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The Academic and Psychological Effects of Teaching Students with Learning Disabilities to Solve Problems Using Cognitive and Metacognitive Strategies

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THE ACADEMIC AND PSYCHOLOGICAL EFFECTS OF TEACHING STUDENTS WITH LEARNING DISABILITIES TO SOLVE WORD PROBLEMS USING COGNITIVE AND METACOGNITIVE STRATEGIES

by

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CHAPTER ONE

Introduction

In the following chapter, I will discuss my transition from focusing on helping students with learning disabilities advance in reading to helping them grow in math. This transition includes finding connections between what I have been successful with in teaching reading skills and how I can use that knowledge to advance students in math. A cornerstone in my approach to teaching reading has been using cognitive and metacognitive strategies, which are general problem-solving tactics that are applied to many scenarios. My investigation will look into the effects of teaching students with learning disabilities to solve math problems using similar strategies.

Out of my six years as an educator, I have taught Read 180, a reading program produced by Scholastic, for five of those years. There are many components that I find useful in Read 180, and all of them contribute in some way to my students' reading growth. My favorite component, however, is the daily routine surrounding the reading of each new passage we encounter as a class. Every day we implement a process that includes steps such as recalling what we already know about the topic, reading headlines and photograph captions, numbering paragraphs, and highlighting vocabulary. Over the years, I've taken Read 180's prescribed approach to reading an article and combined that with my own additions. For example, to help make it more student-centered, we participate in a routine of asking our own questions about the article prior to reading it. When the reading is complete, we go back and look for evidence to answer our own questions. Additions like that were brought into my classroom due to trainings I've received from my district in our professional development. The intentions behind each of these pedagogical decisions has remained the same, though: we read each and every article through the implementation of the exact same routine.

Each year that I have taught this class, I have found myself swearing by this prescribed approach more than I did the year before. In the beginning of the school year, building this routine requires a large amount of repetition and a strict approach with each reading. This eventually leads to the best part of the year: suddenly I will realize that I have become irrelevant.

Sometime in the early winter, I always find myself standing in my classroom and being aware that I could probably walk out right then and there and the students would continue on with their learning without me just fine. That is a bit of an exaggeration, as I am still needed in helping guide their knowledge of literary concepts such as determining the sequence of events or analyzing characters. The general approach to reading and comprehending an article, though, ends up being taken from my hands and being put into the hands of the students. Suddenly, I find myself a step behind in my own classroom. By the time I have prompted them to do any of our pre-reading routines, such as number paragraphs, all the students will already have that step completed. When we are done reading the passage, the students are practically jumping out of their desks to share evidence they have already found that answers one of our questions. And, my favorite part of all, they are leaning over and checking in with their pre-determined partners to make sure they found all the evidence, too, without direction from me. That moment that

I realize my irrelevance in guiding their reading process always makes me feel like I have done my job as a teacher: my students know how to direct their own academic reading.

It is likely impossible to break down what factors have led to my students' growth in reading each year because there are so many best practices wrapped into Read 180's curriculum. I take quantitative measurements often, such as monitoring their progress on the Read 180 computer program, analyzing periodic district testing results, and using Curriculum Based Measures weekly. I am able to show evidence that their abilities are growing each month, but the changes in their abilities cannot be attributed to just one practice. Anecdotally, though, I see a remarkable confidence shift over the year in the students and knowing how we read an article. Oftentimes, in the beginning of the school year, I need to help guide students in being able and willing to share their thoughts about the reading in class. During that point, I spend a lot of time guiding their search for evidence in a text and then also supporting their construction of an answer to share with the class. The change in their eagerness to jump into reading an article as a class each day speaks loudly to me. I find myself reflecting often on the comfort they take in using the routine and the empowerment they seem to find in it.

In this latest year of teaching, math classes arrived for the first time on my daily teaching schedule when I became the co-taught math teacher for 6th, 7th, and 8th grade special education students. Having spent five years in the realm of improving reading, becoming part of the conversation on how to improve math was brand new to me. I joined the math teachers' Professional Learning Community (PLC) to seek ways to improve our students' math scores.

Traditionally in my district, the math scores of our students have been much lower than the reading scores, and those scores have remained stagnant over the past years. The result of this is a group of math teachers urgently trying new methods of teaching math and attempting to measure which are most successful. Being a new part of this process in three different classrooms, my observations can be summed up by this thought: but there are many methods that result in short-term success with math concepts that students are explicitly taught; there are few methods that result in long-term success with math concepts in a broader sense.

The height of frustration for the math teachers in my district is how to teach our students how to approach a math problem that seems slightly unfamiliar. Students will be able to consistently show mastery on a math skill that is presented in a format that they are familiar with. The difficulty comes as soon as the students see a problem that requires the same skills they've mastered, but is presented in a different manner. Suddenly, students who have shown over and over again that they know a math skill, have no idea how to start to solve the problem. In other words, our students need to become more fluent problem solvers.

This next school year, I will take on more math duties by teaching two of my own special education math classes. While my interest in helping our students improve in math was high before, this has upped the ante. Similar to the entire math department, I want to be able to help students approach each math problem with the sense that they can figure out a way to solve it, even if it seems unfamiliar. The vast majority of people need the math skills to approach daily real-life mathematical situations, many of which can be brand new to the real-life problem solver. Using cost-saving techniques, balancing household budgets, and being in charge of managing various work situations all come with the need to feel confident in problem solving, to name a few examples. It is highly relevant for our students to be able to learn the skills of solving the mathematical situations that they encounter if they are to be independent, successful adults.

In my own recent researching of what helps students with learning disabilities improve in math, I found research concluding that using Cognitive Strategy Instruction (CSI) helped improve students' abilities in math. CSI, the process of learning a generalized approach to use towards all problems, struck a chord with me due to its similarity to what I am already familiar with doing in my reading classes. It is, as I have already used in my classroom, using a prescribed method of approaching each work situation that is set before you.

It is now important to note that during these last two years, my school has had a focus on implementing a reading approach called "close reading" in all classrooms. Professional development, teacher evaluations, and daily conversations have surrounded the use of this method in our classrooms. Close reading, similar to what Read 180 uses, is a uniformed way to approach readings. Our goal as a school is to help students be able to automatically use close reading whenever they encounter a challenging article. By consistently using the same practice, we hope it becomes second nature to our students. During these two years, the math department has received an exemption from focusing on close reading. Through conversations, the school has considered having math teachers also use close reading as an approach to word problems. However, each time it comes up, it is only a for a short time before the discussion turns back to focusing on teaching the day-to-day curriculum without adding close reading onto the plates of the math teachers.

Between my own success with using a uniformed approach in the classroom, my school's focus on close reading, and existing research surrounding CSI in math, I would like to apply a CSI method with similarities to close reading in my math classroom in the next school year. In this paper, my research and method implementation will focus on answering this question: *What are the academic and psychological effects of teaching students with learning disabilities to solve word problems using cognitive and metacognitive strategies?*

My hope would be that using CSI in my own classroom - and using a method that is similar to what they are already becoming familiar with throughout their school day - will increase my students' ability to solve unknown mathematical situations. My vision is that this will create an expectation of "student as problem solver" and will help build self-reliance. The end goal is for me to, similar to my reading class, become irrelevant in guiding them in their problem solving.

Being a special education teacher and having a smaller number of students, I have more freedom to implement new methods in my classroom and seeing the effects without upsetting a large system. While this limits my sample size, I am hoping that I can help uncover whether or not it would be worthwhile for the math department to look into focusing on CSI approaches in math. On a smaller scale, if I find that using CSI is effective, I hope to share the method with the other special education teachers who also instruct math.

There is a need for improving the math problem solving abilities of students in the secondary school where I am a teacher. In this study, I will be looking specifically at using CSI to address the problem solving abilities of students with learning disabilities. My goal is to track how they grow quantitatively, taking intermittent samples of their independent work. I also will implement qualitative measures, such as self-ratings and reflections, for the students to complete to see if there is change in their self-confidence towards being a problem solver.

CHAPTER TWO

Literature Review

The following literature review seeks to answer the question: *What are the academic and psychological effects of teaching students with learning disabilities to solve word problems using cognitive and metacognitive strategies?* This research opens with an exploration of the history of students with learning disabilities (LDs) in the United States before looking specifically at students with math disabilities. This will segue into what research has found to be barriers for students with learning disabilities in the area of mathematics and why interventions to improve their performance are necessary. It also looks into which strategies have been seen as successful over the years in improving the math abilities of students with learning disabilities. There will be a closer look at studies that have explored the use of cognitive and metacognitive strategies to address needs in math. The effects of this instruction on students' self-esteem will also be briefly reviewed while looking at studies.

History of Learning Disabilities

According to the National Center for Education Statistics, there were approximately 2.3 million public school students with LDs during the 2011-12 school year (about 4.7% of all public school students). Students with LDs constitute for 36% of students nationwide who have disabilities (United States Department of Education, 2013). In an average class of 30 students in U.S., there will be at least one student with a LD, making the topic of LDs relevant for all educators. However, it is important to note that LDs are not evenly diagnosed or represented across all subsections of students. For example, two-thirds of students with LDs are male. Ethnically, white and Asian students are underrepresented in the identification of students with LDs, while black and Hispanic students are overrepresented relative to the ethnic proportions of the general student population in the United States (Cortiella & Horowitz, 2014). In looking into previously done literature for this study, I will pay special attention to studies that represent these groups.

But in order for us to understand the current educational landscape for students with disabilities, we must first take a step back and look at the history for LDs. While the U.S. federal government did not create a task force, legislation, or earmark funding for LDs until the 1960s and 1970s, LDs can be traced back to the 1800s. European neuroanatomist and physiologist Joseph Franz Gall was one of the pioneers in researching disabilities through studying brain injuries and mental impairment in injured soldiers (Hallahan & Mercer, 2001). Gall thereby established a platform in academia for linking outward achievement to one's inner processing. Another European scientist, Adolph Kussmaul, originated the idea of specific reading disabilities through his concept of "word/text blindness" (Hallahan & Mercer, 2001). This helped take work previously done by scientists like Gall and made it more relevant to the world of education. In the 1920s, researchers in the United States began to be interested in the work that was being done in Europe in this field. During the U.S.'s initial research in field, scientists focused on language and reading disabilities and on perceptual, perceptual-motor, and attention disabilities (Hallahan & Mercer, 2001).

It was the 1960s when education around LDs started to emerge more prominently. Between 1960 and 1975, the term “learning disability” was introduced by a man named Samuel Kirk. During this same time frame, the federal government added LDs to its agenda, organizations were started by parents and professionals, and education programming for students with LDs began forming. In 1965, Barbara Batement founded the discrepancy model for identifying students with LDs. To qualify under the discrepancy model, a child’s performance on a standardized achievement test (e.g. *Woodcock-Johnson*) must be significantly lower than would be expected for that student based on an aptitude test (e.g. IQ tests). This discrepancy model remained the most common way to qualify students as having a learning disability until 2002 (Faulkenberry & Geye, 2014). The Children with Specific Learning Disabilities Act was passed by Congress in 1969, and the U.S. Department of Education was given the power to award discretionary grants to support teacher education and service delivery models for students with LDs. Parents of students with disabilities began rallying together to ensure the rights of their children and that rallying led to the creation of the Education for All Handicapped Children Act (now called the Individuals with Disabilities Education Act or IDEA). This movement helped guarantee parent voice in the decisions regarding their children’s education (Burke & Sandman, 2015). Through 1985, adjustments to programs based on updated research continued to ebb and flow. The development of intervention programs for language, reading, and mathematics were another key takeaway from this era. “Direct instruction” was coined as the term used when discussing the implementation of the intervention programs, and the term continues to be used today in the field of special education (Hallahan & Mercer, 2001).

In recent decades, the definitions of LDs have continued to change. Knowledge has increased around how students learn. There is more evidence on interventions that are based on how students process different information, and how those processes differ between individuals. However, tensions have also come up in recent years regarding the identification of students. There have been concerns over the years that the discrepancy method of identification has flaws and that it over identifies student who are non-white (Hallahan & Mercer, 2001). As mentioned, certain ethnic groups are currently being identified at a higher rate than others, which has led to conversations about whether the discrepancy model is a fair tool.

As a result of those concerns, the President's Commission on Excellence in Special Education, initiated by President George W. Bush in 2002, required the development of alternate ways to qualify for special education that were not based on the discrepancy model. "Response to Intervention" (RTI) was established in 2002, which uses evidence-based interventions to find struggling students. Students who do not progress during intervention periods can then be moved through the process of being evaluated for special education (Faulkenberry & Geye, 2014). One of the purposes driving RTI is that there may be some students who are behind in school due to reasons other than having a learning disability. By having students go through an intervention process, school teams are more likely to find the root of discrepancy. While this sometimes still results in students being identified as needing special education, the hope is that fewer students will be unfairly identified as having a disability (Fuchs, D. & Fuchs, L., 2006).

History of Learning Disabilities in Math

Dyscalculia, more commonly known as mathematics learning disability (MLD), is the impaired ability to process and learn numerical information that cannot be attributed to one's general ability (Faulkenberry & Geye, 2014). During the 1920s, Austrian Josef Gerstmann described a state in which a cluster of disabilities existed together, including dyscalculia. At the time of his research, MLDs were seen as being part of a broader neurological impairment (Bawkin & Bawkin, 1966 as cited in Faulkenberry & Geye, 2014). Most of the initial research focused on trying to separate the origin of MLDs from other neurological processes. It was not until 1962 that MLDs began having a role in schools. During this time, discussions of atypical learners were beginning to enter into a sociopolitical spotlight. This resulted in schools starting to focus more on identifying and remediating students who had MLDs (Faulkenberry & Geye, 2014).

Throughout the research on MLDs, the neurological source has remained a mystery. According to a research review by Faulkenberry and Geye (2014) there are currently three hypotheses for its origin. The first hypothesis focuses on a core deficit in number sense, specifically the ability to calculate both exact numerical values and approximate numerical values. This would affect both symbolic and nonsymbolic processes. A second view holds that, instead of math specific deficits, dyscalculia stems from domain-general deficits in working memory and attention. The final hypothesis posits that the deficit is in the ability to transform symbols into the appropriate value. In this view, symbolic processing is effective, but nonsymbolic processing is uneffective. There is substantial evidence for all of these hypotheses, however, there is not enough knowledge to be able to separate them from each other. (Faulkenberry & Geye, 2014). There is value in learning the source of MLDs, as with any other condition, it can help lead the best way to help address deficits. While that research continues to hone in on how MLDs develop, the education field moves forward with finding ways to best address those deficits without exactly knowing the source.

Barriers for Students with Learning Disabilities

For students with LDs, difficulties with math content typically begin early in elementary school. As students move through their grades, those difficulties often continue into their secondary school experience (Cawley & Miller, 1989; Mercer & Miller, 1992 as cited in Maccini & Ruhl, 2000). Students with LDs frequently do not have general problem-solving knowledge, are not able to process or apply information effectively, and have a difficult time picking an appropriate strategy for approaching a task (Larson & Gerber, in press; Presley, Symons, Snyder, & Cargilia-Bull, 1989; Torgeson, Kistner, & Morgan, 1987; Wong, 1985 as cited by Montague, 1992).

In a study on students in grades two through 12 who exhibit math difficulties, 29 specific mathematical behaviors were identified as being associated with MLDs. A group of LD teachers then rated the frequency with which students exhibited these mathematical skills. This process helped identify which math difficulties were being seen across the age ranges. Word problems were found to be the most problematic for students who had math difficulties or MLDs. The other most frequent barriers were difficulties multi-step problems, difficulties with the language of math, failure to verify answers and settling for the first answer obtained, and not being able to recall number facts automatically (Bryant &Pedrotty Bryant, 2008).

When it comes to solving word problems, students with LDs show patterns of difficulty with representing math problems. In some instances, this can be a result of having difficulties distinguishing between relevant and irrelevant information, which may be due to reading comprehension issues (Blankenship & Lovitt, 1976 as cited in Maccini & Ruhl, 2000). In other instances, students have a difficult time representing word problems and are not able to paraphrase the problem or imagine what it would look like (Montague, Bos, & Doucette, 1991 as cited in Maccini & Ruhl, 2000). Students also often lack knowledge on how to problem solve, and students skip to creating a calculation and omitting critical aspects in problem solving (Fleischner, Nuzum, & Marzola, 1987 as cited in Maccini & Ruhl, 2000). Some students with LDs lack the ability to monitor their problem solving performance (Montague, Bos, & Doucette, 1991 as cited in Maccini & Ruhl, 2000). This lack of self-monitoring may result in incorrect answers. These students may have learned strategies on how to approach problems, but do not know how to check the reasonableness of their answer (Maccini & Ruhl, 2000).

In response to standards created by the National Council of Teachers of Mathematics (NCTM), modern classrooms have been shifted to focus on inquiry-based approaches to problem solving (Baxter, Woodward, Olson, 2001, as cited by Bryant & Pedrotty Bryant, 2008). Teachers have since then spent a considerable amount of time in their math classrooms ensuring that students develop solution strategies for math problems for a range of math concepts through interacting with their peers. Instead of focusing on memorization and rote learning, core math instruction often includes activities that allow students to demonstrate their conceptual understanding and reasoning (Jitendra et al, 2005, as cited by Bryant & Pedrotty Bryant, 2008). For example, instead of asking students, “What is the total area of the floor space in the apartment?” a teacher may ask, “What is the most cost-effective way to carpet the apartment?” The latter question requires students to develop the concrete questions they will need to answer to solve the problem on their own. Findings from naturalistic research, however, suggest that inquiry-based methods, by themselves, are not enough to support the learning process of students with LDs (Woodward, 2004, as cited by Bryant & Pedrotty Bryant, 2008). In a time when inquiry based learning continues to move forward in education, it is pertinent that those teaching students with MLDs learn and implement strategies that will allow for math growth.

An Overview of Successful Practices for Students with Learning Disabilities

Successful interventions for students with LDs have included components of modeling, providing corrective feedback, monitoring responses, and providing the space for independent practice (Maccini & Ruhl, 2000). Teaching students to perform self-monitored problem solving by using a mnemonic strategy has been effective in past studies (Miller & Mercer, 1993; Scruggs & Mastropieri, 1989 as cited in Maccini & Ruhl, 2000). Researchers have also found that upper elementary students improved the ability to solve one-step word problems after having received strategy instruction (Smith & Alley, 1981 as cited by Montague, 1992). Junior-high students, after receiving strategy instruction, improved in solving one- and two-step mathematical problems (Case & Harris, 1981 as cited by Montague, 1992). Similarly, secondary and postsecondary students improved their abilities to represent and solve various algebraic problems, as well as word problems (Hutchison, 1990; Zawaiza, 1991 as cited by Montague, 1992).

A meta-analysis of 58 studies of math interventions with elementary age students with special needs was published in 2008 and it gives further insight into what has had positive effects (Kroesbergen & Van Luit, 2008). The analysis looked at preparatory mathematics, basic skills, and problem solving strategies. There were three key takeaways from the meta-analysis for how students with disabilities progress with problem solving. Direct instruction and self-instruction had higher effects for the students. While there are benefits from using computer-assisted instruction, the students were not able to receive remediation on the basic math difficulties they encountered during their problem solving. For that reason, direct instruction is seen as more beneficial for the students. This supports the notion that traditional interventions with in-person adult teachers are most effective. Peer tutoring also showed smaller effect for students with learning disabilities compared to interventions that did not include using peer-tutoring. In education, children are placed in learning situations where they help and teach each other. When it comes to students with special needs, the meta-analysis found that it did not benefit the students to work in such set-ups. The study showed that the use of peer tutoring should not replace adult-instruction. Self-instruction methods, however, were found to be effective (Kroesbergen & Van Luit, 2008).

In 2014, a meta-analysis was conducted to specifically look at how students with math disabilities learn word problems. The study found that explicitly teaching students with learning disabilities how to solve word problems was an effective approach (Zheng, Flynn, & Swanson, 2014). Other interventions that yielded positive effects include advanced organizers, skill modeling, task difficulty control, elaboration, task reduction, questioning, and providing strategy cues. One study examined during this meta-analysis concluded that peer-tutoring did not benefit students with disabilities (Gersten, et. al, 2009), which is similar to the findings of the 2008 study by Kroesbergen and Van Luit. When looking at students who only had math disabilities compared to students who had both math and reading disabilities, it was found that math interventions have a significantly higher impact on students with only math disabilities (Zheng, Flynn, & Swanson, 2014).

There is evidence that students with MLDs benefit from having mediated instruction alongside inquiry-based experiences. This includes explicit instruction of the skill at hand, combined with strategic instruction (Woodward, 2004, as cited by Bryant & Pedrotty Bryant, 2008). Explicit instruction pertains to the individual sub-skills being discovered in math. Instruction often includes modeling, practice, error correction, and progress monitoring. Strategic instruction, on the other hand, includes Cognitive Strategy Instruction, which will be expanded on further in this chapter. The goal of strategic instruction is to teach students procedural rules and self-regulation cues (Woodward, 2004, as cited by Bryant & Pedrotty Bryant, 2008).

Effects of Metacognitive-Cognitive Instruction

A 1986 study established that teaching cognitive-metacognitive strategies was an effective method for teaching students with LDs how to solve word problems (Montague & Bos, as cited by Montague, 1992). In that study, a group of six students were given instruction on using cognitive-metacognitive strategies for solving mathematical word problems. The teaching process of these strategies included modeling, rehearsal, corrective and positive feedback, guided practice, and mastery testing. After going through the study, students showed significant improvement, being able to generalize skills to more complex problems and maintaining the improvement three months after the study (Montague & Bos, 1986 as cited by Montague, 1992).

Metacognition is a higher order of thinking in which one consciously controls the cognitive activities needed in a task. It is often described as “thinking about thinking” (Livingston, 1997). Education around metacognition focuses on helping students be able to better use their cognitive abilities through learning metacognitive processes. John Flavell is often associated with metacognition due to his study of the subject in 1970s and 1980s (Livingston, 1997). He divided metacognition into three different categories: knowledge of person variables, task variables and strategy variables (Flavell, 1979 as cited by Livingston, 1997).

Metacognitive strategies involve being aware of when to apply a strategy, as well as knowing about cognitive and metacognitive processes (Livingston, 1997). This often means the implementation of sequential processes to help control the order of cognitive processes. This helps make sure that the cognitive process (e.g. solving a word problem) is completed. This process includes checking one's answer through self-questioning, which is a metacognitive skill (Livingston, 1997).

Cognition and metacognition are closely related. Metacognitive strategies often occur before and after cognitive activities. For example, a cognitive activity of being able to understand a text may be followed by a metacognitive strategy like quizzing oneself on the reading. Knowledge that someone has is considered metacognitive when it is used to inform the method being used to obtain cognitive knowledge. If a student is aware of the process that will help him or her has led to solve a problem, putting that process into place makes it metacognitive. It would not be considered metacognitive if it were not actively playing a role in the oversight of learning (Livingston, 1997).

Metacognition results in students having increased benefits from instruction (Carr, Kurtz, Schneider, Turner & Borkowski, 1989, as cited by Livingston, 1997). There are many approaches to using metacognitive instruction in a classroom, but certain implementations yield higher results. A highly effective approach involves giving the student both knowledge of cognitive strategies and practice in using cognitive and metacognitive strategies (e.g. evaluating the outcomes of their efforts). Given students only the knowledge of cognitive strategies or only practice using cognitive strategies without direct teaching does not seem to be as effective (Livingston, 1996, as cited by Livingston, 1997).

Cognitive Strategy Instruction (CSI) is an instructional practice that enhances learning through the development of thinking skills and processes. The goal of using CSI is that students will become more strategic, self-reliant, flexible, and productive in the classroom (Scheid, 1993 as cited by Livingston, 1997). Use of CSI is driven by the idea that there are identifiable cognitive strategies that are being utilized by the best students and that these strategies can be taught to all students (Halpern, 1996 as cited by Livingston, 1997). Putting these strategies into use has led to successful learning (Borkowski, Carr, Pressley, 1987 as cited by Livingston, 1997; Garner, 1990 as cited by Livingston, 1997). The purpose of using CSI is to help build proficient problem solvers who are strategic in their work. It has been found that students with LDs typically have not developed these strategies and have a hard time selecting which strategy to use, putting it into use, and following through with its execution (Swanson, 1990, as cited by Montague & Dietz, 2009). As seen earlier in this chapter, students with LDs have a need for strategies that help them navigate word problems and other multi-step problems.

CSI is made up of a combination of cognitive processes (e.g. visualization) and metacognitive process (e.g. self-questioning). Marjorie Montague's model found seven cognitive processes that were essential to solving math word problems. The seven steps were (a) reading the problem for comprehension, (b) paraphrasing by putting the problem into one's own words, (c) visualizing by drawing a representation of the situation in the problem, (d) hypothesizing or setting up a plan, (e) predicting the answer, (f) computing the answer and (g) checking to see if the answer is correct (Montague, 1992, as cited by Montague & Dietz, 2009).

In CSI, modeling the strategy is critical to the process. Modeling simply entails demonstrating the strategy for students while thinking aloud. This gives students an example of what a successful problem solver sounds like and lets them practice the strategy through imitation. CSI is teaching specific and explicit instructional routines (Montague & Dietz, 2009).

Maccini and Ruhl conducted a study to test the results of implementing the strategy that they created based on problem-solving literature. They titled the method STAR, which follows a structure that includes cognitive and metacognitive strategies (2000). Each lesson had six elements: (a) advance organizer, (b) model, (c) guided practice, (d) independent practice, (e) post-test, and (f) feedback or rewards. Students were also asked to think-aloud while they problem solved, allowing the researcher to determine their level of understanding a problem during both pre-test and post-test conditions (Maccini & Ruhl, 2000).

Results from this study indicated that students with LDs were able to successfully represent and solve word problems involving subtraction of integers. At the end of the study, all students had increased on the following: their percent of strategy use, their mean percent accuracy on problem representation, and their mean percent accuracy on problem solution. The students' abilities to generalize their skills were also measured. Students were given near generalization problems, (i.e., problems with different surface structures involving subtraction of integers) and the students had a mean percent accuracy of 73% on problem representation. On far generalization, outcomes were lower. When given more complex problems that those focused on during treatment, the students had a mean percent accuracy of 29.3% on problem representation (Maccini & Ruhl, 2000).

Students were given a five-point Likert scale to measure their experience of the treatment. A Likert scale is a commonly used way to monitor self-rating. The five points on the scale are a continuum representing different attitudes or feelings that participants might be experiencing. In this instance, the students were asked to rate the following three categories: (a) effectiveness of STAR strategy for teaching integers, (b) effectiveness of manipulatives for representing algebraic concepts, and (c) efficiency of the intervention. On the scale, the students were asked to rate the category a "1" if they strongly disagreed with a statement, a "2" if they disagreed, a "3" if they felt neutral, a "4" if they agreed, or a "5" if they strongly agreed. The average effectiveness of STAR was rated as a 4.67. The students either agreed or strongly agreed that the process helped them remember problem-solving steps, learn about subtracting integers and word problems, and helped them identify when they need to subtract integer numbers when solving word problems. The self-reports also showed that students felt the intervention was worth their time because it helped them improve their mathematical concepts (Maccini & Ruhl, 2000).

A study by Montague investigated the effects of cognitive and metacognitive instruction on the mathematical problem solving of middle school students who had learning disabilities (1992). During this study, the subjects went through two treatments. During the first treatment, the students received cognitive or metacognitive instruction. This first treatment led the students through the process that had them implement seven identified steps. These seven steps required students to read the problem, paraphrase the problem, visualize what was happening, hypothesize about the answer, estimate the answer, compute the answer, and then check the answer (Montague, 1992). The second treatment gave the students instruction in the complementary component of the instructional program. Here, students were given guided practice, modeling, application practice, and testing. This allowed all subjects to eventually receive instruction in cognitive and metacognitive instruction (Montague, 1992).

Montague discusses that, in order to solve mathematical problems, students need to have knowledge of quantitative concept, mathematical operations, and specific knowledge on how to solve problems (1992). Montague states that procedural knowledge on how to solve problems is needed in order to apply declarative knowledge effectively (1992). She said that the need to have knowledge of problem solving skills has to be considered when designing instruction, and that students with LDs particularly need direct instruction on how to deploy problem-solving skills (Montague, 1992).

Her study found that cognitive and metacognitive strategies for mathematical problem solving were more effective with middle school students with LDs when both cognitive and metacognitive strategies were taught versus when the strategies were given alone. The students in her study were able to learn the strategies with ease. Students were able to verbally explain techniques that a good problem solver would use, as well as be able to apply those same techniques to actual problems, as documented by improvement on their performance. The students from her specific strategy did not maintain the improved performance over time, however, which emphasized that teaching generalized approaches needs to be a priority. Students improved from getting four out of 18 problems correct on a pre-test to getting 10 out of 18 problems correct on a post-test (Montague, 1992).

Montague gave pre-treatment and post-treatment interviews, where she presented rating scales to students regarding their attitudes towards math and problem solving. In the post-treatment interviews, four out of six students improved their attitude towards problem solving (Montague, 1992). This improvement on student attitude is consistent with the finding from Maccini and Ruhl's study (2000).

With Montague's study, it should be considered that the sixth graders did not improve as much as the seventh and eighth graders (Montague 1992). This implies that age should be considered when creating math programs for students. Younger students may need more explicit and extended instruction due to their developmental stage. They may also need to be instructed in less complex strategies. Montague also suggests that students be provided with calculators, multiplication charts, and other tools that help support students with their basic facts while they are problem solving (1992). She recommends doing error analysis on students' problem-solving strategies and giving additional support to students on the step that is resulting in mistakes (Montague, 1992).

Montague, Enders, and Dietz provided insight into the use of CSI for improving math problem solving for middle school students with learning disabilities (2011). This was done by using a research-based instructional program in inclusive general education math classes. The researched-based instructional program was *Solve it!*, a cognitive strategy approach that was originally created to improve the mathematical problem solving of students with learning disabilities. The approach was implemented for seven months at eight different schools in eighth grade inclusive classrooms and those results were compared to 16 other schools that were comprised of similar demographics and socioeconomic statuses. Students that receive the intervention improved significantly in math problem solving abilities over the comparison group. The effects were the same between students with LDs, low-performing students, and average students. This suggests that using CSI is an approach that works not only in special education math classrooms, but also in inclusive education environments . This was also delivered by teachers who were not trained as special education teachers and were seeking methods for working with students with special needs (Montague, Enders, & Dietz, 2011).

When implementing CSI, it is important to slow down the pace of instruction at outset. Students need to understand how to use each step in the process and how self-regulation will direct them when solving math problems. At the beginning, it may take 15 minutes to go through solving one problem. As students become used to this process, they increase in the ability to create shortcuts for themselves and still solve a problem correctly. This will result in students moving through problems more quickly - and less time spent on each problem - resulting in more correct answers (Montague, Enders, & Dietz, 2011). During the Montague's study in 1992, five out of six of the students increased the amount of time they spent on completing a word problem. This further suggests that students with LDs may need increased time to complete word problems after having received instruction in these skills.

Chapter Three Overview

The next chapter will define the methods of the capstone research. The research procedures will take into consideration the information that was reviewed here in Chapter Two. In creating the procedure, the researcher will use knowledge of what is difficult for students with MLDs and what has been proven to work for students with MLDs. Examples of previous CSI studies will help guide the creation of the CSI steps and processes used in this paper. The research will be done through a mixed method approach, gathering both qualitative and quantitative data. There will also be descriptors of the subjects and background information about the community the subjects are from.

CHAPTER THREE

Methods

Introduction

Considering the research gathered in Chapter Two, the methods in this study are largely based on work that has been done previously in this field. Notably, work done by Marjorie Montague and her various associates over the years provide a solid framework for understanding what has worked in improving the math skills of middle schoolers with learning disabilities (LDs). In this chapter, I lay out the action research methods that was used in implementing Cognitive Strategy Instruction (CSI) in a middle school special education math classroom. The research methods were designed to answer the question: *What are the academic and psychological effects of teaching students with learning disabilities to solve word problems using cognitive and metacognitive strategies?*

Methods

I chose to approach this question through using a mixed methods approach. In the beginning of planning the proposal, there was consideration of doing a quantitative study. After reviewing the literature, it became apparent that students' self-esteem toward math and problem solving was also worthwhile to track. While the primary purpose of using CSI is to help students improve on problem solving, there would be an additional benefit if it helped improve students' self-esteem in math simultaneously. It is common knowledge that a person is likely to put forth more effort when they feel successful in a realm. Therefore, by also studying the possible effects of CSI on self-esteem, I was able to find out if there would be a secondary reason for teachers to use CSI in their classrooms. By using qualitative data, I can also analyze changes in how students' explained their problem solving. This data was measured through the qualitative collection of information, ensuring that the various experiences of the students were collected. On the other hand, also using quantitative methods for researching allowed for an analysis of the how CSI affected the students' math performance.

Research Setting and Subjects

The action research plan was implemented in a Midwest secondary school for students in sixth grade through 12th grade. According to the 2016 Minnesota Report Card put out by the Minnesota Department of Education, there were 145 students enrolled in the school's special education programming during the 2015-2016 school year. Those 145 students made up 14.9% of the student body. The demographic makeup of the school was 46% Black students, 23% Hispanic students, 17% Asian students, 13% White students, and 1% Native American students. Of the 973 students enrolled in the school, 79% of them received Free/Reduced Price Lunch. The English Learner program included 15% of the student body. In 2015, 55% of students in the school were identified as "Does Not Meet" on the math portion of the Minnesota Comprehensive Assessment (MCA). When looking at just the students in special education, 79.2% of students were identified as "Does Not Meet" that year on the math portion of the MCA.

The students that participated in this study were part of a special education math class that took place in a special education classroom. In the middle school portion of the secondary school, there were three sections of special education math. The students were randomly assigned into their math classrooms for the year, and one of these sections of math was studied in this research. All of the students were part of special education and in grades six, seven, or eight. All of these students also identified as “Does Not Meet” on the 2014-2015 math MCA.

Research Designs and Methods

In this study, the independent variable was the use of CSI in problem solving word problems. The first dependent variable measured was the improvement of the students’ problem solving accuracy on word problems. The second dependent variable was the effects of using CSI on students’ self-esteem and attitude in regards to problem solving. These variables were measured through a concurrent embedded strategy. This approach to data collection is used to gather measurements on two different variables during the same period of time (Creswell, 2009). The primary method of data collection was quantitative, and my qualitative data was secondary.

A pre-test and a post-test were developed based on the Minnesota State Standards and the classroom curriculum that was used in the 2015-2016 school year, Moving with Math Foundations for Algebra. The study was implemented during the course of a yearlong focus on numbers, reasoning, and data. Minnesota State Standards for sixth, seventh, and eighth graders under the standards categories of Number & Operation and Data Analysis & Probability were heavily emphasized in the material. The class had been studying the numbers, reasoning, and data for the duration of the school year without any direct instruction on solving word problems prior to the experiment. The experiment was set up in a one-group pre-test-post-test design.

During the first half of a one-month period, the group received direct instruction on how to use CSI to solve word problems. The CSI approach used the following steps: a) Read and understand b) Circle the question and needed facts c) Decide on the process d) Estimate e) Solve and check back. The teacher spent two days explicitly teaching lessons on how to use this process to solve word problems. The word problems that the class worked on required the students to perform skills on numbers, reasoning, and data.

After the initial lessons on how to use the steps, the groups received daily direct instruction on how to solve problems . Three days a week, students were given a word problem for their "Do Now" activity when they entered class. The five steps to problem solving were projected onto the board during the time. After the students completed the word problem, they answered a question that required a numerical rating with a written explanation: "Rate (1-5) how confident you are that your answer is correct. Why do you think that your answer is correct or incorrect?" On Fridays, students received two additional questions with their word problem. One of the questions required a numerical rating with a written answer and one of them required a written answer: (a) "Rate (1-5) how you feel about word problems. What makes you feel that way?"; (b) "What are the steps you took to solve this problem?" When the students were done with solving the word problem and rating their confidence level, the class reviewed how to solve the problem together. While reviewing the problem, the instructor would explicitly take the class through the five steps of the problem solving procedure.

During the second half of the month, the teacher did not give as much direct instruction on using the CSI, but rather continued to project it on the board and referenced it as the approach the students should be employing. A post-test was delivered to the group after the end of this phase. Both the pre-test and the post-test included questions that are not word problems. This helped compare how a student improved on the explicit math skills being taught (e.g. how to round to the nearest thousand) and how a student improved on solving word problems with the explicit math skills.

Analysis of Information

The quantitative data in this study was more heavily emphasized than the qualitative data. The quantitative data was derived from the pre- and post-tests and analyzed for: a) growth in the students' abilities to solve word problems, b) growth in the students' abilities to solve all problems, and b) comparisons between how the students' growth in solving word problems and solving all problems.

The qualitative data was derived from the weekly reflection questions. The rating scales and the open response were coded to allow for measurement. It was analyzed to look for: a) changes in self-esteem and attitude in the students, and b) changes in the students' use of the CSI, as well as changes in explaining the process.

Chapter Four Overview

The above chapter outlines the methods that were used in this study. In the following Chapter, the results of the mixed method research are presented. Data showing how students improved on solving math problems will be reviewed, along with an analysis of changes in student reflection.

CHAPTER FOUR

Results

Introduction

During the 2015-2016 school year, nine middle school students with disabilities were enrolled in one of the middle school's special education math classes. All of the students in the class were offered the opportunity to be in the study, which included learning steps to solve mathematical word problems and self-rating as to how confident they were in their answers. All of the students submitted signed permission to participate in the study. The work done with the students was aimed to answer the question: *What are the academic and psychological effects of teaching students with learning disabilities to solve word problems using cognitive and metacognitive strategies?*

Students' Abilities in Solving Word Problems

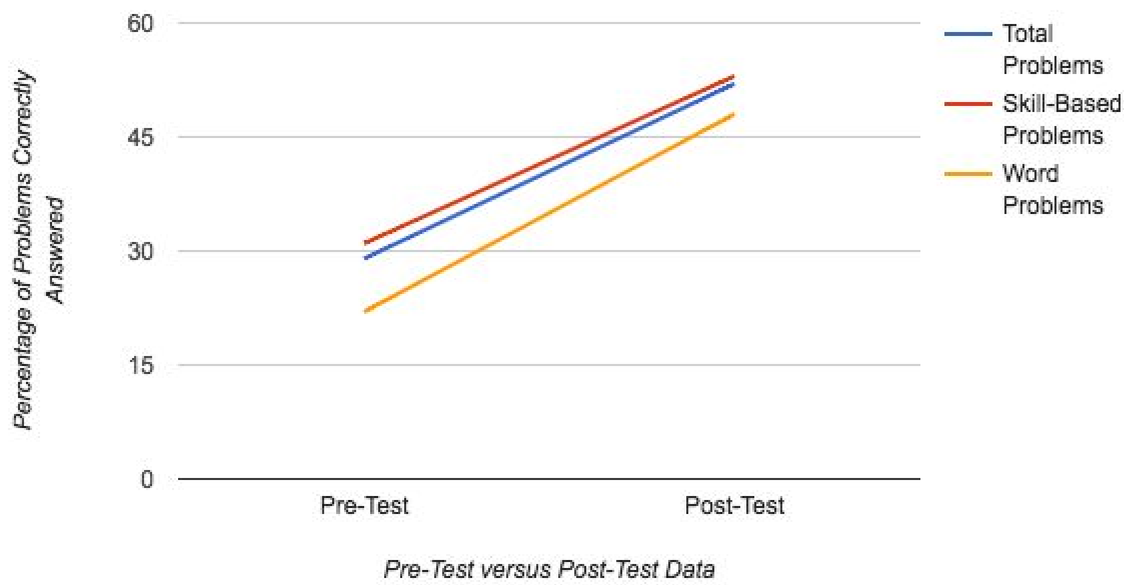
The pre-test was given to all students to gather baseline data. Prior to this test, the students had not received direct instruction on the skills tests nor in problem solving strategies. The test included 36 questions. Of those 36 questions, 26 questions were skill-based math questions and 10 were word problems that required students to apply both the math skills they had acquired and problem solving strategies.

On the pre-test, the average number of questions answered correctly per student was 10.3 out of 36 questions (29%). When looking specifically at the skills-based math problems, the average number of questions correct was 8.1 out of 26 (31%). In comparison, students got an average of 2.2 out of 10 word problems correct (22%). From this data, we can see that students were able to answer 9% more of the skills-based questions than the word problems.

After receiving direct instruction on the mathematical skills and direct instruction in problem solving, the students took a post-test. On the post-test, the average number of questions correct increased to 18.6 out of 36 questions (52%). When again separating out the skill-based math problems, the average number of questions correctly answered was 13.8 out of 26 (53%). Comparing that to the word problems, students got an average of 4.8 out of 10 word problems correct (48%). In this set of data, students were able to answer 5% more of the skills-based questions than the word problems.

When comparing the growth in the three different categories of mathematical problems (skill-based, word, and total), it can be seen that the growth shows a similar pattern across all of the categories. In "total problems," the students increased by 23%. In skill-based problems, the number of questions that students were able to answer went up slightly less than that, increasing by 22%. In word problems, the growth was slightly more, with students answering 26% more questions on average. The graph below shows that the improvement across categories went up by a nearly identical slope. One can note that the gap between skill-based problems and word problems got narrower in the post-test, closing in from a 7% difference to a 5% difference. See *Figure 1* for further reference.

Figure 1. Percentage of problems correctly answered by category



Taking a look into individual students, there were two outliers on either side of the data. Though the average increase in number of problems solved was 7, one student improved from answering 6 of the 36 problems (17%) to answering 24 of the problems (67%). This is an increase of 18 problems which is much higher than the average. On the other side of the data, one student decreased in the number of answers they got correct. That student went from answering 22 questions correctly (61%) to answering 19 questions correctly (53%). Interestingly, the student who grew the most was the student who had the lowest pre-test score. This would allow us to believe that she was able to grow at a rate higher than the class average because she had less previous knowledge. Similarly, the one student to decline in a test score was the student who had the highest pretest score. We can conclude here that part of the reason this student did not show growth is that he already had much of the background knowledge that the course covered.

In order to check to see if these outliers had significant impact on the average growth of the class, it is necessary to also look at what the median and mode for growth was in each category. When looking at the median number of questions students in class grew by, it is found that the median number was 7. Separating that information into the median number of questions students improved on in skills-based problems compared to word problems, we see that the split as the same as the average with students improving by 5 problems in skills-based and 2 in word problems. Analysis of the mode results in the same set of numbers: the most common improvement overall was 7 problems with 5 of those problems being in the skills-based category and 2 being in word problems. The outliers did not impact the overall classroom data.

In the classroom, the students were either in sixth grade or in eighth grade. Separating the data by grades on the pre-test, the eighth graders averaged getting 8.8 of skill-based problems correct (34%) and 2.2 of the word problems correct (22%), with an overall score of 11 out of 36 (31%) of the problems correct. The sixth graders had lower initial scores. Their average skill-based problems correctly answered was 7.3 questions (28%) and 2.3 of the word problems correct (23%). This sixth graders had an initial average of 9.6 questions correct (27%) on the overall test, which is 4% less than the eighth graders.

On the post test, a different story is presented. The eighth graders improved their skill-based questions to answering 11.8 of the 26 questions correctly (45%) and answering 5 of the 10 word problems correctly (50%), with an overall score of 16.8 questions correct (47%). They had an 11% increase in their ability to answer skill-based problems, but showed bigger growth in the word problems category, increasing by 28% more word problems. While the students showed growth across the board, this group had larger gains in their ability to solve word problems. See *Figure 2* to see these growth differences. The sixth graders, in comparison, improved to answering 16.3 of the 26 skill-based questions correct (42%) and answered 4.5 of the 10 word problems correct (45%). This combines to getting 20.8 of the 36 questions correct (58%) on the post-test. Reference *Figure 3* for this data. Looking at this data, we can see that the eighth graders grew at a higher rate than the sixth graders in solving word problems, while the sixth graders showed more growth in skill-based problems. Overall, eighth graders improved by 16% more problems correct and the sixth graders improved by 31% more problems correct.

Figure 2. Percentage of problems correctly answered by 8th grade students

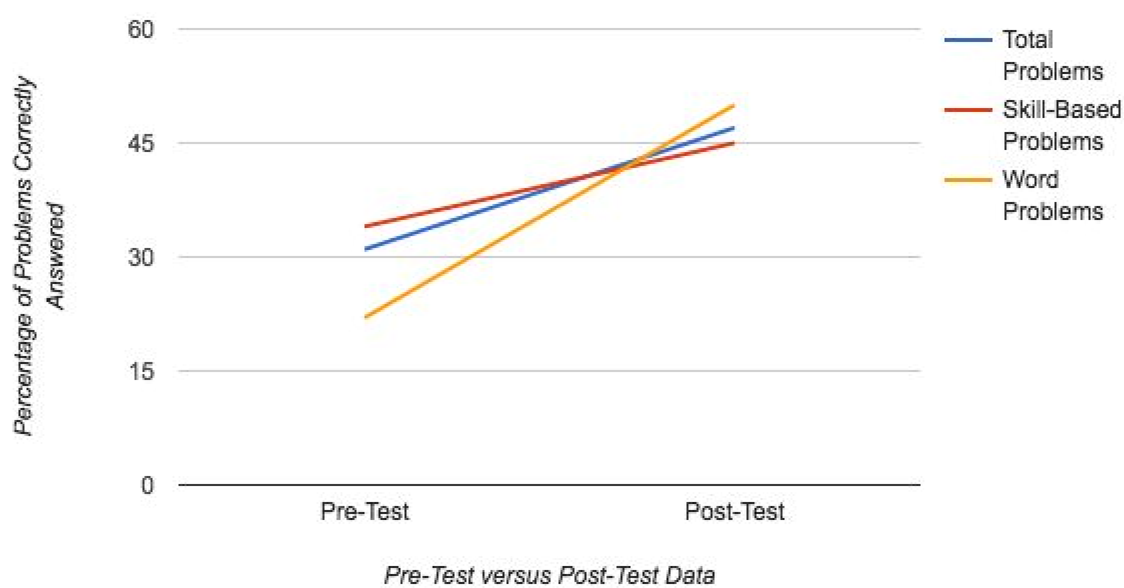
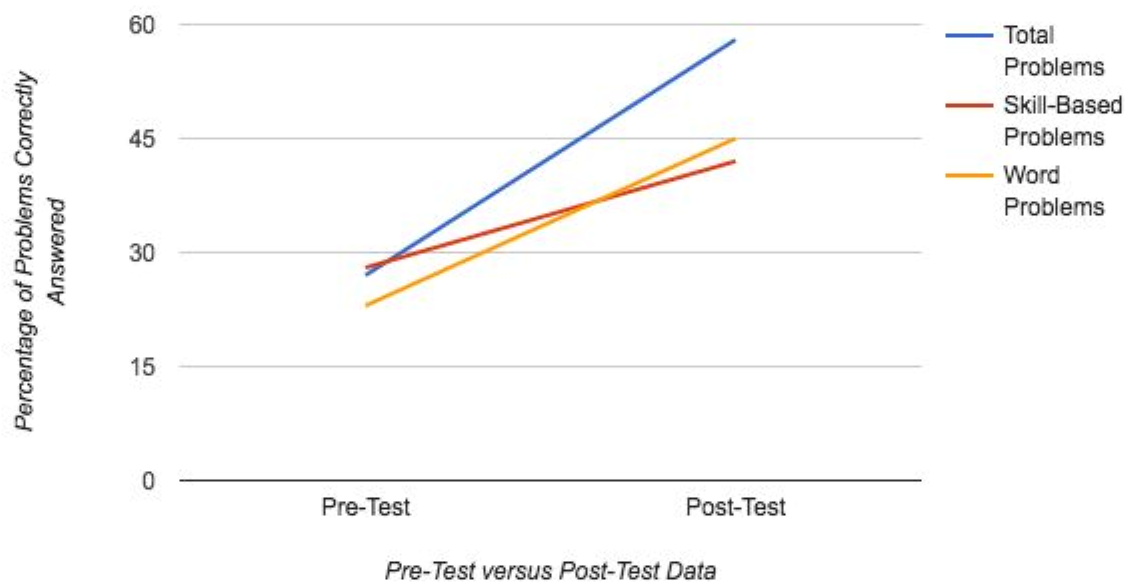


Figure 3. Percentage of problems correctly answered by 6th grade students



While students did improve on word problems, the fact that they grew almost equally on all math problems makes it difficult to decipher whether or not the problem solving steps significantly impacted the growth in that area. Both groups of 8th graders and 6th graders did answer, in the post test, a higher percentage of word problems correctly than skill-based problems.

Students' Self Confidence in Solving Word Problems

The surveys were filled out during class on Mondays, Wednesdays, and Fridays for four weeks. On the survey, students were asked to rate how confident they were in solving a given word problem. The first questions used a 5-point Likert scale and asked the students to circle the number that reflected their confidence level. Number 1 was labeled "Not Confident" and Number 5 was labeled "Really Confident." The below *Table 1* reflects the students' average rating for each week.

Table 1. Question: Rate (1-5) how confident you are that your answer to the word problem is correct.

	W eek 1	**W eek 2**	**W eek 3**	**W eek 4**
S tudent 1	4	3	3	3
Student 2	3	3	4	2
Student 3	4	4	4	4
S tudent 4	5	5	5	5
S tudent 5	5	4	4	2
S tudent 6	2	3	4	3
S tudent 7	4	4	4	3
S tudent 8	3	3	4	3
S tudent 9	3	3	4	3
C lass Average	**3**	**3**	**4**	**3**

Looking at the data initially from Week 1 to Week 4, the numbers do not seem to reflect an increase in confidence. When comparing those weeks, only 22% students went up a Likert level in their answers (i.e. moving from an average of "3" to an average of "4"), while 44% students went down and 33% stayed within the same level. The class average also remained at a "3". However, during Week 4, there was a word problem presented that was difficult for most students. During the first three week of the study, no students rated a problem as a “1.” On the Wednesday of the last week, 55% of students ranked the word problem as a “1.” That singular word problem therefore brought down the average rating of at least half of the students.

In comparison, when looking at students’ ratings in Week 1 to Week 3, 44% of students went up at least one level on the Likert scale, 22% went down a level, and 33% showed no change. The class average also increased from a rating of “3” to a “4.” This might be a more accurate measurement of how students’ confidence was changing, considering that Week 4 included a word problem with a significant number of lower ratings. *Figure 4* displays the differences between Week 1 and Week 3.

Figure 4. Question: Rate (1-5) how confident you are that your answer to the word problem is correct.

Students were also asked each day to write a response answering the question, “Why do you think that your answer is correct or incorrect?” Within the responses submitted during Week 1, 10% of the answers were left blank by the students. Of the responses that were answered, 58% of the answers were variations of “I knew the answer” or “I know how to do it.” Only 10% of students responded with an answer implying that they did not know the answer, such as “I don’t know I forget how to do”.

When answering this question during Week 1, student response length was also measured. The most common response lengths were 3 and 4 words. The overall average response was 5.8 words per response. The longest response provided stated, "Because [I] think my answer is right [because] i [used] my [hundred] [chart] and I [tried]".

When answering that same questions during Week 4, 6% of the answers were left blank by the students. Of the responses that were answered**,** 44% of the answers were affirmations that the student thought their answer was right, such as "cause it is easy" and "my answer is correct." During this week, 28% of students responded with an answer implying that they did not know the answer, such as "it look hard" and "I don't get it". All of the answers stating that the students did not understand it were provided on the question that received the only "1" ratings during the study. The students' answers were again analyzed for response length. The most common response lengths were 3 and 5 words. The overall average response was 6.3 words per response, and increase of 0.5 words from the first week. Examples of some of the answers the provided the most detail included, "incorrect because with three number I don't know which I can us" and "i think it is right [because] i know how to cross out the [zeros] and it is kinda hard."

On Fridays, students were given the additional question, "What are the steps you took to solve this word problem?" During Week 1 of the experiment, 44% of students did not provide an answer to the question. One student wrote the math problem ("36+32 = 68") that they used to solve the problem and one other student wrote "I add it". The remaining 33% of the students provided answers that included different variations of and steps from the 5-step process. For example, one student wrote three bullet points that had the steps, “Read; Solve it; Answer”.

During Week 4, student 55% of students did not give an answer to the question. Again, one student wrote a math problem (“ 6 x 5 = 30”) as a response. Of the remaining students, 22% of the students stated what operation they used to solve the problem (“I multiplied”) and 11% stated that they solved the problem in their mind. Comparing this data to Week 1, there was a decrease in the amount of students who gave responses to the questions. Students giving responses that included the steps from the 5-step process went down to 0 students in the final week.

Looking at the data overall, strong patterns do not emerge. While the students received direct instruction in problem solving steps, students had not received direct instruction on how to reflect upon their work. Part of the lack of change in data can likely be attributed to students not knowing the skills to reflect on the steps they took to solve a problem. Students also became bored of answering the questions as the weeks went on, which likely impacted the data that was collected.

Correlation Between Math Skills and Self Confidence

When looking for connections between students’ growth in correctly solving math problems and growth in self-esteem, the current data does not present enough information to conclude whether or not there is a connection. During the time period when students were using the CSI to solve word problems, there was equal improvement across all math problems. Because there was not a distinct difference in growth between word problems and skill-based problems, we cannot conclude that the growth was due to the use of the

CSI. Similarly, we cannot conclude that improvements in self-confidence in comparing Week 1 to Week 3 or improvements in providing longer explanations to how the student solved the word problem can be attributed specifically to the use of a CSI. The growth in self-confidence may be attributed to overall improvement in math skills, not specifically to improvement in word problems.

Chapter Five Overview

In the next chapter, revelations that were discovered throughout the research process will be discussed. The literature review in Chapter Two will be connected to the findings of this study, limitations of this study will be discussed, and recommendations for future studies will be given.

CHAPTER FIVE

Conclusions

Introduction

The original purpose of this research was to discover a procedure that would help students be independent problem solvers in the math classroom. This desire was born from witnessing students be independent academic readers and hoping that that same self-direction could be harnessed in another subject area. After researching mathematical problem solving for students with learning disabilities, using Cognitive Strategy Instruction (CSI) presented itself as a key step in this process. The following chapter reflects on what was learned in answering the question: *What are the academic and psychological effects of teaching students with learning disabilities to solve word problems using cognitive and metacognitive strategies?* It will discuss the key learnings discovered during the research. Reviewing these learnings will set the foundation to discuss the limitations of this study and what the implications are for further classroom use and for future academic research.

Key Learnings

In considering the data that was presented in Chapter Four, the pattern that stands out the most is the difference in growth between the sixth graders and the eighth graders. Overall, the sixth graders showed a more significant growth than the eighth graders. One could draw the conclusion that, because one group was younger, they would seemingly have more room to grow. Having a lower initial benchmark might have influenced that difference. While I see potential for this conclusions to be true, the eighth graders only showed proficiency on 47% of the questions on the post-test, meaning there was still 53% more of the material that they did not reach mastery on. Due to the majority of the material still being unmastered by the eighth graders, I wonder if it is fair to conclude that the eighth graders did not have as much room to grow. If both groups had low proficiency on the initial test, it seems there might be another reason behind the growth difference.

The biggest difference I saw between these groups that might account for the variations in growth was in student work ethic. I will discuss later in this chapter the limitations of having a small sample size, but the sample size in this study means that individual personalities play a bigger role in final data than they would in a larger sample size. For example, all four sixth grade students in this study happen to have very high work ethics. These students attended more after school sessions with me to work on homework and stayed more on task during class. Of the eighth graders, three of the five students need a lot of support to sustain attention in class and are students that are more likely to have incomplete work at the end of the class period. While these observations are anecdotal, the small group size allowed me to make a high number of anecdotal observations of each participant's daily behavior. The downfall of having this small group means that the difference between sixth and eighth graders in this instance is likely the happenchance personalities of students in this particular class. If these patterns were discovered in a study with a significant sample size, I would wonder if a study into how work ethic ebbs and flows over adolescence in relation to growth in math would be an area to do further studies on.

However, eighth graders did grow more in the category of word problems than sixth graders did. In a study done by Montague, which was discussed in Chapter Two, she found that sixth graders did not grow as much as seventh and eighth graders when using CSI (1992). Her conclusion was that younger students needed more explicit instruction with less complex strategies. The results of my study seem to reflect a similar finding. The younger group did better with the explicit instruction problems (skill-based) and the older group was able to show more growth with the word problems that utilized the CSI. The group of sixth graders in this study might show more growth on word problems in two years when their brains are in a different developmental stage.

Beyond the patterns found in the data, I experienced many learning moments while conducting the research. Throughout the study, I continually encountered students having difficulties with parts of problem solving that I did not anticipate while creating the study. In Chapter Two, a study that found that word problems were problematic for students with math difficulties also indicates that these students struggle with the language of math (Bryant & Pedrotty Bryant, 2008). Another study discussed that students with disabilities have difficulties with representing word problems (Blankenship

& Lovitt, 1976 as cited in Maccini & Ruhl, 2000). Together, these two studies lead to one of the biggest barriers that I encountered.

When presenting students with a new word problem to use our five steps on, students had a very hard time being able to decide which operation to use. Key phrases such as “how much more” and “how many total” did not seem to resonate with my students. Originally, I thought this was an issue of understanding math language, similar to the finding in that aforementioned study. However, as I worked through helping students be able to pick up key phrases, it became more and more apparent that it seemed to be more closely related to not being able to represent math problems. Even when I had drawn out exact depictions of a word problem on the board, the ability to discern whether you would add or subtract seemed like a guessing game almost every time. Slowly, as the weeks moved forward, the guessing seemed to have more accuracy, but never to a point of consistency. Only when the direction was clearly stated (e.g. a problem that said “find the mean”) would students be able to know which step to do each time.

The thing that I would change the most in my future use of CSI in a math classroom is to spend more time emphasizing key words and being able to draw and understand a model of the problem. Because I did not consider these two barriers while designing the study, I addressed these items on the fly instead of having a planned, methodical approach. The first step of the CSI I used had students make sure they understood the problem. In teaching this, I talked about making sure we knew what all the words meant in the story and that the situation “made sense” to the reader. In the future, I would have this step include drawing a diagram of the problem before moving on. While modeling in my class did not always result in understanding, I anticipate that requiring students to draw a model each time would help students build awareness around how they represent what is happening. I would also potentially develop a guide for students to use that would show what keywords might be indicating in a word problem. Even though I would want students to move towards not needing a tool to decipher that, I think it would be a good stepping stone in helping them build that knowledge.

All of this would help eliminate another barrier I observed from students. The fourth step in our problem solving process was to estimate what our answer would be before solving the problem. The point of that step was to help students be aware of what would be a logical answer. If students got an answer that was nowhere near their estimation, it would mean that they should check their math and the procedure they picked. As we were using this CSI, students had a hard time fulfilling this step because they did not have a solid concept of what was happening in the problem. If students were given more instruction on how to model problems and how to decide on an operation, the step of being able to estimate and check that they got a logical answer would become easier. Bryant & Pedrotty Bryant also found that students with disabilities were more likely to fail to verify their answers and settle for the first answer (2008). Giving the students a better foundation for understanding the problem through modeling and language fluency would help them better be able to estimate correct answers.

A second big area of learning for me was in administering the reflection survey. Beyond giving instructions on what the numbers meant and reading the questions, I did not teach students how to reflect on their problem solving process. Originally, the idea behind not giving them much guidance was to allow for the most genuine answers from students. The results from doing that, though, yielded answers that were less descriptive and shorter than I was hoping for. The ability to reflect is a higher order skill and I did not think ahead about how to support this for my middle school students. In the future, I would probably spend a day doing reflection exercises to help students gain a better understanding of what a reflection looks like. I also provide students with disabilities in my reading class with sentence starters to help them formulate their thoughts. Again, I did not want to influence how they described their process and did not give them this sentence starters. In hindsight, I think this tool may have helped them be better able to explain themselves without heavily influencing their responses.

Another limitation of the study that I will discuss later is the short time period that the study happened in. I wonder how students' reflections would have changed given a longer period of time. As the weeks went on in this study, students gave longer answers to the questions, which made me feel like they were building more awareness of how to reflect. Students perhaps would have built their own knowledge on how to reflect if they had been given a longer amount of time to work on this skill. I also wonder how time affected students' ratings on the Likert scale. As students gave longer responses, I noticed that they seemed to be becoming more honest. If students were becoming more accurate in rating themselves, that might mean their numbers were more accurate than in the first week. This could potentially result in a dip in the ratings due to students rating themselves higher in the beginning when they had less self awareness around accurate rating.

Limitations

There were several large limitations presented in this study, as mentioned in the previous section. One of these is that there was only one group of participants. Ideally, the study would have included a control group and an experimental group. When this study was originally designed, it was designed to include two groups. The two groups were going to allow for several different comparison measurements, including being able to see if there was a difference between groups' abilities to solve word problems when one group had learned the CSI and one group had not. In the start of the school year, I was teaching two middle school classes, which would have allowed for the experiment to include two groups.

However, as the school year entered into its second month, it was necessary for the Special Education department to rearrange the courses that were being taught. This resulted in one of my middle school math classes being collapsed and I was given a high school math class instead. With two different classes learning two different sets of material, I was no longer able to have two groups involved in the study. When looking at the results for how students grew in word problems in relation to how they grew in skill-based problems, it is hard to draw conclusions on whether or not the CSI helped improve student growth rate. If there had been a control group, we would be able to analyze whether or not this rate was higher or lower than it would have been without the use of CSI, or if it is exactly the same as when students do not use CSI.

Another limitation was the small number of students. When there are only nine students in a study, the ability to find patterns in the research is signicantly thwarted.

While I did find a pattern in the growth the sixth graders versus the growth of the eighth graders, the groups were too small to confidently claim that the findings would repeat themselves in future studies. The small groups allow for too much individual influence from each student in the group. For example, during the post-test day, one of the eighth graders appeared to be a foul mood. He proceeded to take the test much more quickly than the other students and more quickly than he normally worked. There is potential that this one student did not give his best effort on the test. One inaccurate test, in this size group, can significantly skew the data.

The study was also done in only a four week time period. This short period of time limits the amount of data points we have. This again allows for each data point point to be able to more severely skew the overall data set. We are also not able to see long term patterns and how students' use of CSI and reflection might change over time. As mentioned in Chapter Three, there was a word problem in Week 4 that a lot of students had a very hard time with. Even though it was just one problem in one of the weeks, it had the ability to vastly change the outcome of the overall data on students' self rating. Doing the study over a longer period of time would help eliminate this issue.

Implications

After doing the research and revisiting my Literature Review, it became apparent to me that using a CSI to aid in problem solving is only one part of the process. In future use of the process in my classroom, I would continue to use the framework of the CSI I selected. However, I would include procedures to address other areas indicated as weaknesses for students with disabilities. As mentioned in the section on key learnings, I think students would benefit from extended teaching on how to represent a word problem with a model. In addition, I would give instruction on some of the most frequently used keywords and provide a tool for students to use while solving problems.

Future Research

In future research, I would recommend that a study be implemented in more classrooms over longer periods of time. I would recommend establishing the routine of using CSI and reflecting in the first month of the school year and maintaining the study through the end of the year. I would also recommend that this study be implemented in at least two different classes to increase the number of participants in the study. I think the use of a third classroom as a control group is also necessary to help us better understand the results of using a CSI and reflection. Overall, students being able to grow in the area of word problems at a similar rate as they grew in skill-based problems makes me feel that the use of CSI can benefit from students with disabilities and should be further implemented.

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