THE EFFECTS OF EXPLICIT SELF-REGULATED LEARNING STRATEGY INSTRUCTION ON MATHEMATICS ACHIEVEMENT

by

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ABSTRACT

JANET SINGS JENKINS. The effects of explicit self-regulated learning strategy instruction on mathematics achievement. (Under the direction of DR. DAVID K. PUGALEE)

Self-regulated learning includes the use of a set of strategies for planning, monitoring, and self-evaluating students' efforts toward reaching specific learning goals. This study examined the extent to which explicit self-regulated learning strategy instruction impacted regular eighth grade students' learning behaviors and mathematics achievement. The study was a quasi-experimental design using a control and treatment group which consisted of eighth grade general mathematics students. The treatment was explicit instruction of ten self-regulated learning strategies. Data were gathered using a researcher-designed survey and standardized mathematics test scores. Findings indicated that the treatment group reported a significantly higher level of self-regulated learning strategy use, earned significantly higher mathematics test scale scores, and showed significantly greater academic growth than the control group. Additionally students' use of self-regulated learning strategies was statistically significant in explaining the variance in students' mathematics test scores and academic growth.

DEDICATION

This degree must be dedicated to my family. First to my father and mother, William B. Sings and Mary Lou K. Sings, who have always supported and encouraged my educational endeavors. They sent the message early in my life that education was important and even now they continue to demonstrate that value by reading, studying and learning just for the sake of being well-informed. They are true models of the value of being life-long learners. I appreciate their unconditional love and support more than words can express.

And to my son, Matt Jenkins, who at 21 years old, is continuing the family tradition of life-long learning started by his grandparents. His interests are unique to him, but his willingness to pursue knowledge is not.

And finally to my husband, Andrew Jenkins, who always supports my "projects" even if he isn't sure why I want to take them on. He has said, "If that is what you want to do, then you should do it" many times in response to my crazy ideas. That's what he said when I suggested that maybe I should get my PhD, the craziest of all my ideas. Then he picked up the slack when I was strapped for time; when I had class in the evenings; and when plans had to be changed so I could do research, study, or write a paper. I only hope I have been there for him as much as he has been for me

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CHAPTER 1: INTRODUCTION

Statement of problem and sub-problems

Although researchers define self-regulation in a variety of ways, most are similar to Zimmerman's (2002, p. 65) definition, which states that self-regulation is the "self-generated thoughts, feelings and behaviors that are oriented to attaining goals." Self-regulated learning strategies are those skills and behaviors that students use independently to enable them to reach the learning goals they have set for themselves. The problem is that all students are not knowledgeable about a variety of strategies, how to determine which strategies are most effective for a given task, or how to monitor their progress based on the strategies they have decided to utilize. In most middle grades and high school mathematics classes, the focus of instruction is on mathematics content, as it should be, but without including explicit instruction on the use of self-regulating learning strategies, students may not have all the skills needed to be successful, independent, self-regulated learners.

There are several sub-problems associated with including instruction on the use of self-regulated learning strategies in middle grades mathematics classes, which is the setting for this study. First, teachers are not generally aware of self-regulated learning strategies. There doesn't appear to be a finite list of strategies that should be included along with mathematics instruction. Professional development for mathematics teachers does not usually focus on how to incorporate explicit instruction on self-regulated learning strategies into mathematics instruction. Second, the locus of control in the classroom environment can positively or negatively impact students' use of self-regulated learning strategies. Eshel and Kohav (2003) found that teacher control and student control coexist in the classroom, but self-regulation is fostered in classrooms with strong student control, regardless of the level of teacher control.

Purpose of the study

This study was designed to examine how explicit instruction of self-regulated learning strategies impacted middle grades mathematics classes. Data was collected from students about their use of self-regulation and the strategies associated with self-regulated learning. Standardized test data was used to examine the impact on student achievement.

Research questions

There were two research questions for the study:

1. To what extent does the explicit instruction of self-regulated learning strategies in middle grades mathematics classes aid in developing independent, self-regulated learners?
2. To what extent does explicit instruction of self-regulated learning strategies in middle grades mathematics classes impact student achievement?

Definitions of terms

For this study self-regulated learning strategies refer to the set of specific skills students were taught to help them set learning goals, select appropriate strategies to accomplish assigned and self-identified tasks, manage their time, and to monitor and evaluate their progress toward reaching their learning goals. Being a self-regulated learner refers to the level at which students are able to independently select, use and evaluate self-regulated learning strategies. Student achievement was determined by scores on North Carolina End-of-Grade Mathematics Tests.

The literature does not seem to have a specific definition for explicit instruction as an instructional model. For their study on teacher effectiveness, Yates and Yates (1990, p. 229) define it as a set of practices that a student is offered that includes “direct cognitive guidance, supportive modeling, a relatively complete analysis of convert steps and attack strategies, error correction and extended opportunities for practice prior to being expected to think and perform at the level of a knowledgeable expert.” In a recent “Research Brief,” the National Council of Teachers of Mathematics (2007, p. 1) defined explicit instruction as “instruction that involves a teacher demonstrating a specific plan (strategy) for solving the problem types and students using this plan to think their way through a solution.” Their review of recent research indicated that using explicit instruction with exceptional and low-achieving students produced a moderate to large effect size on student achievement. Both of these definitions refer to the manner in which teachers provide students with the learning opportunities required to acquire specific skills and knowledge. For this study explicit instruction will refer to the methods teachers employed to include the use of self-regulated learning strategies in their regular mathematics lessons.

Limitations

Prior to beginning the study, several limitations were considered. The foundation of this study was the explicit instruction of self-regulated learning strategies in middle grades mathematics classes, and as such, may have been limited by the level of teacher interest and willingness to include explicit instruction of self-regulated learning strategies in their lessons. The teachers may have felt that adding another component to their instruction would have detracted from the available instructional time allotted for teaching/learning mathematics. There was a concern that entrusting the explicit instruction to teachers who were not particularly knowledgeable about the use and instruction of self-regulated learning strategies may negatively have impacted the effects of the explicit instruction and consequently may have skewed the results of the study. There was a professional development component included in the study prior to and during the time when teachers begin their explicit instruction with students. Also, the level of implementation by each teacher, who included explicit self-regulated learning strategy instruction, was monitored to ensure fidelity to the treatment.

There was a concern that other factors which were beyond the control of the researcher, such as teacher experience, variability of mathematics instructional technique, and school based programs may have influenced differences in outcomes for the control and treatment groups. A discussion of how the limitations may have impacted the study implementation and results is included in chapter five.

Outline of the rest of report

Following this introduction to the study, there is a literature review based on studies and articles by experts in the field of self-regulation. Overviews of the methods and procedures that were used in the study are included along with an explanation of the data collection process, statistical analyses and outcomes. Then there is a report of the study findings followed by a discussion of their implications, limitations, ethical considerations, and recommendations.

CHAPTER 2: LITERATURE REVIEW

Chapter overview

Prior to designing this study, a review of the literature was conducted to ensure that the study was based on a sound philosophical foundation and other previously conducted research. This chapter provides information from the current literature beginning with a brief introduction to self-regulation, followed by sections that address self-efficacy and its relationship to self-regulation, a more in-depth discussion of self-regulation, instructional models, and concluding statements that summarize how the literature informed the present study.

Self-regulation introduction

Zimmerman (2002) defines self-regulation as "self generated thoughts, feelings, and behaviors that are oriented to attaining goals (p. 65)." He states, "…self-regulation of learning involves more than detailed knowledge of a skill; it involves the self-awareness, self-motivation, and behavioral skill to implement that knowledge appropriately (p. 66)." He explains that self-regulation is a collection of skills that include specific, reachable goal setting, strategy adoption, self-monitoring, restructuring behaviors to meet goals, time management, self-evaluation, task ownership and adapting for the future (Zimmerman, 2002).

Self-efficacy and its relationship to self-regulation

The theoretical framework for using self-regulated learning strategies is based on

Bandura’s theory of self-efficacy. He defines self-efficacy as “a judgment of one’s capability to accomplish a certain level of performance (Bandura, 1986, p. 391).” Further he explains that one’s belief in one’s own abilities has an effect on the choices one makes. For example, people tend to avoid situations they believe require capabilities beyond the ones they possess. Similarly, people are more willing to engage in tasks that they feel they will be able to complete successfully. This willingness to engage in an activity contributes to the individual’s competency with respect to the skills required to complete the activity. According to Bandura, a person’s belief in how likely he/she is to be successful at a task has an influence on the level of effort the individual is willing to expend. An individual is more likely to put forth greater effort and persist toward the completion of the task if the person feels he/she is capable of successfully completing the task (1986). These ideas have implications for how students should be supported in their efforts to learn new skills and concepts and the importance of providing explicit self-regulated learning strategy instruction.

Bandura’s theory of self-efficacy is rooted in social-cognitive theory, which holds that behavioral, environmental and personal factors interact to determine and define human actions (Schunk & Zimnmerman, 1997). Bandura includes both social constructionist elements that address how cognitive development occurs and it also includes elements of self-determination theory, which addresses motivational factors (Schunk & Zimmerman, 1997; Sullivan, 1998).

Social constructivists fall into two groups. First are those who base their beliefs on Piaget’s work. They believe that human learning is an internal function that addresses the disequilibrium created within the individual when confronted with a conflict between experience and what one believes he/she knows (Sullivan, 1998). In the second camp are those who base their beliefs on Vygotsky's theory, which maintains that learning occurs as the result of human interaction in social settings (Sullivan, 1998).

Bandura's use of social cognitive theory is compatible with both perspectives (Martin, 2004, Schunk & Zimmerman, 1997; Sullivan, 1998). Schunk and Zimmerman (1997) describe a process for self-regulation development that begins with social interaction and modeling and eventually becomes an internal set of processes that are revised and monitored based on an individual's interaction with new experiences and tasks. They suggest that Vygostky's theory explains cognitive features of self-regulation and Piaget's theory explains the self-motivation component that is inherent in those who are successfully able to self-regulate their own learning. In other words social cognitive theory as Bandura uses it to support his theory of self-efficacy blends social learning behaviors (Vygotsky) with motivational factors and personal monitoring (Piaget) to explain how self-regulating behaviors combine to increase self-efficacy (Harrison, Rainer, Hochwarter, & Thompson, 1997). According to Bandura's theory of self-efficacy, as students take control of their own learning and engage in behaviors that they self-evaluate as beneficial, their understanding of their own ability to successfully accomplish future tasks increases and this thereby increases self-efficacy (Bandura, 1986).

Self-efficacy is determined by four factors. The first factor which may contribute to self-efficacy is previous success. If one is successful at completing a task, he/she develops a greater confidence that he/she can successfully complete future tasks (Bandura, 1986); i.e. success breeds success. The second factor that may contribute to self-efficacy is vicarious experience. If an individual observes someone, who he/she perceives to be similarly capable, complete a task then the individual believes that he/she is also capable of completing the task (Bandura, 1986); i.e. if he can do it, so can I. Verbal persuasion is another factor that contributes to self-efficacy. If an individual is told that they are capable of completing a task by someone they trust they may decide that they are indeed capable. The influence of this factor is ultimately limited by the success one has when the task is attempted (Bandura, 1986). It does speak, however, to the power a teacher may have to motivate students to attempt new skills or problems. Finally, the general psychological state of the individual influences his/her self-efficacy. If the individual is highly stressed or agitated about attempting a new task, he/she may not feel as though he/she can successfully complete the task whereas under less stressful conditions, he/she may feel better about the situation in general (Bandura, 1986).

Pajares (1997) has conducted a number of studies related to the influence of self-efficacy and mathematics performance. In one such study he wanted to determine if the type of mathematical assessment would influence students' self-efficacy judgments. Three hundred twenty-seven middle school students were presented with both a multiple-choice assessment and an open-ended performance assessment of similar mathematics problems. Even though students performed better on the multiple-choice test, there was not a significant difference in their self-efficacy judgments. However, the findings did indicate that the higher performing students are better at identifying their level of self-efficacy than lower performing students.

In another study, Pajares (1995) tested different levels of self-efficacy. Working with 391 college students enrolled in different universities, he found that students' mathematical self-efficacy for completing specific mathematics problems was more reliable than their general confidence to perform mathematical tasks or their predictions of earning high grades in mathematics-related courses. The findings of this study differ to some extent from previous studies, which had indicated that students' mathematical confidence was a strong indicator of problem-solving ability. The findings confirmed Bandura's theory that there are different ways of assessing self-efficacy (Bandura, 1986). Pajares (1995) asserts that self-efficacy is more accurately related to specific tasks than to global views of generalized situations. As a result students could confidently predict their capability to complete specific problems, but were less able to accurately predict their capability to complete all mathematics problems of a particular type or to earn a high grade in a class. However, students generally are very aware of their capabilities, which is why teachers and counselors are advised to seriously consider students' self-efficacy in the same way they consider test scores when making course placement decisions.

In another study, Pajares (1999) explored the relationship between the mathematical self-efficacy, motivation and performance of 273 middle school students. He found that self-efficacy was a strong predictor of mathematical performance when the data were controlled for the effects of motivational influences. Additionally he found that students' attitudes and achievement in mathematics decreased during the year the study was conducted. These findings are consistent with other studies in this area. However students' mathematical confidence did not decrease during the same time period. The data collected for this study indicated that the decrease in performance and self-efficacy was greater for regular education students than for gifted students.

Zimmerman (1990) has also studied the effects and influence of self-efficacy.

Most of his work seems to have been conducted with very young children, but in one particular study he explored fifth, eighth and eleventh grade students' abilities to use self-regulated learning and estimate their mathematical efficacy. He found that students' self-efficacy increased with age. High school students' self-efficacy was greater than middle school students', which was greater than the elementary school students. This seems contradictory to studies which indicate that students' mathematical confidence decreases with age. It is important to note that confidence to complete a task may be low, but by being able to accurately predict one's inability to successfully complete the task, self-efficacy is high. Self-efficacy is a measure of one's ability to accurately predict their capability; it is not the same as one's confidence level.

Zimmerman (1990) found that students who more actively engaged in self-regulated learning strategies also had higher levels of self-efficacy than other students. It may be that students who are more actively engaged in the pursuit of learning are more aware of their strengths and limitations and thus their self-efficacy increases as their active involvement in learning increases. He provides an overview of the underlying beliefs and assumptions of self-regulated learning theory. He states, "self-regulated learning theorists view students as metacognitively, motivationally, and behaviorally active participants in their own learning process (Zimmerman, 1986, p. 308)." The metacognitive component recognizes student behaviors such as planning, organizing, self-instructing, self-monitoring and self-evaluating during the learning process. The motivational component examines the level at which students perceive themselves as competent, capable, and independent learners. The behavioral aspect of self-regulation refers to students' abilities to recognize, select, and design appropriate learning strategies and environments (Zimmerman, 1986).

Pajares and Miller (1994) address the flaws in a number of studies that have previously attempted to determine if self-efficacy and self-concept are predictors of students' problem-solving performance. They based their study on Bandura's social cognitive theories of self-efficacy, which defines self-efficacy as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances (p. 193)."

The authors explain the difference between self-concept and self-efficacy. Although they admit that the two constructs are often used interchangeably by many researchers, they are inherently different. Self-efficacy "is a context-specific assessment of competence to perform a specific task, a judgment of one's capabilities to execute specific behaviors in specific situations (Pajares & Miller, 1994, p. 194)." Self-concept is a more generic perception of one's competence. Self-concept may be specific to a subject area, but is not specific to individual tasks.

Example of self-concept: "Are you good at math?"

Example of self-efficacy: "Can you solve this specific problem?"

The authors remind us that measures of self-efficacy should occur immediately prior to performing the specified task. Many self-efficacy study designs are flawed by asking students to respond to self-efficacy instruments after task performance or an extended time prior to the task performance.

A study conducted by Pajares and Miller (1994) found that "self-efficacy had stronger direct effects on (mathematics problem-solving) performance than did any of the (other) variables (p. 198)" examined in the study, such as mathematics self-concept, perceived usefulness of mathematics, prior mathematics experience, and gender. Several aspects of the study supported Bandura’s theories. First, the overall findings indicate the power of self-efficacy. Second, most students’ overestimated the level of their performance. That is also consistent with social cognitive theory.

Pajares (2002) states that Bandura’s social cognitive theory of human functioning is the framework for both self-efficacy and self-regulated learning. Pajares explains self-efficacy by stating, “Individuals engage in behavior, interpret the results of their actions, use these interpretations to create and develop beliefs about their capability to engage in subsequent behaviors in similar tasks and activities, and behave in concert with the beliefs created (Pajares, 2002, p. 116).” In the same journal, Zimmerman (2002) explains, “the self-motivated quality of self-regulated learners depends on several underlying beliefs, including perceived efficacy and intrinsic interest (p.66).” One of the most crucial of these beliefs is the students’ knowledge of their capabilities to successfully complete a task or activity, which is the essence of self-efficacy beliefs (Pajares, 2002). This is a compelling argument to substantiate the value of self-efficacy as a driving force for the use of self-regulated learning strategies.

Pajares (2002) refers to a number of studies that indicate that gender may be a factor in students’ self-efficacy and use of self-regulated learning strategies. However, the differences vary by subject and grade span. He addresses several reasons why gender may appear to be a greater influence than it actually is. First he mentions that there is not a statistical difference between the self-efficacy of students with similar academic capabilities. He also indicates that differences seem to align to societal expectations that boys do well in mathematics and science and that girls do better in language arts. Pajares hypothesizes that the methods used for measuring self-efficacy may also create differences among genders. Finally he mentions that boys and girls seem to respond to questions about self-confidence and capability differently. Girls tend to be more humble while boys tend to overestimate, exaggerate or brag (Pajares, 2002).

Self-regulation

Self-regulation is defined in several ways by various researchers. Zimmerman (1986) defines self-regulated learning strategies as the "actions directed at acquiring information or skills that involve agency, purpose (goals), and instrumentality self-perceptions by a learner (p. 615)" for the purposes of a study he conducted with 80 high school students, 40 from the high achievement track and 40 from the low achievement track. Fourteen categories of self-regulation strategies were identified from interviews with the students. Use of the strategies predicted with 93% accuracy the academic track of the students, thereby indicating that higher achieving students use a greater variety of self-regulated learning strategies and with greater consistency than lower achieving students.

Zimmerman (1986) refers to 14 categories of self-regulated learning strategies that have been identified as contributing to academic achievement. The categories are identified as follows: 1. self-evaluation; 2. organizing and transforming; 3. goal-setting and planning; 4. seeking information; 5. keeping records and monitoring; 6. environmental structuring; 7. self-consequences; 8. rehearsing and memorizing; seeking social assistance from 9. peers, 10. teachers, and 11. adults; and reviewing records such as 12. tests, 13. notes, and 14. textbooks. Zimmerman also recognized learning behaviors that were initiated by someone other than the student, but did not include them as self-regulating strategies.

In another article on attaining self-regulation, Zimmerman (2000) defines self-regulation as the “self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals (p.14).” He goes on to describe the 3 phases of self-regulation: forethought, performance and self-reflection. The forethought phase includes goal setting, planning, and self-motivation to perform. Self-motivation is dependent upon one’s self-efficacy, or belief in one’s ability to perform effectively, one’s expectations, interest in the task, and goal commitment. The performance phase includes the use of self-control, focus and strategy implementation. The final phase, self-reflection, includes evaluation, self-satisfaction and self-reward.

Self-regulating strategies are divided into three phases of a cyclical process. Forethought is the first phase. This phase includes task analysis, goal setting, planning and self-motivation. The second phase is the performance phase. This phase includes self-control and self-observation. This is the operational phase of completing a task. The third and final phase is the self-reflection phase. In this phase, students self-evaluate their efforts and develop a sense of satisfaction at their accomplishment. The final stage provides the motivation and impetus to tackle another task and so it is the basis for the forethought phase (Zimmerman, 2002). It is this stage that is enhanced by explicit instruction in self-regulated learning strategies. Students who have strategies that they have used to successfully complete previous tasks, will also have the confidence to approach future tasks with a better understanding of their capabilities and limitations. It is the self-awareness of one’s abilities that increases self-efficacy. Since the phases are cyclical, however, explicit instruction on strategies for other phases will ultimately impact the whole process of self-regulation. Further Zimmerman (2002) concludes by stating, “Recent research shows that self-regulatory processes are teachable and can lead to increases in students’ motivation and achievement (p. 69).”

Research indicates that attempts to teach problem-solving heuristics to mathematics students based on Polya’s method has not achieved the positive results expected. It seems that developing and successfully utilizing problem-solving strategies is both problem and solver specific. In numerous studies, teaching heuristics has not produced measurable differences when compared to control groups that did not receive specialized problem-solving instruction (Schoenfeld, 1985). However, teaching students to use heuristics as generalized strategies for problem-solving is different from teaching self-regulated learning strategies. The heuristics that are taught to students are generally thought processes, whereas self-regulated learning strategies are taught as learning behaviors, which are not situation or task specific.

Zimmerman (2000) states that low levels of self-regulation are related to poor achievement in all aspects of life. He uses examples other than education, such as personal health care, to illustrate the point. He states that social learning experiences, or the lack thereof, contribute to the acquisition of self-regulation strategies. He states that individuals who have low levels of self-regulation grew up in “homes or communities where they (self-regulation strategies) are not taught, modeled, or rewarded (p.27).” This makes it important to include explicit self-regulated learning strategy instruction as a component of a complete instructional program.

According to Pintrich and De Groot (1990), there are three motivational components linked to self-regulated learning. First is an expectancy component, which includes self-efficacy. Do students expect they will be able to learn the material? Second is a value component, which indicates how interested students are in the learning task or how important they believe the task to be. Third is an affective component, which addresses students' emotional response to the task. Do they like it?

Hagen and Weinstein (2000) state, "The more students can take responsibility for their own learning, the more likely they are to attribute success to their own efforts. If students believe that their efforts will make a difference in what and how much they learn, then they are more likely to expend higher levels of effort in their studies (p. 53)." This is an extremely potent statement about the power of taking ownership of one's own learning, which further supports the potential benefits of providing explicit self-regulated learning strategy instruction to students as an integrated component of their regular mathematics instruction.

In addition to their connection to self-regulated learning, motivation and responsibility for learning are at the heart of metacognition according to Borkowski (2001). He explains that self-regulation is a function of metacognition. Additionally he expresses concern that self-regulation strategies are very complex and usually not the focus of classroom instruction. This study addresses that concern by creating a treatment that provides explicit instruction of self-regulation strategies. Kaplan (2008) also addresses the relationship among metacognition, self-regulation and self-regulated learning. His conclusion is that the three concepts are uniquely different, but extremely inter-related. He believes that the three constructs "share a common core that involves self-awareness and regulatory action and yet they are nevertheless meaningfully different from each other (p. 479)." However since the concepts are intricately connected, metacognition is somewhat dependent upon students' ability to engage in self-regulation.

Howard-Rose and Winne (1993) express the concern that they attempted to isolate elements of self-regulated learning that occur dynamically in instructional situations that develop instantaneously during classroom interaction and students' engagement with learning tasks. They mention that previous researchers have failed to measure the individual components of self-regulated learning because the previous models have been one-dimensional. They attempt with their study to create a multi-level dimensional model that recognizes the complexity and interaction of the components.

The study participants were 33 twelfth-grade students from two senior high schools located in a medium-sized metropolitan area. All participants were volunteers from an original pool of 180 students. The study sample was heterogeneous based on performance (GPA), cognitive ability (Raven's Progressive Matrices), and socioeconomic background (Howard-Rose & Winne, 1993). Students were asked to complete 6 tasks. The tasks were designed to favor the self-regulated learning components. Students completed a survey, The Academic Attribution Scale, to address the source of their success or failure at completing the tasks. The Academic Self-Concept Scale was administered to assess self-efficacy. The SRL (Self-Regulated Learning) Rating Scale was also administered. The Metacognitive Questionnaire was administered to collect data on the cognitive processes students used to complete the tasks. Students were trained to record their cognitive activity while completing the tasks through a processing called "tracing." Students were scored on the tasks using a pre-test/post-test matrix. Finally students were videotaped while they worked on the tasks. The video tapes were analyzed for data related to the components of self-regulated learning (Howard-

Rose & Winne, 1993).

Based on statistical analyses, triangulation and aggregation methods, the data were unreliable. There did not appear to be any consistent relationships among the data sources for the various components of self-regulated learning. In other words, the researchers were unable to isolate and quantify the specific components of self-regulated learning (Howard-Rose & Winne, 1993). The researchers did not identify how to isolate components of self-regulated learning, but they did eliminate at least one method that other researchers will not have to try and they shed light on the intricacy and multi-faceted nature of the construct.

Instructional models

Zimmerman (2000) explains that "self-regulatory processes can be acquired from and are sustained by social as well as self sources of influence (p.29)." He provides a four level model of regulatory skill acquisition. The first level is observation. At this level an individual sees someone exhibiting a skill they perceive to be beneficial. The second level is emulation. At this level the individual attempts the skill with assistance. The third level is self-control. At this level the individual uses the skill with supervision. The fourth and final level is self-regulation. At this level, the individual can use the skill independently and can adapt its use to various situations.

Pintrich and De Groot (1990) indicate that self-regulation and motivation are important components of academic performance. They define self-regulated learning as strategies for planning, monitoring and modifying thoughts and actions. These include strategies students use to assist themselves with learning, remembering and understanding the material. Some examples of self-regulated learning strategies include rehearsal, elaboration and organization.

Schunk and Ertmer (2000) define self-regulation as the "self-generated thoughts, feelings, and actions that are planned and systemically adapted as needed to affect one's learning and motivation (p. 631)." They include goal-setting, focusing on instruction, effective use of strategies for organizing, coding, and rehearsing information, designing an effective learning environment, help-seeking activities, maintaining a positive attitude and appreciation of learning, and being pleased with one's efforts and learning outcomes among their list of self-regulating strategies.

They describe several interventions and their effect on self-efficacy and self-regulation. The first intervention is goal-setting. The authors site several studies, which indicate that establishing specific process (learning) and product (outcome) goals results in greater achievement than not having goals or having generalized goals such as "do your best." The second intervention is monitoring. Their conclusion based on several studies indicated that combining specific goal-setting with monitoring and progress feedback resulted in the highest levels of self-efficacy and achievement. The third intervention is self-evaluation. They concluded, based on the studies included in their review that providing learning goals instead of performance goals was more important in determining achievement than self-evaluation, but the use of self-evaluation with learning goals increased achievement (Schunk and Ertmer, 2000).

Weisnstein, Husman and Dierking (2000) define learning strategies as "any thoughts, behaviors, beliefs, or emotions that facilitate the acquisition, understanding, or later transfer of new knowledge and skills (p. 727)." They examine several models for implementing self-regulated learning instruction. These include learning to learn instruction, supplemental instruction, summer intervention for under-prepared students, integrated programs, and learning assistance centers. Based on several studies, learning to learn instruction appears to have the greatest impact on achievement. Within learning to learn models, systematic approaches appear to be the most effective. One model highlighted identifies the following eight steps: 1. set a goal; 2. reflect on the requirements of the tasks and the resources available to complete the task; 3. develop a plan; 4. select strategies for accomplishing the task; 5. implement the strategies; 6. monitor and evaluate the effectiveness of the strategies and overall progress toward completing the task; 7. modify the strategies as needed; and 8. evaluate the final product and determine if the process and strategies could be useful in the future.

Pape and Smith (2002) were concerned that low achieving/performing students frequently expressed that they thought they were working appropriately and diligently, but weren’t passing exams. At first Smith thought the students were not working at the level they reported, but an initial investigation indicated that in many cases students were attending class and tutorial sessions, completing homework, studying outside of class, etc. but their efforts were not resulting in the level of achievement one would expect. She decided to develop and implement a 10-week strategy-embedded developmental mathematics course that would provide explicit instruction about how to take good notes, read a mathematics book, utilize available resources, set goals, monitor progress, evaluate and revise goals, analyze and evaluate exam errors, etc. Her study indicated that the students who participated in the course earned higher grades, were better able to assume responsibility for their learning successes and failures, and used a larger variety of self-regulated learning strategies than other students.

Kiewra (2002) presented a model for teaching self-regulated learning strategies that he called "NORM" for note-taking, organizing, relating, and monitoring. He gave examples of strategies specific to each area of NORM. He also provided procedures for successfully teaching the strategies. First, teachers should "introduce" each strategy. Next, the teacher should "sell" the strategy by explaining why it is effective. Then, the teacher should "generalize" the strategy by sharing other examples of how it could be used. Finally, the teacher should "perfect" the strategy by providing students opportunities to practice it.

Butler (2002) presented a similar model, which she called SCL, strategic content learning. The first step in SCL, is task analysis, which includes recognizing the expectations of the task and what information is given and/or needed. The next step is to determine which strategies could be used to successfully complete the task. Finally the student is assisted as he/she self-monitors and evaluates his/her progress towards completion of the task. Butler explained how using her model, SCL, for teaching self-regulated learning strategies is consistent with constructivist theories that suggest knowledge is acquired by connecting new experiences to prior knowledge. She explains that SCL is also consistent with sociocultural learning theories which suggest that knowledge is developed through social interaction. So her model for teaching self-regulated learning strategies supports ideals presented by both Piaget and Vygotsky.

Although Butler (2002) provides information about how SCL can be used one-on-one, with small groups and with a whole class. The method has been used primarily one-on-one and with small groups of secondary exceptional children.

Harris (2002) focused on using Self-Regulated Strategy Development (SRSD) as a method for teaching students to become independent self-regulated learners. There are six stages of SRSD. First teachers assist students as they compare the task at hand to their past experience and knowledge. Second, teachers and students discuss various strategies that could be used to complete the task. Third, teachers demonstrate the strategy by modeling or thinking out loud. Fourth, teachers assist students in memorizing and internalizing the strategy. Fifth, teachers support students as they master the strategy. And finally, in the sixth stage, students are able to independently use the strategy as teachers gradually withdraw their support.

Horner (2002) also describes a method for teaching self-regulated learning strategies. The first step is goal-setting, followed by the selection and use of appropriate learning strategies. The author mentioned modeling, coaching, scaffolding, and articulation as methods teachers may utilize as components of cognitive apprenticeship, which is an instructional method teachers may use to support students as they acquire new strategies. The final phase of self-regulation mentioned by Horner (2002) is self-evaluation. The cognitive apprenticeship components in this phase are reflection and exploration. Reflection is defined as comparing one’s own strategies to those of experts and to one’s personal expectation for performance. Exploration is the term used when students are encouraged to develop and solve their own problems.

Dweck (2000) explains that there are two types of motivational goals. One type is learning-oriented goals. With these goals students are engaged in tasks for the sake of learning itself. However, with performance-oriented goals, the second type, students are motivated to complete tasks because they want good grades or a reputation as a good student. Learning-oriented goals are the ones that promote self-regulated learning.

Martinez-Pons (2002) explains that self-regulated learners recognize their own strengths and weaknesses, are able to set goals for task performance, monitor their own progress as they work, and are able to change strategies as their progress warrants. He makes the point that these skills are the basis for life-long learning, which is becoming more important as technology drives rapid changes in the skills needed for the workplace. He (2002) builds on Zimmerman's social-cognitive model for developing self-regulation skills. This model describes a student who first observes the desired strategy, emulates the strategy, self-controls by developing the ability to use the strategy independently in the observed situation, and then self-regulates by internalizing the strategy so that it may be utilized in a variety of situations.

Martinez-Pons (2002) also examines parental influences on the development of self-regulated learning strategies. He states that school structure depends on students becoming self-regulated learners, which is evident by the level of autonomy with which students are expected to work as they move into higher and higher grade levels. He indicates that there is evidence that students demonstrate some levels of self-regulation beginning in the fourth grade, but they aren't able to evaluate their own work yet.

Newman's (2002) work focuses on the importance of adaptive help seeking. He explains that self-regulated learners have a number of strategies from which they can draw to complete tasks. He explains that one is adaptive help seeking, which actually requires several skills. First students must be able to recognize when help is needed; they must possess the social skills to contact the person most suitable for providing the needed assistance; they must be personally motivated to make the connection; and they must be in a classroom environment that is safe for seeking help. Further he explains that teachers have an extremely important role in determining if students will seek help. The first component of the teacher's role is teacher-student intersubjectivity, this is the relationship teachers and students have which supports students' work in the classroom. The second component of the teacher's role is imbedded in students' beliefs about seeking help. Some students may feel that seeking help is an indication of incompetence and embarrassing. Teachers can help set the tone in the classroom so that help seeking is viewed as a valuable tool for learning thereby limiting negative feelings.

Newman (2002) also refers to the use of learning goals versus performance goals. He speaks to how important it is for teachers to establish learning goals which will facilitate the use of adaptive help seeking instead of performance goals which may squelch students' interest in seeking assistance when it is needed. He also makes the point that many self-regulated strategies are used by students independently, but adaptive help seeking requires students' to reach out to others.

Eshel and Kohavi (2003) believe that teacher control and student control operate independent of each other. In this case, classroom control refers to the authority to make decisions about learning. Teacher controlled learning is direct teacher driven instruction. Student controlled learning is collaborative with the students having input into learning goals and methods. Further their study examines the relationship between teacher control, student control and the use of self-regulated learning strategies, self-efficacy, and student's motivation for learning. They expected to find that perceived teacher control and student control operate independently of each other and that high teacher control and high student control provide the most conducive environment for the use of self-regulated learning strategies and increased student achievement.

The study participants consisted of over 300 sixth graders who attended school in a small Israeli town. The sample was about equally divided between males and females. The classes were not tracked or assigned to teachers based on any particular student characteristics such as previous achievement. Mathematical achievement was determined using scores from tests administered by the Israeli Center for Educational Technology. The use of self-regulated learning strategies, perceived locus of control, mathematical self-efficacy, and motivation were determined from survey instruments which were administered five times over a period of two and a half years (Eshel & Kohavi, 2003).

Data analysis indicated that perceived teacher control and student control do operate independently of each other. They are not mutually exclusive on a continuum, but can support each other in an environment where control is shared. High teacher control and high student control provide the best case scenario for increasing student achievement. That is to say that teachers need to be a strong presence for providing instruction and students need to feel as though they have the leeway to make choices and decisions about instructional methods and learning goals. However, strong student control, not shared control, provided the best environment for developing self-regulated learning, self-efficacy, and motivation to learn (Eshel & Kohavi, 2003).

Randi and Corno (2000) examine various classroom interventions teachers may use to support the development and use of self-regulated learning strategies among students. They promote a curriculum-embedded approach to self-regulated learning strategy instruction instead of teaching the skills in isolation. They suggest that self-regulated learning strategies should be taught in a content specific environment, where the self-regulated learning strategies are intertwined with the content instruction. One model of instruction they discuss is the use of cognitive apprenticeship. This method uses explicit modeling and coaching to acquire new skills. They suggest that an external support system provided by the teacher that is gradually removed as students internalize the behavior and are able to use it independently will effectively develop the use of self-regulating learning strategies.

Collaborative innovation is another model of instruction examined. The collaborative innovation process is a joint effort between teachers and researchers to design instructional methods that combine theory and practice. This method allows teachers to adapt instructional theories to their particularly instructional styles and the learning styles of the students (Randi and Corno, 2000).

Learning through story is a third model discussed for developing self-regulated learning strategies. This model is best suited for humanities classes. The model uses literature and story-telling to lead students to the use and understanding of self-regulated learning strategies (Randi and Corno, 2000).

Conclusion

The previous research offers many interesting and useful ideas and theories about self-regulated learning. These have been used to inform the study described here. One underlying belief is that students can be and should be active participants in their own learning and when they are, their mathematical self-efficacy and achievement increases (Zimmerman, 1986). Additionally higher achieving students use a broader range of self-regulating strategies than lower achieving students. High achieving students are able to select and consistently apply appropriate strategies based on the problem or task at hand (Zimmerman, 1986). Conversely, students who have limited exposure to self-regulated learning strategies are less likely to develop them on their own (Zimmerman, 2000). Furthermore the research indicates that self-regulated learning strategies can be taught (Zimmerman, 2002). Pape and Smith's (2002) research indicates that a structured program of explicitly taught self-regulated learning strategies imbedded in mathematics content instruction can increase student achievement and influence student learning behaviors. Research conducted by Randi and Corno (2000) also reiterates the value of providing self-regulated learning strategy instruction in the context of specific content instruction.

Although several methods were incorporated into the instructional design of the strategies used as the treatment in this study, Kiewra's (2002) method of introduce, sell, generalize, and perfect is the primary model. The treatment also incorporated Dweck's (2000) theory of performance versus learning goals. Teaching students to recognize the difference between the two types of goals and then writing their own learning goals was among the strategies used to address the forethought phase of self-regulation (Zimmerman, 2000).

Instruction on other strategies addressed the remaining two phases of self-regulated learning. Strategies such as creating a test, selecting additional problems for review, and organizing notes were taught to address the performance phase. The self-reflection phase of self-regulated learning was addressed using strategies such as self-consequating and revising a learning plan (Zimmerman, 2000).

The study described here was designed to build upon the current research and apply it with eighth grade mathematics students with the intent of contributing to the knowledge base and generating additional information that could be useful for teachers as they work to create more-independent learners and higher achieving mathematics students.

CHAPTER 3: METHODS AND PROCEDURES

Chapter introduction

This chapter provides a description of the procedures and processes used to prepare for and implement the study. Sections include the purpose of the study, design, survey development, pilot study procedures and outcomes, treatment development, sampling methods and participants, data collection procedures, data analysis procedures, and a brief conclusion.

Purpose

This study examined how explicit instruction of self-regulated learning strategies impacted eighth grade mathematics classes. Data was collected from students about their use of self-regulation and the strategies associated with self-regulated learning. Standardized test data were used to examine the impact on student achievement. The purpose and design of the study are supported by guidelines developed by The American Statistical Association (2007) for mathematics education research. The study design was based on the cyclic model for knowledge production and improvement of practice highlighted in the report.

Design.

This study used a quasi-experimental design. The independent variables were the two groups, control and treatment. The treatment group received explicit instruction incorporating self-regulated learning strategies into their regular mathematics instruction.

The dependent variables were the results from students' self-reported responses on a survey designed to measure the extent to which students are incorporating self-regulated learning strategies into their independent learning behaviors and students' scale scores from their seventh and eighth grade North Carolina End-of-Grade Mathematics Tests.

For this study, student achievement was measured using a pretest/posttest design. The pretest data were collected from students' North Carolina Seventh Grade End-of-Grade Mathematics Test scores. The posttest data was collected from students' North Carolina Eighth Grade End-of-Grade Mathematics Test scores. Students who did not have a seventh grade mathematics test score were not included in the data.

Participation in North Carolina end-of-grade testing is required for all students who are enrolled in North Carolina public schools. The scale scores from these tests were used as the measure of student achievement for this study. Some students participated in end-of-grade testing through alternate assessments. These results were not used. Only scale scores that were created through regular test administrations, with or without accommodations, were used.

The North Carolina End-of-Grade Mathematics Test was used to produce the scores analyzed in this study. The accountability division of the Department of Public Instruction designs, develops, and produces the North Carolina End-of-Grade tests. The tests are created based on pre-determined parameters and are field-tested using a scientifically selected sample from the students within the state. These tests are considered to be reliable and valid within the limits set for achievement tests by the state. New editions of the mathematics tests are created when the curricula is revised. The new forms remain operational until the next curricula revision takes place. Students who participated in this study took the third edition of the North Carolina End-of-Grade Mathematics Test. This edition was introduced at the end of the 2005-2006 school year. The data collected during that first administration was used to norm the test and the same norms are still being used. For the seventh grade mathematics test the state mean scale score the year of the norming was 357.8 and the standard deviation was 9.65. The mean for the eighth grade test was 359.2 and the standard deviation was 9.21. The norming determined a range of scale scores for each grade. For the seventh grade test, the scale scores range from 332 to 383. The eighth grade scale scores range from 332 to 384 (Public Schools of North Carolina, 2009; North Carolina Department of Public Instruction, 2008; North Carolina Department of Public Instruction, 2009).

The state mean for the seventh grade North Carolina End-of-Grade Mathematics Test administered at the end of the 2007-2008 school year, which is when the students in this study were administered the test, was 359.1 and the standard deviation was 9.5. The state mean for the eighth grade North Carolina End-of-Grade Mathematics Test administered at the end of the 2008-2009 school year, was 362.8 (North Carolina Department of Public Instruction, 2009) (Note: The standard deviation had not been released by the North Carolina Department of Public Instruction at the time this report was written.)

Teachers are required to receive training prior to administering the tests and to follow the directions in the manual for standardized administration. School administrators, school test coordinators and the district test coordinator monitor the administration of the tests to ensure the proper procedures are followed (Public Schools of North Carolina, 2008-2009).

The effectiveness of the explicit instruction in developing independent, self-regulated learning behaviors was determined using a repeated measures design. A survey of students' use of self-regulated learning strategies was conducted prior to the implementation of explicit self-regulated learning strategy instruction. It was expected that students in both the control group and treatment group already used some self-regulation strategies. The initial administration of the survey established a baseline for the two groups and provided data to determine their comparability. The survey was repeated after the completion of the explicit self-regulated learning strategy instruction and again at the end of the school year to measure any change that may have occurred in student learning behavior following a time lapse after the explicit instruction. Since the primary instruction of the self-regulating learning strategies occurred during the second quarter of the school year with the remainder of the year used to reinforce their use, there was a possibility that there may be a decline in the students' self-reported use of the strategies. This is the reason it was important to administer the survey in the middle of the year as well as at the end. The use of a survey to assess students' self-regulated learning behavior is supported by Creswell (2005) who states that surveys are used in quantitative research to collect data related to "attitudes, opinions, behaviors, or characteristics of the population (p. 354)."

Prior to beginning the study, lessons which incorporate the use of self-regulated learning strategies and a survey which addresses students' use of and attitudes towards self-regulated learning strategies were developed. A survey that would meet the needs of this study was not readily available, so a student survey was created. A pilot study was conducted, at a school other than the one selected for the study, to assess the reliability and validity of the survey. Information gained during the pilot study was used to refine the instrument.

Survey Development and Pilot Study

Winne and Perry (2000) define self-regulation as a concept related to learning that is "metacognitively guided (p. 333)" They define metacognition as "the awareness learners have about their general academic strengths and weaknesses, cognitive resources they can apply to meet the demands of particular tasks, and their knowledge about how to regulate engagement in tasks to optimize learning processes and outcomes (p. 333)." They suggest that self-regulated learning can be measured as an aptitude or as an event. Questionnaires, structured interviews, and on occasion teacher ratings have been used to measure self-regulated learning aptitude. Measuring self-regulated learning as an event is more complex. It involves observing a change in behavior from a situation where self-regulated learning was not in existence to a subsequent situation, where there are indicators of its presence.

Measuring self-regulation as an aptitude also includes examining students' use of appropriate behaviors. Zimmerman (1986) explains that the behavioral aspect of self-regulation refers to students' abilities to select and use appropriate learning strategies. This study will focus on the behavioral aspect of self-regulated learning because it is reasonably measured using self-reported student data. This is the rationale for surveying students about their use of self-regulated learning strategies as a means of measuring their progress toward becoming independent, self-regulated learners.

According to Winne and Perry (2000), "Self-report questionnaires are the most frequently used protocol for measuring SRL (self-regulated learning), perhaps because they are relatively easy to design, administer, and score. These measures inherently provide (a) information about learners' memories and interpretations of their actions, and (b) their explanations of cognitive and metacognitive processes researchers cannot observe (p. 542)." Questionnaires measure self-regulated learning as an aptitude.

The survey was developed using the three-step model reported by Winne and Perry (2000). First items were collected or created. An exploratory factor analysis was performed to determine the relationship between the items and the self-regulated learning model being used. Second, reliability coefficients were calculated to determine internal consistency. Third, the questionnaire results were correlated to an external measure such as achievement scores (Winne & Perry, 2000). The importance of using instruments that measure the construct intended was stressed. They remind researchers that it is important to examine the characteristics that define the population and the extent to which the selected sample reflect those characteristics. They note that reliability is the most important issue when using self-reported questionnaires (Winne and Perry, 2000).

This study sought to measure the extent to which students were developing into independent, self-regulated learners. The researcher collected information about students' use of self-regulated learning strategies as the evidence that students were functioning as independent, self-regulated learners from a survey. Survey items were developed using the behaviors identified in several studies as being indicative of self-regulated learning (Zimmerman, 1986; Pape and Wang, 2003; Smith, 1998). Items were reviewed in draft form by experts in the field of research and self-regulation to ensure content validity (Huck, 2004). Revisions were made based on their feedback. There were 30 items included in the survey, not including items which asked participants to provide demographic information. The items were written so that there were ten items aligned to each of the three phases of the self-regulation cycle: forethought, performance, and self-reflection (Zimmerman, 2002).

Four items on the survey asked for demographic information regarding each student's age, free or reduced price lunch status, limited English proficiency status, and the highest educational level attained by either parent. This information was self-reported by students as they responded to survey items. Additionally each student's race and gender were collected from the same electronic file that provided their North Carolina End-of-Grade Mathematics Test results. These data are considered components of the test data and are part of each student's results. This information was pulled from the district's official student information system when test materials are prepared. It is not self-reported by students.

A pilot study was conducted in spring 2008 to determine the validity of the survey in measuring students' use of self-regulation. Huck (2004) states that "a measuring instrument is valid to the extent that it measures what it purports to measure (p. 88). Dilllman (2000) reiterates the value of a pilot study in estimating item nonresponse rates, variable distributions and reliability. He also indicates that a pilot test allows the researcher to determine the effectiveness of the items. Creswell (2005) writes that a pilot test gives an indication of the extent to which the intended population is able to understand and respond to the questions. This is particularly important when the population is school age students. It could have been possible that the questions were appropriate for adults but not for children.

Ninety-nine eighth grade students participated in the pilot study. 42.42% were female and 57.58% were male. The sample of students was ethically diverse. 54.54% were white; 4.04% were Asian, 26.26% were black; 5.15% were Hispanic; and 10.10% were multi-racial. Self-reported information indicated that 38.38% were economically disadvantaged based on their free and reduced price lunch status. 48.48% were not economically disadvantaged. The remaining 13.13% did not respond.

An exploratory factor analysis was performed to determine the effectiveness of the items in assessing the information desired and to ensure construct validity (Huck, 2004). Collectively the 30 items were designed to measure the frequency with which students engaged in self-regulating behaviors, however they were also divided so that each of the three phases of the self-regulation cycle: forethought, performance, and self-reflection (Zimmerman, 2002) were represented. The factor analysis explained 45.86% of the total variance. Overall the items aligned as expected. One item, which stated, "I think about what I am supposed to do before I begin studying math," was revised to use the word "plan" instead of "think." It was felt that the change more clearly indicated forethought. Two items, "I think math is an important subject for me to learn, even if it isn't my favorite," and "I read math problems more than one time to make sure I understand the important information," aligned to two phases about equally, but the determination was made to leave them in the survey without revisions with the understanding that they could be removed from the study data if they did not perform well. Two items, "I ask myself questions about the math topic before I start studying it," and "I look for similar math problems I know how to work to help me solve challenging problems," were removed from the survey prior to use in the study. Based on the exploratory factor analysis, these two items did not address the intended phase.

After the deletions of the two items were made to the survey data, coefficient alpha for the remaining 28 items was used to assess the internal consistency of the assessment. Coefficient alpha of .91 indicated that the items were internally consistent. Coefficient alpha was also used on the items as they were assigned to each phase of self-regulation to assess the internal consistency within the phase. Coefficient alpha of .79 for the forethought phase, .80 for the performance phase, and .83 for the self-reflection phase indicated that the items were internally consistent for each phase. It is not surprising that the reliability coefficient for the items in each phase is lower than the reliability coefficient for the survey as a whole since each phase is represented by only a few items, but all are sufficiently reliable.

Using the advice of research experts, the demographic questions, which had been the first items on the survey used during the pilot, were moved to the end of the survey prior to administering it during the actual study. This minor revision along with the item revision and deletions mentioned earlier resulted in the instrument used to collect student self-regulating learning behavior during the study. A copy of the survey as it was presented to students during the study is provided in Appendix A.

Treatment development and implementation

A list of possible strategies was compiled from the studies referenced in the literature review. During the spring of the previous school year the eighth grade mathematics teachers at a school other than the one selected for the study were invited to participate in a focus group to discuss this list of various self-regulated learning strategies proposed for the treatment. The purpose of the focus group was to determine which strategies would be most appropriate for use in middle grades mathematics classes. Prior to beginning the study, it was assumed that the teachers in the study would not fully embrace the incorporation of self-regulated learning strategies into their regular instruction if they saw it as an imposition. The idea was to choose strategies that were valuable and could be utilized as a seamless component of the regular content instruction. It was determined that the treatment teachers must feel that the strategies were worthwhile or they would most likely not support them in the instruction (Zimmerman, 2006). Ultimately the strategies were selected by the researcher in collaboration with the treatment group teachers based on the results of the focus study.

The focus group consisted of all of the five eighth grade mathematics teachers at a large urban middle school located in a southern state. Their consensus indicated that the following strategies were most appropriate for middle school mathematics students:

- Using an organized, interactive note-taking method such as the Cornell method
- Teaching students an active study method that focused on strategies that are interactive, proactive and productive
- Working with students to enhance their abilities to articulate their processes, steps and thoughts as they are solving problems
- Helping students to develop a process for error analysis
- Developing methods that assist students with checking their work and solutions as a component of problem solving
- Teaching students to identify specific short term goals with self-determined consequences and rewards

- Helping students to analyze problem characteristics to identify the types of items that would be most appropriate for assessment purposes
- Helping students to effectively use the resources provided in the mathematics textbook
- Teaching students test review strategies
- Assisting students with how, when and from whom they should seek help when they are not sure of how to solve a problem

The focus group teachers indicated that using content mapping and additional heuristic methods already addressed in mathematics instruction would not be beneficial.

The researcher developed a teacher's guide with descriptions of the ten lessons that would be used as the explicit self-regulated learning strategy instruction. These lessons were the treatment implemented during the study. The lessons followed the instructional design in the model developed by Kiewra (2002). The teacher's guide is provided in Appendix B.

Treatment teachers were also given large, colorful posters to display in their classrooms. The posters were designed to remind students to use the strategies and to keep a focus on the process and purpose of self-regulated learning. Copies of the posters are provided in Appendix C.

Once specific strategies, procedures and instruments were finalized, the eighth grade mathematics teachers at a moderate-sized middle school of a small urban school district in a southern state were assigned as participants in either the control group or the treatment group, which included explicit instruction on self-regulated learning strategies as a component of their regular mathematics instruction. The teachers in the treatment group were trained on the use and instruction of self-regulated learning strategies.

Based on an analysis of 18 professional development models, a report from The Urban Institute (2005) found that effective professional development for mathematics teachers included training that includes information about content and how students learn. Their report supports the value of content specific self-regulated learning strategies and teacher training that is designed to change teacher behavior with the intent of increasing student achievement. Although their analysis did not indicate that there is an increased benefit gained for mathematics classes from continuing professional development throughout a school year, the researcher of this study continued to communicate with the treatment teachers to incorporate explicit instruction of self-regulated learning strategies into their mathematics lessons on a periodic basis as an effort to monitor and support implementation of the treatment.

The Urban Institute report (2005) also debunked the myth that classroom visits increase the effectiveness of professional development, but for the purposes of this study, administrators made periodic classroom observations to assess the level to which teachers were implementing the self-regulated learning strategy instruction. A checklist was developed to record the data collected during the observations. A copy of the checklist is provided in Appendix D.

Prior to beginning the treatment and before any training was provided to the treatment teachers, the survey was administered to both the control and treatment groups of students. For each administration of the survey, the materials were prepared and provided by the researcher. The survey was administered by each participating teacher to their respective students following the directions that accompanied the survey materials.

After the baseline administration of the survey was administered, the treatment teachers met with the researcher for training on how to implement the treatment. They were directed to teach the strategies that related to the forethought phase of self-regulation first. Lesson plans for teaching these strategies are provided in the guide (Appendix B) as Strategy 1: Setting Learning Goals, Strategy 2: Making a Learning Plan, and Strategy 3: Reviewing and Improving a Learning Plan. Teachers were directed to require students to continue using these strategies throughout the period of time when they would be providing explicit instruction. The treatment teachers were told that the remaining seven strategies should be taught in the weeks following the instruction of the first three strategies. They were asked to include explicit instruction on a strategy when it would be a good fit with their regular lessons. For example, they should incorporate Strategy 4: Preparing for a Test when their regular lesson included a test review. Teachers were asked to try to incorporate one new strategy a week until all ten strategies had been taught. During the approximately ten weeks when the explicit instruction was being implemented, the teachers were asked to require students to continue using any strategy that had already been taught if it was appropriate for the day's lesson. Treatment teachers were asked to keep a log of the dates they initially taught each strategy, to make comments about how the students responded, and to reflect on how effective they felt the lesson was. A copy of the log is provided in Appendix E.

After the explicit instruction of all ten strategies had taken place, treatment and control teachers administered the survey a second time. Since a school quarter is only nine weeks and it required at least ten weeks to provide explicit instruction on all the strategies, the second survey was given to both control and treatment groups during third quarter prior to spring break. It was expected that the treatment group would report an increased use of self-regulated learning behaviors as a result of the instruction. This administration of the survey followed the same format as the previous administration. The materials were prepared and provided by the researcher and the teachers administered the survey to their respective students following the directions included with the survey materials.

Following the explicit instruction of the strategies, treatment teachers were asked to encourage students to continue to use the strategies and to remind students if there was a time in their regular lesson when a strategy would seem to be beneficial, but they were asked not to require students to use the strategies.

The third and final administration of the survey occurred at the end of the school year, several weeks after the second administration of the survey and after the explicit instruction had ended. This administration of the survey was conducted using the same procedures as the other two administrations. The third administration occurred after a relatively lengthy period of time when students were encouraged, but not required to use the strategies. It was anticipated that there may be some decrease in the treatment group's use of self-regulated learning behaviors since at this point they would be optional.

As recognition of their participation in the study, the control and treatment teachers received positive feedback from the researcher, ongoing recognition of and appreciation for their efforts, and periodic reminders of the value of their role in the study and its possible contribution to the knowledge base. Additionally, a small piece of candy was provided for them at the time of each survey administration and they were given a $10 gift certificate to a local restaurant after the completion of the study. Participating students in both the control and treatment groups were given a small piece of candy and a "thank you" sticker as they completed the survey each time. None of these rewards were promised prior to beginning the study.

Sampling and participants.

The study was conducted at a moderate size middle school in a small urban school district in a southern state. The school had about 800 students total in grades seven and eight, with a relatively even distribution between the grades. All four of the full-time eighth grade mathematics teachers and all eighth grade students who were enrolled in regular eighth grade mathematics were asked to participate. The four eighth grade mathematics teachers were assigned as instructors to either the control group or the treatment group based on their interest and willingness to participate. The researcher felt that teachers must have an interest in implementing the strategies in order to commit to the work and to ensure the fidelity of the treatment implementation. All of the regular eighth grade mathematics classes were assigned as wholes to the same group as the teacher. Students were invited and encouraged to participate in the study three different times during the first quarter of the school year. Eighty-four students agreed to participate. Consent was obtained from the teachers, school administrators and the district superintendent. Parental consent and student assent was obtained from the students.

One of the teachers, who originally agreed to participate as a control teacher, decided prior to the beginning of the school year in which the study was conducted to remain on maternity leave for the entire school year. A regular teacher had not been assigned to her classes at the beginning of the school year when students were being recruited to participate, so the decision was made to use only one teacher and the students from her classes who agreed to participate as the control group.

Treatment teachers were asked to complete a log recording the date the self-regulated learning strategy lessons were taught and their comments about the lessons. This was done as another way of verifying the fidelity of the treatment implementation. A copy of the log is provided in Appendix E. One of the treatment teachers indicated in her log that she had become frustrated with several of the strategies and struggled providing the students instruction on them. She didn't include several of the strategies in her explicit instruction of self-regulated learning strategies. Since her implementation of the treatment was incomplete, the decision was made to remove her and her students from the data. The data generated from the two remaining teachers, one control and one treatment, were used for all analyses included in the study.

After removing those teachers and students from the data, 61 students remained in the study. Twenty-six students were in the treatment group and 35 were in the control group. Data regarding several demographic factors were collected using items on the survey. Gender and race were collected from the test result files. The sample was ethnically diverse. Self-reported free and reduced price lunch status was used to determine if students were economically disadvantaged. On the survey students were asked to report if they received English as a Second Language (ESL) services. Students were also asked to identify the highest education level obtained by either parent. Any exceptional students who were taught mathematics in special classes designated for students with disabilities were not included in the study sample. Tables 1-5 show demographic information for both groups of students.

This sample, although small, was reasonably representative of the school as a whole. Enrollment changed as students moved during the year, but the school was approximately evenly divided by gender (North Carolina Department of Public Instruction, 2009). Based on state data, 62.42% were economically disadvantaged based on free and reduced meal application data (North Carolina Department of Public Instruction Child Nutrition Services, (2008). The total population of the school was racially diverse with approximately 19.58% of the students Hispanic, 33.38% black, and 45.47% white (North Carolina Department of Public Instruction, 2008).

Table 1

Gender of participants

	Control		Treatment		Total	
	n	% of group	*n*	% of group	*n*	% of group
Male	14	40.00	14	53.85	28	45.90
Female	21	60.00	12	46.15	33	54.10
Total	35	100.00	26	100.00	61	100.00

Table 2

Race of participants

	Control		Treatment		Total	
	n	% of group	*n*	% of group	*n*	% of group
Black	9	25.71	5	19.23	14	22.95
Hispanic	11	31.43	6	23.08	17	27.87
Multi-racial	2	5.71	0	0.00	2	3.28
White	13	37.14	15	57.69	28	45.90
Total	35	100.00	26	100.00	61	100.00

Table 3

Economic status of participants

	Control		Treatment		Total	
	n	% of group	*n*	% of group	*n*	% of group
Disadvantaged	21	60.00	17	65.38	38	62.30
Not disadvantaged	14	40.00	9	34.62	23	37.70
Total	35	100.00	26	100.00	61	100.00

Note. Economic status was determined by the participants' self-reported free, reduced price, or full pay lunch status.

Table 4

Limited English proficiency status of participants

	Control		Treatment		Total	
	n	% of group	*n*	% of group	*n*	% of group
LEP	9	25.00	3	11.54	12	19.67
Not LEP	26	72.22	23	88.46	49	80.33
Total	36	97.22	26	100.00	61	100.00

Note. Limited English proficiency status was determined by participants' self-reported contact with the English as a Second Language support staff. Therefore students who are officially identified as limited English proficient students may have progressed to the point where they do not receive direct services and so they may not have identified themselves as lacking English language proficiency.

Table 5

Parent education status of participants

	Control		Treatment		Total	
	n	% of group	*n*	% of group	*n*	% of group
Not high school graduate	8	26.67	8	33.33	16	29.63
High school graduate	13	43.33	8	33.33	21	38.89
Community College	6	20.00	3	12.50	9	16.67
Four-year College	3	10.00	5	20.83	8	14.81
Total	30	100.00	24	100.00	54	100.00

Note. The level of parents' education status was self-reported by students.
Note. The community college category included technical school and trade school.
Note: Seven students did not respond to this item.

Data collection.

The survey was administered to all participating students at three different times during the year. The first administration occurred prior to the beginning of the explicit instruction on self-regulated learning strategies. The second administration occurred after the completion of the explicit instruction. The final administration occurred within the final two weeks of the school year. Although the surveys collected identifying information for the purpose of matching the surveys throughout the study, the data has been and will be kept confidential. It is only reported in aggregate.

The survey was administered using a paper and pencil format each time. Students were given individual copies of the survey and a general purpose answer sheet. Data were collected from the answer sheets mechanically using an optical scanner and Remark software and then exported to SPSS.

Students' mathematics achievement, as measured by their scale scores on the North Carolina End-of-Grade Mathematics Test, was collected at the end of the school year from the data file created by the school district for the North Carolina Department of Public Instruction. Student achievement test scores were generated through the regular administration of North Carolina End-of-Grade tests, following the state procedures for uniform standardized test administration. These tests were administered in the last 15 days of the school year.

As a component of the state accountability program, the North Carolina Department of Public Instruction uses students' current and previous test scores to produce a standardized scale score that is used to measure students' academic progress. The standardized scale scores are used to predict how a student should perform on the current end-of-year test if the student meets the state's expectation for the student's progress. This is referred to as the ABC growth prediction. Since these standardized scale scores and growth predictions are generated from students' End-of-Grade Mathematics Test scale scores, they were also used in the data analysis (North Carolina Department of Public Instruction, 2009).

Data analysis.

This section provides an overview of the type of statistical analyses that were made using the data. The results are provided in the next chapter. A number of statistical tests were used to determine which factors significantly impacted students' self-regulated learning behavior and their mathematical achievement.

Although reliability tests and an exploratory factor analysis were performed during the pilot study to analyze the ability of the survey to assess the constructs being examined, the tests were repeated on the data that were collected during the actual study to ensure that the instrument was an appropriate measurement tool for the intended purpose.

The survey responses, other than those designed to collect demographic data, were collected using the following Likert-scale: 1 = Never, 2 = Seldom, 3 = About half the time, 4 = Usually, and 5 = Always. According to Wright (1997) Likert-scale data can be treated as interval data if the difference between consecutive descriptors represents an equal increase in frequency. The response choices on the survey asked students to indicate the frequency with which they engaged in the behavior indicated in each item. A higher score indicated a greater frequency than a lower score. In order to use statistical tests with the survey data, the assumption was made that the interval between the response choices was equivalent and therefore could be treated as interval scale data. Demographic data was processed as nominal data.

Chi-Square tests were used to compare the two groups based on demographic factors which included gender, race, economic status, English as a second language status, and the educational level of students' parents. Independent t-tests were used to verify that the control groups and treatment groups were comparable based on their responses to the first survey administration and their seventh grade End-of-Grade Mathematics Test scores, which were collected at the end of the previous school year. MANOVA was used to determine if the two groups were comparable based on their responses to the baseline survey questions when they were grouped by the phases of self-regulation.

Stevens (1999) says that using univariate analyses repeatedly increases the chance that a Type I error will be made. By considering the variables in combination, one is more likely to identify small differences in the variables that would be missed if separate tests were run. Also, using a multivariate test is more likely to identify differences if the dependent variables are correlated within the groups

In response to the study research questions, a repeated-measure ANOVA was used to examine the differences in groups' survey results at both the whole test level and at the phase level. Stevens (1999) suggests that there isn't an advantage to using a multivariate approach to repeated measure tests for controlling Type I errors. In fact he says that ANOVA is more powerful if the assumption of sphericity is met or compensation is made.

Separate independent t-tests were used to determine the difference in the groups' mathematics scale scores and ABC growth. When the data analysis used scale scores, students who did not have either a pretest or posttest score were eliminated listwise.

Stepwise regression was used to determine the amount of variance in students scale scores and ABC growth that could be accounted for using their survey results.

The same analyses were repeated to examine results based on demographic and phase level responses. SPSS was used to perform all statistical tests. The alpha level for all tests was set at $\alpha = .05$.

Conclusion

Most schools and school districts include the desire to create life long learners as part of their mission statements, but many of the procedures used in schools actually focus on developing short term performance goals instead of long term, independent learning goals, which would promote the development of life long learning skills. This study attempts to examine the use of strategies that would help students develop the skills and behaviors necessary to become successful mathematics learners, which in turn will promote life-long learning.

Findings in a number of other studies indicate that explicit instruction of self-regulated learning strategies is beneficial in developing mathematical self-efficacy and increasing student achievement (Pajares, 2002; Pintrich & De Groot, 1990; Pape & Smith, 2002; Martinez-Pons, 2002). This study was designed to continue the research generated by these other researchers.

Finally, the study seeks to contribute to the knowledge base by connecting the explicit instruction of self-regulating learning strategies to middle school student mathematics achievement. Although this study is limited to the students in one school district, it is believed that it will provide the foundation for future studies that are broader and more inclusive of the schools across the state.

CHAPTER 4: FINDINGS

Chapter introduction

This chapter provides the results of the data analysis conducted using the survey responses and End-of-Grade Mathematics Test scores. It is organized around the two research questions, which were the focus of this study. They are listed below:

1. To what extent does the explicit instruction of self-regulated learning strategies in middle grades mathematics classes aid in developing independent, self-regulated learners?
2. To what extent does explicit instruction of self-regulated learning strategies in middle grades mathematics classes impact student achievement?

The chapter is divided into five sections. The first section provides information about the quality of the instruments. The second section addresses the comparability of the control and treatment groups prior to treatment. The third and fourth sections directly respond to the research questions. The fifth and final section provides information regarding the connection between students' use of self-regulated learning strategies and their academic achievement.

The assumption of normal distribution was checked and met for all data. Brown (1997) states that if the absolute value of skewness is less than twice the standard error of skewness, the data are within the range for normal data. Skewness and the standard error of skewness for all data sets are provided in Table 6. All data were collected through independent observations. Other assumptions were addressed and the results are included throughout the chapter as the findings are reported.

Table 6

Skewness and standard error of skewness (ses)

		n	skewness	ses	2 times ses
First Survey Administration	Total	57	-0.31	0.32	0.63
	Phase 1	57	-0.32	0.32	0.63
	Phase 2	57	-0.40	0.32	0.63
	Phase 3	57	-0.61	0.32	0.63
Second Survey Administration	Total	51	-0.59	0.33	0.67
	Phase 1	51	-0.29	0.33	0.67
	Phase 2	51	-0.40	0.33	0.67
	Phase 3	51	-0.65	0.33	0.67
Third Survey Administration	Total	53	-0.62	0.33	0.65
	Phase 1	53	-0.41	0.33	0.65
	Phase 2	53	-0.24	0.33	0.65
	Phase 3	53	-0.62	0.33	0.65
7th Grade Math EOG		56	-0.60	0.32	0.64
8th Grade Math EOG		55	-0.47	0.32	0.64
ABC Growth		54	-0.15	0.32	0.65

Instrumentation quality

There were 28 items on the survey that was used during the study. A copy of the survey as it was administered to study participants is provided in Appendix A. The survey was administered 3 times. The first time was used as a baseline to determine students' use of self-regulated learning behavior prior to the implementation of the treatment. A factorial analysis was performed on the data collected from the first administration of the test to check for construct validity. Based on the results three items

9, 12, and 27 were deleted from the data analysis. Item 9 did not load on any factor with a value equal to or greater than .4. Item 12 loaded on phase 1 and phase 2 at a value that was slightly greater than .4 for both phases. Since it loaded about equally on two phases, it was not considered an effective item. Item 27 also loaded on two factors, both at a value greater than .5, but since it loaded about equally on both phase one and three, it was not considered an effect item. The remaining 25 items were assigned to the three phases of self-regulation based on the fact that they loaded primarily to a single phase with a minimum value of at least .4. Table 7 indicates the alignment of the items to the three phases.

Table 7

Alignment of survey items based on self-regulation phase

Phase	Item
Forethought	1, 5, 7, 8, 17, 18, 19, 28
Performance	2, 10, 11, 13, 14, 16
Self-reflection	3, 4, 6, 15, 20, 21, 22, 23, 24, 25, 26
Deleted items	9, 12, 27

The remaining 25 items were tested for reliability. For the first administration, a coefficient alpha of .90 indicated that the items were internally consistent when the survey was considered as a whole. Coefficient alpha was also used on the items as they were assigned to each phase of self-regulation to assess the internal consistency within the phase. For the baseline administration, there was a coefficient alpha of .78 for the forethought phase, .69 for the performance phase, and .83 for the self-reflection phase indicating that the items were internally consistent for each phase. The reliability was deemed to be within an acceptable range for each phase considering the limited number of items.

Reliability tests were also run for the second and third administrations of the survey. Table 8 shows the coefficient alpha values for both the survey as a whole and the three phases for each administration. There is a concern that reliability for phase one items on the second administration of the survey was low, relative to the same items for the other administrations. Since this administration occurred immediately after the conclusion of the treatment, this may be the result of inconsistent behavior due to changes as students incorporated the new self-regulated learning strategies combined with the limited number of questions. No changes were made to compensate for the less than desirable reliability since the reliability for the survey as a whole was acceptable.

Table 8

Coefficient alpha values for the survey

	1st Administration	2nd Administration	3rd Administration
Whole survey	.90	.88	.91
Phase 1	.78	.59	.74
Phase 2	.70	.68	.70
Phase 3	.83	.88	.89

According to the technical report from the North Carolina Department of Public Instruction (2008), the eighth grade North Carolina End-of-Grade Mathematics test has a reliability of .92 using coefficient alpha and meets all the standards required by the state for standardized testing.

Group comparability

A number of statistical tests were run to determine the comparability of the control and treatment groups. It is possible that demographic factors such as race, gender, economic status, level of English language proficiency, and/or the educational level of students' parents may influence students' academic achievement and use of self-regulated learning strategies. Chi-Square tests were used to determine if the control group and treatment group were significantly different with regards to these demographic factors. Pearson Chi-Square test indicated that the two groups were not significantly different with regards to gender ($\chi^2 = (1, n = 61) = 1.15, p = .28$). There was not a significant difference between the two groups based on race ($\chi^2 = (3, n = 61) = 3.51, p = .32$). The economic status of the two groups was not statistically significant ($\chi^2 = (1, n = 61) = 1.84, p = .67$). Limited English proficiency status was not significantly different for the two groups ($\chi^2 = (1, n = 61) = 1.90, p = .17$). The final demographic factor analyzed was the educational level of students' parents. Chi-Square indicated that the two groups were not significantly different with regards to this factor either ($\chi^2 = (3, n = 54) = 2.05, p = .56$). Since no statistically significant differences were identified based on the demographic factors analyzed, the groups were considered comparable based on these factors and no controls were needed in subsequent analyses.

The first administration of the survey was used as the baseline. Since neither the control group nor treatment group had received any explicit instruction on self-regulated learning strategies, the students' responses on this administration were used to determine if there was a significant difference between the two groups prior to beginning the treatment.

Students responded to the items on the survey using a Likert-type scale with one representing the lowest possible response and five representing the highest possible response. As explained in the previous chapter, these scores were treated as interval scale scores. An average of each student's responses was calculated to create a single score that was used to represent the student's overall response to the survey. Similarly averages were created for each student based on his/her responses to the items as they are aligned to each phase of the self-regulation cycle. These averages were used to compare the two groups on the total survey and on each phase.

An independent t-test was performed to compare the students' averages on the whole survey. The assumption of homogeneous variances was satisfied (Levene's test, $F = 1.08$, $p = .30$). The mean scores for the two groups were not significantly different, $t(55) = 1.13$, $p = .27$. The mean for the control group was 3.82 ($SD = 0.52$) and the mean for the treatment group was 3.97 (SD = 0.47).

A MANOVA was used to compare students' survey responses based on each phase of self-regulation. Table 9 shows the means and standard deviations. The assumption of homogeneous variances was satisfied for each phase. (Phase 1 Levene's test, $F = 0.08$, $p = .78$; Phase 2 Levene's test, $F = 2.20$, $p = .14$; Phase 3 Levene's test, $F = 0.35$, $p = .56$). There was no significant difference between the means of the two groups on any of the phases. For Phase 1 $F(1, 56) = 0.41$, $p = .53$; for Phase 2 $F(1, 56) = 0.22$, $p = .64$; and for Phase 3 $F(1, 56) = 3.11$, $p = .08$. Students in both the control and treatment groups indicated they used the strategies addressed in phase two less than the strategies aligned to the other phases.

Table 9

MANOVA means and standard deviations

	Phase 1			Phase 2			Phase 3		
	M	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
Control	3.84	0.54	32	3.36	0.59	32	4.13	0.54	32
Treatment	3.93	0.59	25	3.44	0.78	25	4.36	0.45	25

In North Carolina, students are tested each spring using the state developed standardized mathematics test. The students in this study took the seventh grade North Carolina End-of-Grade Mathematics test at the end of seventh grade, prior to entering the eighth grade and beginning the study. Students' scale scores on the seventh grade mathematics test were used to determine if the treatment group and the control group were comparable in terms of their previous academic achievement. An independent t-test was performed to make the comparison. The assumption of homogeneous variances was satisfied (Levene's test, $F = 0.00$, $p > .99$). The mean scores for the two groups were not significantly different, $t\ (54) = 0.61$, $p = .54$. The mean for the control group was 355.48 ($SD = 6.12$, $n = 33$) and the mean for the treatment group was 356.48 ($SD = 5.78$, $n = 23$).

Based on the tests run to compare the two groups prior to beginning the treatment, it was determined that the groups were also comparable in terms of their use of self-regulated learning strategies and prior academic achievement. Therefore it was not be necessary to control for either of these two factors in subsequent analyses.

It is more difficult to compare the control and treatment teachers since empirical data was not collected for them. However, it is important to note that both teachers were fully licensed to teach middle grades mathematics and had about the same number of years of teaching experience. Prior to beginning the study, the control teacher had seven years of teaching experience and the treatment teacher had eight. Neither teacher has a master's degree, but the treatment teacher is currently enrolled in a master's program. And both teachers are highly respected by their administrators as effective teachers.

Research question 1

The first research question asked, "To what extent does the explicit instruction of self-regulated learning strategies in middle grades mathematics classes aid in developing independent, self-regulated learners?" The null hypothesis for this question is

H_o: There will not be a difference between the survey responses of the control and treatment groups.

An average score for each of the survey administrations was calculated for each participant based on the Likert-scale value of their responses. These averages were used in a repeated measures ANOVA to test the null hypothesis. Students who did not complete all three administrations of the survey were eliminated listwise. Mauchly's Test was significant indicating that the assumption of sphericity was violated ($W = .74$, $df = 2$, $p = .001$). Greenhouse-Geisser and Huynh-Feldt corrected results were considered to compensate for the violation. Both indicated a significant within-subjects difference, however the effect size was small. Greenhouse-Geisser is being reported since it is considered the more conservative of the two ($F(1.59, 69.77) = 6.48$, $p = .005$, partial $\eta^2 = .13$) (Huck, 2004). The means and standard deviations are reported in Table 10. Although both groups showed an increase, the treatment group increased at a faster rate. Pairwise comparisons using Bonferroni indicated that the students' used self-regulated learning strategies at a significantly higher frequency on the second (p = .05) and third (p = .02) administration as compared to the first administration.

Table 10

Total survey means and standard deviations

		M	*SD*	*n*
1st Survey Administration	Control	3.76	0.49	26
	Treatment	4.00	0.42	20
	Total	3.87	0.47	46
2nd Survey Administration	Control	3.86	0.46	26
	Treatment	4.15	0.33	20
	Total	3.99	0.43	46
3rd Survey Administration	Control	3.89	0.43	26
	Treatment	4.20	0.46	20
	Total	4.03	0.47	46

The assumption of homogeneous variances was satisfied for the between-subject's effect for all three administrations of the survey (1st administration: Levene's test, F = 0.07, p = .80; 2nd administration: Levene's test, F = 2.92, p = .09; 3rd administration: Levene's test, F = 0.27, p = .61). The between-subjects effect showed a significant difference in students' responses based on the teacher ($F(1, 44)$ = 5.56, p = .02, partial η^2 = .11) with the treatment group scoring higher than the control group on each administration of the survey. However the effect size was small. Most teachers include study skills in their instruction, but the explicit instruction provided to the treatment group appears to have made a difference for that group of students.

It is important to note that the second administration of the survey occurred before spring break and the third administration occurred at the end of the school year, after the state mandated achievement tests were administered. Both the control and treatment teachers plan to complete their instruction of new content material prior to spring break and then turn their focus to end-of-year test preparation when students return after the break. This may explain, to some extent, the change reported by both groups of students from the second to the third administrations.

Based on these results the null hypothesis should be rejected, but the small effect size would suggest using caution before drawing the conclusion that the treatment made a practical difference. At this point, it seems helpful to analyze the data in more depth using demographic factors as well as group assignment to look for differences. The demographic factors that were considered are gender, race, economic status, English language proficiency, and parents' education level. Age was not considered an important demographic factor. Since the students are all in the same grade, their ages are all about the same. Most of the students (90.16%) were either 14 years old at the beginning of the study or turned 14 during the school year.

A repeated-measures ANOVA was run to determine if there was an effect based on gender. Mauchly's Test was significant indicating that the assumption of sphericity was violated ($W = .75$, $df = 2$, $p = .003$). Greenhouse-Geisser and Huynh-Feldt corrected results were considered to compensate for the violation. Neither one indicated a significant within-subjects difference indicating that gender was not a determining factor in the use of self-regulated learning strategies across the three administrations of the survey. Using Greenhouse-Geisser $F(1.60, 67.35) = 0.23$, $p = .47$, partial $\eta^2 = .005$. The means and standard deviations are reported in Table 11.

Table 11

Total survey means and standard deviations for gender

	Group	Gender	*M*	*SD*	*n*
1st Survey Administration	Treatment	Male	3.88	0.34	9
		Female	4.10	0.46	11
		Total	4.00	0.42	20
	Control	Male	3.73	0.39	9
		Female	3.78	0.54	17
		Total	3.77	0.49	26
	Total	Male	3.80	0.36	18
		Female	3.91	0.53	28
		Total	3.87	0.47	46
2nd Survey Administration	Treatment	Male	4.06	0.27	9
		Female	4.23	0.36	11
		Total	4.15	0.33	20
	Control	Male	3.71	0.56	9
		Female	3.94	0.39	17
		Total	3.86	0.46	26
	Total	Male	3.88	0.46	18
		Female	4.05	0.40	28
		Total	3.99	0.43	46
3rd Survey Administration	Treatment	Male	4.16	0.30	9
		Female	4.23	0.57	11
		Total	4.20	0.46	20
	Control	Male	3.73	0.46	9
		Female	3.98	0.40	17
		Total	3.89	0.43	26
	Total	Male	3.95	0.43	18
		Female	4.08	0.48	28
		Total	4.03	0.47	46

The assumption of homogeneous variances was satisfied for the between-subject's effect for all three administrations of the survey (1st administration: Levene's test, $F = 0.41$, $p = .75$; 2nd administration: Levene's test, $F = 1.62$, $p = .20$; 3rd administration: Levene's test, $F = 0.89$, $p = .45$). The between-subjects effect did not show a significant difference in students' responses based on the gender ($F(1, 42) = 1.86$, $p = .18$, partial $\eta^2 = .04$) indicating no real difference between the survey responses of males and females.

A repeated-measures ANOVA was also run to determine if there were any significant differences based on students' race. Mauchly's Test was significant indicating that the assumption of sphericity was violated ($W = .73$, $df = 2$, $p = .002$). Greenhouse-Geisser was used to compensate for the violation. There was not a significant within-subjects difference indicating that race was not a determining factor in the use of self-regulated learning strategies across the three administrations of the survey. Using Greenhouse-Geisser $F(4.72, 61.38) = 0.58$, $p = .71$, partial $\eta^2 = .04$. The means and standard deviations are reported in Tables 12-13.

Table 12

Total survey means and standard deviations for race (1st administration)

	Group	Race	*M*	*SD*	*n*
1st Survey Administration	Treatment	Black	4.24	0.06	4
		Hispanic	4.09	0.66	5
		White	3.87	0.33	11
		Total	4.00	0.42	20
	Control	Black	4.07	0.37	7
		Hispanic	3.72	0.41	8
		Multi-racial	3.88	0.45	2
		White	3.54	0.57	9
		Total	3.77	0.49	26
	Total	Black	4.14	0.30	11
		Hispanic	3.86	0.53	13
		Multi-racial	3.88	0.45	2
		White	3.72	0.47	20
		Total	3.87	0.47	46

Table 13

Total survey means and standard deviations for race (2nd and 3rd administrations)

	Group	Race	*M*	*SD*	*n*
2nd Survey Administration	Treatment	Black	4.31	0.16	4
		Hispanic	4.34	0.31	5
		White	4.01	0.33	11
		Total	4.15	0.33	20
	Control	Black	4.06	0.42	7
		Hispanic	3.92	0.55	8
		Multi-racial	4.02	0.26	2
		White	3.62	0.37	9
		Total	3.86	0.46	26
	Total	Black	4.15	0.36	11
		Hispanic	4.08	0.50	13
		Multi-racial	4.02	0.26	2
		White	3.83	0.39	20
		Total	3.99	0.43	46
3rd Survey Administration	Treatment	Black	4.46	0.26	4
		Hispanic	4.39	0.31	5
		White	4.02	0.52	11
		Total	4.20	0.46	20
	Control	Black	4.12	0.37	7
		Hispanic	3.96	0.51	8
		Multi-racial	3.84	0.33	2
		White	3.67	0.36	9
		Total	3.89	0.43	26
	Total	Black	4.24	0.36	11
		Hispanic	4.12	0.48	13
		Multi-racial	3.84	0.33	2
		White	3.86	0.48	20
		Total	4.03	0.47	46

The assumption of homogeneous variances was satisfied for the between-subject's effect for all three administrations of the survey (1st administration: Levene's test, $F = 1.80$, $p = .13$; 2nd administration: Levene's test, $F = 0.80$, $p = .57$; 3rd administration: Levene's test, $F = 0.39$, $p = .88$). The between-subjects effect did indicate that there was a significant difference in students' responses based on race ($F(3, 39) = 3.31$, $p = .03$, partial $\eta^2 = .20$). Bonferroni was used to make a pairwise comparison. The survey results indicated a significant difference between the self-reported use of self-regulated learning strategies between white students and black students, with black students reporting a higher frequency of use for each administration of the survey. This difference was not dependent upon being in the treatment or control group.

The survey results were disaggregated based on students' self-reported economic status. Students who reported receiving either free or reduced price meals were identified as economically disadvantaged. Students who reported paying the full price for their meals were identified as not economically disadvantaged. A repeated-measures ANOVA was used to determine if economic status had an effect on students' use of self-regulated learning strategies. The results were similar to most of the other results based on demographic factors. There was no significant difference for either the within-subjects effect or the between-subjects effect. Greenhouse-Geisser is being reported for the within-subjects effect ($F(1.59, 70.13) = 1.60$, $p = .21$, partial $\eta^2 = .04$) because the sphericity assumption was violated using Mauchly's Test ($W = .75$, $df = 2$, $p = .002$). Table 14 shows the means and standard deviations.

Table 14

Total survey means and standard deviations for economic status

	Economic Status	*M*	*SD*	*n*
1st Survey Administration	Disadvantaged	3.85	0.42	27
	Not disadvantaged	3.89	0.54	19
	Total	3.87	0.47	46
2nd Survey Administration	Disadvantaged	4.00	0.42	27
	Not disadvantaged	3.96	0.45	19
	Total	3.99	0.43	46
3rd Survey Administration	Disadvantaged	4.08	0.42	27
	Not disadvantaged	3.95	0.53	19
	Total	4.03	0.47	46

Levene's test indicated that the assumption of equal variances was met for the between-subjects effect based on economic status (1st administration: Levene's test, F = 0.14, p = .71; 2nd administration: Levene's test, F = 0.26, p = .61; 3rd administration: Levene's test, F = 1.70, p = .20), but there was no significant difference between economically disadvantaged students and the students who are not economically disadvantaged ($F(1,44) = 0.10$, p = .75, partial η^2 = .002).

Although the data collected identifying students with limited English language proficiency was not based on their official designation using state criteria, it does seem that it is a factor that should be analyzed. A repeated-measure ANOVA was run to determine if students' self-reported indication of English language proficiency was a significant factor in their use of self-regulated learning strategies. There was not a significant within-subjects effect. Greenhouse-Geisser is being reported ($F(1.59, 69.79) = 0.84$, p = .41, partial η^2 = .02) because the sphericity assumption was violated according to Mauchly's Test (W = .74, df = 2, p = .002).

There was not a significant between-subjects effect when English language proficiency was used as the factor ($F(1,44) = 0.46$, $p = .50$, partial $\eta^2 = .01$). The assumption of equal variances was met according to Levene's test (1st administration: Levene's test, $F = 0.33$, $p = .57$; 2nd administration: Levene's test, $F = 0.49$, $p = .49$; 3rd administration: Levene's test, $F = 0.001$, $p = .97$). Means and standard deviations are reported in Table 15.

Table 15

Total survey means and standard deviations for English language proficiency

	English language proficiency	*M*	*SD*	*n*
1st Survey Administration	Proficient	3.70	0.51	8
	Not proficient	3.90	0.46	38
	Total	3.87	0.47	46
2nd Survey Administration	Proficient	3.95	0.57	8
	Not proficient	4.00	0.40	38
	Total	3.99	0.43	46
3rd Survey Administration	Proficient	3.96	0.52	8
	Not proficient	4.04	0.46	38
	Total	4.03	0.47	46

Parent education level was the final factor analyzed. A repeated measures ANOVA indicated that there was a significant difference in the within-subjects effect of students' use of self-regulated learning strategies based on parents' education level. The assumption of sphericity was violated (Mauchly's $W = .68$, $df = 2$, $p = .002$) so Greenhouse-Geisser was used ($F(4.55, 51.52) = 2.86$, $p = .03$, partial $\eta^2 = .20$).

There were several interactions observed among the groups. The most dramatic change was reported for students whose parents had a community college, trade school, or technical school degree. They reported the lowest level of self-regulated strategy use on the first administration of the survey and had the highest reported mean on the second. They reported a slight decline in usage from the second to the third administration. Figure 1 shows the interaction. The students whose parents did not have a high school diploma showed steady increases throughout the three administrations. Of the groups analyzed, they reported the highest use of self-regulated learning strategies on the final administration.

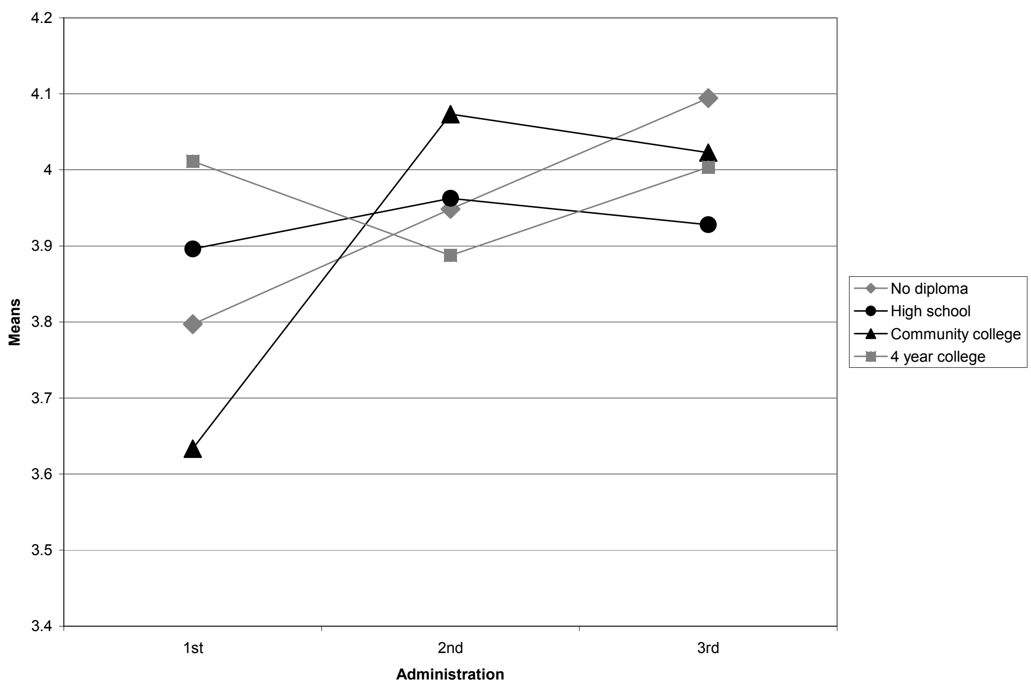

Figure 1

Interaction for parent education level

Students whose parents were high school graduates indicated an increase in the use of self-regulation during the second administration, but by the third administration their usage had returned almost to the same level as the first administration. Although the mean increased from the second to third administration, students, whose parents have a four-year college degree, indicated a decrease in their use of self-regulated learning strategies overall. However none of the differences observed were dependent upon group assignment.

When referring to the results for students who indicated their parent(s) had completed community college, trade school or technical school and for students who indicated their parent(s) had completed a 4-year college degree or graduate degree, it is important to note that only a small number of students are represented in either category. The *n*-counts were reported in Table 5. Therefore it is possible that the responses of only a few students may have had a great impact on the total means reported.

There was not a significant between-subjects effect. The assumption of equal variances was met according to Levene's test (1^{st} administration: Levene's test, $F = 0.90$, $p = .52$; 2^{nd} administration: Levene's test, $F = 1.89$, $p = .10$; 3^{rd} administration: Levene's test, $F = 0.91$, $p = .51$). Means and standard deviations are reported in Tables 16-17.

Table 16

Total survey means and standard deviations for parent education (1st and 2nd administrations)

	Parent Education Level	Group	*M*	*SD*	*n*
1st Survey administration	No diploma	Treatment	3.99	0.40	7
		Control	3.61	0.44	7
		Total	3.80	0.45	14
	High school	Treatment	3.86	0.60	5
		Control	3.92	0.39	10
		Total	3.90	0.45	15
	Community college	Treatment	4.00	0.11	2
		Control	3.45	0.81	4
		Total	3.63	0.69	6
	4-Year College	Treatment	4.01	0.41	4
		Control	4.01	0.49	3
		Total	4.01	0.41	7
	Total	Treatment	3.96	0.42	18
		Control	3.76	0.51	24
		Total	3.85	0.48	42
2nd Survey administration	No diploma	Treatment	4.10	0.39	7
		Control	3.79	0.63	7
		Total	3.95	0.53	14
	High school	Treatment	4.09	0.38	5
		Control	3.90	0.40	10
		Total	3.96	0.39	15
	Community college	Treatment	4.22	0.03	2
		Control	4.00	0.35	4
		Total	4.07	0.30	6
	4-Year College	Treatment	4.11	0.27	4
		Control	3.59	0.57	3
		Total	3.89	0.47	7
	Total	Treatment	4.11	0.32	18
		Control	3.85	0.47	24
		Total	3.96	0.43	42

Table 17

Total survey means and standard deviations for parent education (3^{rd} administration)

	Parent Education Level	Group	*M*	*SD*	*n*
3^{rd} Survey administration	No diploma	Treatment	4.30	0.32	7
		Control	3.89	0.56	7
		Total	4.09	0.48	14
	High school	Treatment	3.90	0.71	5
		Control	3.94	0.40	10
		Total	3.93	0.50	15
	Community college	Treatment	4.24	0.08	2
		Control	3.92	0.43	4
		Total	4.02	0.38	6
	4-Year College	Treatment	4.17	0.44	4
		Control	3.69	0.53	3
		Total	3.97	0.51	7
	Total	Treatment	4.15	0.46	18
		Control	3.89	0.45	24
		Total	4.00	0.47	42

In addition to analyzing the data using demographic factors, averages were calculated for each student based on the phases of self-regulation. Statistical tests similar to the analysis previously described with the survey results as a whole were conducted on the averages for each phase. It seemed important to report the results for the whole survey based on each demographic factor, even if they were not significant, in order to provide an overview of the data. However for the phase level analysis, only results that indicate significant findings are reported.

For phase one, the forethought phase, the only significant difference was a within-subjects effect for students who are economically disadvantaged and those who are not. The assumption of sphericity was met using Mauchly's Test ($W = .89$, $df = 2$, $p = .07$). A repeated measures ANOVA indicated that students who are economically disadvantaged had a significant increase in their use of self-regulated learning strategies, but the change was not based on group assignment ($F(2,88) = 9.17$, $p < .001$, partial $\eta^2 = .17$) and the effect was small. The means and standard deviations are reported in Table 18.

Table 18

Phase 1 means and standard deviations for economic status

	Economic Status	*M*	*SD*	*n*
1st Survey Administration	Disadvantaged	3.83	0.55	27
	Not disadvantaged	3.80	0.52	19
	Total	3.82	0.53	46
2nd Survey Administration	Disadvantaged	3.93	0.44	27
	Not disadvantaged	3.86	0.48	19
	Total	3.90	0.45	46
3rd Survey Administration	Disadvantaged	4.12	0.44	27
	Not disadvantaged	4.02	0.55	19
	Total	4.08	0.49	46

There was also a between-subjects effect which indicated that the treatment group used phase one self-regulated learning strategies significantly more than the control group ($F(1,44) = 4.65$, $p = .04$, partial $\eta^2 = .10$). The assumption of equal variances was met according to Levene's test (1st administration: Levene's test, $F = 0.19$, $p = .67$; 2nd administration: Levene's test, $F = 3.00$, $p = .09$; 3rd administration: Levene's test, $F = 0.85$, $p = .36$).

The repeated measures ANOVA conducted for phase 2 , performance, indicated a significant between subjects effect based on group assignment, with the treatment group scoring higher than the control group ($F(1,44) = 4.74$, $p = .04$, partial $\eta^2 = .10$). The assumption of equal variances was met according to Levene's test (1st administration: Levene's test, $F = 0.19$, $p = .67$; 2nd administration: Levene's test, $F = 3.00$, $p = .09$; 3rd administration: Levene's test, $F = 0.85$, $p = .36$).

The analysis for phase 3, self-evaluation, also indicated a significant between subjects effect based on group assignment. The repeated measures ANOVA indicated that the treatment group scored higher than the control group ($F(1,44) = 3.98$, $p = .04$, partial $\eta^2 = .08$), but the effect size was small. The assumption of equal variances was met according to Levene's test (1st administration: Levene's test, $F = 2.33$, $p = .13$; 2nd administration: Levene's test, $F = 4.96$, $p = .05$; 3rd administration: Levene's test, $F = 1.44$, $p = .24$). Given that the survey results as a whole indicated that the treatment group used self-regulated learning strategies significantly more than the control group, it is not surprising to find similar results at the phase level.

Research question 2

The second research question asked, "To what extent does explicit instruction of self-regulated learning strategies in middle grades mathematics classes impact student achievement?" The null hypothesis for this question is

H_o: There will not be a difference between the student achievement of the control and treatment groups.

The findings for the first research question indicated that the only factor consistently impacting the use of self-regulated learning strategies was the group assignment, so that will be the only factor considered when analyzing this question. For this study it isn't pertinent to determine if other demographic factors impact students' academic achievement unless they are related to students' use of self-regulated learning strategies.

An independent t-test indicated that the treatment group ($M = 361.40$, $SD = 4.18$, *n* = 25) had significantly higher (*t* (53) = 2.30, *p* = .03) eighth grade End-of-Grade mathematics scale scores when compared to the control group (*M* = 358.43, *SD* = 5.20, *n* = 30). The assumption of homogeneous variances was satisfied using Levene's test (*F* = 1.42, *p* = .24).

Given the nature of the scale scores used for the North Carolina End-of-Grade tests, it is considered unusual for a small change in instruction to create a measurable change in average scores. Generally speaking, there are only minor fluctuations in scale scores expected from year-to-year. The scale scores used for North Carolina End-of-Grade Mathematics Tests are designed along a continuum beginning with the North Carolina Grade 3 Mathematics Pretest and ending with the North Carolina Eighth Grade End-of-Grade Mathematics Test. *The North Carolina Mathematics Tests Technical Report, Edition 3* prepared by the North Carolina Department of Public Instruction (2008) indicates that the mean change in scale scores from the seventh to eighth grade mathematics test is less than two points (actually 1.76). The increase in the mean demonstrated by the treatment group was almost three (2.80) times the increase expected for students statewide and almost twice (1.67) the increase demonstrated by the control group.

In addition to comparing raw scale scores, an independent t-test was conducted using students ABC growth. ABC growth is based on standardized scale scores (North Carolina Department of Public Instruction, 2009). As a component of the North Carolina accountability model, the North Carolina Department of Public Instruction calculates a prediction for each student's score for the current year based on the student's scores from previous years. The difference between this prediction and the student's actual score is considered to be the student's growth. The expectation is that a student who performs exactly as predicted would show zero growth. A positive difference indicates that the student has made more progress during the year than expected. Similarly, a negative difference indicates that the student did not make the expected progress, Using ABC growth to analyze students' academic performance is important because it takes into consideration a student's previous performance and it makes the expectation for both low and high performing students comparable.

The results of the t-test (t (52) = 2.55, p = .01) indicated that the treatment group (M = 0.368, SD = .49, n = 24) showed significantly greater ABC growth than the control group (M = 0.02, SD = 0.6, n = 30). The assumption of homogeneous variances was satisfied using Levene's test (F = 1.99, p = .16).

Based on the comparisons of the students' academic achievement using both raw scale scores and ABC growth, the null hypothesis should be rejected. The indication is that the explicit self-regulated learning strategy instruction had a positive impact on student achievement.

Connection between self-regulated learning and student achievement

The findings thus far indicate that the explicit self-regulated learning strategy instruction had an impact on both students' learning behavior and their mathematics achievement, which leads to the question, "How much of the variance in students' mathematics test scores can be explained by their use of self-regulated learning strategies as measured by their survey responses?" A stepwise multiple regression was conducted to determine the relationship between students' seventh grade mathematics test scores, the average of their responses on the third administration of the self-regulated learning survey, and their eighth grade mathematics scale scores. Seventh grade mathematics scores were used because one would expect that students' eighth grade mathematics achievement is based to some extent on their previous level of performance. The third administration of the survey was used because it was given to students during the same time period as the End-of-Grade Mathematics Test. The means and standard deviations are reported in Table 19. The correlation coefficients are reported in Table 20.

Table 19

Regression means and standard deviations for eighth grade EOG scores

	M	*SD*	*n*
8th Grade Math EOG	359.81	4.70	48
7th Grade Math EOG	356.04	6.01	48
Survey	4.04	0.47	48

Table 20

Correlation coefficients for eighth grade EOG

		8th Grade Math EOG	7th Grade Math EOG	Survey
Pearson	8th Grade Math EOG	1.00	.65	.10
Correlation	7th Grade Math EOG	.65	1.00	-.30
	Ave All S3	.10	-.30	1.00

The variance accounted for by students' seventh grade mathematics scale scores (R^2) equaled .42 (adjusted $R^2 = .40$), which was statistically significant, $F = 32.91$, $p <$

.001. Adding students' responses to the self-regulated learning survey increased the variance accounted for (R^2) to .51 (adjusted R^2 = .49), which was also statistically significant, F = 8.83, p = .005. Students' use of self-regulated learning strategies accounted for an additional 10% of the variance in their eighth grade mathematics test scores. The unstandardized regression coefficients (B) and intercept, the standardized regression coefficients (β), and the semipartial correlations (sr) are reported in Table 21.

Table 21

Unstandardized regression coefficients (B) and intercept, the standardized regression coefficients (β), semipartial correlations (sr), t-values, and p-values for eighth grade EOG

Model		B	β	sr	t-value	p-value
1	Intercept	180.03			5.74	.000
	7th Grade Math EOG	0.51	0.65	.65	5.74	.000
2	Intercept	139.80			4.37	.000
	7th Grade Math EOG	0.58	0.74	.71	6.81	000
	Ave All S3	3.28	0.32	.41	2.97	.005

ABC growth is based on scale scores, but measures student achievement in a different way. Therefore it is worthwhile to determine the extent to which students' use of self-regulated learning strategies is related to their ABC growth. A stepwise multiple regression was conducted to determine the relationship between students' seventh grade mathematics test scores, the average of their responses on the third administration of the self-regulated learning survey, and their eighth grade mathematics ABC growth. The means and standard deviations are reported in Table 22. The correlation coefficients are reported in Table 23.

Table 22

Regression means and standard deviations for ABC growth

	M	*SD*	*n*
ABC Growth	0.13	0.56	48
7th Grade Math EOG	356.04	6.01	48
Survey	4.04	0.47	48

Table 23

Correlation coefficients for ABC growth

		ABC Growth	7th Grade Math EOG	Survey
Pearson	ABC Growth	1.00	-.26	.41
Correlation	7th Grade Math EOG	-.26	1.00	-.30
	Survey	.41	-.30	1.00

Seventh grade mathematics scores were eliminated from the model because they were negatively correlated to ABC growth. This is only somewhat surprising. The ABC growth model is based on previous student performance so the growth calculation has already been adjusted to account for students' seventh grade scores. ABC growth for all students is expected to be zero. Any differences, which are what is used in this analysis, are not based on students' scores, but on how they performed relative to how they were expected to perform. The calculations are made using standardized scores so that the expectation for growth is comparable for both low and high performing students.

The variance accounted for by students' responses to the self-regulated learning survey equaled (R^2) .16 (adjusted R^2 = .15), which was statistically significant, F = 9.005, p = .004. The unstandardized regression coefficients (*B*) and intercept, the standardized regression coefficients (*β*), and the semipartial correlations (*sr*) are reported in Table 24.

Table 24

Unstandardized regression coefficients (B) and intercept, the standardized regression coefficients (β), semipartial correlations (sr), t-values, and p-values for ABC growth

	B	*β*	*sr*	*t*-value	*p*-value
Intercept	-1.86			-2.80	0.008
Survey	0.49	0.41	.41	3.00	0.004

The indication is that students' use of self-regulated learning strategies is a significant predictor of their mathematics achievement using either their mathematics test scale scores or their growth predictions.

CHAPTER 5: DISCUSSION

Chapter introduction

The study is complete. The treatment was implemented; the data collected and analyzed; but what does it mean? The discussion in this chapter is designed to make meaning out of the information that was gathered. The chapter begins with an overview of the study, followed by sections which address conclusions, implications, limitations, ethical considerations, and recommendations for future research.

Study overview

The purpose of this study was to examine how explicit instruction of self-regulated learning strategies impacted middle grades mathematics classes. Two research questions were investigated. The first one asked about students' progress toward becoming self-regulated learners as the result of the explicit instruction and the second asked about changes in students' mathematics achievement that may be associated with the use of self-regulated learning strategies.

A survey was designed and administered on three occasions to collect data about students' use of self-regulated learning strategies. A teacher's guide, which included ten lessons that the treatment teachers used to provide explicit self-regulated learning strategy instruction, was written. Other materials that were used to support the treatment implementation and to monitor the progress of the treatment were created.

After permission was obtained from school and district administrators, teachers were contacted and assigned to either the treatment or control group. Students were recruited to participate in either the treatment group or control group, depending on their mathematics teacher's assignment. Parental consent and student assent were collected and then the survey was given to all participating students. The treatment was implemented over a ten week period and then the survey was administered a second time to both treatment and control group students. Even though the explicit instruction of self-regulated learning strategies was completed before the end of the school year, treatment group students were encouraged to continue using the strategies as they were appropriate. The survey was administered for a third and final time at the end of the school year.

Along with the survey responses, standardized test data were used to examine the impact on student achievement. Students' North Carolina End-of-Grade Mathematics Test scores from both the seventh grade and eighth grade were collected from the school district's electronic database.

Finally, statistical tests were used to determine comparability of the treatment group and control group. The instruments were tested to ensure that they produced reliable data. Then the survey responses and mathematics test scores were analyzed and reported.

Conclusions

Although the effect size was small, the findings are encouraging. The students in the treatment group indicated they used self-regulated learning strategies more than the treatment group as the year progressed. It is not surprising that both groups of students indicated they used some self-regulated learning strategies and that use increased over the course of the three survey administrations for both groups of students. Teachers generally include hints and suggestions about how to be a successful learner as a component of their instruction. They encourage students to study. Usually when teachers include study skill strategies with their instruction, they focus only on performance phase strategies. For this study, the treatment went beyond a focus on traditional study skills to include strategies that addressed all three phases of self-regulation. This was evident when the survey responses indicated significant differences, with the treatment group showing greater frequency of self-regulated learning strategy use, at each phase as well as when analyzed as a whole.

Additionally, the treatment included explicit instruction using a model that has been previously identified as effective for teaching students how and when to use each strategy. Ordinarily, when teachers include instruction on study skills as a component of their overall instructional program, they do so in a manner that is focused on how the strategies they share will accomplish performance goals instead of learning goals. Whereas the intent of explicit self-regulated learning strategy instruction is to help students learn strategies which will support their efforts to reach learning goals. This is evident by the significantly higher mathematics achievement scores realized by the treatment group.

These findings complement other research studies that indicate that self-regulation can be taught (Zimmerman, 2002) and that the instruction is most effective when it is imbedded in content instruction (Pape & Smith, 2002; Randi & Corno, 2000). Zimmerman's (1986) work indicates that there are benefits for students who take an active role in their own learning, which is what using self-regulated learning strategies enables students to do. Based on this study, it appears that students can be taught to take an active role in their own learning and when that occurs mathematics achievement increases.

In this age of school accountability, teachers and administrators are always looking for programs that will increase student achievement. The findings from this study indicated that including explicit self-regulated learning strategy instruction may be a beneficial addition for this purpose. Even though the effect size was small, it was heartening to see that the treatment group showed both significantly higher mathematics test scale scores and ABC growth. It is very difficult to demonstrate a significant change in scale scores by introducing a small supplement to instruction, so even a minimal increase is worth investigating further.

It is important to note that students' use of self-regulated learning strategies explained a significant percentage of the variance in both mathematics test scale scores and ABC growth. This provides evidence that there is a connection between students' use of self-regulated learning strategies and their mathematics achievement. This is also not surprising. The current research indicates that to be the case (Pape & Smith, 2002).

Implications

Although the findings were significant, the results in this study did not indicate that including explicit self-regulated learning strategy instruction was a great benefit based on the small effect size, but it didn't do any harm either. That doesn't sound important, but it is. There are very few instructional changes that can be implemented as easily and inexpensively as the ten strategies selected for use in this study. They required no special materials. The posters are optional. And only limited professional development is needed. Teaching the strategies does not require excessive instructional time and the data indicate they were beneficial to students' mathematics achievement. And the addition of explicit self-regulated learning strategy instruction did not detract from the content instruction. In fact it appears as though the effect, although small, was positive.

Most of the significant findings were based on the group assignment, treatment or control. The other factors examined demonstrated very few significant differences. This is more evidence that the difference was made by the treatment. Even though the differences between the treatment group and control group had a small effect size, there was a significant difference noted. Almost without exception the only factor of those examined that indicated any difference at all was the treatment.

Of the few significant differences identified that weren't based on group assignment, the students who reported the most significant increases in the use of self-regulated learning strategies were black students and those who reported that their parents did not have a high school diploma or had only a community college, technical school or trade school degree. In the school district where the study was conducted, black students are the lowest performing subgroup (North Carolina Department of Public Instruction, 2009). Traditionally students who come from families with limited education have fewer opportunities to learn self-regulation (Zimmerman, 2000). So the students who were most significantly impacted are among the groups of students that are least likely to obtain self-regulating behaviors without explicit instruction and the same students who are most likely to benefit not only in terms of improved learning behavior but also by increased achievement.

Overall it appears as though the treatment was effective and worthwhile. The requirements for implementation are minimal, especially when weighed against the possible benefits. Adding explicit self-regulated learning strategy instruction is a small but valuable addition to mathematics content instruction. The recommendation for mathematics teachers would be to include explicit self-regulated learning strategy instruction.

Limitations

There are several limitations associated with this study. The first is the small sample size. When the study was designed, it was expected that most of the 300 eligible eighth graders would volunteer to participate. After three attempts to recruit them, fewer than 100 actually agreed. Some had to be eliminated as explained previously, leaving many fewer students in the study than anticipated.

Even though the control and treatment teachers were comparable in years of experience and training, there may be differences in their instructional styles that cannot be accounted for. Although both the control and treatment teachers are regarded by their administrators as effective mathematics instructors, there may be a number of factors influenced by the nature and ability of the teachers that could account for differences in students' achievement. This is always a concern when a study does not have random assignment.

In addition to implementing this study, the school district implemented a $1.5 million technology grant that required all the teachers in the school where the study was conducted to attend intensive professional development and infuse technology into their instruction. The treatment and control teachers were both required to participate in the implementation of the grant. However, there isn't any way of knowing for sure that they equally used the new technology with their students. Also, the extra effort and time required would have been an additional commitment for the treatment teacher beyond what was required for the study.

Finally, the treatment teacher was enrolled in master's level college classes throughout the year the study was conducted. This is another commitment of effort and time that could have distracted the teacher from the requirements of this study, but it also adds expertise as a teacher, which may have enhanced his overall skills as a teacher.

Ethical considerations

Any time humans participate in research, ethical issues should be considered. In the study described here, however, the possible danger to the participants of this study was minimal. The explicit instruction of self-regulated learning strategies was an integrated component of students' regular mathematics instruction. North Carolina End-of-Grade Mathematics Test scores were collected electronically from the school district databases. The only disruption to students' regular schedules was the time required to complete the surveys, which totaled less than an hour. The students do not appear to have suffered any ill or unintended side-effects. Prior to their participation, informed consent was obtained from their parents and informed assent was obtained from the students. Their responses on the surveys and how they relate to students' test scores have been and will continue to be kept confidential. Only the researcher knows the identities of the participants and their corresponding survey responses. Results of the study will always be reported in terms of aggregate statistical information, graphs, charts and a narrative that describes the data and analyses of the data, without revealing information about specific students.

Since teachers were divided into two groups one or both groups may suffer an unintentional side effect. While the study was intended to offer insight into factors that may be used to enhance students' achievement that may cause the control teacher to feel that her students were deprived from beneficial instruction, although that doesn't appear to be the case. An overview of the results has been presented to the participating teachers and the school administration. An offer was made to share the materials with other teachers who would like to use them.

Recommendations

Given the limitations of this study and the small effect size of the results, it would be meaningful to replicate the study with a larger sample size and in more than one school. Using more than one control and one treatment teacher would allow researchers to more effectively account for other differences in instructional style and teacher capability.

This study only included ten self-regulated learning strategies. It may be worthwhile to continue to develop and implement more strategies. The research shows that higher performing students use a greater variety of strategies (Zimmerman, 1986). Ten was a good place to start. It means that teachers can provide the initial instruction in slightly more than a quarter of the school year, but the treatment could be enhanced by adding more strategies. One of the initial treatment teachers became frustrated with some of the strategies and chose not to implement them. If there were more strategies, teachers would be able to choose strategies they are comfortable using and still have a variety of strategies to share with students.

Although a measure of self-efficacy was not included specifically in this study, it is reasonable to conclude that since the findings from this study mimic those from other studies, providing explicit self-regulated learning strategy instruction will also increase students' mathematical self-efficacy. If so, there should be additional benefits to student achievement (Pajares & Miller, 1994). Future studies may want to include a component that measures self-efficacy in addition to or as it relates to self-regulated learning.

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APPENDIX A: SELF-REGULATED LEARNING SURVEY

Administrator Directions

When you are ready to administer the survey, distribute a copy of the survey and an answer sheet to each participating student. Make sure that each student gets the answer sheet with his/her name and identification number.

Make sure that each student has a number two pencil.

Administrators may read any or all parts of the survey to students, but may not explain, clarify, or paraphrase survey questions or statements.

Collect the surveys and answer sheets when students have completed the survey. Return all materials to Janet Jenkins in the testing office. An envelope has been provided with the survey materials.

Read the following directions to students prior to beginning the survey.

SAY: Read the directions that are printed on the survey to yourselves as I read them aloud.

Directions: This survey is designed to collect information about how eighth grade students learn and study math. Your responses will not be reported to anyone at your school or your parents.

Do not put your name on the survey or the answer sheet. The top of the answer sheet has a label with your name and identification number. The identification number was created for use in this study. It is not the same as any other identification number you may have. Please check to make sure that the identification number has been bubbled correctly in the “identification number” section at the bottom of the answer sheet. Please make any corrections that are necessary. Once you have checked the identification number and made corrections if needed, you should remove the label. You may keep it or throw it away.

Read each statement or question. Complete the survey by using a number 2 pencil to bubble the circle on the answer sheet that represents your response to each item. Choose only one response for each item. Notice that the items are printed on the front and back of each page.

Self-Regulated Learning
Student Survey Questions

Directions: This survey is designed to collect information about how eighth grade students learn and study math. Your responses will not be reported to anyone at your school or your parents.

Do not put your name on the survey or the answer sheet. The top of the answer sheet has a label with your name and identification number. The identification number was created for use in this study. It is not the same as any other identification number you may have. Please check to make sure that the identification number has been bubbled correctly in the "identification number" section at the bottom of the answer sheet. Please make any corrections that are necessary. Once you have checked the identification number and made corrections if needed, you should remove the label. You may keep it or throw it away.

Read each statement or question. Complete the survey by using a number 2 pencil to bubble the circle on the answer sheet that represents your response to each item. Choose only one response for each item. Notice that the items are printed on the front and back of each page.

1. I read the examples in the math textbook.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

2. I take notes about how to work math problems when the teacher shows examples.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

3. I work to get a good grade, even if math is not my favorite class.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

4. I complete all of the tasks the math teacher assigns.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

5. I make sure that I have all the materials I need to complete math assignments.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

6. I listen to my math teacher to make sure I understand what I am expected to do.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

7. I plan what I am going to do before I begin studying math.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

8. I think math is an important subject for me to learn, even if it isn't my favorite.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

9. I come to math class everyday.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

10. I work extra math problems to make sure I understand what I'm doing.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

11. I study by reviewing my notes from math class.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

12. I make up sample math problems for extra practice.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

13. I talk with someone about how to solve math problems.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

14. I write down the steps used to solve a math problem to help me remember them.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

15. I check my work to see if it is correct and then rework any I get wrong.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

16. I review problems from the chapter before a math test.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

17. I read math problems more than one time to make sure I understand the important information.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

18. I try to remember the meanings of words, formulas and other facts.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

19. I ask myself questions about math lessons to make sure I understand what I'm supposed to be learning.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

20. I ask for help when I realize I don't understand how to solve a math problem.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

21. When I realize that a math problem is difficult, I look for a similar problem that is easier to try first.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

22. I expect to earn good grades in my math class.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

23. I usually understand the lesson presented in my math class.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

24. I expect to be able to work most math problems I am assigned.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

25. I try to learn from my mistakes.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

26. I am able to complete the math class work and homework assignments.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

27. I am usually able to understand the information presented in the textbook.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

28. When I realize that the method I am using to solve a math problem isn’t working, I am able to try a different method.
    a. Never
    b. Seldom
    c. About half the time
    d. Usually
    e. Always

29. What is your lunch status? (This question is optional. You may choose to skip it.)
    a. Free
    b. Reduced-price
    c. Full pay

30. What is your age?
    a. 12 years old
    b. 13 years old
    c. 14 years old
    d. 15 years old
    e. 16 years old

31. Using the following educational levels, what is the highest level completed by *either* of your parents/guardians?
    a. Did not finish high school
    b. High school graduate
    c. Community college, technical, trade, business school, or junior college graduate
    d. Four-year college graduate
    e. Graduate school degree

32. Do you receive services from the ESL (English as a Second Language) teacher?
    a. Yes
    b. No

Thank you for completing the survey and participating in the study.

APPENDIX B: GUIDE FOR TEACHERS

Guide for Explicit Self-Regulated Learning Strategy Instruction

Self-regulated Learning Overview

Self-regulated learning includes the use of a set of strategies for planning, monitoring, and self-evaluating students' efforts toward reaching specific learning goals. Self-regulated learning strategies are those skills and behaviors that students use independently that enable them to reach the learning goals they have set for themselves.

Zimmerman (2002) defines self-regulation as the "self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals (p.65)." He goes on to describe the 3 phases of self-regulation: forethought, performance, and self-reflection. The forethought phase includes goal setting, planning, and self-motivation to perform. Self-motivation is dependent upon one's self-efficacy, or belief in one's ability to perform effectively, one's expectations, interest in the task and goal commitment. The performance phase includes the use of self-control, focus, and strategy implementation. The final phase, self-reflection, includes evaluation, self-satisfaction and self-reward (Zimmerman, 2000).

Zimmerman (1986) refers to 14 categories of self-regulated learning strategies that have been identified as contributing to academic achievement. The categories are identified as follows: 1. self-evaluation; 2. organizing and transforming; 3. goal-setting and planning; 4. seeking information; 5. keeping records and monitoring; 6. environmental structuring; 7. self-consequences; 8. rehearsing and memorizing; seeking social assistance from 9. peers, 10. teachers, and 11. adults; and reviewing records such as 12. tests, 13. notes, and 14. textbooks.

Lesson Design

Kiewra (2002) provides procedures for successfully teaching self-regulated learning strategies. First, teachers should "introduce" each strategy. Next, the teacher should "sell" the strategy by explaining why it is effective and modeling how to use it. Then, the teacher should "generalize" the strategy by sharing other examples of how it could be used. Finally, the teacher should "perfect" the strategy by providing students opportunities to practice it.

Directions:

Introduce self-regulated learning and provide explicit instruction using the first three lessons. These should be taught first, since they are the foundation for the other strategies. Then provide explicit instruction on the remaining strategies as they are appropriate for the day's math lesson. Make an effort to introduce one additional strategy each week for 10 weeks. During the 10-week period, continue to encourage and require students to use the strategies that have already been taught. After the initial 10-week instructional period, continue to encourage students to use the strategies and remind them of times when a strategy may be appropriate, but do not require their use.

Strategy 1: Setting Learning Goals (Forethought Phase)

There are two types of goals: performance goals and learning goals. Performance goals are more behavior oriented. Successfully reaching performance goals may promote learning, but do not ensure it. Examples of performance goals include making good grades, completing tasks on time, earning extra credit points, etc. Learning goals are based on cognitive enhancement. Examples of learning goals include understanding how changing the slope effects a line's placement; understanding the meaning of new vocabulary terms; and being able to explain the difference between different forms of an equation.

Introduce it: Explain that during the next few weeks the lessons and assignments are going to include some helpful suggestions for becoming successful students. Remind them that being a successful student takes effort to make sure that they have not only completed the assignments, but learned the skills and concepts.

Since this is the first strategy, there will need to be an introduction of the three part cycle of being a successful learner. The first part is planning, which includes goal setting. The second part is taking action, which includes implementing the plan. The third part is review, evaluating and improving the plan so that it will be more effective the next time. Explain that this lesson will focus on goal setting.

Sell it: Explain that there are performance and learning goals. Share examples of each type of goal (see above) and ask students to generate some to share with the class. Model for students by thinking out loud what a learning goal might be for the day's math lesson and ask them to write a learning goal for themselves for the day's assignment. **What do they want to know or be able to do when they complete the assignment?** Invite students to share what they wrote.

Generalize it: Remind students that they should be able to create a learning goal for every lesson in every class. This strategy will help them to determine what they should have learned during any lesson.

Perfect it: Ask students to write a learning goal for the day's assignment at the top of their homework paper in addition to completing the assignment. During the time when explicit instruction is being provided, students should be asked to write a learning goal on the top of every assignment. This will help them to get used to thinking about the assignment in respect to the learning that should be occurring while they are completing the assignment.

Strategy 2: Making a Learning Plan (Forethought Phase)

Introduce it: Remind students that the first part of being a successful learner is to make a plan for learning. The first part of that is establishing a learning goal, which was addressed in the previous strategy. This strategy focuses on the next part, which is creating a plan to reach the goal.

Sell it: Call on a student to share their learning goal for the previous lesson. Ask students to share the types of materials and/or resources they have that could help them to accomplish the goal. For example they may need basic school supplies such as a book, paper, pencil, class notes, a quiet place to work, etc. Then they will need to start on the task. Their plan may include reviewing the examples given in class or the textbook before attempting a problem from the assignment. They may read the first problem in the assignment and then refer to similar examples from their notes or the textbook. They may begin by reviewing any new vocabulary terms or formulas. Demonstrate an example of how students might use planning to approach an example problem from the current assignment.

Generalize it: Remind students that they should have a learning goal and a plan for accomplishing every assignment.

Perfect it: Ask students to write their learning goal, materials, and 1 or 2 components of their plan for the day's assignment on their homework paper in addition to completing the assignment.

Strategy 3: Reviewing and Improving a Learning Plan (Self-reflection Phase)

Introduce it: Remind students that carrying out the plan or acting on the plan is the second part of being a successful learner and that should have happened as they completed the previous assignment. Now it is time for the third and final part of the process and this is the most important part. They should reflect back on the plan and determine if it worked. Were they able to reach their learning goal?

Sell it: After reviewing the previous day's assignment, ask students to read their learning goal to themselves. Ask them to honestly determine if they accomplished the goal. Suggest that if you were to give them a quiz on the knowledge or skill practiced in the assignment, are they confident they would do well? Now ask them to think about what they can do the next time they have a similar assignment to make their plan work better. If they didn't review their notes first, maybe they should try that. If they didn't have their materials organized, maybe they should try that. Remind students that since each person could have a different learning goal and a different plan, their ideas for reviewing and improving the plan may be different too. This process is focused on helping them to become successful learners, and that means that it is dependent upon them and will be different from one student to another.

Generalize it: Remind students that taking charge of your own learning will ultimately help them to become successful learners in every class, but it takes work and effort on their part.

Perfect it: Ask students to include a learning goal and plan on the day's assignment in addition to the working the problems. Ask them to also write one sentence about how their approach to this assignment is different from the way they usually complete assignments.

Strategy 4: Preparing for a Test (Performance Phase)

This strategy should be used as part of a test or quiz review. When students are studying for a quiz or test, they often have difficulty choosing appropriate problems to review. They usually select the most difficult problems and then may become frustrated when they are unsuccessful working them. This creates additional anxiety before the real test and decreases students confidence and motivation for performing well.

Introduce it: Explain that when teachers are creating a quiz or test, they look for problems and tasks that will require students to demonstrate their knowledge of the skills and concepts taught.

Sell it: Model for students how you would select a couple of problems for a quiz or test on the material recently taught. Think out loud sharing the characteristics of each problem selected. Explain why you think the problem would be appropriate for a quiz or test.

Generalize it: Remind students that being able to "think like the teacher" and select problems that are similar to ones that may be on the test is a skill that can be used in any class.

Perfect it: Ask students to work with a partner to select a few problems from the unit that they think might be selected for a quiz. Ask each pair to include a sentence about each problem that explains why they selected it. After they have had time to select problems, ask pairs to share one of their choices. Provide feedback to the class about whether or not you agree or disagree with the selection. Provide an explanation of your decision. Direct students to work independently to complete a similar task as a review for the upcoming quiz or test.

Strategy 5: Selecting Additional Problems for Practice (Performance Phase)

Introduce it: Explain that sometimes students are still not comfortable with particular skills or concepts, even after they have completed all the problems the teacher assigned. Just a couple of problems for additional practice may help students reach their learning goal for a particular lesson.

Sell it: Remind students that when textbook problem sets are written, the odd-numbered problem is usually paired with the next even-numbered problem, which requires a similar skill to complete. Teachers usually assign the even-numbered problems because the answers to the odd-numbered problems are in the back of the textbook as a reference. It can be helpful to choose to work the odd-numbered problem and then check the answer in the back of the book to make sure the student is on the right track before working the even-numbered problem that is similar. Or it may be helpful to work the odd-numbered problem after working the similar even-numbered problem if the student feels that they still aren't comfortable with that type of problem and extra practice may help. Model the process for students by selecting an even-numbered problem to work and then the parallel odd-numbered problem. Remember to check the solution in the back of the book. Remind students that if they work an odd-numbered problem and get an answer that is different from the one in the back of the book, they should go back and check their work for mistakes.

Generalize it: Remind students that they may always choose to answer additional problems or questions in any class to reinforce their learning efforts.

Perfect it: To support this strategy, ask students to pick any two odd-numbered problems to add to the assignment in addition to the even-numbered problems assigned by the teacher. Ask them to write one sentence explaining why they picked the problems.

Strategy 6: Error Analysis (Performance Phase)

Introduce it: Sometimes when students make mistakes, it turns out that they are making the same type of error repeatedly. This strategy will help students make corrections in the problems they missed and to categorize the kinds of mistakes they're making. It should help them to isolate and correct the misconceptions and misunderstandings they may have that are resulting in incorrect responses.

Sell it: Assign students to work with a partner to correct any problems they missed on the last test or quiz. Beside each problem, they should record what mistake they made. For example, that they may find a careless error; that they didn't know how to work the problem; that they skipped a step in a process; that they misunderstood the process and did a step incorrectly; or that they made some other mistake they can identify. Once they have finished making their corrections and identifying their mistakes, ask students to summarize their errors. Were they unique, similar, or the same mistake repeated in several problems?

Generalize it: Remind students that by recognizing the types of mistakes they are making, they can revise their learning plan to address the areas they need to work on or watch out for. This is a skill that can be used in every class.

Perfect it: Ask students to write one sentence summarizing the type of mistakes they made and what changes they will make to ensure that they don't make the same or similar mistakes the next time.

Strategy 7: Self-Consequating (Self-reflection Phase)

Introduce it: Self-consequating is when students reward or reprimand themselves based on their evaluation of their own performance. In other words it is when a student recognizes his/her own efforts and acts accordingly.

Sell it: Explain that sometimes rewards and consequences come from teachers, parents and other adults, but self-consequating is something each student does for himself or herself. Sometimes a reward is as simple as feeling good about ourselves when we know that we have done the right thing or being proud of an accomplishment. But it may be something that is more concrete such as allowing ourselves to do or have something special. Ask students to think of ways they reward themselves for accomplishing their goals. Make a list for the class.

Explain that there are also times when we are disappointed in ourselves such as when we meant to put in extra time studying for a test and didn't. In this situation, the student may not earn the grade he/she would like, but that is a consequence that comes from the teacher. The student should also apply a consequence. Similarly to feeling proud when we do well, a consequence may be the bad feeling we have about doing less than our best. But students may apply a more concrete consequence by deciding to do some extra studying so they will be more prepared the next time instead of watching a show they had planned to. Ask students to think of ways they can reprimand themselves for not accomplishing their goals. Make a list for the class.

Generalize it: Remind students that everyone has to take responsibility for their actions or lack thereof. The ability to reward or reprimand oneself applies not only to school situations. Students can use self-consequating to help them reach learning goals as well as personal goals.

Perfect it: Ask students to write how they will reward themselves for reaching their learning goal for the day's lesson and how they will reprimand themselves if they don't.

Strategy 8: Organizing Notes (Performance Phase)

Introduce it: In order for the notes student take in class to be worthwhile, the notes have to be meaningful, clear and used by the students as a resource for concept understanding and development.

Sell it: Some students use flash cards or other types of note cards to organize their notes. Some just re-write their notes in a way that organizes the ideas. Some students use highlighting to identify important information. For this class, students are going to use an approach that doesn't require any special materials other than notebook paper, pencils, and scissors. The process presented for organizing notes works to help study vocabulary terms, processes, and problem solving. Model the following process for students. First, fold a piece of notebook paper in half lengthwise (hotdog fold). Then cut strips into the top layer. The number of strips should match the items to be organized from the classnotes plus one. For example, it could be the number of steps in a process, the number of vocabulary terms in the lesson, or the number of steps used to solve a particular problem. On the top strip, write the topic covered by the strips. On each of the remaining strips, write the vocabulary terms or the step number of the process. Lift the strip and on the paper underneath, write the definition of the vocabulary term or the part of the process required for the step number recorded on the top strip.

Generalize it: This technique for organizing notes can be used with any information that is broken into parts. To study all students have to do is look at the term on the top of the strip and then quiz themselves on the information that is written underneath. They can lift the strip for reminders or to check their responses for accuracy.

Perfect it: Ask students to create a similar organization page for the information presented in the day’s lesson.

Strategy 9: Mnemonics (Performance Phase)

Introduce it: Explain that mnemonics are ways students can use to help them remember information.

Sell it: Using a shortcut to help trigger our memories can be very helpful. Share examples such as these. When multiplying with negative numbers, is the answer positive or negative? (In this mnemonic, "good" is positive and "bad" is negative.)

- A good thing happening to a good person is good. (Positive x positive = positive.)
- A good thing happening to a bad person is bad. (Positive x negative = negative.)
- A bad thing happening to a good person is bad. (Negative x positive = negative.)
- A bad thing happening to a bad person is good. (Negative x negative = positive.)

A mnemonic for remembering the order of operations is **P**lease **E**xcuse **M**y **D**ear **A**unt **S**ally. They first letter of each word represents the operation. P is for parenthesis and other grouping symbols; E is for exponents; M is for multiplication; D is for division; A is for addition; and S is for subtraction.

A mnemonic for the prefixes in the metric system is **K**ids **H**ate **D**oing **M**ath **D**uring **C**lass on **M**ondays. In this one the first letter in each word represents the prefixes. K is for kilo; H is for hector; the first D is for Deka; the first M is for meter; the second D is for deci; the C is for centi; and the last M is for milli.

To help remember the date, people often recite that “in 1492 Columbus sailed the ocean blue.” Although this example is not math, it shows how a rhyme can be used as a mnemonic device.

Model how to develop a mnemonic by picking a set of steps or terms in the current lesson and creating a sentence that can be used to trigger the memory. Ask students to work with a partner to create their own. Point out to students that using a mnemonic is only useful if the mnemonic helps them connect to the information they are trying to remember and is easier to remember than original information.

Generalize it: Remind students that they can create mnemonics to help them remember any information.

Perfect it: Ask students to create an original mnemonic that will help them remember vocabulary terms or a set of steps in a process as part of their assignment for the day's lesson.

Strategy 10: Writing the Steps (Performance Phase)

Introduce it: People who study how students learn math have found that when students can explain a process, it helps them to understand it better and be more successful using it.

Sell it: Model for students how you can go through each step used solving a problem and explain what you did and why. Show them an annotated example in the textbook. Ask students to work with a partner to work two problems. Each student should work one of the problems independently first. After they have finished, they should take turns explaining what they did and why in each step to their partner. The partner should ask probing questions to help the student provide complete explanations.

Generalize it: Remind students that teachers are extremely knowledgeable about what they are teaching. If the students can explain a concept or skill to someone else as if they are teaching it that is an indication that they have really learned it.

Perfect it: Ask students to select (or assign them) one problem from the day's assignment and write an explanation about how they solved the problem, step-by-step, including what they did and why.

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APPENDIX C: POSTERS

Successful Students Take Responsibility for Their Own Learning

- Prepare for a Test
- Select Additional Problems
- Complete Error Analysis
- Self-Consequate
- Organize Notes
- Create Mnemonics
- Write the Steps


Successful Students Take Responsibility for Their Own Learning
Set Learning Goal
Plan & Act
Review & Improve

APPENDIX D: CLASSROOM OBSERVATION CHECKLIST

Self-Regulated Learning
Classroom Observation Checklist

Teacher: ______________________________ **Date:** ______________________________

Class Observed: ______________________ **Observer:** __________________________

Indicator	Not Observed	Observed
Teacher Observations		
The lesson included the use of self-regulated learning strategies.		
The teacher uses vocabulary related to self-regulated learning.		
The teacher reminds students to use self-regulated learning strategies.		
The teacher reinforces students' use of self-regulated learning strategies.		
The teacher assisted students with using self-regulated learning strategies.		
The teacher modeled self-regulated learning strategies.		
The teacher integrates self-regulated learning strategies with content instruction.		
Student Observations		
The students' behaviors indicate the use of self-regulated learning strategies.		
The students use vocabulary related to self-regulated learning.		
Environmental Observation		
There is evidence in the classroom that self-regulated learning strategies are being used.		

Comments:

APPENDIX E: TEACHER LOG

Teacher Log

Teacher: ______________________________

Strategy	Date First Introduced	Comments/Reflections
1: Setting Learning Goals		
2: Making a Learning Plan		
3: Reviewing and Improving a Learning Plan		
4: Preparing for a Test		
5: Selecting Additional Problems for Practice		
6: Error Analysis		
7: Self-consequating		
8: Organizing Notes		
9: Mnemonics		
10: Write the Steps		