an exam. (REVERSED)
er1_1rev	I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do. (REVERSED)
er2_1	I work hard to do well in this class even if I don’t like what we are doing.
er3_1rev	When course work is difficult, I give up or study only the easy parts. (REVERSED)
er4_1	Even when course materials are dull and uninteresting, I manage to keep working until I finish.
sh1_1	If I needed help in this class I would ask someone for assistance.
sh2_1	If I needed help understanding the lectures in this class I would ask for help.
sh3_1	If I needed help with the readings in this class I would ask for help.
ah1_1	If I didn’t understand something in this class I would guess rather than ask someone for assistance.
ah2_1	I would rather do worse on an assignment I couldn’t finish than ask for help.

ah3_1	Even if the work was too hard to do on my own, I wouldn't ask for help with this class.
se1_1	I believe I am the kind of person who is good at mathematics.
se2_1	I believe I am the kind of person who can do mathematics.
se3_1	I believe I can learn well in a mathematics course.
se4_1	I feel that I will be able to do well in future mathematics courses.
se5_1	I believe I can understand the content in a mathematics course.
se6_1	I believe I can get an "A" when I am in a mathematics course.
se7_1	I believe I can do the mathematics in a mathematics course.
TIME 2	
msr1_2rev	During class time I often miss important points because I'm thinking of other things. (REVERSED)
msr2_2	When reading for this course, I make up questions to help focus my reading.
msr3_2	When I become confused about something I'm reading for this class, I go back and try to figure it out.
msr4_2	If course materials are difficult to understand, I change the way I read the material.
msr5_2	Before I study new course material thoroughly, I often skim it to see how it is organized.
msr6_2	I ask myself questions to make sure I understand the material I have been studying in this class.
msr7_2	I try to change the way I study in order to fit the course requirements and instructor's teaching style.
msr8_2rev	I often find that I have been reading for class but don't know what it was all about. (REVERSED)
msr9_2	I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying.
msr10_2	When studying for a course I try to determine which concepts I don't understand well.
msr11_2	When I study for this class, I set goals for myself in order to direct my activities in each study period.
msr12_2	If I get confused taking notes in class, I make sure I sort it out afterwards.
mst1_2	I tell myself that I should keep working just to learn as much as I can.
mst2_2	I persuade myself to keep at it just to see how much I can learn.
mst3_2	I challenge myself to complete the work and learn as much as possible.
mst4_2	I convince myself to work hard just for the sake of learning.
mst5_2	I tell myself that I should study just to learn as much as I can.
mst6_2	I think about trying to become good at what we are learning or doing.

rtse1_2	I usually study in a place where I can concentrate on my course work.
rtse2_2	I make good use of my study time for this course.
rtse3_2rev	I find it hard to stick to a study schedule. (REVERSED)
rtse4_2	I have a regular place set aside for studying.
rtse5_2	I make sure I keep up with the weekly readings and assignments for this course.
rtse6_2	I attend class regularly.
rtse7_2rev	I often find that I don't spend very much time on this course because of other activities. (REVERSED)
rtse8_2rev	I rarely find time to review my notes or readings before an exam. (REVERSED)
er1_2rev	I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do. (REVERSED)
er2_2	I work hard to do well in this class even if I don't like what we are doing.
er3_2rev	When course work is difficult, I give up or study only the easy parts. (REVERSED)
er4_2	Even when course materials are dull and uninteresting, I manage to keep working until I finish.
sh1_2	If I needed help in this class I would ask someone for assistance.
sh2_2	If I needed help understanding the lectures in this class I would ask for help.
sh3_2	If I needed help with the readings in this class I would ask for help.
ah1_2	If I didn't understand something in this class I would guess rather than ask someone for assistance.
ah2_2	I would rather do worse on an assignment I couldn't finish than ask for help.
ah3_2	Even if the work was too hard to do on my own, I wouldn't ask for help with this class.
se1_2	I believe I am the kind of person who is good at mathematics.
se2_2	I believe I am the kind of person who can do mathematics.
se3_2	I believe I can learn well in a mathematics course.
se4_2	I feel that I will be able to do well in future mathematics courses.
se5_2	I believe I can understand the content in a mathematics course.
se6_2	I believe I can get an "A" when I am in a mathematics course.
se7_2	I believe I can do the mathematics in a mathematics course.
Grouping variables	
MetaSelfReg1	metacognitive self-regulation collective mean values, time 1
MetaSelfReg2	metacognitive self-regulation collective mean values, time 2
MastSelfTalk1	mastery self-talk collective mean values, time 1

MastSelfTalk2	mastery self-talk collective mean values, time 2
RegTimeStudyEnv1	regulating time and study environment collective mean values, time 1
RegTimeStudyEnv2	regulating time and study environment collective mean values, time 2
EffReg1	effort regulation collective mean values, time 1
EffReg2	effort regulation collective mean values, time 2
SeekHelp1	intention to seek needed help collective mean values, time 1
SeekHelp2	intention to seek needed help collective mean values, time 2
AvoidHelp1	intention to avoid help collective mean values, time 1
AvoidHelp2	intention to avoid help collective mean values, time 2
SelfEff1	mathematics self-efficacy collective mean values, time 1
SelfEff2	mathematics self-efficacy collective mean values, time 2
Identifier	(1) control group, (2) intervention group

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