THE IMPACT OF STARS MNEMONIC STRATEGY INSTRUCTION ON ALGEBRA TEST SCORES FOR STUDENTS WITH DEFICITS IN MATH

by
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Abstract

Within the field of special education, students with disabilities consistently score lower on standardized mathematics exams compared to their general education counterparts. Attempts at improving student achievement have taken place at the local, state, and national levels, students have made minimal gains. This study examined the experiences of special education teachers who teach mathematics by integrating a cognitive strategy, the *STARS* mnemonic strategy, with Algebra instruction and by examining the experiences of students who received this instruction. The intervention sought to engage teachers with improving mathematical and strategy instruction, increasing student mathematical performance on the New York State Common Core Algebra Regents Exam, and changing teachers' perception of teaching and students' perception on learning. A mixed methods study was conducted to explore the experiences of teachers who integrated the *STARS* mnemonic strategy with their lessons, as well as the experiences of students who received this instruction. The 2 teachers and 44 students were from an urban, public charter higher school in the Bronx, New York. Teacher and student satisfaction surveys, teacher and student focus groups, and teacher instructional rating scales were used to understand teacher and student experiences. Common Core Algebra Regents Exam scores were also used to determine the effects of the intervention on student mathematical performance. Although statistically significant differences were not found, teachers demonstrated a change in their perception of teaching and students changed their perception on problem solving in mathematics. Qualitative data showed that teachers and students benefited from the intervention.

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This dissertation is about implementing the best instructional practices for students with deficits in mathematics. The beginning of this dissertation process allowed me to explore and analyze instructional and learning problems within the context of my school. I developed a great appreciation for educational research, as it has provided me with insights into solving some of our most challenging problems.

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Dedication

This dissertation is dedicated to all my teacher colleagues and supervisors, but most importantly to my students.

Table of Contents

List of Tables

List of Figures

Executive Summary

Students with disabilities score lower on state and national exams than their general education peers. Twenty-six states require all students, including students with disabilities, to take and pass one or more exit exams to graduate and earn a high school diploma (Center on Education Policy [CEP], 2009). Mathematics exit tests were among the lowest scores on these exams (CEP, 2009). Despite steady progress over recent decades in the national graduation rates among students with disabilities, by 2010 only 68% of students with disabilities graduated high school (National Center for Learning Disabilities, 2013). In New York State, the graduation rate for students with disabilities in 2016 was only 53% (New York State Education Department [NYSED], 2016) and the passing rate on the Common Core Algebra Exam for the same group of students was only 41.5% (Rubel, 2016). Lower mathematical achievement for students with disabilities can prevent students from passing exams and jeopardizes them from graduating high school. Efforts have been made to increase students with disabilities' achievement so that they can pass these exams, including changes to special education teacher preparation and training, but scores and graduation rates remain low (Goe & Coggshall, 2006; Murphy & Marshall, 2015; Sindeler, Daunic, & Rennells, 2004). This dissertation will first explore factors contributing to lower Algebra test scores for students with disabilities. It will then present the findings from a needs assessment study that supports the research about the contributing factors. Next, an evidence-based intervention to address the problem of practice will be analyzed and used to guide an intervention study. Finally, results from the intervention study will be discussed.

Student Achievement on the New York State Common Core Algebra Regents Exam: A Problem of Practice

In New York State, satisfactory scores on the high school Common Core Regents Examinations can earn students a Regent's Diploma, but their low scores can limit students' admissions into colleges, minimize scholarship opportunities, and cause financial burdens, which limit career opportunities. Students who do not earn satisfactory scores can jeopardize their chances of graduating high school in four years. Recent scores and graduation statistics have indicated that students with disabilities have a difficult time meeting satisfactory benchmarks (Davis & Gray, 2007; Maccini & Gagnon, 2007).

Student deficits in cognitive skills, such as attention, memory, and metacognition, have been shown to contribute to lower test scores (Miller & Mercer, 1997). To address these deficits, special education teacher programs provide future teachers with the knowledge of effective teaching strategies and skills to help students with disabilities to learn and achieve satisfactory scores on criterion-based exams. However, early career special education teachers often do not have sufficient guidance or mentoring support to improve (Billingsley, Carlson, & Klein, 2004). Special education teachers who teach mathematics often report that they may be aware of effective instructional strategies, but struggle to implement them in their classrooms (Hills, 2007; Hollins, 2011; Windschitl, 2002). Moreover, continuing professional development for special education teachers does not necessarily focus on learning and implementing these effective strategies, but rather on literacy, classroom management, and on improving student procedural rather than conceptual skills (Boyd & Bargerhuff, 2009; Wang & Odell, 2002). Newer mathematical curricula emphasize problem solving that requires students to develop a deeper, conceptual understanding of mathematics beyond basic computation and procedural skills to problem solve (Boyd & Bargerhuff, 2009; Tambychik & Meerah, 2010). This finding indicates that special education teachers who teach mathematics may not be graduating programs with enough evidence-based strategies and skills to successfully integrate mathematical problem-solving strategies in their classrooms. Such a deficit may be a contributing factor to the lower scores among students with disabilities.

The problem of lower Algebra test scores occurred in an urban charter high school in the Bronx, New York. The school had approximately 1,100 students from Grades 9 through 12. About 87% of the students were eligible for free or reduced-price lunch, and 25% of the students had an Individual Education Plan (IEP). In 2015, only 74.1% of students with identified deficits in mathematics passed the New York State Common Core Algebra Regents Exam, and only 50% of the students with similar characteristics passed in 2016.

Needs Assessment Study

To understand the problem better within the context of the school setting, I designed and conducted a mixed-methods study to explore ways in which student cognitive factors and teacher factors, such as teacher quality, preparation, certification, and academic background, influenced student achievement on the Common Core Algebra Regents Exam. Seven ninth-grade Algebra teachers completed surveys and participated in a focus group. Two, special education certified only teachers reported that they did not feel prepared to teach students Algebra in comparison to the five teachers who had certification in mathematics. They also reported that their professional development as teachers focused mostly on literacy and classroom management, as opposed to improving mathematical instruction. This finding supported the research indicating that special education teachers did not receive adequate training and support once they entered the classroom (Wang & Odell, 2002). Twenty-four special education students participated in the needs assessment study by completing surveys, and 12 of these students participated in a focus group. Students indicated that they did not believe their teacher understood how they learned and that their teachers did not use instructional methods to help them retain and apply mathematical knowledge.

Designing an Intervention to Support Student Achievement

Findings from the needs assessment study and literature review indicated special education teachers perceived that they lacked effective instructional strategies in problem solving for mathematics to help students with disabilities pass the Common Core Algebra Regents Exam. To address this problem, an evidence-based practice, cognitive strategy instruction, was selected for this study. Several criteria from the literature informed the design of the intervention study. First, teachers needed designated times throughout the school year to receive mentoring from veteran teachers (Darling-Hammond, Chung Wei, Andree, & Richardson, 2009; Desimone & Garet, 2015; Hull, Balka, & Miles, 2009; Krawec & Montague, 2014). Second, teachers needed to understand cognitive strategy instruction and needed to believe that the strategy would help students achieve in mathematics (Zollinger, Brosnan, Erchick, & Bao, 2010). Third, teachers needed to follow the intervention implementation as intended (Nagro & Cornelius, 2013; Obara & Sloan, 2009). Fourth, the monitoring of the cognitive strategy instruction was necessary (Campbell & Markus, 2013).

The *STARS* mnemonic strategy was selected as a cognitive strategy tool to help students with deficits in mathematics to improve their attention, memory, and metacognition to demonstrate problem-solving skills on the Common Core Algebra Regents Exam. Research has shown that students with deficits in mathematics have deficiencies in these skills that prevents them from initiating and persisting in mathematical problem solving (Curran & IRIS Center, 2003; Impecoven-Lind & Foegen, 2010). The goal of the study was to train and support special education teachers to implement the *STARS* mnemonic strategy with algebra instruction, so that students with disabilities could use the strategy to solve mathematical problems and pass the Common Core Algebra Regents Exam.

The intervention was designed to coincide with the school's schedule of teacher planning meetings at the school. A designated teacher coach (the experimenter in the study) was assigned to coach and monitor the teacher participants. Teachers and the teacher coach met for a total of 16 hours to plan lessons using the *STARS* mnemonic strategy, practice delivering these lessons, review instructional feedback, and improve instruction for future lessons. Teachers used a rubric that was adapted from the school's instructional framework to plan and execute lessons. Rubrics assist teachers in designing instruction to meet the goals of the curriculum (Andrade, 2005)

Implementing the Intervention

The findings from the needs assessment study and literature review prompted me to design a teacher-coaching model that integrated mathematical content with cognitive strategy instruction. Teachers learned about the *STARS* mnemonic strategy and incorporated strategies into eight Essential Skills Review Classes. Two Algebra teachers with certifications in special education volunteered to participate in the intervention study from March 2017 through June 2017. The following research questions were asked:

RQ1: Will students with deficits in mathematics, who experience the *STARS* mnemonic strategy during the 2016-2017 school year, have a significantly higher pass rate on the Common Core Algebra Regents Exam compared to a comparison group of students from the previous two school years?

RQ2: To what extent do teachers follow the implementation of *STARS* mnemonic strategy instruction?

RQ3: What effect does *STARS* mnemonic strategy instruction have on students' perceptions of mathematical problem solving?

RQ4: What effect does *STARS* mnemonic strategy instruction have on teachers' perceptions of student mathematical problem solving?

Data were collected from post-intervention student and teacher surveys and student and teacher focus groups. Teacher implementation fidelity was monitored, and it was determined that both teachers who participated in the study implemented the intervention with fidelity. Students who participated in the intervention had either an Individual Education Plan (IEP) and/or scored in the bottom 30th percentile on the Measurement of Academic Progress (MAP) exam. Common Core Algebra Regents Exam scores for students with similar criteria were collected for years 2015 and 2016 to compare it with scores from the students who participated in the intervention in 2017. Although no statistical differences were found in student exam scores, both students and teachers demonstrated changes in perception about mathematical learning and teaching. Student responses from the survey and focus groups indicated that the *STARS* mnemonic strategy helped them improve their problem-solving skills. The *STARS* mnemonic acted as a tool and a roadmap to initiate student problem solving and prompted students to complete important cognitive steps in the problem-solving process. Teachers also reported feeling more confident in teaching mathematics because they saw students successfully attempt and solve mathematical problems more readily with the help of the *STARS* mnemonic. The intervention also supported teachers in the planning process and helped teachers anticipate student misunderstandings.

The mixed-method study, although small, provided an opportunity for teachers to receive the necessary support to employ effective mathematical problem-solving strategies in the classroom. Teachers reported that they were more confident in teaching with a strategy that could potentially increase student achievement. Students also reported that they were more confident in solving mathematical problems. This study provided support for using cognitive strategy instruction to enhance student learning and achievement.

Chapter 1

Introduction

Over the past decade, the Federal and state governments have engaged in a variety of educational reform efforts targeted at improving the quality of public education (Burch, Steinberg, & Donovan, 2007; Choi, 2011). Some of these reform efforts have included higher standards of accountability and assessment (Burch et al., 2007; Choi, 2011; Mehta, 2013; Tyack & Cuban, 1995). One highly visible aspect of these reform movements, standardized testing, has sparked debate (Duckworth, Tsukayama, & Quinn, 2012). Since the passage of the No Child Left Behind Act of 2001 (NCLB), local, state, and federal officials have used standardized tests and other assessments to measure progress and student achievement. NCLB requires 95% of students with disabilities to participate in statewide assessments to measure student achievement (Anderson, Carlson Le Floch, Elledge, & Taylor, 2009). In addition to this federal regulation, New York State uses these same "high-stakes" testing methods to determine promotion and graduation for all students in the state (NYSED, 2016a). Students must obtain passing scores on five comprehensive exams: one each in Mathematics, English, Science, and two exams in History, in addition to passing the courses in those subjects.

Recent scores and graduation statistics have indicated that students with disabilities have a difficult time meeting NYSED testing requirements, resulting in many schools' adjusting their structure, curriculum, and instruction to address this dilemma (Maccini & Gagnon, 2007). Although New York's testing requirements were intended to ensure student achievement and access to quality education, those requirements present many challenges to students with disabilities and their teachers. Students now face the possibility that a score on a single high- stakes test may prevent them from graduating high school with a diploma and entering college (Davis & Gray, 2007). Adding to this dilemma, students with disabilities are often in classrooms with special education teachers who frequently struggle to find and integrate effective problem-solving practices into the curriculum, so students can learn according to their needs and demonstrate achievement on state tests (Boekaerts & Corno, 2005; Davis & Gray, 2007; Doğru & Kalender, 2007; Fuchs & Fuchs, 2005; Hills, 2007; Windschitl, 2002). The lack of application of effective problem-solving strategies may contribute to the achievement gap between students with disabilities and their general education peers (Sindeler et al., 2004).

Problem of Practice

My Problem of Practice (POP) focuses on lower test scores of students with disabilities on the New York State Common Core Algebra Regents Exam compared to those of their general education peers (NYSED, 2016b). New York State requires every high school student to pass this exam as a mathematics requirement to obtain a Regents Diploma, the lowest-level high school diploma for college admittance granted by New York State (NYSED, 2016a). Not passing the Common Core Algebra Regents Exam before tenth grade jeopardizes the chances of a student graduating high school in four years. It also can negatively affect the chances of a student receiving scholarships and admittance to college, thus decreasing the possibility of success in future careers. Although teachers of students with disabilities have attempted to introduce differentiated problem-solving strategies to accommodate their students' learning needs in mathematics, students are still struggling to demonstrate proficiency at the same level as their general education peers (Wilson, 2013).

The Context of the Problem of Practice

The problem of students with disabilities' scoring lower on mathematics tests can be found at a charter high school in the Bronx, New York. However, studies on student mathematical achievement indicate that this problem is not isolated to the school where the study took place. Aron and Loprest (2012) investigated the standardized mathematics test scores of 123 students in five different special education programs. They found that students with mild learning disabilities in self-contained mathematics classrooms, scored on average, lower on standardized mathematics exams than did their peers who participated in a general education setting. Maccini and Gagnon (2005) asserted that students with disabilities experience difficulties with mathematics due to characteristics that impede their performance, especially in problem solving and computation. This does not mean that students with disabilities cannot achieve at the same level as their general education counterparts; rather, students with disabilities require instruction that is appropriate to the way they learn (Baroody & Hume, 1991; Impecoven-Lind & Foegen, 2010). Further research has demonstrated that lower achievement for students with disabilities may not be entirely due to the students' disabilities. Student achievement has been linked to teacher quality, which includes components such as preparation, certification, and academic background (Aron et al., 2012; Fetler, 2001; Mintrop & Sunderman, 2009; Quigney, 2009).

States' obligation to adhere to the new Common Core State Standards (CCSS) for mathematical practice highlight the importance of having students successfully solve real-world problems (NYSED, 2013; Wilson, 2013). The increased emphasis on problem solving in these standards is problematic for students with disabilities as they demonstrate deficiencies in skills needed to problem solve (Lenz, 2006; Swanson, Jerman, & Zhen, 2008; Swanson, Lussier, & Orosco, 2013). Specifically, the transfer of mathematical knowledge to problem solving is not automatic; rather, it requires instruction to prevent difficulties with problem solving (Fuchs et al., 2008). There has been a renewed interest in how to modify instruction to ensure that students with disabilities are developing and retaining the skills to successfully problem solve (Wilson, 2013).

The new, standards-based curriculum also identified eight mathematical practices that students must develop to be considered proficient problem solvers in mathematics: (a) make sense of problems and persevere in solving them, (b) reason abstractly and quantitatively, (c) construct viable arguments and critique the reasoning of others, (d) model with mathematics, (e) use appropriate tools strategically, (f) attend to precision, (g) look for and make use of structure, and (h) look for express regularity in repeated reasoning (Common Core State Standards Initiative, 2010, p. 63). The implementation of these mathematics practices requires teachers to adjust their instruction to assist students develop and employ these skills (Swanson et al., 2013; Wilson, 2013). Only recently have states changed their teacher certification and preparation requirements so that new teachers entering the classroom are prepared to help their students achieve with the new Common Core curriculum (Paliokas, 2014). The change in curriculum and skills needed to be proficient problem solvers coupled with the lack of appropriate instructional training specific for these skills can be a contributing factor for lower test scores.

In this chapter, I will present a careful analysis of research that examines some of the factors related to students with disabilities' scoring lower on standardized mathematical tests. Social cognitive theory and social constructivism will be used as theoretical frameworks to situate this problem within the professional context of an urban charter high school in the Bronx, New York. Results from the literature review will be described to help identify possible areas for intervention that could help increase mathematical achievement for students with disabilities.

Theoretical Framework

A student's high school mathematics experience provides an important foundation for understanding student learning and achievement. Students with disabilities require special instruction to ensure that they can achieve at the same level as their general education peers; however, Sindeler and colleagues (2004) have noted that students with disabilities are often in classrooms where the mathematical instruction is not aligned to how they learn. This section will discuss two theories: social cognitive theory and social constructivism. Social cognitive theory will be used as a framework to understand the problem of student mathematical achievement on the Common Core Algebra Regents Exam. Social constructivism will be used as the framework to understand teacher quality as a mediating variable for the problem of practice.

Social Cognitive Theory

The foundation of social cognitive theory derives from the idea that learning occurs through observation (Bandura, 1977). A major premise to this theory is the notion that a person's behavior, cognition, and environment impact how that person learns. This suggests that individuals operate because of a reciprocal and dynamic interaction that includes their behavior (skills and actions), environment (social and physical surroundings), and personal characteristics (thoughts, expectations, emotions, and beliefs), where a change in one entity can influence the other two. For example, how individuals interpret the results of their own behavior informs and changes their environment and the personal factors they possess that, in turn, inform and change behavior.

Students acquire learning by processing experiential, observational, and symbolic information (Bandura, 1977; Goddard, Hoy, & Hoy, 2000). Social cognitive theory asserts that learning and human behavior occurs through conscious and nonconscious modeling of individuals within the environment (Bandura, 1977). The ability to learn from other peoples' experience through observation reduces the need for students to learn by trial and error. It also allows students to store information that is not currently necessary for reference in the future. Skills are initially learned through observation which are then refined and perfected through continuous enactment.

In the case of education, students observe and model their behavior upon teacher's behaviors; students try to imitate the teachers' actions to produce desirable learning outcomes (Goddard et al., 2000). In mathematics, students observe their teachers perform mathematical operations and problem-solving techniques; however, the mere act of modelling and demonstrating how to do problems does not guarantee students will acquire the teacher's knowledge and skill. Only when students attempt to enact, repeat, and make sense of the modeled behavior and adjust the process to reach a certain goal will they be able to successfully solve problems. This suggests that students need opportunities to practice and make sense of what they learned through observation.

At the heart social cognitive theory is self-efficacy. This is defined as "an individual's belief in his or her own ability to organize and implement action to produce the desired achievements and results" (Bandura, 1995, p. 3). Self-efficacy is the basis for human motivation and personal accomplishment where an individual's attitude and beliefs can shape their outlook on activities and the future. A student's self-efficacy beliefs about their ability to be successful in an activity and their personal expectations are strongly related to actual performance (Wigfield & Eccles, 2000). If students value an activity, they would exert more effort and persist longer on that activity. The value placed on the activity and their expectations and confidence about their abilities are affected by their previous experiences and perceived difficulty of the task.

A student's self-efficacy can play an important part in the learning process by influencing the amount of time and effort the student puts toward a given task and how well that student adjusts to difficult situations (Benken, Ramirez, Li, & Wetendorf, 2015; Wigfield & Eccles, 2000). Students with disabilities have often had difficulties with mathematics in the past and these past experiences could affect the way they view and approach current mathematical problem solving (Bergen, 2013). Students who are in classrooms that build their confidence with mathematics and provide them with opportunities to experience success with mathematics can positively impact student views on their mathematical abilities (Bergen, 2013). Social cognitive theory would assert that students' mathematical learning and their success with mathematical problem solving is dependent on their experience within the classroom. It also suggests that students' biological and cognitive factors can play a key role in how they experience mathematical learning.

Student Factors Related to Mathematical Problem-Solving Success

Although the National Council of Teachers of Mathematics (2000) expressed the need to integrate more problem-solving instruction into the classroom, some teachers struggle to adapt their instruction to incorporate rigorous concepts and processes needed for students to be proficient problem solvers (Fuchs & Fuchs, 2005; Krawec & Montague, 2014; Montague, Warger, & Morgan, 2000; Xin, Jitendra, & Deatline-Buchman, 2005). Problem solving in mathematics requires students to think differently and go beyond the simple computation required of them in lower-level mathematical courses (Schweiger, 2003; Tambychik & Meerah, 2010). Students engaged in problem solving are now expected to connect previously learned mathematical skills to solve new and novel, real-world problems (Wilson, 2013). This shift in mathematical thinking requires students to adjust the ways they approach and solve problems (Impevocen-Lind & Foegen, 2010; Krawec & Montague, 2014). For teachers of students with disabilities, this problem is even more complex. Students with disabilities are more likely to be deficient in the cognitive skills that are required to successfully initiate, persist through, and solve a problem (Krawec & Montague, 2014; Maccini & Gagnon, 2007; Manalo, Bunnell, & Stillman, 2000). The combination of student deficits in the cognitive skills required by the new Common Core curriculum, students' previous experience with mathematical problem solving, and teachers' challenge related to teaching these students contributes to mediocre student learning and lower test scores. The following sections present an overview of student cognitive skills that could limit successful mathematical problem solving for students with disabilities.

Attention, memory, and metacognition. Students with disabilities often show deficits in cognitive skills such as attention, memory, and metacognition (Miller & Mercer, 1997). Deficits in these skills prohibit students from initiating and completing mathematical problems. In mathematics, retrieval-based processes are essential to problem solving. And while counting strategies and number sense often improve with age and natural maturity, difficulties in retrieving basic facts persist throughout childhood and the adult years for students with disabilities (Geary, 2004). Therefore, memory deficits prevent students with disabilities from retaining mathematical facts and procedures and recalling them when needed for problem solving.

When given mixed-review mathematical problems, students with disabilities lack the skills to determine which mathematical facts are relevant to the current problem (Geary, 2004). This problem is exacerbated when these same mathematical review skills are needed to solve complex word problems because students with disabilities are (a) unable to determine the relevant mathematical facts, and (b) unable to initiate important procedural steps to solve the problem (Miller & Mercer, 1997). As a result, students with disabilities need instruction that will provide cues to aid them in determining which mathematical concepts and skills are relevant to a problem, while at the same time helping them activate their prior knowledge so they can initiate steps in the problem-solving process.

Attention is important for learning and processing information. Maccini and Gagnon (2007) assert that students with attention deficiencies struggle to identify relevant information in mathematical problems because irrelevant or distracting information causes an overload of the students' cognitive systems. The students often mistakenly assume all information is needed for the problem-solving process, and this thus makes it difficult for them to initiate problem solving. Once they begin to use both relevant and irrelevant information, students exert their energy on procedures that are not necessary to solve the problem. Students not only arrive at the wrong answer, but they mentally exhaust themselves and cause mental overload that affects subsequent problems (Miller & Mercer, 1997).

Weaknesses in metacognition can also negatively affect students' problem-solving abilities. Specifically, metacognitive difficulties can lead to challenges in identifying, monitoring, and coordinating the sequence of steps required to solve multi-step problems (Impecoven-Lind & Foegen, 2010; Kearns & Fuchs, 2013; Maccini & Gagnon, 2007). Students with disabilities often skip steps in mathematical problems or do not realize that they have obtained the solution because they do not monitor their problem-solving process (Maccini & Gagnon, 2007). A key element to metacognition is the ability to recognize the limit of one's ability or knowledge and then to actively work to extend the ability or expand that knowledge (Bransford, Brown, & Cocking, 2000). This metacognitive weakness suggests that students with disabilities struggle with assessing their own ability to solve problems, evaluate their solutions for accuracy, and generalize the use of strategies. Students with disabilities may lack metacognitive skills. Research, however, has indicated that they can improve their metacognition through learning strategies that help them monitor their performance and eventually generalize their thinking processes to other tasks (Bransford et al., 2000; Geary, 2004).

Students with disabilities who previously demonstrated deficits in attention, memory, and metacognition continue to show these deficits throughout their childhood and teenage years (Impecovan-Lind & Foegen, 2010). Teachers, however, often lack the strategies that are geared toward improving students' attention, memory, and metacognitive skills (Krawec & Montague, 2014; Montague, Enders, & Dietz, 2011; Van Garderen, 2008, Xin et al., 2005). Rather, teachers often use direct instruction to teach problem solving. This means that they (a) give the students a problem, (b) demonstrate how to work out the solution, and (c) have the students repeat/model the procedure (Montague et al., 2011). This type of instructional strategy assumes that students have the attention, memory, and metacognitive skills to solve problems (Montague et al., 2011) and places much of the responsibility for student learning on the teacher (Marchand-Martell, Slocum, & Martella, 2004; Montague et al., 2011). The continuous use of direct instruction and other non-cognitive instructional methods place students at a disadvantage when it comes to problem solving because it does not promote attention, memory, and metacognitive skills. The goal of direct instruction is to control what is in the curriculum so students can produce more work in less time (Marchand-Martell et al., 2004). The outcome of direct instruction and other non-cognitive methods is that students may be able to work out solutions under teacher direction, but they lack the problem-solving skills required for independent work.

Teachers who are aware of students' deficits in attention, memory, and metacognition are more likely to be familiar with instructional strategies that can improve their learning and problem solving (MacArthur, 2012). However, teachers are often unsure of how to integrate these strategies into their curriculum and classroom instructional practice. The increased focus on testing continues to push teachers to emphasize the mastery of procedural steps to problem solving without considering students' needs to increase their attention, memory, and metacognitive skills. Most often, students see a strategy once and are unable to see its connection to solving a similar problem. Students can benefit from strategies that can be used and adjusted to solve other mathematical problems. This finding suggests that there is a gap between what teachers know about effective instructional strategies and the instructional strategies they integrate within classroom instruction (Krawec & Montague, 2014; MacArthur, 2012; National Council of Teachers of Mathematics [NCTM], 2000; Sowder, 2007). Teachers who are aware of how cognitive-based teaching strategies can promote learning and problem solving for students with disabilities need mentoring and coaching to find opportunities to practice and implement these strategies within their classroom instruction. Implementing such strategies could allow students to improve their attention, memory, and metacognition and ultimately improve their ability to problem-solve on exams.

Student Perception of Teacher Instructional Quality

Studies on teacher instructional quality have mostly focused on the teacher and what he or she does in the classroom to affect student learning (Hubbard, 2001). In recent years, teacher instructional quality from the student perspective has added insight into teacher practices and evaluation (Brekelmans & Wubbels, 2005; Walker & Greene, 2009). Students have a unique perspective for describing their classroom learning environments since they most likely have experienced different types of teaching and learning activities from teachers. In particular, students who believe their teachers' instruction can help them learn are more likely to model teachers' behaviors and associate their success with the classroom experience (Archer et al, 2016). Students thus can provide data about teaching from more than one perspective.

Findings from a study on student perception of teacher instructional quality indicated that students who reported a sense of belonging in the classroom were more likely to focus on developing an understanding of mathematics and then use cognitive effort to make that understanding possible in new situations (Walker & Greene, 2009). Teachers are able to foster this sense of belonging in the classroom through their different instructional activities, which can result in more positive learning outcomes for their students. Students who reported having a more positive sense of belonging to the classrooms showed increased efforts to regulate their learning and seek help when they needed it (Walker & Greene, 2009). This then provides opportunities for students to further explore and solidify their understanding of concepts being taught in class. An important outcome was that students had the ability to initiate their learning process and see how their learning was relevant to their future. This outcome shows that students' awareness of what their teachers are doing in the classroom can have an impact on student learning.

Other studies have noted the importance of student perception of teacher instructional quality and its relationship to student achievement (Goe, Bell, & Little, 2008; Wilkerson, Manatt, Rogers, & Maughamm, 2000). Wilkerson and colleagues (2000) conducted a study of nearly 2,000 K-12 students and asked them to rate their teachers on content knowledge and instructional strategies and to evaluate how they thought these factors affected their own academic achievement. The researchers also asked teachers and their principals to rate themselves. When the ratings were analyzed and compared to student achievement scores, the researchers found that student ratings of teachers were significantly more accurate than teachers' and principals' self-ratings in predicating student achievement. This result seems to show that students are more aware than their teachers of their teachers' instructional quality and of the relationship between teacher instruction and their own academic achievement. Moreover, teachers have reported that survey results of students' perception of their instructional quality have been extremely valuable in identifying their strengths and weaknesses with certain content topics and strategies; teachers use it as a tool for professional development (Goe et al., 2008).

Noguera's (2007) study focusing on student needs for the classroom provides additional support for taking students' learning perspectives into consideration. The qualitative study was conducted in ten Boston public high schools and asked students to report on what they thought effective teaching looked like in their classrooms. Students presented their ideas about how to improve teacher instruction by offering suggestions for effective teacher practices. One of the main findings was that students believed teachers "should have a strong command of the material and a passion for the subjects they teach" (Noguera, 2007, p. 207). A more recent study by The Bill & Melinda Gates Foundation's Measures of Effective Teaching (MET) Project (2013) supported Noguera's (2007) research and added that students who felt that their teachers had a solid command of their content could foster a more creative learning environment that included activities to help address student deficits (Archer et al., 2016). When students are in classrooms that address their learning needs, they are more likely to develop positive attitudes about their learning (MET, 2013). In the context of the mathematics classroom, positive experiences can further empower students attempt more problems which can then lead to improved mathematical thinking (Benken et al., 2015; Kargar, Tarmizi, & Bayat, 2010). Students' opportunities to reinforce their content knowledge, demonstrate this knowledge, and experiment with using the strategies increases with more practice. The study also showed a positive correlation between students' views on their teachers' instruction and student achievement scores (Archer et al., 2016).

The findings from the studies demonstrated that student learning can be affected by students' views of their teacher's instruction. Students who believe that their teachers understand how they learn and subsequently use instructional strategies to target their learning needs are more likely to attempt problem solving and associate their positive experience with teaches' instruction (Archer et al., 2016; Noguera, 2007). Although many teachers may be considered highly qualified according to state and national standards for what constitutes highly qualified teachers, a better measure is what teachers do in the classroom. Students' perceptions of teachers and their instruction has in recent years become a good indicator of what is a highly qualified teacher because studies have indicated that high student achievement results are correlated to student ratings of their teachers' effectiveness (Noguera, 2007). The next section will explore social constructivism as a framework to think about teacher quality as a mediating variable to student achievement on mathematics tests.

Social Constructivism

Social constructivism views learning as a social interaction where the environment plays a fundamental and significant role in cognitive development (Vygotsky, 1978). Specifically, the social constructivist lens challenges a person to connect their prior knowledge to new information through the interaction of a more knowledgeable peer (Ertmer & Newby, 1993). Vygotsky's (1978) research on the *zone of* *proximal development* details this gap between what an individual can learn without help and what he or she can learn with the help of an adult or a more capable peer. The interaction between and among teachers and students is the focal point of social constructivism since both teachers and students are responsible for contributing to student learning (Windschitl, 2002). Social constructivism reinforces the idea that knowledge is evolving as learning opportunities are presented to students (Ormrod, 2007; Windschitl, 2002). However, students' prior knowledge and their mathematical strengths and weaknesses have direct effects on how students question and make connections about the mathematical content they are learning (Hills, 2007; Windschitl, 2002). Students who are continuously engaged with their environment and communicate through discussions on their learning are more capable of developing knowledge and apply this knowledge in novel settings (Ormrod, 2004).

Social constructivism is based on the notion that social interactions between individuals and their environment provide opportunities to internalize knowledge (Vygotsky, 1978). For mathematical learning, the application and flexible use of preexisting knowledge is necessary for building connections to newer mathematical activities and tasks (Landrum, Cook, Tankersley, & Fitzgerald, 2007; Ormord, 2004; von Glasersfeld, 1987). Student learning can be assisted and promoted when the teacher fosters a learning environment that takes into consideration individual student needs (Cobb, 1994; Volante, 2006). Students are then able to make sense of mathematics while developing their own identity as problem solvers. This theoretical lens also asserts that knowledge and learning is not fixed but rather developing and evolving (Ertmer & Newby, 1993).

Social constructivism operates under the understanding that learning is personal (Christie, 2005; von Glaserfeld, 1987), and the nature of the learner's social interaction with their environment is important to the development and application of knowledge (Vygotsky, 1978). Students are expected to be engaged with high-level mathematical problem-solving processes in newer mathematical curricula where they build upon their previous knowledge and independently make connections to new ideas. Students need to be in classrooms where activities, exercises, and learning materials help students adapt to and master different ways of using their knowledge to solve problems.

Teachers who are knowledgeable and capable of employing a variety of instructional strategies addressing the different ways that students experience mathematics can help students be successful. Students, especially those with disabilities, can increase their learning when they are in environments that are differentiated and responsive to their needs (Christie, 2005; Confrey, 1994). A key component to social constructivism is the idea that students learn more effectively and deeply when they can relate problems to real-world contexts. This requires careful instruction where teachers are providing opportunities for students to develop their own thinking to problem solve (Glago, 2005). When students learn to persist through problem solving, answer their own questions, and derive answers that are reasonable, they become less dependent, more independent, and self-reliable (Scruggs & Mastopieri, 1997).

Teacher Factors Related to Mathematical Problem-Solving Instruction

As previously noted, students with disabilities lack the cognitive skills of attention, memory, and metacognition that are necessary for their proficiency as mathematical problem solvers. Teachers may be aware of their students' deficiencies in these skills but continue to employ ineffective teaching strategies. To better understand why teachers of students with disabilities are continuing this trend of employing ineffective instructional strategies, it was useful to investigate the current literature on teacher instructional quality. A review of the literature focuses on the premise that mathematical achievement for students with disabilities is impacted by teacher preparation and certification as well as teachers' academic backgrounds (Bentz & Bentz, 1990; Berget & Burnette, 2001; Hollins, 2011; Hursh, 2005; Koehler, Feldhaus, Fernandez, & Hundley, 2013; Kretlow, Lo, White, & Jordan, 2008; Shen, 1999). Each of these factors will be examined in the context of overall teacher quality and how it contributes to students' scoring lower on mathematics exams.

Teacher quality and educational policy. The Coleman Report (1966) documented the impact of teacher instructional quality on student achievement and it suggested that an investment in upgrading teacher quality could have the greatest effect on student achievement (Goldhaber, 2016). This is especially true for students from disadvantaged backgrounds (Goldhaber, 2016). Since the release of the Coleman Report in 1966, many studies have further analyzed the impact of teacher quality on student achievement: students who receive high-quality instruction learn more than other students (Darling-Hammond, 2000; Goldhaber & Brewer, 2000). Darling-Hammond (2000) argues that high-quality teachers have two essential characteristics: (a) an understanding of learners and their learning, and (b) development and adaptive expertise that allows them to make judgments about what is likely to work in different contexts. Research on classroom instruction suggests that teachers are not necessarily using instructional strategies that support student learning (Boekaerts, 2006; Davis & Gray, 2007; Fuchs &

Fuchs, 2005). This is partially the result of the increased focus on standardized testing and the pressure to prepare students for tests rather than instructing them to use strategies for becoming proficient problem solvers (Davis & Gray, 2007). The shift to prepare students for standardized testing rather than become proficient problem solvers meant that teachers' instructional quality was moving away from mastering the two essential characteristics that Darling-Hammond (2000) described. Some teachers are using instructional strategies aligned with popular learning theories for students with disabilities, such as strategies aligned with social constructivism. But teachers are often inexperienced and implement the strategies in ways that do not allow students to learn important concepts and employ appropriate problem-solving techniques (Doğru & Kalender, 2007; Hills, 2007; Windschitl, 2002). This indicates that although teachers are familiar with certain theories and instructional strategies associated with such theories, teacher application of the strategies is inconsistent with what constitutes high-quality teaching.

Research literature has noted that, with the increased focus on teacher accountability for increasing student test scores, there is a paradigm shift in how education is delivered for students with disabilities (Boekaerts & Corno, 2005; Cimbricz, 2002; Davis & Gray, 2007). The introduction of NCLB ushered in a new focus on standardized testing in which both students and teachers are adjusting their learning and instruction to accommodate testing strategies. Teachers of students with disabilities are limiting opportunities to implement effective instructional strategies in favor of teaching more test-taking strategies. They do this precisely because the score on a test is what matters most to school administration and to local and national officials (Boekaerts & Corno, 2005; Paris & Paris, 2001).

Test preparation is becoming a common practice in classrooms with students with disabilities. Hursh (2005) investigated the instructional practices of 27 special and general education teachers in New York school districts. Special education teachers spent more time than general education teachers on test preparation for the State standardized tests in mathematics, reading, science, and history. Teachers spent most of this time teaching students how to eliminate wrong answers, guess, and make inferences based on the question (Hursh, 2005). But this type of instruction is not very effective, based on standardized-test results for students with disabilities who received the instruction (Hursh, 2005). Students continue to lack the ability to express their knowledge on standardized tests when presented with the content that they have learned in new and novel settings (Donahue Institute, 2004). This problem can be remedied by helping students approach a learning opportunity through a systematic method of training that allows them to acquire and practice thinking skills so that they can retrieve information and apply it to new settings (Kretlow et al., 2008). However, teachers are still focused on using instructional strategies that assume students have the appropriate cognitive skills to learn and apply the same test-preparation skills taught to their general education peers (Boekaerts & Corno, 2005; Kretlow et al., 2008).

Teachers of students with disabilities must understand that students with disabilities require different instruction from their general education peers; strategies that work well for one group may not necessarily generalize to another. These teachers often do not have the opportunity to see how certain instructional strategies rooted in learning theories, such as social constructivism, can have positive effects on student learning before they enter the classroom. Their implementation of ineffective instructional and testing strategies stems from this lack of opportunity and pressure to prepare students to take and pass standardized tests. They therefore must be coached to apply instruction that is aligned with more effective instructional strategies so that students can learn and demonstrate their achievement. This will allow them to help students with disabilities approach learning and testing through systematic methods that increase students' ability to think and adapt their learning in different formats. This implies that the preparation teachers receive before they enter the classroom is an important factor that contributes to teacher instructional quality.

Teacher preparation. Teacher preparation programs have been criticized for their inability to help teachers bridge learning theory from coursework to classroom application (Hollins, 2011). Learning to teach is a multi-dimensional process that requires teacher candidates to synthesize, integrate, and apply knowledge to facilitate and maximize student learning. It is essential that teacher preparation programs adhere to a program that (a) allows their teachers to practice instructional strategies specific to the students they teach, and (b) reflect on how these strategies improve instruction and learning. However, many programs are designed with loosely connected components that do not necessarily produce teachers who are equipped with the teaching skills to be effective in the classroom (Hollins, 2011). Teacher preparation programs geared toward preparing special education teachers are not immune to this problem. In fact, in many cases, they are more affected by the complexity of teaching and student learning because teachers are required to have more specialized knowledge in how students learn and in the teaching strategies needed to instruct their students. Studies have suggested that the content of preparation programs may not adequately reflect the skills teachers need to provide quality instruction and to address the needs of students with disabilities (Kretlow et al., 2008; Quigney, 2009; Wilcox & Samara, 2009). Although special education teacher programs may focus on a wide range of content, they lack the necessary training required of special education teachers so that they can enter the classroom with the knowledge of applying appropriate instructional skills.

The issues described above regarding special education teacher preparation are further exacerbated by a special education teacher shortage. The shortage of special education teachers has prompted school districts to either expedite their teacher preparation programs or reduce requirements to become a teacher though alternative certification programs such as Teach for America (Henderson, Klein, Gonzalez, & Bradley, 2005). Nationally, about 98% of school districts reported in 2008 that they had shortages of qualified special education teachers to fill vacancies every year (Higher Education Consortium for Special Education [HECSE], 2008). For the 2012-2013 school year, New York City reported that 68% of their schools had special education teacher vacancies during the first two months of the school year (New York City Teaching Fellows, n.d). To meet these challenges, some states and institutions of higher education established alternative certification programs that allow individuals with a baccalaureate degree to be employed by school districts under a provisional or transitional teaching certificate while completing teacher certification requirements (Hawk & Schmidt, 2005; Henderson et al., 2005). Currently, approximately 20% of special education teachers in the United States have entered the classroom through some form of expedited or reduced teacher preparation program (U.S. Department of Education, 2015).

Alternative certification. Alternative certification is best defined as a pathway to teacher licensure that is different from the standard program, in which a teacher is prepared in a state-approved graduate teacher education program. Alternative certification can vary in length, structure, delivery mode, and candidate population (Darling-Hammond, 2000; Rosenberg, Boyer, Sindelar, & Misra, 2007). While these factors may be attractive to non-traditional teacher candidates and to districts that seek to fill large numbers of teacher vacancies in special education, those skeptical about alternative certification continue to debate whether alternative certification programs produce effective teachers (Berget & Burnette, 2001; Koehler et al., 2013). Most notably, urban school districts that rely heavily on alternative certification programs to fill special education teacher vacancies have some of the largest gaps in achievement between students with disabilities and general education students (Koehler, et al., 2013; Lee, Patterson, & Vega, 2011; Okpala, Rotich-Tanui, & Ardley 2009). For example, New York City reports that 22% of special education teachers have obtained certification through New York City Teaching Fellows, the largest program for alternative certification in New York State (New York City Teaching Fellows, n.d.).

There is a relationship between teacher certification status and student achievement (Darling-Hammond, 2000; Goldhaber & Brewer, 2000; Kane, Rockoff, & Staiger, 2008; Sindeler et al., 2004). Forty-two percent of teachers who obtained their special education certification through alternative routes reported having greater difficulties than their general education counterparts in planning mathematics and English curricula, executing lessons, and diagnosing students' learning needs (Bentz & Bentz, 1990). These difficulties may be attributed to the shorter period these teachers have spent in preparation and certification programs before entering the classroom and the lack of practical experience in bridging what they learn from their preparation programs to classroom practice (Cohen-Vogel & Smith, 2007; Gomez & Grobe, 1990).

The literature on alternative certification therefore suggests that the need to place teachers in the classroom may have surpassed the need to produce quality teachers for students who need them the most. Many teachers who participate in alternative certification pathways may not be as adequately prepared as their traditionally trained colleagues with the proper teaching strategies and instructional methods to effectively teach students. However, working with coaches or under the supervision of mentor teachers may benefit special education teachers who participate in alternative certification pathways. Students of alternatively certified teachers who worked with a veteran teacher to plan and execute lessons showed academic growth in just one school year (Darling-Hammond, Holtzman, Gaitlin, & Heilig, 2005). Effective teacher preparation, especially for those who are alternatively certified, should extend beyond their initial training to include mentored coaching throughout their first few years of teaching (Corcoran, McVey, & Riordan, 2003; Supovitz & Turner, 2000).

Academic background. Another factor contributing to low teacher instructional quality that is critical to the effectiveness of classroom teachers is their prior knowledge of and background in the content they teach. Teachers of students with disabilities who teach mathematics are less likely than their general education counterparts to have a substantial background in mathematics. The completion of four or more college-level classes in mathematics is considered as having a substantial background (Phillips, 2010). Teachers with less mathematics background reported that their mathematics instruction was affected by the fact that they felt less comfortable teaching mathematics because the content was unfamiliar to them (Phillips, 2010; Shen, 1999). In comparison, teachers with adequate background in the subject they teach, such as Social Studies or English Language Arts, reported more confidence in teaching their subject matter and a more positive outlook on their students' learning (Torney-Purta, Klandl Richardson, & Henry Barber, 2005). They were also more likely to design lessons that engage students in the learning process and help students view the subject from a more positive perspective (Phillips, 2010; Torney-Purta et al., 2005). Moreover, student performance on standardized tests was positively impacted by teachers who had a background in the subject they taught compared with teachers who did not have a background in their teaching subject (Goldhaber & Brewer, 2000). Although teacher content knowledge does not necessarily translate to the most effective teaching strategies, a strong background in the subject they teach provides teachers with a foundation that allows them to implement effective teaching strategies in the classroom.

The comparison between teachers with less mathematical background and those who have an adequate background in mathematics suggests that experience with the academic subject they teach can influence teacher instruction and student learning. More specifically, a teacher's confidence in mathematics impacts instructional practices and how students perceive the subject (Lee et al., 2011). If teachers do not have the mathematical background and therefore do not understand how to best teach mathematics to their students, then their students will not have a good model to base their learning and demonstrate mathematical achievement.

Conclusion

The problem of lower test scores for students with disabilities is complicated. A review of the literature suggests that the major factors contributing to this phenomenon include both student and teacher factors (Bentz & Bentz, 1990; Berget & Burnette, 2001; Hollins, 2011; Hursh, 2005; Krawec & Montague, 2014; Maccini & Gagnon, 2007; Manalo et al., 1997; Mintrop & Sunderman, 2009; Quigney, 2009; Shen, 1999). Students with disabilities require special instruction to help them learn the same content as their general education peers, but teachers do not necessarily have the proper training to design and implement instruction to meet their needs. The Common Core State Standards, whose curriculum requires teachers to teach mathematics differently than before, add another layer to the complex issue surrounding lower test scores. Teachers who use teaching strategies geared toward older mathematics curricula are finding little success in teaching students mathematics for the new curriculum. Teachers may have knowledge of learning theories to help situate their teaching, but teachers are often not supporting their instruction by basing it on these theories.

The results of a needs assessment study will be presented in the next chapter. This study was conducted to confirm or enhance the findings from the literature review within the context of the profession practice.

Chapter 2

Needs Assessment Study

The literature for the problem of practice indicated that teacher factors, such as teacher quality, which includes preparation, certification, and academic background, as well as student cognitive factors, influence student achievement as demonstrated by test scores (Aron et al., 2012; Bentz & Bentz, 1990; Berget & Burnette, 2001; Fetler, 2001; Hollins, 2011; Hursh, 2005; Impecoven-Lind & Foegen, 2010; Maccini & Gagnon, 2007; Mintrop & Sunderman, 2009; Quigney, 2009). While each of these factors, as identified in the literature, are possible contributing factors to inhibit increases of standardized mathematics test scores among students with disabilities, the quality of instruction in the classroom continues to be the most challenging to improve (Bergert & Burnette, 2001; Mintrop & Sunderman, 2009). Preparation and certification programs have accounted for differences in teaching, and this has encouraged teachers to use research and evidence-based strategies grounded in popular learning theories, but classroom application is still lacking (Bergert & Burnette, 2001; Koehler, et al., 2013; Lee et al., 2009; Okpala et al., 2009). A mixed-methods needs assessment study was conducted to (a) determine underlying reasons why teachers were not applying effective strategies to their instruction, and (b) understand possible ways to help teachers improve their instruction so that students with disabilities have adequate skills and strategies to pass the New York State Common Core Algebra Regents Exam. The results are presented in this chapter.

The literature for the problem of practice also included student perception of teacher quality as a factor in test scores. As a result, an examination of student perception of teacher quality was completed to give a more thorough understanding of how students evaluate their learning. Results could possibly give more insight into what teachers can do to help improve their students' learning and scores on the Common Core Algebra Regents Exam.

The purpose of the needs assessment study was to determine whether the contributing factors related to lower standardized mathematics test scores mentioned above were also contributing factors to lower test scores for students with disabilities in a charter high school in the Bronx, New York. The results from the needs assessment study were analyzed, and an intervention was designed and implemented to address these factors.

The following research questions helped to guide the data collection process and provided a framework to determine which instruments were needed to collect the data.

RQ1: What was the pass/fail rate for students with and without disabilities on the New York State Regents Exam for the 2013-2014 School Year?

RQ2: What types of preparation and qualifications do self-contained special education teachers who teach mathematics have compared to certified mathematics teachers?

RQ3: What knowledge and confidence do self-contained special education teachers have about mathematics compared to certified mathematics teachers?

RQ4: What knowledge and preparation in instructional strategies do self-contained mathematics teachers have that is similar or different from general education mathematics teachers?

RQ5: How do students in self-contained mathematics classrooms perceive their ability to perform mathematical operations?

RQ6: How do students in self-contained mathematics classrooms perceive their teacher's knowledge of and confidence in teaching mathematics?

Method

To examine whether teacher certification and preparation influenced the mathematics test scores of students with disabilities, a causal-comparative research design was selected. This type of design allowed the researcher to determine differences that already existed between or among groups of individuals without any intervention (Onwuegbuzie & Leech, 2006). The mixed-method design was convergent in nature and was used to inform the needs assessment study. The quantitative and qualitative data were collected concurrently and analyzed and compared. The qualitative data was used to explain, elaborate, and clarify the quantitative findings to provide a more in-depth understanding of the data that were collected (Creswell & Clark, 2012). Table 2.1 shows the mixed methods data collection used for this needs assessment study.

Table 2.1

Needs Assessment Mixed Methods Data Collection

Measure *(Variable Measured)*	Quantitative	Qualitative	Data Collection Type	Data Analysis
Integrated Algebra Regent's Exam Scores *(Pass/Fail Rates)*	X		Exam Scores	Descriptive Statistics
Teacher Survey *(Teacher Certification, Teacher Preparation, Academic Background, Teacher Quality)*	X		Web-Based Survey	Descriptive Statistics
Teacher Focus Group *(Teacher Certification, Teacher Preparation, Academic Background, Teacher Quality)*		X	Interview	Inductive Thematic Analysis
Student Survey *(Student Perception of Teacher Instructional Quality)*	X		Written Survey	Descriptive Statistics
Student Focus Group *(Student Perception of Teacher Instructional Quality)*		X	Interview	Inductive Thematic Analysis

Participants

Teachers. Seven teachers taught ninth-grade Algebra during the time of the needs assessment study: four teachers were certified only in mathematics; one teacher was dually certified in mathematics and special education; one teacher was dually certified in special education and another subject area; and one teacher was certified in special education only. All the teachers who had a certification in special education were the teachers of record in a self-contained algebra classroom. The four teachers with only a mathematics certification taught in a general education classroom and did not teach any student with a disability. Teachers signed a consent form prior to their participation in the teacher survey and focus group.

Students. A total of 24 students from two separate self-contained ninth-grade Algebra classes participated in a survey. Twelve of the 24 students elected to participate in a focus group. All students in the survey and focus group had an Individual Education Plan (IEP) classification with a high incidence disability and scored in the lower 20th percentile on the Measure of Academic Progress (MAP) test at the end of their eighth-grade year. During the 2013-2014 school year, the school were the needs assessment study took place used the 20th percentile criteria to place students in self-contained algebra classes. No other data was collected regarding student demographics were provided. Consent forms were collected from the students prior to their participation in the student survey and focus group.

Setting

The needs assessment study took place at a public charter high school in the Bronx, New York. The charter school is a Title 1 school, with 87% of its students receiving free or reduced-price lunch and 99% identifying as either African-American or Latino. In addition, 21% of the students have an IEP, and approximately 80% of the students with IEPs are in a self-contained mathematics classroom (Public Charter High School, 2015).

Of the 243 students taking Algebra in 2013-2014, 55 students had an IEP, and two students had a 504 plan. A 504 plan indicates that a student has a disability and may have testing accommodations, such as extended time testing, but they do not require specialized instruction. The most prevalent disability classification on an IEP was Learning Disability; however, there were 21 students with a classification of Speech & Language Impairment, Emotional Disturbance, or Other Health Impairments. For the purpose of this study, there was no differentiation of disabilities, since all students with IEPs were in the same classroom together in a self-contained or inclusive setting.

Instruments

Four instruments were used in the needs assessment study to collect quantitative and qualitative data. Teacher and student surveys were given in March 2015, and teacher and student focus groups were conducted around the same time.

Teacher survey. Teachers were asked to provide information about their general teaching experience, teacher certification status, teacher preparation program, views on their own teaching quality and effectiveness, and their knowledge of special education (see Appendix A). Likert scales were used to help quantify teacher views on certain qualities of teacher preparation and quality of instruction. Some of the statements teachers were asked to rate were, "I am familiar with typical difficulties students have with Algebra" and "I can effectively design and execute mathematical lessons that reflect the diversity of learning and learning styles." The teacher survey was modeled after a survey conducted by researchers at the University of Albany and Stanford University on teacher experiences in the New York City Department of Education and on the charter school's internal teacher evaluation questionnaire (Teacher Policy Research, 2012).

Teacher focus group. The purpose of the teacher focus group was to supplement the data from the survey and to clarify some of the findings. The questions focused on how teachers viewed the content of their preparation programs and whether they felt they were effective in preparing them to deliver quality instruction (see Appendix B). Strategies for teaching mathematics to students with disabilities were also discussed, especially regarding strategies that the teachers had learned in their preparation programs. The focus group also addressed what teachers were doing to grow as professionals who could increase student achievement and test scores. Some of the prompts teachers responded to were, “Describe the teaching techniques and strategies that are the most effective for you and your students” and “Describe some of the different student learning styles and how you adjust lessons to benefit the different styles.”

Student survey. The student survey focused on student beliefs about learning mathematics and how the students perceived their teacher’s instruction (see Appendix C). General questions about their grade level and whether they had an IEP or a 504 plan were also part of the survey. Not all students in a self-contained mathematics class were classified as needing special education services, but students with an IEP or a 504 plan were eligible to participate in the survey. The survey was modeled after the charter school’s internal student ratings survey that the school gives students twice each school year. Students were asked to rate their agreement with prompts about their learning and school environment on a Likert scale. A rating of 1 indicated that they strongly disagreed with the prompt while a rating of 5 indicated that the students strongly agreed with the prompt. Some of the prompts included, “My teacher understands how I learn.” “My teacher makes me feel I can do the math.” “The math class is structured in a way that is good for my learning.” and “My teachers designs lessons that are easy to follow.”

Student focus group. The student focus group concentrated on asking students about their experiences in the mathematics classroom (see Appendix D). Specifically, questions about how students perceived their teacher's instruction and how they learned mathematics were discussed. The discussion attempted to address students' concerns, given their deficits in mathematics. Some of the prompts that students responded to included, "What types of activities or strategies does your teacher use in class that make you feel like you can do mathematics?" and "What could teachers do to help students with mathematics?"

New York State regents examination. The Regents Examinations are administered through the New York State Education Department under the authority of the Board of Regents for the State University of New York. Selected New York State teachers are tasked to create tests with questions three years before their administration. This allows for field-testing and evaluation of test questions (Watson, 2010). New questions become part of a field test form and are administered to a random sample of students to examine reliability. According to NYSED's Assessment Report (2015), field-test forms with a reliability coefficient of 0.44 to 0.70 are selected to be a part of an operational exam. It should be noted that the field tests forms were short (8-10 items); operational tests were composed of more items and therefore can be expected to have higher reliabilities than the field tests (NYSED, 2015). The New York State Regents Examination in Algebra was the primary examination for this study. This Regents exam was based on the Integrated Algebra curriculum that was implemented in New York at the beginning of the 2004-2005 school year. Topics from the curriculum include solving and graphing linear equations, solving and graphing linear inequalities, solving right triangle trigonometry, finding area and perimeter of two-dimensional shapes, computing statistics, among other topics (NYSED, 2005)

New York State requires a scaled score of 65 out of 100 to demonstrate achievement and move to the next course (NYSED, 2015). In 2014, New York State administered its last Integrated Algebra Regents Exam and implemented the new Common Core Algebra Regents Exam. While the minimum passing scaled score for the new exam remained a 65, New York determined that a student needed to earn a score of 70 in order to be considered college- and career ready (NYSED, 2015). Field test questions modeled after the new Common Core Algebra curriculum were first administered in 2011, and similar reliability scores were used to determine which questions would become part of the new exam (NYSED, 2015). Topics from the Common Core Algebra curriculum include solving and graphing linear, absolute value, exponential, and quadratic equations, modeling linear, exponential, and quadratic functions in real-world context, and interpreting statistical data (NYSED, 2013).

Procedure

This section discusses participant selection, data collection, and data analysis for the needs assessment study.

Participant Selection

The charter school's data manager was contacted in February 2015 to help assist in identifying students with disabilities who were placed in ninth-grade Algebra classes. The data manager also provided the names of their Algebra teachers. A meeting was set up between the experimenter and the Algebra teachers to introduce the study. Teachers randomly selected students to participate in the student focus group.

Data Collection

Students took the Integrated Algebra Regents Exam in Algebra in June 2014. Some students took the exam again in August 2014. If a student did not pass the exam in June 2014, then the student would attend summer school and take the exam again in August 2014. The highest score was recorded on the student's official transcript. The school's data manager compiled the Regents Exam scores for students with an IEP three days after the August 2014 administration. The data manager categorized the scores into passing scores and failing scores. This included the combined scores for June 2014 and August 2014.

In March 2015, teacher surveys were conducted online using the free survey software Survey Monkey. Teachers who teach Algebra were sent a website link via their work emails inviting them to complete the survey. In the email, the teachers were instructed to complete the survey within one week of receiving the email.

The teacher focus group was held one week after the completion of the online survey in an empty classroom during the teachers' common planning period, with only the Algebra teachers present. The focus group lasted for approximately forty minutes. Data were captured digitally, and the experimenter also wrote down notes.

The student survey was administered in March 2015. The students were asked to take the survey at the end of their Algebra class period in lieu of a final assessment that was normally part of the classroom routine. Students recorded their responses on a survey sheet and handed it to their teacher to give to the experimenter.

Students who were randomly selected by their teacher to participate in the focus group met with the experimenter during the students' mandatory study hall within one week of the . The experimenter asked questions about their experiences in the mathematics classroom. The focus group took approximately 30 minutes.

Data Analysis

The next step in the procedure was to analyze the data. Teacher Survey data were uploaded into an Excel spreadsheet from Survey Monkey, and responses were separated by teacher certification type. Teachers' responses to the survey were tallied for each statement and an overall percentage was recorded for each level of agreement. For the teacher focus group, an inductive thematic analysis was conducted to code and identify emerging themes related to teacher quality and student learning. To identify themes, initial impressions from a holistic look at the responses were categorized and grouped together after listening to the focus group's digital recording (Glaser & Strauss, 1967). Similar phrases within each category were then identified and labeled with a code.

Student responses to the Student Survey were tallied and placed into an Excel spreadsheet similar to the one containing the teacher survey data. Students' responses to the survey were tallied for each statement and an overall percentage was recorded for each level of agreement. Inductive thematic analysis was also used to identify emerging themes related to student perception of teacher quality and instructional practices students experienced in Algebra classrooms. Similar to the teacher focus group analysis, initial impressions were categorized and grouped together after listening to the student focus group's digital recording. The researcher also included handwritten notes from the focus group as part of the analysis.

Both teacher and student responses to the focus group questions were open-ended. Teachers and students were asked additional questions based on responses to the original questions. The codes and phrases were compared with the quantitative data results to determine emerging themes and concepts. It was imperative to triangulate the data and then to compare the qualitative with the quantitative data so that the researcher could have a better understanding of how the data complimented each other.

Student pass/fail rates and scores for the June 2014 and August 2014 administration of the Algebra Regents Exam were collected from the charter school's data manager, and the scores were aggregated for general education students and students with IEPs. The data manager also provided the passing rates of students with a 504 plan.

Results

Results and a short discussion of the findings from each research question from the needs assessment study will be discussed, followed by a discussion of the results within the context of the findings from the literature review.

Student Passing Rates on the Common Core Algebra Regents Exam

To compare the passing rates of students with disabilities with the passing rates of their general education peers on the Regents Exam in Algebra, scores from the June 2014 and August 2014 administration were divided between those who passed with a minimum scaled score of 65 and those who did not pass. This is the criteria that the current school uses to determine if students move to the next mathematics level. It is also the minimum requirement to graduate with a Regents Diploma. Table 2.2 shows the results of the combined passing rates for the June 2014 and August 2014 administrations of the exam.

Table 2.2

June 2014 and August 2014 Integrated Algebra Regents Exam Combined Results—Pass/Fail Rates by Student Group

Student Group	Fail *N (%)*	Pass *N (%)*
General Education	14 (7.4)	176 (92.6)
Students with an IEP	23 (41.8)	32 (58.2)

The results indicated that 58.2% of students with disabilities met the minimum requirement of 65 to pass the exam in June and August 2014 (Public Charter High School, 2015). However, 92% of general education students passed the exam. Thus, a lower percentage of students with disabilities passed the Regents Exam in Algebra.

Teacher Preparation, Certification, and Background

To address the second research question related to the comparative levels of preparation of special education teachers and general education mathematics teachers, teacher responses to surveys were analyzed descriptively and qualitatively (Table 2.3). While the sample population for the teacher survey was small (n = 7), there were a few salient data points. For teacher certification, 6 out of the 7 teachers obtained their full state certification through an approved alternative certification pathway, such as Teach for America or New York City Teaching Fellows. All teachers hold a Master's Degree in Education.

Table 2.3

Teacher Certification Pathway

Certification Pathway	*N*
Traditional Certification	1
Alternative Certification	6

Table 2.4 is a matrix that shows the subject area in which each teacher is certified, along with characteristics of their academic background.

Table 2.4

Teacher Certification Subject Area and Academic Background

Teacher Participant	Certification Area	Academic Background
1	Mathematics	Finance
2	Mathematics	Engineering
3	Mathematics	Finance
4	Mathematics	Accounting
5	Special Education	History
6	Special Education	Studio Art
7	Special Education and Mathematics	History

In terms of academic and career background, 4 out of the 7 teachers had a certification in mathematics, with either an undergraduate major or a closely-related major to mathematics, such as Finance, Accounting, or Engineering. One teacher with a dual certification in special education and mathematics satisfied the mathematics certification requirements through College Level Examination Program (CLEP) tests and proficiency exams. Two teachers had a special education certification, but that certification was not in mathematics or a related major subject area at the undergraduate or graduate level or through previous work experience. Each of the three teachers with special education certificates was the teacher of record in a self-contained Algebra class and was designated as a high qualified teacher in special education according to NCLB.

Teacher Instructional Quality

The third research question centered on self-contained special education teachers' knowledge of and confidence in mathematical content as compared to those characteristics in general education mathematics teachers. Responses to this question were recorded descriptively and qualitatively. When asked to rate themselves on the prompt "I am comfortable with mathematical content," two special education teachers without the mathematics certification gave themselves neutral ratings. In contrast, all general education mathematics teachers and the special education teacher with a mathematics certification responded with either "agree" or "strongly agree." This indicated that special education teachers who teach mathematics without a mathematics certification are not comfortable with the content they are teaching students. By contrast, those with a certification in mathematics are comfortable with the content. In addition, these same two special education teachers reported that they were still developing their skills for teaching mathematics. While all four of the general education mathematics teachers and the special education teacher with a mathematics certification reported that they were familiar with the curriculum, the same two special education teachers also reported that they were unfamiliar with the Algebra curriculum and standards.

Further investigation through the teacher focus group revealed that the special education teachers who teach mathematics claim that their students' low scores on their Regents Exams are due to their teaching abilities. When asked to further clarify their responses, the special education-certified teachers reported that they "do not know how to create mathematical lessons just by looking at the curriculum. I don't know how to do some of the math so I am even more lost when I am asked to write a lesson" (Participant 6). Special education teachers felt more confident in teaching mathematics when they were asked to improve a lesson that was already planned to include learning strategies for students with disabilities. The same teachers also reported that it is more difficult form then to devise their own lesson plans: "It's harder for me to create a lesson from scratch, but I can take a lesson the Algebra teachers made and adapt it for my students" (Participant 5). Some of the strategies the special education teachers asserted they were comfortable integrating into their lessons included organizational strategies, note-taking, and setting goals. None of the strategies mentioned were content or instruction specific.

Responses from the survey and focus group indicated that special education teachers and general education teachers employ different teaching strategies in the classroom. Compared to special education teachers, general education mathematics teachers are more able to apply larger theoretical concepts and implement application-based lessons. All four general education mathematics teachers replied, "strongly agree" to the statements, "I am able to adjust daily lessons to help all students learn," "I am able to adjust lessons 'on the spot' when students struggle," and "I am able to apply theoretical concepts and ideas underlying mathematical applications." Seventy-five percent of the general education mathematics teachers strongly agreed with the statement, "I am familiar with typical difficulties students have with Algebra," while only one of the special education teachers (33.3%) strongly agreed. This indicated that two of the special education teachers do not understand some of the challenges students experience with mathematics, although their general education mathematics colleagues report that they do.

General education teachers also reported that they were comfortable using technology, manipulative materials, and models to demonstrate abstract algebraic concepts. In the focus group discussion, general education mathematics teachers reported attending mathematics conferences and workshops to help facilitate student learning. The special education teachers, on the other hand, generally attended professional development sessions on literacy or student behavior. They went to those sessions because that was what school leadership thought should be their focus. The responses from the focus group showed that special education teachers had fewer opportunities to improve their instruction for mathematics, and that what the school considered instructional improvement was primarily focused on areas that were not necessarily applicable to their classrooms.

The fifth research question asked students about their perception of their ability in mathematics. Twenty-four students with disabilities who were enrolled in a self-contained mathematics class for the 2014-2015 school year took a survey that asked about their experiences in mathematics. All students (100%) either agreed or strongly agreed with the statement, “I struggle with math this year.” This indicated that students were aware of their mathematical deficiencies in high school. In addition, 22 students (91.7%) reported that they had struggled with mathematics in previous years; two students (8.3%) did not respond to that statement. Discussions from the focus group also revealed that students with disabilities felt that their struggles with mathematics had started in kindergarten and included problems with basic number sense and basic number operations. Many students explained that they had been placed in remedial mathematics classes for most of their elementary and middle school years. This demonstrates that the students’ struggle with mathematics was pervasive, and they had experienced difficulties in mathematics before they entered high school.

To address the last research question, students were asked about how they perceived their teacher’s knowledge of and confidence in teaching mathematics. Most students, when asked about their perceptions of teaching practices, responded that their teacher supported them. Other data, however, indicated that they were often confused and believed that the teacher did not understand how they learn. Nine students (37.5%) either disagreed or strongly disagreed with the statement, “My teacher understands how I learn,” and “My teacher explains the same concept in different ways.” Students in the focus group explained that their teachers often adhered to one method to solve a problem, and that that method was often too abstract to understand. Furthermore, students in the focus group claimed that teachers did not necessarily design lessons that were easy to follow. Participants in the focus group stated that they felt their teacher often moved to newer mathematical topics even when they had not mastered previous topics. The survey responses, coupled with the responses in the student focus group, showed that teacher instruction in the self-contained mathematical classroom was not taking into consideration the individual learning needs of students with disabilities.

Discussion

This section will situate the results from the needs assessment study within the findings from the literature review.

Teacher Instructional Quality

Results from the teacher survey and teacher focus groups about their instructional quality were mixed. The special education teachers tended to rate their confidence and abilities to teach mathematics at around the same level as their general education mathematics colleagues. Both groups of teachers reported that they were comfortable with designing and executing lessons to reach the diverse needs of students. However, the special education teachers reported that they were unfamiliar with the Algebra curriculum and the types of questions that were on the Regents Exam. This prevents special education teachers from designing lessons to incorporate different strategies that target students' mathematical deficits (Goldhaber & Brewer, 2000; Torney-Purta et al., 2005). Responses from the teacher focus group showed that the special education teachers often used lessons from the general education mathematics teachers and differentiated them for the needs of their students. Research suggests that students who are exposed to high-quality and differentiated instruction learn more and perform better on tests (Darling-Hammond, 2000; Goldhaber & Brewer, 2000). Research also suggests that high-quality instruction requires teachers to understand curriculum in order to design and execute appropriate lessons and strategies (Borko et al., 1992; Hill, Rowan, & Ball, 2005). Since the general education mathematics teachers reported that they understand the curriculum and knew what types of questions appeared on the Regents Exam, they could teach and use appropriate strategies conducive to helping students score well on the exam. This suggests that special education teachers, who do not understand the curriculum, are teaching content but not necessarily adjusting their teaching strategies to strategies that are specific to their students' learning needs.

Special education teachers' responses in the focus group further clarified that while they know about learning theories and certain instructional strategies and how they can help increase student achievement and test scores, they do not necessarily know how to use the strategies in the classroom. Hill and colleagues (2005) argue that teacher knowledge about mathematics and learning theories does not mean teachers can effectively translate that knowledge to classroom teaching.

Teacher preparation. Teachers who participated in the needs assessment study obtained their graduate degrees from universities that had partnerships with alternative teaching programs. The special education teachers reported that their preparation programs did not support them in implementing strategies that were proven to be effective for students with disabilities. Henderson and colleagues (2005) found that teachers were satisfied with the amount of time it took for them to earn their degrees and full teaching certification through the alternative certification programs. On the other hand, teachers also reported that they did not feel prepared to use appropriate teaching strategies in the classroom (Henderson et al., 2005). Wilcox and Samaras (2009) also reported that special education teachers receive different training in their preparation programs. While certification in mathematics requires courses on mathematical instruction, special education courses focus on language, literacy, and behavior management (Quigley, 2009; Wilcox & Samaras, 2009). Special education preparation and training do not align with general education preparation and training. So, because their preparation is focused on improving other skills, special education teachers who end up teaching mathematics would not have the necessary training to teach mathematics to students with disabilities.

Teacher preparation does not just include the classes and training before the teacher enters the classroom; rather, teacher preparation is a continuous process and requires ongoing professional development (Darling-Hammond et al., 2005; Laczko-Kerr & Berliner, 2002). Darling-Hammond (2000) argues that professional development is necessary because it serves as a bridge between what teachers learn in their preparation programs and classroom practice. But the special education teachers who participated in the needs assessment study claimed in their focus group that their school encouraged them to participate in professional development that emphasized behavior and classroom management because the school wanted them to improve in that area. Despite test score data showing that students with disabilities score lower on their tests, the school continues to emphasize different aspects of classroom instruction for their special education teachers and their general education teachers. The latter, unlike the former, participate in professional development on mathematical instruction.

At the time of the focus group, the special education teachers who taught Algebra said that they were asked to teach Algebra immediately before the 2014-2015 school year. The general education mathematics teachers were expected to teach Algebra, and they therefore had the training and time to adequately prepare lessons and materials, but the special education teachers did not have the same opportunity to prepare for the school year.

Alternative certification. The seven teachers who participated in the needs assessment study obtained their certifications through alternative certification programs, such as Teach for America and NYC Teaching Fellows. No teacher had a teaching certification prior to entering the alternative certification program. All teachers met the requirements for an initial teaching certification through the alternative programs based on their academic coursework and fields of experience. While these programs have attracted professionals and recent college graduates to careers in teaching, it has also been shown that these teachers, despite their previous academic coursework and field experience are not as effective as traditionally certified teachers (Berget & Burnette, 2001; Koehler et al., 2013). Koehler and colleagues (2013) investigated the mathematics test scores of students under the supervision of both alternatively certified mathematics and alternatively certified special education teachers who teach mathematics. They found that students with disabilities scored lower than the general education students who were in classrooms with alternatively certified mathematics teachers. The test scores and passing rates of the students in this needs assessment study mirror the results of the study done by Koehler and colleagues (2013).

Academic background. The general education mathematics teachers have undergraduate degrees in mathematics or an area of study closely related to mathematics. The special education teachers have undergraduate degrees in areas of study other than mathematics. Through their alternative certification programs, certified mathematics teachers and special education teachers have different course requirements. Mathematics certification requires more courses on mathematics instruction, while special education certification requires courses on language, literacy, and behavior management (Quigley, 2009; Wilcox & Samaras, 2009). Therefore, special education teachers who teach mathematics have a different instructional focus, and, because they lack the academic content background, they are not as able to integrate best instructional practices with mathematical content. This supports Phillips' (2010) and Shen's (1999) research suggesting that students with disabilities score lower on mathematics tests because special education teachers lack the content knowledge to apply content effectively with proven instructional strategies.

Student Perception of Teacher Instructional Quality

Research suggested that students' perception of their teacher's instructional quality was accurate in predicting student achievement (Wilkerson et al., 2000). Students with disabilities in the focus group reported that their teachers often did not use strategies and other teaching methods conducive to their learning needs, even though the special education teachers reported feeling comfortable with executing lessons that met the needs of their students. A major theme from the student survey and focus group responses is that students with disabilities did not think their teacher understood how they learned or could explain mathematical content in different ways. Test scores also showed that students needed more, not less, effective instruction, since students with disabilities scored lower than their general education peers. Archer and colleagues (2016) found that students who were aware of their own learning needs knew effective instruction when they experienced it. Student responses from the focus group indicated that they were not learning how to use strategies to help them solve mathematical problems but rather learned strategies to eliminate answers and recall mathematical equations. If students do not feel they are in a classroom with effective instruction to problem solve, then their view of the content and their scores would be lower than those who feel they are in an effective classroom.

Summary

The literature on lower mathematical test scores for students with disabilities suggested that there is a relationship between teacher quality, which includes preparation, certification, and academic background, and student test scores (Darling-Hammond, 2000; Felter, 1999; Laczko-Kerr & Berliner, 2002). More specifically, NCLB (2001) has cited this correlation to support its criteria for special education teachers to be proficient in both special education practices and content knowledge. In general, however, literature suggests that special education teacher preparation has not focused on the knowledge and skills needed for content but rather on knowledge of assessment (Vernon-Dotson, Floyd, Dukes, & Darling 2014).

Findings from the needs assessment study indicated that teachers of students with disabilities may not feel as confident either in their mathematics preparation or in their abilities to employ instructional strategies to raise student achievement. The fact that an increasing number of special education teachers enter the classroom as full-time teachers without adequate content and instructional training further complicates the issue of teacher preparation and quality (Hawk & Schmidt, 2005). The needs assessment study provided an opportunity to evaluate the types of teacher training programs, content education, and evidence-based strategies teachers need for effective instruction. The study also confirmed that students' perception of their teachers' instruction had an impact on students' confidence in mathematics and test scores. Researching evidence-based strategies for mathematical instruction for students with disabilities and how to implement those strategies informed the issue and guided the dissertation.

Chapter 3

Intervention Literature Review

Problem solving is becoming an increasingly critical skill in today's mathematics curriculum (Krawec & Montague, 2014; Swanson et al., 2013). Success in mathematical problem solving has been correlated with mathematical achievement; thus, students need to develop proficiency in problem solving to facilitate their success in school (Bryant, Bryant, & Hammill, 2000). More importantly, changes in society have resulted in an increased focus on problem solving, so students must be equipped with the necessary critical thinking skills to be prepared for life beyond high school. As careers became more technical, school and district leadership have adjusted their mathematics curricula to meet the needs of a changing society (NCTM, 2000; Xin et al., 2005). Hudson and Miller (2006) argued that problem solving reinforces many critical thinking skills that have become a part of the twenty-first century work environment. Schools have implemented changes in curricula geared toward improving problem solving mainly through Common Core State Standards (CCSS), but teachers also need to change their instruction to ensure that students are developing the skills they need to problem-solve from the new curricula (Codding, Mercer, Connell, Fiorello, & Kleinert, 2016).

The New York State Common Core Learning Standards in Mathematics (NYSCCLSM) emphasizes six main instructional shifts: focus, coherence, fluency, deep understanding, application, and dual intensity (EngageNY, 2012). Under this curriculum, students are required to understand mathematical content and demonstrate conceptual understanding of problem solving in mathematics. It also requires students to persevere through their problem-solving process (EngageNY, 2012). The development of the new

Common Core Curriculum began with researched-based learning progressions detailing what is known about how students' mathematical knowledge, skill, and understanding develop over time (Confrey, 2007). The new curriculum does not define the intervention methods or instructional strategies that are necessary to support students' learning of mathematical topics and concepts. The teachers must interpret the curriculum and decide how to teach it. This is where many teachers, but especially newer special education teachers, have a difficult time adjusting their instruction; they do not necessarily have the teaching skills to implement effective strategies to help students become proficient problem-solvers.

As problem solving has become an essential focus in the new Common Core mathematics curricula, older instructional practices do not meet the educational needs of the students (Xin et al., 2005). This is especially true for students with disabilities (Xin et al., 2005). The Common Core Curriculum offers no support or guidance to teachers in best instructional practices, so teachers have attempted to transfer their instructional techniques from the old curriculum to the new one. However, teachers have seen negative results, and students have struggled to problem solve. The common model of teacher demonstration and student replication may have been sufficient for previous curricula, but this model is inadequate and lacks the necessary teaching tools for students to persevere and become proficient problem solvers (Saavedra & Opfer, 2012). The shift to more problem solving therefore requires shifts in instructional strategy that target students' independent thinking process (NCTM, 2000). Teachers must adapt their instruction to improve their ability to teach students how to use these skills.

The needs assessment study confirmed the research that found that teachers of students with disabilities were not necessarily instructing students with the strategies they needed to be become proficient problem-solvers. Special education teachers from the needs assessment study reported that they were aware of not using instructional strategies necessary for the Common Core mathematics curriculum. This is partially because they do not necessarily understand the curriculum and/or content. The curriculum required them to use more teaching strategies that help their students improve their problem-solving skills and persevere through problem solving, but the teachers did not know those strategies or could not apply them to the classroom. Problem solving is an essential component of the new curricula. Since students with disabilities are known to be deficient with using effective strategies for problem solving, teachers need to implement instruction that helps them develop their problem-solving skills. It is imperative that teachers of students with disabilities learn about these strategies and employ them in their classrooms to ensure that the gap between the test scores of students with disabilities and their general education counterparts does not persist or grow.

Cognitive strategy instruction was selected as an intervention to assist students with increasing their achievement on the Common Core Algebra Regents Exams. Special education teachers, especially those who are new to teaching, can also benefit from instructional support and guidance from more veteran teachers through coaching and mentoring (Darling-Hammond, 2006; Zollinger et al., 2010). Coaching has shown to increase the quality of newer teacher instruction because it provides an opportunity for coaches to a) address teacher gaps in academic knowledge, b) help teachers plan more effective lessons, and c) demonstrate to teachers strategies that facilitate student learning

(Campbell & Malkus, 2013). Moreover, coaching sessions that focus on integrating specific strategies, such as cognitive strategy instruction, can positively impact both teacher instruction and student achievement (Desimone & Garet, 2015).

Cognitive Strategy Instruction

Research across academic domains has consistently demonstrated the inability of students with disabilities to problem solve because they lack the necessary cognitive skills, such as attention, memory, and metacognition, needed to be successful problem solvers (Kraai, 2011; Montague & Applegate 1993; Roberts, Torgesen, Boardman, & Scammacca, 2008; Suriyon, Inprasitha, & Sangaroon, 2013). Montague and Applegate's (1993) study on middle school students with disabilities revealed the participants' inability to accurately solve problems because they were unaware of effective strategies that could facilitate problem-solving tasks. Even with this knowledge, however, some students appeared to lack the tools necessary to monitor and evaluate the use of those strategies.

Researchers have long investigated the explicit teaching of cognitive procedures to facilitate mathematical problem solving (Fleischer & Manheimer, 1997; Hutchinson, 1993; Maccini & Hughes, 2000; Montague et al., 2011; Polya, 1957). Cognitive strategy instruction is one approach that has been shown to improve the knowledge and application of effective procedures and strategies to increase achievement in problem solving (Case, Harris, & Graham, 1992; Impecoven-Lind & Foegen, 2010; Krawec & Montague, 2012 Montague, 2008; Montague et al., 2011). Cognitive strategy instruction utilizes instructional methods such as modeling, scaffolding, and verbal rehearsal to assist students in improving their attention, memory, and metacognitive skills (Krawec &

Montague, 2014). The knowledge and application of these procedures and skills places a high demand on all students' metacognitive abilities, but evidence shows that these areas represent a particular struggle for students with disabilities (Montague & Applegate, 1993; Rosenzweig, Krawec, & Montague, 2011). Furthermore, cognitive strategy instruction emphasizes the teaching of cognitive procedures, in which students are taught to select and apply specific mathematical facts and procedures relevant to a problem (Montague, 2008). More specifically, a key component of cognitive strategy instruction is the explicit teaching of metacognitive skills, where students are taught how to self-instruct, ask themselves questions, and evaluate their performance. This technique allows students to actively monitor the execution of their thinking in relation to the solution of the problem and therefore propels students to attend to the original intention of the problem.

An underlying assumption of student problem solving is that it requires students to perform a sequence of steps without critical thought or planning. Traditionally, students are taught how to problem solve through rigid procedures and rules, and they then try to replicate these procedures with similar problems. However, a strict adherence to these strategies prevents students from regulating their thinking and accurately solving the problem (Sowder, 2007). This is partially because students will use concepts or mathematical operations from a previous problem, thinking that they are needed for the current problem. Students are more concerned with replicating the step-by-step procedures from class examples than in understanding the problem and adapting their knowledge to solve the problem (Case et al., 1992; Impecoven-Lind & Foegen, 2010). Such adherence to strict procedures to solve mathematical problems leads to low scores on assignments and the appearance that students with disabilities lack the knowledge to problem solve in mathematics.

There are many cognitive steps that go into problem solving, and cognitive strategy instruction can help facilitate a greater understanding of the thinking processes and skills that are required to successfully solve a problem (Tate & Rousseau, 2007). Polya (1957) proposed a four-step procedure to problem solving whereby students understand the problem, devise a plan, carry out the plan, and look back. The procedure provides a framework for how teachers can teach problem solving in mathematics. Teachers need to expand on this procedure because students with disabilities require more guidance than it provides on how to improve and utilize their cognitive skills to successfully problem solve.

Teaching cognitive strategies calls for a shift in how teachers think about teaching and learning, from their current emphasis on rigid procedures to a more fluid thought process that allows students to adapt their thinking and prior knowledge to solve the current problem. Cognitive strategies do not require students to adhere to set operational procedures; rather, they cue students to start problems, go back to previous stages in the problem to self-correct, self-monitor, and reaffirm their progress (Krawec, Huang, Montague, Kressler, & de Alba, 2012). This strategy encourages students to discover a path to solving a problem that is specific to their strengths and allows them to follow procedures that they create and use, rather than memorizing and applying operational procedures the teacher gave them.

The central idea underlying cognitive strategy instruction, therefore, is to teach students who lack the cognitive skills to use the cognitive processes used by proficient learners during problem-solving tasks. Students are taught this through instruction that emphasizes metacognitive skills. As noted in the research, students with disabilities tend to skip essential steps or reach an answer without knowing it (Maccini & Gagnon, 2007; Miller & Mercer, 1997). This would indicate that students with disabilities have a difficult time monitoring their thinking and thought process during a problem. In order for students to demonstrate their mathematical knowledge and ability to solve problems, a strategy to help them monitor their thought process may be necessary.

Montague (2003) developed a cognitive strategy instructional method called *Solve It!* with the purpose of helping students monitor their thinking when solving mathematical problems. Specifically, this cognitive strategy method prompted students to focus on relevant information (attention), activate their prior knowledge (memory), and monitor their thinking process (metacognition). The framework for *Solve It!* was provided by Mayer's (1985) problem-solving model: (a) translation, (b) integration, (c) planning, and (d) execution.

In the translation phase, students learn to read the problem for understanding and then paraphrase by putting the problem into their own words with relevant information. This strategy allows students to internalize the problem in language beneficial for their understanding of the problem and exclude non-essential information. Next, the integration phase prompts students to visualize the problem by creating a replication of the problem that depicts the relationship among its parts. For mathematics, this is often in the form of an equation whose unknown variable students identify. Students then enter the planning phase where they hypothesize solutions and select appropriate operations needed to solve the problem. The final stage, execution, requires students to employ their mathematical skills to solve the problem and then check their solutions. Although the procedure is sequential, it serves to remind students of the different pathways they can take to activate their prior knowledge, focus on the problem, and monitor their thinking. It also provides an opportunity for students to go back to the problem and correct any mistakes and misunderstandings.

The *Solve It!* instructional strategy became popular in many school districts, leading Krawec and colleagues (2012) to investigate its effectiveness as an instructional program. Twenty-four teachers and 161 students in Pre-Algebra and Algebra classes participated in a two-year study of the *Solve It!* strategy instruction in Miami-Dade County Public Schools. Students were assigned into intervention (n = 88) and comparison (n = 73) groups. The teachers in the intervention group employed the *Solve It!* strategy instruction; the teachers in the comparison group were instructed to utilize their previous year's curriculum with no major adjustments to their instruction. Both groups had a mixture of average-achieving students and students identified with learning disabilities. Teachers who taught in the intervention group were provided with a three-day professional development before the start of the school year and were given scripted lesson plans to implement throughout the year. A subset of students in both the treatment and comparison groups were administered the Math Problem Solving Assessment (MPSA), a structured interview that asks students about their cognitive process in solving mathematical problems. All students were given content pretests at the beginning of the school year and posttests at the end of the school year.

Results from the posttests indicated that average-achieving students in the treatment group made improvements in mathematical problem solving (10.5% increase).

Students identified with learning disabilities in the treatment group also made gains in problem solving (12.2% increase). The comparison groups of average-achieving students and students with disabilities showed a slight decrease (1.3%) in posttest scores. The results showed that the cognitive strategy instruction had a positive effect on students' problem-solving abilities.

Surveys and focus groups following the administration of the MPSA showed that average-achieving students and students with disabilities in the treatment group used more cognitive strategies than did students in the comparison groups (Krawec et al., 2012). Furthermore, the students who received cognitive strategy instruction were more confident in solving problems than were students in the comparison group. The researchers argued that the emphasis on teaching students specific strategies to monitor their thinking and learn how and when to use those strategies shifted the students' focus from mastering basic recall of mathematical facts to applying broader concepts in the context of the problems (Krawec et al., 2012). Students therefore took a more active role in recalling knowledge while performing the steps to solve a problem.

Mnemonic Devices as Cognitive Strategy Instructional Tool

The results of Krawec and colleagues' study of Montague's (2003) *Solve It!* demonstrates that cognitive strategy instruction can be a possible intervention for students with disabilities in the mathematics classroom. This is because it provides students with the tools and training to build and reinforce their attention, memory, and metacognitive skills. An essential characteristic of successful problem solvers is their ability to focus on relational terms and concepts more than just on the numbers presented in the mathematical problem (Pape, 2003). Problem-solving instruction for students should include strategies that strengthen their ability to attend to relevant and important information and to recall procedures so that they can persist through the problem (Hutchinson, 1993; Impecoven-Lind & Foegen, 2010; Krawec & Montague, 2014; Manalo et al., 2000; Montague, 2003). Although teachers have had success with cognitive strategy instruction in the classroom, that does not guarantee that students would use these skills independently. Rather, teachers reported that students were more confident in employing the strategies under supervision (Impecoven-Lind & Foegen, 2010). If students were to use those strategies independently, they would need a tool to cue them to initiate and follow through on the metacognitive processes required to solve a problem (Manalo et al., 2000).

One method to help students employ cognitive strategies when problem solving is through the use of a mnemonic device. A mnemonic device is a technique that students can use to improve their ability to remember something (Levin & Levin, 1990); it is a memory technique to help the brain encode and recall important information. Some mnemonic devices are used to help students recall basic facts while others help students recall important rules, steps or procedures (Manalo et al., 2010). The latter is called a process mnemonic (Manalo et al., 2010). A process mnemonic can be used in mathematics as a prerequisite to employing cognitive strategies because mathematics emphasizes the execution of action sequences to solve a problem (Rosenzweig et al., 2011). A process mnemonic can also make mathematical problem solving more accessible to students with disabilities because it prompts students to initiate the problem-solving process with a personal and familiar word that the student can easily remember (Lombardi & Butera, 1998; Mastopieri, Scruggs, & Fulk, 1990; Mastopieri, Scruggs, &

Levin, 1987). Without a personal connection to the problem-solving processes, students with disabilities have a much more difficult time accessing their knowledge and attending to the important concepts and relevant information necessary to initiate the problem-solving process. When taught appropriately, process mnemonic devices help learners who are dependent on teacher support to become independent and active learners and to monitor their thinking about a problem (Manalo et al., 2000; Rosenzweig et al., 2011). Furthermore, process mnemonics can reduce mathematical anxiety, making students more willing to attempt word problem solving because it gives them a structure and roadmap to complete in order to arrive at an answer (Onwuegbuzie & Wilson, 2003).

Process mnemonics cue students to activate their thinking process and guide them to use the necessary cognitive tools to solve problems (Lombardi & Butera, 1998). Some process mnemonic devices can prompt a student confronted with a mathematical problem first to identify text information that is relevant to solving the problem and to differentiate it from irrelevant information (Impecoven-Lind & Foegen, 2010). This makes the students think about the goal of the problem by selecting and focusing his or her attention on the most essential and relevant parts of the problem. This initial step has historically been the biggest challenge for students with disabilities. But if a mnemonic device can be used to help students develop the skill to select and screen important information, then they have the opportunity to concentrate on what is relevant and necessary to solve the problem.

Process mnemonics also facilitate the activation of prior knowledge (Rosenzweig et al., 2011). Since word problems require students to apply basic mathematical facts to larger mathematical concepts, activation of prior knowledge is an important step in problem solving. If students can retrieve only the necessary mathematical facts based on the relevant information, then students will be more likely to think about how to use their previous knowledge for the problem. Once they recall the information they need to solve the problem, students can then access their memory about certain topics and then think about how to integrate this knowledge into a coherent representation that is meaningful for their understanding of the problem (Brissiaud & Sander, 2010). If students can represent their thinking about a problem in the form of written representation, they are more likely to see the connection of this representation to other, previous representations. This step will trigger students to think about the mathematical procedures that are needed to solve the problem while preventing them from engaging in spontaneous strategy production (Scruggs, Mastropieri, Berkeley, Marshak, 2010). Students who spontaneously use random strategies to solve problems are not able to focus their attention on the task; they are more likely to use concepts and irrelevant information that prevents them from problem solving successfully.

STARS **Mnemonic Strategy**

STARS is a process mnemonic device that assists students in activating their thinking about the procedures they need to solve a mathematical word problem (Curran & IRIS Center, 2003). Building on Polya's (1957) four-step problem-solving framework and Montague's (2003) *Solve It!* strategy, the *STARS* mnemonic strategy guides students through sequential steps to use and improve their cognitive skills so that they can translate abstract ideas into meaningful mathematical representations that are both personal and relevant to how they learn (Maccini & Gagnon, 2007; Manalo et al., 2000). *STARS* is an acronym; each letter represents a step toward solving a problem:

- **S**earch the problem for mathematical operations or skills by identifying key terms and concepts.
- **T**ranslate the problem into an expression or equation if necessary.
- **A**ttack the problem by solving for the unknown variable.
- **R**eview the solution and check your answer by…
- **S**ense: Does my answer make sense based on the original problem?

STARS can be generalized to many word problems because it is not specific to a particular mathematical topic. Its utility, rather, lies in the fact that it can be generalized to a variety of mathematical problems because the steps concentrate on activating and reinforcing students' cognitive abilities to start and work through problems. *STARS* prompts students think about the problem and focuses their attention on only the skills they need to solve the problem. Therefore, the *STARS* mnemonic device can help improve students' attention to only the ideas and concepts that are required to successfully problem solve.

Once students are able to isolate the mathematical concept and words that are at the center of the problem, they are more likely to activate their prior knowledge and memory about the given concept (Curran & IRIS Center, 2003; Geary, 2004; Rosenzweig et al., 2011). This is important because students who are unable to determine the difference between relevant and irrelevant information will focus their energy on ideas, processes, and numbers that will not help them achieve the correct answer (Maccini & Gagnon, 2007). The *STARS* mnemonic strategy does not necessarily improve students' memory; rather, it provides students with access to associate certain mathematical concepts with content knowledge so that they can concentrate their attention and energy on working with the correct information to solve the problem. This ability to associate topics with relevant information is beneficial because it allows students to apply their knowledge in a strategic, mathematically appropriate fashion. The continuous identification of certain words and its relationship with mathematical concepts is what will help students improve their memory about mathematics.

Translating mathematical concepts and key words into an algebraic equation can be problematic. Students can incorrectly translate concepts and words to form equations that will eventually give them incorrect answers (Pape, 2004; Yazadani, 2008). The first step in the *STARS* mnemonic strategy requires students to search the problem for key terms that are associated with concepts and operations, and the second step requires students to take this understanding and create an equation. Although students may incorrectly identify words and concepts and write incorrect equations, the *STARS* mnemonic strategy still allows students to complete the problem-solving process. Students can receive credit for persevering through the problem and showing work. Students who actively complete each step in the *STARS* mnemonic, even with the incorrect translation, have the opportunity to re-read and alter their equations based on understanding of the problem. This is because the Review and Sense steps of the mnemonic prompts students to reflect, analyze, and ask questions about their attempted solution and therefore allow students to revise their work.

The “Sense” step extends Polya’s (1957) four-step problem-solving procedure. Students who simply complete the “Review” step are completing Polya’s “Look Back” step. “Sense,” however, requires students to think about the original problem and analyze whether their solution is reasonable. This helps students engage their metacognitive skills because it makes them actively reflect on and analyze the outcome of the process and procedures they took to arrive at their solution. This is also the step in which students can recognize mistakes and go back to previous steps, adjust their equation or make corrections in computation, and reach a different, but perhaps more accurate solution. Polya's original fourth step simply asks students to "look back" and "examine their answer" (Polya, 1957, pp. ix) but does not encourage students to actively reflect, analyze, and monitor the solution in the same way *STARS* does.

The *STARS* mnemonic strategy can also serve as a checklist for students as they progress through the problem-solving process. Process mnemonics can serve as checklists that can remind students of the steps required to reach an answer (Mevarech & Amrany, 2008). Since *STARS* is a process mnemonic where each letter represents a step in the problem-solving process, students can use it as a checklist to keep track of their work and go back and correct their thinking about a problem if needed. The benefit of the last step in *STARS* is that it prompts students to think about whether or not the answer they get is a viable solution to the original problem (Wetzstein & Hacker, 2004). Students can re-evaluate their work, change their equation based a more correct understanding of the problem, and repeat the computational steps. *STARS* therefore helps students monitor their thinking and gives them opportunities to evaluate and confirm their work.

As students become accustomed to using the *STARS* mnemonic strategy to problem-solve, they will be able to independently replicate this process without teacher supervision (Hott, Isbell, & Oettinger Montani, 2014). The goal of cognitive strategy instruction is to train students to use their thinking skills to work through and persist in problem solving, and the *STARS* mnemonic strategy makes these thinking skills accessible to students with disabilities (Curran & IRIS Center, 2003; Lombardi & Butera, 1998). It also promotes the idea that these thinking skills are applicable to a variety of mathematical problems. When students see the usefulness of strategies, such as *STARS*, across a broad spectrum of topics and concepts, they are more likely to replicate this strategy to their benefit (Darling-Hammond et al., 2009). If students understand and experience the universal utility of the *STARS* mnemonic strategy in problem solving, then they will utilize the strategy each time they problem solve and therefore reinforce their cognitive skills.

Teacher Coaching

The previous section detailed the *STARS* mnemonic as a device that teachers can use to deliver cognitive strategy instruction. Despite growing evidence to integrate effective instructional strategies in the mathematics classroom, the level of implementation of such strategies is quite low (Reinke, Stormont, Herman, Newcomer, & King, 2014). Instructional interventions that are implemented with high fidelity are more likely to produce positive outcomes than instructional interventions with low fidelity (Durlak & Dupre, 2008). The application of effective instructional strategies can be due to minimal implementation practice during teacher preparation programs (Reinke et al., 2014). In particular, teachers report that their teacher training lacks opportunities to try instructional strategies in actual classrooms (Durlak & Dupre, 2008; Reinke et al. 2014). The literature review and results from the needs assessment study confirmed this challenge for newer special education teachers. Teachers need instructional support to ensure cognitive strategy instruction is implemented with fidelity in the mathematics classroom.

Providing new special education teachers with the supports and tools they need for effective strategy implementation can improve student achievement in mathematical problem solving. Coaching is a supportive professional development practice where a more veteran teacher works directly with a classroom teacher toward changing current instructional practices and improving a teacher's overall teaching skill (Denton & Hasbrouck, 2009). On-site coaching can provide guidance to teachers as they come to understand new curricula or seek to improve content knowledge (Durlak & Dupre, 2008). Essential components of effective teacher coaching include the modelling of effective instructional practices for the teacher, instructional rehearsal, and immediate classroom observation feedback (Darling-Hammond, 2009; Durlak & Dupre, 2008). Teacher coaching can therefore assist teachers in increasing their confidence by improving the teachers' abilities to instruct with effective practices while also improving students' perceptions of problem solving in mathematics. The frequency of the coaching can also ensure implementation fidelity (Solomon, Klein, & Politylo, 2012).

Sloan and Obara (2009) used a case study to investigate the role of mathematics coaching in providing instructional support during Georgia's implementation of new middle school mathematics standards. The study included 104 middle school mathematics teachers who participated in one of three professional development coaching groups: one group of teachers had no mathematics coaching, another group of teachers had less than 8 hours of mathematics coaching, and the last group had more than 8 hours of mathematics coaching. Selection into the groups was random. Teachers took a Likert-type, post-intervention survey to measure their self-perception of instructional ability. Teachers were also asked to identify the number of years they have taught mathematics.

Teachers' self-perceived ability to adapt instruction was regressed on hours of coaching and years of teaching experience. The amount of coaching was found to be statistically significant and positively related to teachers' perceived instructional ability (Sloan & Obara 2009). Moreover, the relationship between teachers' self-perception and instructional ability was the greatest for the group with 8 hours or more compared with the other two groups (Sloan & Obara, 2009).

The study suggested that teachers can benefit from long-term, site-based professional development programs that focus on improving instructional delivery and a deep understanding of student learning (Sloan & Obara, 2009). Although the study did not measure student achievement in relation to the number of hours teachers spent in coaching sessions, it does provide evidence for increasing teacher confidence and efficacy in instruction. As previously noted in this document, teachers who are confident in their instruction and their knowledge about mathematics and instruction are more capable of designing lessons that assist their students learn (Phillips, 2010; Torney-Purta et al., 2005). Their study could be provide more insight on student mathematical achievement if the researchers analyzed state test scores for the students of the participating teachers. A closer look at how coaching can impact student achievement is warranted now that Sloan and Obara's (2009) study indicated that coaching can support teacher confidence in instructional efficacy.

Campbell and Malkus (2011) investigated the impact of mathematics coaching on student standardized test scores in 36 urban and urban-edge schools in Virginia. The control-treatment study employed 12 instructional coaches to mentor and support newer mathematics teachers in the schools. Each coach was randomly assigned 3 schools that were geographically near each other. Coaching sessions included both group and individual sessions where coaches developed instructional content aligned with state standards, assisted teachers in analyzing student data and designing lessons, and provided feedback for future instructional growth. At the end of a three year period, scores for students who were in schools with mathematics coaches were significantly higher on Virginia's high-stakes standardized mathematics achievement test than their peer schools who were part of the control group. When looking at the data more closely, the researchers found that student scores from the first year of the study were not significant compared to student scores from the control group (Campbell & Malkus, 2011). However, student scores in the treatment group were consistently greater in the second and third year of the study than the control group. This suggests that continuous and ongoing coaching can have positive impacts on student achievement as demonstrated by standardized tests.

The mathematics coaches in the study engaged in substantive coursework and training before their placements in the treatment schools. Their training included but not limited to studies on learning theories, instructional modeling practices, how to give and receive feedback, etc (Campbell & Malkus, 2011). Moreover, this study was conducted in elementary schools so the authors caution about generalizing their findings to other school settings. The study, however, yielded critical components of coaching that should be applied regardless of the age group of the students or experience of the teachers. Specifically, coaches should not just be veteran teachers but teachers who are prepared to support teachers. Coaching should also be ongoing in order to make positive impacts on student achievement. This coincides with the research suggesting that coaching should be at least 30 hours in length and up to three years after a teachers' initial classroom placement (Corcoran et al., 2003; Darling-Hammond, 2009; Supovitz & Turner, 2000).

Conclusion

Students with disabilities show deficits in attention, memory, and metacognition (Geary, 2004; Impecoven-Lind & Foegen, 2010; Krawec & Montague, 2014; Maccini & Gagnon, 2007; Miller & Mercer, 1997). All of these deficits affect students' abilities to solve mathematical word problems. An intervention that targets these deficits is necessary if teachers want to prepare students for careers after high school and to raise their achievement levels. Both Polya's (1957) problem-solving framework and Montague's (2003) intervention study provided a structure for developing an improved intervention that concentrates on helping students with disabilities improve their success with word problems through attention, memory, and metacognition. The major difference between what has been previously implemented with mathematical problem solving and the *STARS* mnemonic strategy is that *STARS* provides students with an easy-to-remember device that prompts students to initiate the problem-solving process, persevere through the problem, and reflect and analyze to ensure they have reached an appropriate solution. Teacher coaching that includes the integration of the *STARS* mnemonic strategy with mathematical instruction can help teachers employ cognitive strategy instruction in the classroom by giving the students a tool that will make cognitive skills accessible to students so that they can activate their thinking independently of the teacher.

Research Problem

Students with disabilities at a charter high school in the Bronx, New York, score lower than their general education peers on the New York State Common Core Algebra

Regents Exam, an exam students must pass to graduate high school and earn a Regents Diploma. Recently, in 2015, New York indicated that the minimum score to be considered college- and career-ready was a scaled score of 70 on the Common Core Algebra Regents Exam, although a scaled score of 65 was considered to be passing (NYSED, 2015). As of the June 2016 administration of this exam, only 62% of students with disabilities have met or exceeded the score of 70, in comparison to 87% of their general education peers. Sixty-seven percent of students with disabilities passed the exam with a minimum score of 65. About one quarter of the students with disabilities are at risk of not graduating from high school in four years. Because the Common Core Algebra Regents Exam is focused on problem solving, students with disabilities need mathematical instruction that will prepare them to solve a variety of problems on the Common Core Algebra Regents Exam. An instructional intervention using the *STARS* mnemonic strategy will be implemented, and data will be collected to determine whether that intervention had positive impacts on student test scores.

Chapter 4

Intervention Procedure

The needs assessment study and intervention literature indicated that students with disabilities can benefit from mathematical instruction that is focused on strengthening their attention, memory, and metacognitive skills (Hutchinson, 1993; Impecoven-Lind & Foegen, 2010; Krawec & Montague, 2014; Manalo et al., 2000; Montague, 2003). Such instruction will improve their ability to problem solve (Montague, 2003). Teachers can also benefit by learning how to implement this instruction into their classrooms (Impecoven-Lind & Foegen, 2010). The goal of the *STARS* mnemonic strategy is multifaceted: to improve student passing rates on the Common Core Algebra Regents Exam, to increase students' confidence when problem solving, and to increase teachers' confidence with using effective instructional strategies for teaching problem solving. The *STARS* mnemonic strategy provides a framework to help students engage their thinking about a problem. As students become accustomed to using the *STARS* mnemonic strategy to problem solve, they should be able to replicate this process absent teacher supervision (Curran & IRIS Center, 2003; Hott et al., 2014; Lombardi & Butera, 1998). This chapter will present an overview of the purpose of the study, as well as the research design, participant selection, data collection, and data analysis.

Purpose of the Study

The purpose of this intervention study is to understand the impact of the *STARS* mnemonic strategy on student mathematical performance, as demonstrated by scores on the New York Common Core Algebra Regents Exam. The study also seeks to understand students' and teachers' perceptions of problem solving after the intervention is completed. The goal is for students to use the *STARS* mnemonic strategy to be successful in mathematical problem solving on the 2017 Common Core Algebra Regents Exam. Students must pass in order to graduate from high school. It was hypothesized that the *STARS* mnemonic strategy would help a greater proportion of students who have deficits in mathematics pass the Common Core Algebra Regents Exam in 2017 compared to similar students who took the exam in 2015 and 2016. It is also hypothesized that the teacher participants will feel more confident teaching Algebra because they will be implementing an intervention strategy that is meant to help students improve their attention, memory, and metacognitive skills. Progress toward those goals was analyzed through multiple data collection procedures. Those included Common Core Algebra Regents Exam scores, periodic informal student assessments, video observation of teachers implementing the *STARS* mnemonic strategy, teacher and student satisfaction surveys, and teacher and student focus groups. The research questions that guided the intervention study were:

RQ1: Will students with deficits in mathematics who experience the *STARS* mnemonic strategy during the 2016-2017 school year have a significantly higher pass rate on the Common Core Algebra Regents Exam compared to a comparison group of students from the previous two school years?

RQ2: To what extent do teachers follow the implementation of *STARS* mnemonic strategy instruction?

RQ3: What effect does *STARS* mnemonic strategy instruction have on students' perceptions of mathematical problem solving?

RQ4: What effect does *STARS* mnemonic strategy instruction have on teachers' perceptions of students' mathematical problem solving?

Method

This section will describe the research design, participants, the setting, instruments, data collection, and data analysis procedures for the chosen intervention.

Research Design

The *STARS* mnemonic strategy addressed the need for teachers of students with disabilities to understand and integrate instructional strategies to help students improve their problem-solving skills. The intervention occurred during the spring of the 2016-2017 school year. Teacher and student participant selection was based on findings from a needs assessment study that was administered during the 2014-2015 school year and on student academic needs from the 2016-2017 school year.

The study used a non-equivalent control group quasi-experimental design. The purpose of the study was to determine if students who have deficits in mathematics and who experienced the *STARS* mnemonic strategy passed the Common Core Algebra Regents Exam in 2017 with a greater proportion than did similar students who took the Exam in 2015 and 2016. The selection of students was not randomized. Approximately 44 students enrolled in four self-contained Algebra classrooms taught by two teachers during the 2016-2017 school year were invited to participate in the study as the treatment group. Common Core Algebra Regents Exam scores of students who had been enrolled in self-contained Algebra classrooms for the 2014-2015 and 2015-2016 school years were used as the comparison group. Students in the treatment group participated in review classes to learn and practice using the *STARS* mnemonic strategy when problem solving.

Then, their scores from the June 2017 Common Core Algebra Regent Exam were recorded and compared to the comparison groups' scores from earlier years to determine if a greater proportion of treatment students passed the exam.

Implementation Fidelity

Monitoring implementation fidelity was needed to ensure teachers were incorporating the *STARS* mnemonic strategy according to their lesson plans. Research suggests that the efficacy of an instructional method is enhanced when there is a means to implement it effectively and with integrity (Krawec & Montague, 2014; Moyer-Packenham, Bolyard, Oh & Cerar, 2011). Video recordings of teacher participants were used to assess the delivery of the instructional intervention and to determine if changes in instruction were needed to improve student problem solving and test scores (Nagro & Cornelius, 2013). The teacher coach evaluated and rated teacher delivery of the *STARS* mnemonic strategy by watching the video recordings of the review classes and assigned a 1 (not effective), 2 (effective), or 3 (highly effective) to each component of the lesson based on a teacher evaluation rubric that was designed for this intervention study (see Appendix E). Sample lesson plans that were used in this intervention study can be found in Appendix F.

The teacher coach provided a debriefing of the lesson during the subsequent coaching sessions. The teacher coach showed the teacher the video and they reflected together on the instructional delivery. If a teacher received a 1 (not effective) or 2 (effective) on any components of the teacher evaluation rubric, the teacher coach addressed the component(s) and worked with the teacher to improve instruction for the next Essential Skills Review Class. The teacher coach acknowledged 3 (highly effective) ratings and encouraged teachers to continue their instructional behaviors for those components.

Participants

Treatment students. Approximately 44 students who were enrolled in four ninth-grade self-contained Algebra classes were invited to participate in the study. Eligibility criteria for participants enrolled in the self-contained Algebra classes included having either an IEP or a score below the 30th percentile on the Measure of Academic Progress (MAP) exam. All current ninth-grade students had taken the MAP exam at the end of their eighth-grade year. Students who scored at or below the 30th percentile on the MAP exam are determined to need special instruction for mathematics, regardless of their IEP status. Thirty-eight students had an IEP while 8 students did not have an IEP but who scored in the lower 30th percentile on the MAP exam. No students had a 504 plan. Students participating in the study who had an IEP were classified as having a high incidence disability such as a learning disability, speech and language impairment, emotional disturbance, or other health impairments. Five students were identified as English Language Learners (ELL) and six students were identified as former English Language Learners (FELL). Twenty-one students identified as Black and 23 students identified as Hispanic/Latino. Thirty-six students qualified for free or reduced lunch. Twenty-six males students and 18 female students participated. The students were randomized into one of four self-contained Algebra classes for the purpose of the intervention study.

Comparison students. A total of 51 students from school years 2014-2015 (n = 27) and 2015-2016 (n = 24) who attended a self-contained Algebra class with typical instruction served as the comparison group. Similar to the treatment group, these students had an IEP and/or scored below the 30th percentile on the MAP test at the end of their eighth-grade year and placed in a self-contained Algebra class.

Teachers. Two special education teachers were selected to deliver the intervention. Both teachers were certified in special education but were not certified in mathematics. Both teachers had fewer than four years of teaching experience; neither had an academic background in mathematics nor a career background related to mathematics.

Teacher coach. The teacher coach was dually certified in Special Education and Mathematics for grades 7-12. The teacher coach had seven years of experience teaching Algebra to students with disabilities and two years' experience mentoring new teachers. The teacher coach has been identified as a master teacher by the school for exemplary teaching and positive results on student learning as demonstrated by test scores. The teacher coach was the experimenter in this intervention.

Setting

The intervention study occurred at an urban public charter high school in the Bronx, New York. The school is medium-sized, with approximately 1,100 students from grades 9 through 12. For the 2016-2017 school year, 87% percent of the students were eligible for free or reduced-price lunch, and 21% of the students had an IEP. The most prevalent classification on an IEP is learning disabilities (84%). Others classifications include speech and language impairment (7%), emotional disturbance (5%), and other health impairments (4%). The school has a student population that identifies as 50% Hispanic/Latino, 49% African-American, and 1% Asian.

The school where the intervention study took place increased the ninth grade enrollment during the 2016-2017 school year. This could account for the larger sample of students who were eligible to participate in the intervention study.

The charter high school is known nationally for its high academic standards and a 99% graduation rate. As of June 2016, the school had a 97% college matriculation rate. The school has an extended school day; students attend classes for approximately nine hours each day. Many students arrive early to school or stay after school hours to participate in small-group tutoring from their teachers or peers. Other efforts to increase student achievement include incentives such as enrichment field trips for earning high grades in classes and State tests, recognition in local newspapers, and occasional free dress days for students earning a 3.5 out of a 4.0 grade point average.

Curriculum. New York State implemented the Common Core Algebra Curriculum during the 2013-2014 school year. Teachers at the charter school have broken down the Common Core Algebra curriculum into 13 different units. Within the 13 units, the Mathematics Department at the school identified eight essential mathematical skills, which, if mastered, would help students initiate and solve Common Core Algebra problems. According to the Algebra teachers, these essential skills were taught at the middle school level, yet students struggle to employ these skills to solve more complicated Algebra problems. These essential skills include: solving equations, performing operations with fractions, understanding operations in a problem, graphing linear equations, identifying characteristics of horizontal and vertical lines, multiplying integers, performing operations with exponents, and identifying when to factor quadratics. These essential skills were taught in previous years but without the *STARS* mnemonic strategy.

Instruments

Common Core Algebra regents exam. Students took the Common Core Algebra Regents Exam on June 13, 2017. The students received a scaled score ranging from 0 to 100. The New York State Education Department requires students to receive a minimum scaled score of 65 to pass the exam.

Teacher evaluation rubric. Teachers' instruction was evaluated according to a rubric designed for this intervention. The rubric for teacher evaluation was adapted from the KIPP Framework for Excellent Teaching (KFET; see Appendix E). Various instructional coaches and leaders from the national KIPP network designed the framework (2014) to reflect four components that contribute to student growth and achievement: self and others, classroom culture, the teaching cycle, and knowledge. Specifically, this study adapted the rubric for teacher evaluation from the KIPP teaching cycle. The teaching cycle evaluates a teacher's lesson delivery from the warm-up problem in the first five minutes of class through the lesson introduction, guided practice, and independent student practice. It finishes by assessing the closing of the lesson and final assessment. The teaching cycle section of the framework includes evaluation of lesson planning and instructional feedback. The school's mathematics department head and the Assistant Principal of Instruction trained the teacher coach to evaluate teachers. The teacher coach was evaluating teachers for two years prior to the intervention study.

Student exit tickets. At the end of the third, fifth, and eighth Essential Skills Review Classes, students were asked to answer an algebra problem on an Exit Ticket, a one-question, informal assessment on a topic not covered in the review class (see Appendix G). The question on each of the three Exit Tickets was an actual past Common Core Algebra Regents question. The first two Exit Tickets had scaffolded prompts next to the problem based on the *STARS* strategy. The Exit Ticket for the eighth day had no prompts. Teacher participants verified whether students used the *STARS* mnemonic strategy to help them problem-solve. The Exit Tickets allowed teacher participants to determine if they needed to adjust their lessons to address student deficits with the strategy. Teachers were instructed to de-identify student work before discussing the Exit Tickets with the teacher coach.

Student satisfaction survey. Students took a post-intervention survey at the conclusion of the study (see Appendix H). The survey asked the students to what extent they agreed with statements regarding their use of strategies, such as the *STARS* mnemonic strategy, to problem-solve. They selected their level of agreement on a Likert Scale where 1 indicated that they strongly disagreed with the statement and 5 indicated that they strongly agreed with the statement. The student survey was adapted from the NYC Schools Survey that is given to all students in grades 6-12 in the NYC public school system including those in public charter schools (NYC Department of Education [NYCDOE], 2015a). The survey also took elements from the internal student satisfaction survey that the charter school administers twice a school year.

Student focus groups. Students were invited to participate in a focus group on the last day of the Essential Skills Review Classes. The focus groups provided an opportunity to gather qualitative data and explore issues that cannot be reported on surveys. It also allowed the experimenter to ask questions on the spot and explore student thoughts about the *STARS* mnemonic strategy more deeply than in the surveys. Some examples of the questions from the focus group include, “How does the *STARS* mnemonic strategy help you solve math problems?” “Why do you think your teacher taught you about the *STARS* mnemonic strategy?” and “How successful do you feel at problem-solving.” Additional questions can be found in Appendix I.

Teacher satisfaction survey. The teachers took a post-intervention survey following the conclusion of the last Essential Skills Review Class. The teacher survey focused on statements about teaching problem-solving strategies, including the *STARS* mnemonic strategy, and their experience with the coaching sessions (see Appendix J). Teachers selected their level of agreement on Likert Scale where 1 indicated that they strongly disagreed with the statement and 5 indicated that they strongly agreed with the statement. The teacher survey was adapted from the NYC Schools Teacher Survey that is given to all teachers in the NYC public school system including those in public charter schools (NYCDOE, 2015b). The survey also took elements from the internal teacher satisfaction survey that the charter school administers twice a school year.

Teacher focus group. The teacher participants also participated in a focus group following the completion of the final Essential Skills Review Class. Similar to the student focus group, the teacher focus group allowed to gather qualitative data that cannot be reported on surveys. The teacher coach asked questions about the teachers’ experience with the *STARS* mnemonic strategy instruction and their experience with the coaching sessions. Some examples of the questions from the focus group include “How do you think the *STARS* mnemonic strategy improved students’ problem-solving skills?” “Explain how you felt using the *STARS* mnemonic strategy as a teaching method?” and

"How do you think the coaching sessions helped you improve your instruction?" Additional questions can be found in Appendix K.

Procedure

Teacher participants instructed the student participants using the *STARS* mnemonic in eight Essential Skills Review Classes during their Algebra class time. Prior to each Essential Skills Review Class, teachers met individually with the teacher coach for two coaching sessions. One 40-minute coaching session to write the lesson plan that included the *STARS* mnemonic strategy occurred five school days before each Review Class. The second coaching session was used to practice instruction with the *STARS* mnemonic strategy and occurred two days before each Essential Skills Review Class. The teacher coach and teacher participants had to reschedule coaching sessions due to school priorities. Each of the eight Essential Skills Review Classes was video recorded and used in the coaching sessions to help improve teacher instruction of the *STARS* mnemonic strategy. Details of the study are described below.

Coaching sessions. Teachers initially met with the teacher coach (the experimenter of the study) for an initial coaching session to preview the lesson design format and protocols for instruction with the *STARS* mnemonic strategy. In preparation for the intervention, teachers met with the teacher coach five school days prior to each of Essential Skills Review Classes. These coaching sessions lasted for approximately 40 minutes. Together, the teacher and teacher coach designed a lesson plan that integrated the *STARS* mnemonic strategy with a specific Essential Skills topic. The teachers and the teacher coach used a template lesson plan that followed the format of the teaching cycle in the school's Framework for Excellent Teaching: warm-up problem, introduction to the mnemonic strategy, guided practice with the mnemonic strategy, independent practice with the mnemonic strategy, and a final class assessment. Lesson Plans that were used in the Essential Skills Review Lessons can be found in Appendix F. Some of these lessons were further adapted and modified for each teacher leading up to the lesson depending on their strengths and areas for instructional growth. The coaching sessions referenced the teacher evaluation rubric to ensure that teachers understood what was expected from their instruction.

The teachers and the teacher coach met once more two days prior to each Essential Skills Review Class. An integral part of the coaching session was the modeling of the *STARS* mnemonic strategy to the teacher participants. The modeling of effective strategy instruction can increase teachers' confidence in the using the strategy with their instruction (Garet, Porter, Desimone, Birman, & Yoon, 2001). The teachers practiced delivering instruction using the *STARS* mnemonic strategy, and the teacher coach gave instructional feedback. This session also lasted approximately 40 minutes. The teachers then had the opportunity to revise lesson plans.

Mnemonic strategy instruction. *STARS* is a process mnemonic that assists students in activating their thinking about the procedures they need to solve a mathematical problem (Curran & IRIS Center, 2003). Process mnemonics guide students through sequential steps so that they can use their cognitive skills to translate abstract ideas into meaningful mathematical representations that are both personal and relevant to how they learn (Maccini & Gagnon, 2007; Manalo et al., 2000). In the designated review classes, the *STARS* mnemonic was used as the main instructional strategy. *STARS* is an easy-to-memorize acronym in which each letter represents a step to solving a problem:

- **S**earch the problem for mathematical operations or skills by identifying key terms and concepts.
- **T**ranslate the problem into an expression or equation if necessary.
- **A**ttack the problem by solving for the unknown variable.
- **R**eview the solution and check your answer by…
- **S**ense: Does my answer make sense based on the original problem?

The first step, represented by the letter "S," is the most important. It requires students to read the problem and identify a key term or terms that will trigger their prior knowledge about the relationship between the key word(s) and its/their associated mathematical operation (Pape, 2003; Pape, 2004). Students were instructed to look for a key term or terms specific to the language used in the Common Core Algebra curriculum (this language has also appeared on previous Common Core Algebra Regents Exams). Students created graphic organizers in their notebooks to include key terms associated with each topic of the Essential Skills Review Classes. Identifying key terms is an important step in the problem-solving process because it helps students strengthen their understanding of the problem and the mathematical operations to which these key terms relate (Montague, 2003). Research has found that key-term instruction has been problematic for mathematical problem solving because students may often commit a reversal error, the use of an opposite operation for the identified term (Pape, 2003; Pape, 2004). Although reversal error is problematic and can lead students to obtain an incorrect answer, the purpose of the *STARS* mnemonic strategy is to prompt students to initiate and persist in problem solving. The last step of the *STARS* mnemonic encourages students to think about their answer in the context of the problem and this is where students can recognize their reversal error and change the original equation if necessary.

Once students identified the key term and related them to the appropriate operation, they then followed the next steps in the *STARS* mnemonic strategy to solve the problem. When students used the *STARS* mnemonic strategy to guide them through the problem-solving process, they activated their cognitive skills, such as planning, implementing, verifying, and self-monitoring, to reach a solution. Improvement in these cognitive skills indicates that the students are becoming expert problem solvers (Schoenfeld, 1992).

Essential skills review class. The eight essential skills are skills required to solve mathematical problems. They coincide with major curriculum strands in the first seven units of the typical Common Core Algebra curriculum. There was one Essential Skills Review Class for each of the first seven units, with the exception of Unit 1, which had two Essential Skills Review Classes. The purpose of these Essential Skills Review Classes was to teach students how to read problems and recognize when they need to use the essential skills to initiate and solve Common Core Algebra problems. The review classes were scheduled approximately two weeks apart, beginning in Spring 2017. They replaced the review classes for the Common Core Algebra Regents Exam that normally would have occurred. A timeline of the Essential Skills Review Classes and their topics are presented in Table 4.1.

Table 4.1

Essential Skills Review Class Timeline and Topics

Essential Skill Topic *(subtopic)*	Unit #	Timeline
Basics of Algebra *(solving equations)*	1	March 29, 2017
Basics of Algebra *(operations with fractions)*	1	April 5, 2017
Identifying Functions *(understanding operations within functions)*	2	April 12, 2017
Linear Functions *(solving and graphing lines)*	3	April 26, 2017
Piecewise Functions *(horizontal and vertical lines)*	4	May 3, 2017
Systems of Linear Equations *(multiplying integers)*	5	May 17, 2017
Exponential Functions *(operations with exponents)*	6	May 31, 2017
Polynomial and Quadratics (*identifying three ways to factor*)	7	June 7, 2017

The Essential Skills Review Classes followed the same structure as normal mathematics classes but used the *STARS* mnemonic strategy as the main component of instruction. The teachers started the classes with a warm-up problem that the students completed independently within the first five minutes of class. Warm-up problems were consistent with the mathematical topic in Essential Skills Review Class for that day but were less rigorous. The teacher coach and the teacher participants decided that the warm-up problems should be problems where students get correct to build their mathematical confidence. The teachers then introduced the *STARS* mnemonic strategy during a 10-15-

minute mini-lesson. They explained the procedure that was associated with each letter in *STARS*. An introduction to the *STARS* mnemonic occurred on the first Review Class day. Teachers reviewed the mnemonic in subsequent Review Classes during the first 10-15 minutes of class. Teachers then demonstrated the step-by-step process using each of the letters in the *STARS* mnemonic to solve a problem. Once the modeling was complete and all student questions were answered, students had approximately 10 minutes to try one or two mathematical problems using the *STARS* mnemonic strategy. The teacher monitored students' work and assisted students as needed. The teacher engaged students in conversations about how they were using the *STARS* mnemonic strategy and the purpose for using the steps in the mnemonic. Then the teacher brought the students back to full-class instruction and debriefed with them. After that, students had the opportunity to work independently or with another student on problems while the teacher targeted students who were having difficulties with the mnemonic and/or problem solving. Teachers consistently reminded students to use the *STARS* mnemonic strategy. As the class ended, students engaged in a whole-class conversation about the benefits of the *STARS* mnemonic strategy, and then completed an Exit Ticket. The Exit Ticket consisted of one mathematics problem that the students were asked to solve using the *STARS* mnemonic strategy. The students submitted the Exit Ticket to the teacher.

Data Collection

Data collection for this mixed methods research design included collecting qualitative and quantitative data concurrently and then integrating them to explain the results (Creswell & Clark, 2011). Data were gathered through several instruments: Exit Tickets, scores from the Common Core Algebra Regents Exam, Student and Teacher

Surveys, and Student and Teacher Focus Group discussions (see Table 4.2). All data were stored in a separate folder and stored in the teacher coach's office cabinet. Teacher and student surveys conducted at the end of the intervention were kept in the same location until they were needed for analysis. All surveys and focus group responses were anonymous to insure confidentiality. The teacher participants de-identified the surveys or the Exit Tickets if students identified themselves before handing them over to the teacher coach for collection and analysis.

Table 4.2

Intervention Mixed Methods Data Collection and Timeline

Measure *(variable measured)*	Quantitative	Qualitative	Data collection type	Timeline
Common Core Algebra Regents Exam *(student mathematical performance)*	X		Test Score	June 15, 2017
Teacher Video Observation *(implementation fidelity)*		X	Observation	Selective observation
Student Survey *(student satisfaction)*	X		Written survey	May 25, 2017
Student Focus Group *(student satisfaction)*		X	Interview	May 25, 2017
Teacher Survey *(teacher satisfaction)*	X		Written survey	May 25, 2017
Teacher Focus Group *(teacher satisfaction)*		X	Interview	May 26, 2017

Common Core Algebra Regents Exam. Teachers received the scores of the Common Core Algebra Regents Exam on June 15, 2017. Students received a scaled score from 0-100. The school's data manager then entered the scores into a spreadsheet and filtered the results to separate the scores of the students who participated in the study. The data manager removed individually identifiable information from the spreadsheet and electronically delivered the results of the students who participated in the intervention to the teacher coach. The teacher participants and the teacher coach then counted the number of students who passed and failed. For the purpose of this intervention study, only pass/fail results were analyzed.

Student exit tickets. At the end of the third, fifth, and eighth Essential Skills Review Classes, the teachers gave students an informal assessment with a mathematics problem that was not related to the Essential Skills Review Class topic. Teachers collected those Exit Tickets and checked to see if the students used the scaffolded prompts, checklists, and other tools taught during the intervention lessons.

Student satisfaction surveys. Satisfaction surveys were given to students at the conclusion of the last Essential Skills Review Class. The teacher participants explained to the students the purpose of the survey and instructed students not to identify themselves on the survey. The survey took approximately 3 minutes to complete. The teacher participants collected the student surveys, de-identified any surveys with student names, and handed the surveys to the teacher coach.

Student focus groups. A student focus group was administered after school on the final day of the intervention study, during the students' mandatory study hall. A Study Skills teacher conducted the focus group and asked students about their experience with the *STARS* mnemonic strategy and whether or not they felt this strategy helped them solve problems. The Study Skills teacher recorded responses anonymously on the free software VoiceRecorder.

Teacher satisfaction survey. The teacher participants took the teacher satisfaction survey at the beginning of the final coaching session. The teacher coach explained to the teachers the purpose of the survey.

Teacher focus group. The two teachers who participated in the intervention study also participated in a focus group. This occurred immediately following the teacher satisfaction survey. The teacher coach conducted the focus group and recorded the teachers' responses on the free software, VoiceRecorder, and also took handwritten notes.

Data Analysis

Four data points were analyzed in this study: (a) the number of students who passed the Common Core Algebra Regents Exam in June 2017 compared to similar students from 2015 and 2016, (b) teacher fidelity of the delivers of the *STARS* mnemonic strategy intervention, (c) teacher and student satisfaction surveys, and (d) teacher and student focus group responses. Table 4.3 describes in detail the types of data analysis that was used as well as the research questions they helped to answer.

Table 4.3

Research Questions, Data, Timeline, Analysis

Research Questions	Data	Collection Timeline	Analysis
Will students, with deficits in mathematics, who experience the *STARS* strategy during the 2016-2017 school year have a significantly higher pass rate on the Common Core Algebra Regents Exam compared to a control group of students from the previous two school years?	Common Core Algebra Regents Exam	June 13, 2017	Chi-Square Test of Independence
To what extent do teachers follow the implementation of the *STARS* mnemonic instruction?	Teacher Evaluation	March – May 2017	Scheduled Observations
What effect does *STARS* mnemonic strategy instruction have on students' perceptions of mathematical problem solving?	Student Survey Student Focus Group	May 25, 2017	Descriptive Statistics Inductive Thematic Analysis
What effect does *STARS* mnemonic strategy instruction have on teachers' perceptions of students' mathematical problem solving?	Teacher Survey Teacher Focus Group	May 25, 2017 May 26, 2017	Descriptive Statistics Inductive Thematic Analysis

Statistical tests. Student test score data was analyzed through a chi-square test of independence to compare pass/fail scores from the June 2017 Common Core Algebra Regents Exam to the pass/fail scores from the June 2015 and June 2016 Common Core Algebra Regents Exam. The median score for each component of the Essential Skills Review Class were calculated over all observations. Teachers who were rated with at least a 2.5 median score over all observations were considered to have implemented that class component with fidelity. The total number of responses for each statement on the student and teacher survey was recorded and the percentage of each agreement or disagreement was calculated.

Qualitative coding. Recordings of the focus groups were transcribed and then uploaded to the free coding and analysis software DeDoose. The data were analyzed using an inductive coding process (Thomas, 2006). Data were coded based on topics from the literature review findings, such as beliefs about instructional quality, student perception of teacher quality, teacher perception of students' problem-solving, among other themes. The experimenter was open to coding new themes that emerged from the intervention study.

Conclusion

The literature review and needs assessment study informed the design and implementation of the *STARS* mnemonic strategy intervention. The purpose of the intervention was to support and improve teacher instruction of important problem-solving skills and increase student passing rates on the Common Core Algebra Exam. It also sought to improve student and teacher perception of problem-solving skills. The research questions guided the data collection and analysis. This chapter provided an overview of the *STARS* mnemonic strategy, the purpose of the study, implementation procedures, data collection, and analysis. The next chapter will describe major findings from the *STARS* mnemonic strategy intervention that took place in an urban public charter high school in the Bronx during the Spring semester of the 2016-2017 school year.

Chapter 5

Results and Discussion

The purpose of this dissertation was to examine the impact of the *STARS* mnemonic strategy on student pass rates for the Common Core Algebra Regents Exam. The intervention study also set out to determine if the coaching component of the *STARS* mnemonic strategy improved teachers' perception of teaching and student problem solving. Students' perception of their teacher's instruction and their own problem solving were also examined through surveys and focus groups. This chapter presents the results for each research question, discussion of the findings, theoretical implications, implications for practice, recommendations for future research, and limitations.

RQ1: Will students with deficits in mathematics who experience the *STARS* mnemonic strategy during the 2016-2017 school year have a significantly higher pass rate on the Common Core Algebra Regents Exam compared to a comparison group of students from the previous two school years?

RQ2: To what extent do teachers follow the implementation of *STARS* mnemonic strategy instruction?

RQ3: What effect does *STARS* mnemonic strategy instruction have on students' perceptions of mathematical problem solving?

RQ4: What effect does *STARS* mnemonic strategy instruction have on teachers' perceptions of students' mathematical problem solving?

Common Core Algebra Regents Exam Results

The Common Core Algebra Regents Exam was administered on June 13, 2017. The pass/fail results for 2017 were compared to the pass/fail results in 2015 and 2016

(Table 5.1). Students who earn a passing score of at least 65 have met the New York State graduation requirements for graduation so this intervention study only examined the pass/fail results. A total of 44 students participated in the intervention study, missing one student from the exam.

Table 5.1

Comparison of Common Core Algebra Exam Score Results from 2015 & 2016, and 2017

	2015 *N (%)*	2016 *N (%)*	2017 *N (%)*	Total *N (%)*
Pass	20 (74.1)	12 (50)	31 (72.1)	63 (100)
Fail	7 (25.9)	12 (50)	12 (27.9)	31 (100)
Total	27 (100)	24 (100)	43 (100)	94 (100)

A chi-square test of independence was performed to examine the relationship between pass/fail results for the comparison and intervention study groups. The relation between these variables was not significant, [χ^2 (df = 2, N = 94) = 4.254, p = .1192].

Students with deficits in mathematics, who experienced the *STARS* mnemonic strategy during the 2016-2017 school year, did not have a significantly higher pass rate on the Common Core Algebra Regents Exam compared to the combine student results from the previous two school years.

Implementation Fidelity

The research question related to teacher implementation fidelity was answered by examining the values of Teacher Ratings from the Teacher Evaluation Rubric. The median rating for each component over all eight Essential Skills Review Classes is presented in Table 5.2 for Teacher A and Teacher B. Teachers were rated based on the Teacher Evaluation rubric that was adapted for this intervention study.

Table 5.2

Median Teacher Ratings for Essential Skills Review Class Components

	Teacher A *Mdn*	Teacher B *Mdn*
Essential Skills Review Lesson with *STARS* Mnemonic Strategy (planning)	3	3
Teacher Use of Supporting Materials	2.5	3
Warm-Up Problem	3	2.5
Introduction to Mnemonic Strategy	3	3
Demonstration of Mnemonic Strategy	3	3
Student Practice with Mnemonic Strategy with Teacher Guidance	3	3
Independent Student Practice with Mnemonic Strategy	3	3
Exit Ticket/Check for Understanding	3	3
Timing	2.5	2.5

The rubric consisted of eight class components: Essential Skills Review Lesson with *STARS* Mnemonic Strategy, Teacher Use of Supporting Materials, Warm-Up Problem, Introduction to Mnemonic Strategy, Demonstration of Mnemonic Strategy, Student Practice with Mnemonic Strategy with Teacher Guidance, Independent Student Practice with Mnemonic Strategy, Exit Ticket/Check for Understanding, and Timing. A score of 1 indicated that the teacher was ineffective with delivering the class component. A score of 2 indicated that the teacher was effective with delivering the class component. And a score of 3 indicated the teacher was highly effective with delivering the class component. Teachers who were rated a 3 for a class component followed the lesson plan as intended but may have adequately adjusted their lesson delivery to accommodate student learning needs.

Both Teacher A and Teacher B were rated a 3 on five components: Essential Skills Review Lesson with *STARS* Mnemonic Strategy, Introduction to Mnemonic Strategy, Demonstration of Mnemonic Strategy, Independent Student Practice with Mnemonic Strategy, and Exit Ticket/Check for Understanding.

At least one teacher was rated a 2.5 on the components Teacher Use of Supporting Materials and Student Practice with the Mnemonic Strategy Under Teacher Guidance. Teachers asserted that they would like to work on these areas of instruction for future lessons (June, 2017). Both teachers received a median score of 2.5 on the Timing component over all the observations.

Students' Perception of Mathematical Problem Solving

Students perception of mathematical problem solving was measured by the values of Student Satisfaction Survey responses post intervention and responses in the Student Focus Group. Students completed a post-intervention Likert-type survey rating the extent to which they agreed with six statements about their learning and mathematical problem solving. Table 5.3 presents the results from the students' post-intervention survey. The sample size for this survey (N = 44) reflects the total number of student participants, even though one student was absent from the Common Core Algebra Regents Exam in June 2017.

Table 5.3

Student Satisfaction Survey Results: Post-Intervention

	Strongly Disagree *N (%)*	Disagree *N (%)*	Neutral *N (%)*	Agree *N (%)*	Strongly Agree *N (%)*
My teacher understands how I learn.	0 (0)	1 (2.3)	7 (15.9)	15 (34.1)	21 (47.3)
My teacher teaches me how to use strategies to solve a math problem.	0 (0)	1 (2.3)	2 (4.6)	20 (45.5)	21 (47.7)
My teacher uses strategies that are easy to understand.	0 (0)	1 (2.3)	9 (20.4)	13 (29.6)	21 (47.7)
I like using the strategies my teacher teaches me.	3 (6.8)	6 (13.6)	10 (22.7)	13 (29.6)	12 (27.3)
I think the strategies my teacher teaches me help me learn.	0 (0)	1 (2.3)	5 (11.6)	18 (41.9)	19 (44.1)
My teacher uses written or oral explanations to help me learn.	0 (2.3)	1 (2.3)	3 (6.8)	15 (34.1)	25 (56.8)

Most students (80 to 90%) agreed or strongly agreed to five of the statements in the student satisfaction survey. The statement, "I like using the strategies my teacher teachers me," was the only statement where students (n = 3) strongly disagreed. This statement also received a higher number of students (n = 6) who disagreed than any other statements.

Qualitative data about students' perceptions of mathematical problem solving were collected through focus groups. Table 5.4 presents selected student responses to focus group questions. Three themes emerged: Strategy Knowledge and Application, Mathematical Knowledge, and Student Satisfaction. Results from the needs assessment study and literature review provided a framework for coding major themes. Both the teacher participants and the teacher coach reviewed the student responses and agreed on the themes the quotes represented.

Table 5.4

Student Focus Group Responses – Selected Quotes

	Student Quotes
Strategy Knowledge and Application	"I think *STARS* helped me problem solve because it made me focus on what the question wanted me to do. There were steps I needed to do in order to solve a problem, and I never realized how many steps there were until I saw *STARS*. I didn't know I had to do that much thinking for a problem, but now I feel like I can actually solve a problem." "When I see a really long and wordy problem, I know I have to use *STARS*. I can complete homework assignments now and not get incompletes. I can also show my teacher that I am using each step because I check them off, and she can see where I am at in the problem. She can give me points for trying. I do this for tests, too." "Before, we were taught that if we were doing a quadratic, we had to do this step and that step. It was too much for me to memorize. But now, it's like, this is how you have to think about a problem." "Because I have these steps, I remind myself what task I need to do or if I got stuck, I knew exactly where I got stuck." "I liked how she showed us the strategy. It was very clear to me how I can use it to solve a problem." "I never learned about the 'sense' part. No one has taught me to reflect on my answer like that before. I would either plug my answer back in and see if my equation worked out." "I like *STARS*, but I am not sure I actually need to write it down in order to use the strategy." "I know I can at least do something for a problem and not leave it blank."
Mathematical Knowledge	"My homework grades increased after I started using *STARS*." "I started to see which math showed up over and over again in the problems so I knew which operations to use when I saw certain words." "Before this, I rushed through the problems without asking if my answers were correct. That Sense part was really important for me." "I know when I see 'growing exponentially' I know that we are dealing with exponential functions and that my equation has to look a certain way. I know where to put the numbers in the equation." "If the problem asked me to find the number of meters from here until the wall, I know I had to get a number that is positive. You can't have negative meters in a distance problem. You could, but it's not realistic so your answer would be wrong."
Student Satisfaction	"Yeah, I like it. But I know I don't have to write down *STARS* every time I use it." "I like using *STARS* because it reminds me that I can actually do math." "We already do *STARS*, but it just hasn't been presented to us like this before." "I don't see the need to use it (STARS)."

Strategy knowledge and application. Students found different parts of the *STARS* mnemonic strategy to be helpful. Student A shared,

> I think *STARS* helped me problem solve because it made me focus on what the question wanted me to do. There were steps I needed to do in order to solve a problem, and I never realized how many steps there were until I saw *STARS*. I didn't know I had to do that much thinking for a problem, but now I feel like I can actually solve a problem (June 2017).

Problem solving is a process, and the *STARS* mnemonic strategy helped students see mathematical problems as multi-step and dynamic. This student's response showed that the strategy made problem solving more accessible for students with deficits in mathematics because it provided them with a specific tool for solving problems. For some students, the strategy provided a guide for their thinking, "Because I have these steps, I remind myself what task I need to do or if I got stuck, I knew exactly where I got stuck" (Student D, June 2017). The strategy provided structure for student thinking and allowed each student to attempt problems by initiating the problem-solving process.

Mathematical knowledge. Additional responses from the student focus groups revealed that the *STARS* mnemonic strategy allowed students to initiate and complete the problem-solving process. One student explained, "I know I can at least do something for a problem and not leave it blank" (Student C, June 2017). Another student agreed with Student C. He explained that he feels more confident in approaching problems because he received higher scores on homework assignments and quizzes after using the *STARS* mnemonic strategy (Student D, 2017). Students who found the *STARS* mnemonic strategy helpful asserted that they could complete problems on homework, quizzes, and tests more readily than before:

> When I see a really long and wordy problem, I know I have to use *STARS*. I can complete homework assignments now and not get incompletes. I can also show my teacher that I am using each step because I check them off, and she can see where I am at in the problem. She can give me points for trying. I do this for tests, too (Student H, June 2017).

Another student explained that he used to get problems wrong because he never reviewed his work: “Before this, I rushed through the problems without asking if my answers were correct. That Sense part was really important for me” (Student F, June 2017).

These reactions showed that students as a whole were completing more work than in the past, but students were also finding different components of the *STARS* mnemonic strategy to be helpful. Students had different experiences with the strategy based on their individual deficits: While Student H required the strategy to help her initiate and keep track of her problem-solving process, Student F needed the strategy to help him check if his answer was reasonable given the context of the problem. Student learning is very personal, and although the *STARS* mnemonic strategy has specific and prescribed steps, each student used the strategy in a different way depending on his or her problem-solving deficits.

Student satisfaction. Approximately 20% of the students who participated in the intervention reported that they did not like the strategies that their teacher teaches them. However, approximately 85% of the students agreed or strongly agreed with the statement “I think the strategies my teacher teaches me helps me learn.” A student in the focus group reiterated their belief that the strategy helped them problem solve, "I like using *STARS* because it reminds me that I can actually do math" (Student A, June 2017), while at the same time acknowledged that they may not write out the mnemonic every time they solve a problem, "I know I don't have to write down *STARS* every time I use it" (Student A, June 2017). This indicated that this student may have internalized the strategy for mathematical problem solving.

Overall, most students reported that the *STARS* mnemonic strategy helped them improve their perception about problem solving in mathematics and were satisfied with their teachers' instruction.

Teacher's Perception of Student Mathematical Problem Solving

Teachers completed a post-intervention Likert-type survey rating their perception of student mathematical problem solving. Both teachers strongly agreed with the statements, "I believe the *STARS* Mnemonic Strategy is a good strategy to teach my students" and "I plan on using the *STARS* Mnemonic Strategy in my other math classes." Both teachers agreed and one teacher strongly agreed with the statement, "I think my students improved their mathematical performance because of the *STARS* mnemonic strategy." The survey results demonstrated that teachers responded well to the intervention and had positive experiences teaching the *STARS* mnemonic strategy. Teachers must have seen positive results with the strategy because they want to use it in future mathematics classes.

The teacher focus group also revealed that the coaching sessions assisted the teachers with lesson planning. They also reported that the coaching sessions helped them build their instructional knowledge and delivery by giving them multiple occasions to practice instruction and receive feedback from the teacher coach on how to improve. Instructional support through the coaching sessions allowed teachers to implement the *STARS* mnemonic strategy with fidelity and as a result they were able to see positive impacts on student learning. Three themes emerged from analyzing the focus group responses: Instructional Support, Lesson Delivery, and Strategy Knowledge and Application. Table 5.5 represents selected quotes from the Teacher Focus Group.

Table 5.5

Teacher Focus Group Responses – Selected Quotes

	Teacher Quotes
Instructional Support	"I really think my performance as a teacher has been changed because of the planning time we had together. I got to experience the strategy and see how I could use it in my teaching so I actually used it." "It was helpful to see you demonstrate and explain how to teach using the strategy. I could see how it was useful for students." "Since this is only my second year teaching, I think I benefited from having a coach help me teach math more effectively." "For me, effective teaching means I can get my students to work and think independently." "I practiced the strategy with you and this made me understand what the students feel and think."
Lesson Delivery	"I was not sure if students 'bought into' the mnemonic. Should I have stayed at that point? Should I have moved on? I didn't know." "I know this is an area I need to work on. The strategy is useful but I need to work on making sure I don't harp on the instruction of it too long." "I would like to practice my lesson timing. This is what I need to work on the most, I think." "I anticipated where students would have trouble with the content and the strategy. This made me spend time on what was important." "I am wondering how I can use this strategy throughout the year and not just to prep for the exam."
Strategy Knowledge and Application	"I saw them using *STARS* even when I did not remind them to. It was like students had something to go to when they saw a problem. Even if they did not get the answer, I saw them persisting through the problem and not giving up." "We are really good at teaching content. But we are not so good at teaching strategies. This is something teachers need to focus on." "Teaching strategies are difficult, I am not sure what strategies I used when I get stuck on a problem so this made me reflect on what I actually do so that I can problem-solve." "Most of the time when students are stuck on how to solve a problem they just start doing things with the hope that they get some points. There is no method or strategy. They just went for it and didn't realize that what they were writing on their tests meant absolutely nothing, but once they used the strategy, I saw them focus on their thought process and decide how to approach the problem in their own way." "I actually saw how they did more work with *STARS* than before so I know they are learning and getting the practice they need."

Instructional support. Teachers who receive instructional support report higher levels of confidence and satisfaction with their teaching (Ingersoll & Strong, 2011). They tend to develop more effective lesson plans, are able to adjust classroom activities to support students' needs, and can foster a more positive classroom environment (Ingersoll & Strong, 2011). This can lead to increased student learning satisfaction and achievement (Impecoven-Ling & Foegen 2010; Ingersoll & Strong, 2011; Phillips, 2010; Torney-Purta et al., 2005). Teacher B reported that she enjoyed planning the lessons with the teacher coach. Through the coaching sessions, she learned how to use the *STARS* mnemonic strategy and embed it with her lessons. She said, "It was helpful to see you (the teacher coach) demonstrate and explain how to teach using the strategy. I could see how it was useful for students" (Teacher B, June 2017). Teacher A also identified the coaching sessions as an important component to her development as a teacher, "I really think my performance as a teacher has been changed because of the planning time we had together. I got to experience the strategy and see how I could use it in my teaching so I actually used it" (June 2017).

Lesson delivery. Teachers from the focus group reported that the timing of their lessons was a component they wished to further develop and improve. Teacher B indicated that real-time decision making was a challenge, "I was not sure if students 'bought into' the mnemonic. Should I have stayed at that point? Should I have moved on? I didn't know" (June 2017). As the *STARS* mnemonic strategy lessons progressed, Teacher A said that she structured her lessons around anticipated areas of misconception, "I anticipated where students would have trouble with the content and the strategy. This made me spend time on what was important" (June 2017). This showed that teachers were aware of their lesson delivery and took steps to ensure that they were implementing the *STARS* mnemonic strategy according to fidelity.

Strategy knowledge and application. Modeling best instructional practices can help teachers gain knowledge and implement these practices into the classroom (Barlow, Frick, Barker, & Phelps, 2014). Teachers acknowledged their strengths in teaching content but also acknowledge their weaknesses with strategy instruction, “We are really good at teaching content. But we are not so good at teaching strategies. This is something teachers need to focus on” (Teacher A, June 2017). Students who experienced the *STARS* mnemonic strategy instruction used the strategy and teachers reported the change in their students’ mathematical thinking, “I actually saw how they did more work with *STARS* than before so I know they are learning and getting the practice they need” (Teacher B, June 2017). The strategy was a tool the teachers used to instruct students and thus it allowed the students to access their cognitive skills so that they can successfully problem-solve.

Teacher A reflected on how students solved problems before and after the introduction of the strategy. She said:

> Most of the time when students are stuck on how to solve a problem they just start doing things with the hope that they get some points. There is no method or strategy. They just went for it and didn’t realize that what they were writing on their tests meant absolutely nothing, but once they used the strategy, I saw them focus on their thought process and decide how to approach the problem in their own way (June 2017).

The focal point of this study was the examination of how to teach students to problem solve. This teacher's response showed that there was a shift in how students problem solved once they were introduced to the *STARS* mnemonic strategy. The intervention gave students a method to engage in mathematical thinking in order to successfully problem-solve.

Both Teacher A and Teacher B encouraged students to use the *STARS* mnemonic strategy during the Essential Skill Review Classes and saw students using the strategy on problems outside of the Review Classes. Teacher B noted, "I saw them using *STARS* even when I did not remind them to. It was like students had something to go to when they saw a problem. Even if they did not get the answer, I saw them persisting through the problem and not giving up" (June 2017). Students who persisted through problem solving were more likely to show mathematical work that could get them points on the Exam. Although more work does not necessarily translate to higher scores or demonstrate more mathematical knowledge, it increases the chances that correct mathematical procedures are being attempted. More work also makes it more likely that students are showing that they have some conceptual and computational understanding of the mathematics required to solve the problem.

Discussion of the Findings

This section will integrate results from the intervention study with the literature on both student mathematical problem solving and teacher instruction of mathematical problem solving. The intervention sought to address the need for teachers to instruct with effective problem-solving strategies to positively impact student achievement. It also sought to examine the impact the STARS mnemonic strategy had on student and teacher perception of problem solving. The analysis will provide a deeper understanding on how the *STARS* mnemonic strategy benefited both teachers and students.

Student Mathematical Achievement

The chi-square test of independence showed no significant difference between the pass/fail exam results for comparison and intervention groups. This could indicate that the *STARS* mnemonic strategy intervention did not have an impact on student mathematical performance as demonstrated by the Common Core Algebra Exam results. There was a greater percentage of student passing for 2017 when compared to 2016; however, passing rates were similar when comparing 2017 and 2015. There are no clear findings for the improvement in Common Core Algebra Regent Exam results. Examining the results of teacher and student focus groups as well as teacher and student satisfaction surveys could offer more insight into the impact of the strategy on student mathematical problem solving. It would also deliver detailed explanations about the implementation of the intervention that the chi-square test of independence cannot provide.

Teacher participants and the teacher coach took a holistic approach in examining student exit tickets from the third, fifth, and eight Essential Skills Review Classes for students' use of the *STARS* mnemonic strategy. Additional data about the number of students who used the strategy and obtained correct answers could provide more knowledge about the impact of the *STARS* mnemonic strategy on student mathematical problem solving. Since the teacher participants were instructed to de-identify student exit tickets before analysis, it was not possible to triangulate student success with the strategy and the Common Core Algebra Regents exam results.

Instructional Support

Coaching sessions supported the integration of the *STARS* mnemonic strategy intervention. The coaching sessions allowed teachers to devise lesson plans and practice delivering instruction with a teacher coach. The purpose of the coaching sessions was to improve student learning by increasing the teachers' confidence in their instruction and providing them with a positive support structure. Newer teachers without instructional support often employ non-effective instructional strategies and have lower student achievement in their classrooms (Darling-Hammond, 2000; Davis & Gray, 2007; Fuchs & Fuchs, 2005). This leads to lower teacher self-efficacy and more negative beliefs about their ability to improve student learning (Woolfolk Hoy & Spero, 2005). This sentiment was reflected in the needs assessment study. Teachers who receive instructional support during their first few years of teaching report higher levels of confidence. They also employ instructional strategies that benefit student learning (Chval, et al., 2010; Darling-Hammond, 2006; Fuchs & Fuchs, 2005; Woolfolk Hoy & Spero, 2005). The coaching sessions in the intervention study were designed to provide support and opportunities to guide teachers in making the best instructional decisions for students with deficits in mathematics.

Results from the teacher focus group responses (Table 5.5) and teacher surveys showed that the coaching and planning sessions contributed to teachers' efficacy with instruction. Kane and colleagues' (2016) research indicated that structured coaching and planning meetings with a teacher and a teacher coach increases the chances of newer teachers' implementing effective strategies with fidelity. The teacher coach modeled the *STARS* mnemonic strategy with teacher participants and gave advice on how to incorporate it into their lessons. Teachers are more likely to try instructional methods that have been modeled for them because teachers can see and experience how these methods improve student learning (Garet et al., 2001). Teachers also find professional development to be most valuable when it provides a space and opportunity for hands-on work that increases their content knowledge and their ability to incorporate instructional strategies into their lessons (Darling-Hammond et al., 2009). The instructional support provided in the coaching and planning sessions shifted the focus of teacher instruction from completing procedural operations to more mathematical understanding and reasoning.

Teacher instruction also provided the benefit of increased opportunity for teachers to predict and address student misconceptions. Teachers prepared and rehearsed responses to student questions and misunderstandings as part of the coaching process. Knowing where students will have questions and misunderstandings can help increase the effectiveness of instruction by providing student support where it is needed (Ingersoll & Strong, 2011; Krawec & Montague, 2014). As instructed, the teachers purposefully incorporated and addressed errors in their example problems. This is an important component to effective instruction because it demonstrates to students that teachers understand student learning and can address students' learning deficits in order to increase their mathematical achievement (Krawec & Montague, 2014). This finding was also supported in the student satisfaction survey responses: approximately 80% of students agreed or strongly agreed to the statement that teachers understood how they learn.

Students in the focus groups reported that their teachers had not emphasized or even taught problem solving in the past; rather, teachers had focused on set procedures to obtain an answer. One student explained, “Before, we were taught that if we were doing a quadratic, we had to do this step and that step. It was too much for me to memorize. But now, it’s like, this is how you have to think about a problem” (Student F, June 2017). This student’s response demonstrated a shift in teachers’ instruction. The student’s answer also showed a change in how students approached problem solving, from rote memorization and replication of steps to more fluid thinking and analysis (Krawec et al., 2012). Therefore, teacher instruction with the *STARS* mnemonic strategy was more aligned with NCTM’s increased focus on teaching problem solving skills (NCTM, 2000). The strategy also helped the teachers modify their instruction to reflect the problem-solving skills necessary for the new Common Core Algebra curriculum (Kane et al., 2016).

Students’ Perception of Mathematical Problem Solving

Student ratings on the post-intervention survey and focus groups responses (Table 5.4) revealed that students found the *STARS* mnemonic strategy to be useful for mathematical problem solving. Approximately 77% of the students (n = 34) surveyed either agreed or strongly agreed with the statement “My teacher uses strategies that are easy to understand.” More significantly, about 93% of students (n = 42) either agreed or strongly agreed with the statement “My teacher teaches me how to use strategies to solve a math problem.” However, only a little more than half of the students (58%) surveyed reported that they liked using the strategy. There appears to be a disconnect between students’ understanding of the utility of the *STARS* mnemonic strategy for problem solving and their views about the strategy. Students' view on strategies improves over time as they see how the employment of the strategies produces positive results and experiences (Doabler et al., 2012). One student reported their satisfaction with the strategy, "Yeah, I like it. But I know I don't have to write down *STARS* every time I use it" (Student D, June 2017). This response indicated that some students may have already internalized the strategy and that implementing the strategy when problem solving is automatic.

Observing teachers using the strategy is important for students' understanding of how it benefits student thinking and problem solving. A student responded, "I liked how she showed us the strategy. It was very clear to me how I can use it to solve a problem" (Student C, June 2017). Teachers who model problem-solving tasks with effective strategies demonstrate the mathematical thinking process and prompt students to rehearse the same thinking process (Dole, Nokes, & Drits, 2009; Krawec & Montague, 2014). Students who observe this cognitive modeling process will view problem solving more positively, as modeling encourages students to analyze their own thought process and determine their learning needs (Archer et al., 2006). It also demonstrates to students that a more knowledgeable person uses strategies to problem solve. Modeling therefore prompts students to replicate such problem-solving processes (Dole et al., 2009). The instruction of the *STARS* mnemonic strategy likely helped students see the utility of the strategy and encouraged students to attempt problem solving.

Students who have more positive experiences with a particular strategy will be more motivated to think mathematically and devote more effort to the content than will students who hold more negative views (Benken et al., 2015; Kargar et al., 2010).

Benken and colleagues (2015) further asserted that teachers who model effective strategies are more likely to help students develop a positive attitude about problem solving. This is because the students see how these strategies can improve their mathematical thinking, which motivates them to attempt more mathematical problem solving. Students' opportunities to reinforce their content knowledge, demonstrate this knowledge, and experiment with using the strategies increases with more practice.

Targeting cognitive deficits. The effectiveness of the *STARS* mnemonic strategy lies in its ability to improve three essential cognitive skills for problem solving: attention, memory, and metacognition. Improving these skills can improve student problem solving and, by extension, exam scores. (Impecoven-Lind & Foegen, 2010; Krawec & Montague, 2014; Maccini & Gagnon, 2007; Miller & Mercer, 1997).

Attention. Chapter 3 of this document explained how the *STARS* mnemonic strategy aims to improve students' attention to information and concepts relevant to the problem. Figure 1 demonstrates one student's annotations on an exit ticket where the student used the *STARS* mnemonic to identify the important information to solve the problem. The student boxed the rate of change ($3.50 for each), underlined the initial value ($2.25), and boxed the total cost ($44.25). All of these numbers and words represent important components to a linear function: initial values correspond to the y-intercept, *b*; the rate of change represents the slope, *m*; and the total cost represent the *y*-value. The *STARS* mnemonic strategy prompted this student to identify and select key terms and apply specific mathematical facts and procedures relevant to the problem (Impecoven-Lind & Foegen, 2010; Montague, 2008). The student also eliminated non-important information. This skill helped the student select and attend to the most relevant parts of the problem and thus think about the goal of the problem. The student further indicated their understanding of the *STARS* mnemonic strategy by drawing arrows to the corresponding parts of their work. This is evidence that the student used the strategy.

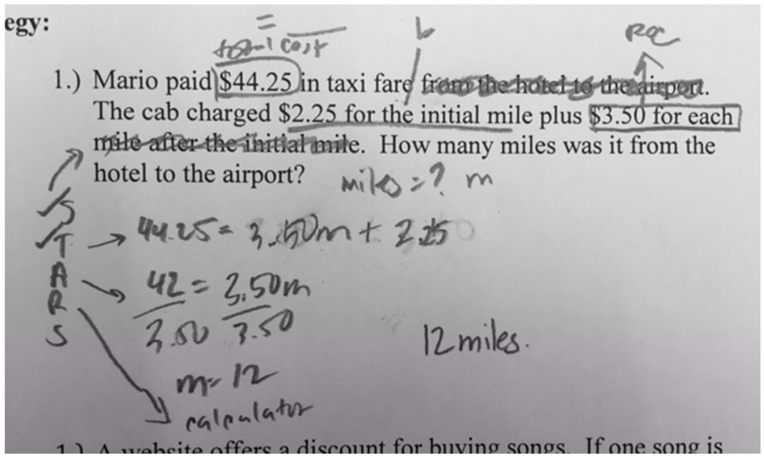

Figure 5.1. Student Exit Ticket with annotations indicating the elimination of irrelevant information and the identification of key terms and concepts for problem solving.

The strategy also assisted students in maintaining their focus on specific parts of the problem-solving process. One student in the focus group, who identified himself as having attention issues, reported, “Because I have these steps, I remind myself what task I need to do or if I got stuck, I knew exactly where I got stuck” (Student I, June 2017). Not only was this student aware of his attention deficits, he was also aware of how the *STARS* mnemonic strategy helped him combat these deficits. Figure 2 shows a student participant who volunteered to complete a problem on the board. He wrote the steps for the *STARS* mnemonic strategy before solving the problem to keep track of his problem-solving process. The student also indicated that he understood the concept of “slope” by circling and identifying the term “costs $3.00.” The identification of “slope” prompted the student to associate this word with a linear function. He then was able to translate the word into an appropriate mathematical equation.

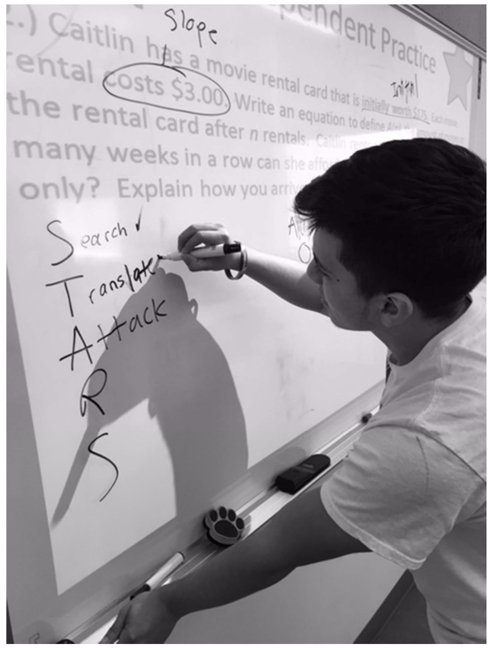

Figure 5.2. Student writing out the steps of the *STARS* mnemonic strategy to keep track of his problem-solving process.

Problem solving is a multi-step process and requires many cognitive skills, including attention (Miller & Mercer, 1997). The *STARS* mnemonic strategy helps students with their attention deficits by giving them a checklist of steps to remind them of what they need to do to complete the problem (Mevarech & Amrany, 2008). Students who are unable to attend to the important and relevant information experience an overload of their cognitive processes. They then become overwhelmed and quit the problem-solving process (Maccini & Gagnon, 2007). The *STARS* mnemonic strategy helped students attend to only the relevant information while also giving them a roadmap that prompts them to initiate certain procedures to solve the problem. The *STARS* mnemonic keeps students on a focused track to reach a solution and therefore reduced the chances of students engaging in spontaneous strategy production (Scruggs et al., 2010). Students can use the steps to remind themselves where they are in the problem-solving process so they can decide what is needed to successfully problem solve. As students become more aware of how certain strategies improve their learning, and specifically their attention, they will be more willing to use the strategies on additional problems (Doabler et al., 2012)

Memory. Figure 3 shows student work from an exit ticket. Since neither the teacher participants nor the teacher coach was not watching this student complete the exit ticket, it can be assumed from the check marks and arrows that the student used the *STARS* mnemonic strategy and identified a key term that reminded him/her of an important mathematical concept: zeros indicate "$f(x) = 0$." The student then set the equation equal to zero and proceeded to solve the problem as a quadratic while monitoring his/her problem-solving process by checking off each step.

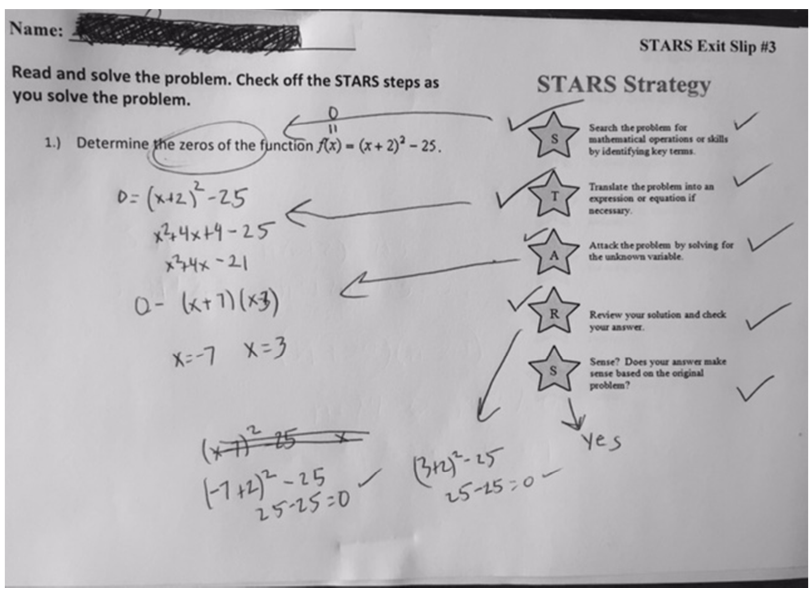

Figure 5.3. Student Exit Ticket with work identifying a concept in algebra and then using it to solve the problem.

Students will increase their chances of retrieving mathematical facts and procedures from memory when they have more opportunities to use a strategy that provides them access to their knowledge. They will associate their positive experiences with problem solving and solidify their understanding that certain strategies can be beneficial to their learning and demonstration of content mastery (Benken, et al., 2015; Brissiaud & Sander, 2010). While not all students explicitly said their memories improved as a result of the *STARS* mnemonic strategy, one student from the focus group claimed they were able to remember important mathematical facts after seeing them repeated in multiple problems. This student reported, “I started to see which math showed up over and over again in the problems so I knew which operations to use when I saw certain words” (Student D, June 2017). This student’s response echoes the literature that promotes instruction aimed at helping students recall certain mathematical facts and procedures by associating them with particular key words and concepts in problems (Brissiaud & Sander, 2010; Miller & Mercer, 1997). Students in the study started to see the connection between words and mathematical facts and procedures, so they knew they had to use those facts to solve the problem. The *STARS* mnemonic strategy prompted students to locate these words and therefore activated their knowledge about the problem.

Another student explained how they were able to associate key terms with important mathematical operations: “I know when I see ‘growing exponentially’ I know that we are dealing with exponential functions and that my equation has to look a certain way. I know where to put the numbers in the equation” (Student G, June 2017). This student’s response demonstrated that they completed the first step of the *STARS* mnemonic strategy, “Search” by identifying a key term, and they were thinking about the second step, “Translate.” Although this students’ response was more aligned with the key-word approach (Pape, 2003; Pape, 2004), it is an example of how students can internalize the *STARS* mnemonic strategy and solve problems without a written prompt. Students who get this far in the problem on the Common Core Algebra Regents Exam can earn at least one point for writing a correct equation. This one point could mean the difference between passing and failing the exam. Even if the equation is incorrect because of a key-word approach failure (e.g., students can mistake “growing” for an exponential function when the problem models a linear function growth), students can still earn points for the problem if they calculate correctly based on their mistake.

Metacognition. Students who lack metacognitive skills find it difficult to know where to start a problem or evaluate where they need to make corrections (Bransford et al., 2000). Research has indicated that students can improve their metacognitive skills by learning a strategy that helps them monitor and keep track of their performance (Bransford et al., 2000; Geary, 2004; Manalo et al., 2000; Montague et al., 2009; Rosenzweig et al., 2011). Moreover, the strategy helps students avoid replicating step-by-step procedures from class examples that may not apply to the problem at hand. Instead, they can work to understand each problem and adapt their problem-solving according to what is needed to solve that particular problem (Case et al., 1992; Impecoven-Lind & Foegen, 2010; Montague et al., 2011).

The *STARS* mnemonic strategy was modeled after Montague’s (2003) *Solve It!* strategy and Polya’s (1957) framework for problem solving. The last step in the *STARS* mnemonic strategy, “Sense,” enhanced the two strategies by reminding students to monitor their problem-solving process and solution. Although students may have felt that *STARS* was similar to strategies they had used in the past, students reported that the “Sense” step was new to them and prompted them to monitor their thinking about a problem. Student C explained, “If the problem asked me to find the number of meters from here until the wall, I know I had to get a number that is positive. You can’t have negative meters in a distance problem. You could, but it's not realistic so your answer would be wrong" (June 2017). Another student replied that the "Sense" step had never been taught (Student D, June 2017). Previously, students would usually circle the numbered answer without knowing whether the answer was a reasonable solution to the problem. Proficient problem solvers can evaluate their solutions for accuracy and assess their own ability to problem solve (Bransford et al., 2000; Krawec et al., 2012). The response from the students in the focus group demonstrates that students with disabilities can improve their metacognition using strategies such as *STARS* that effectively target their metacognitive weakness.

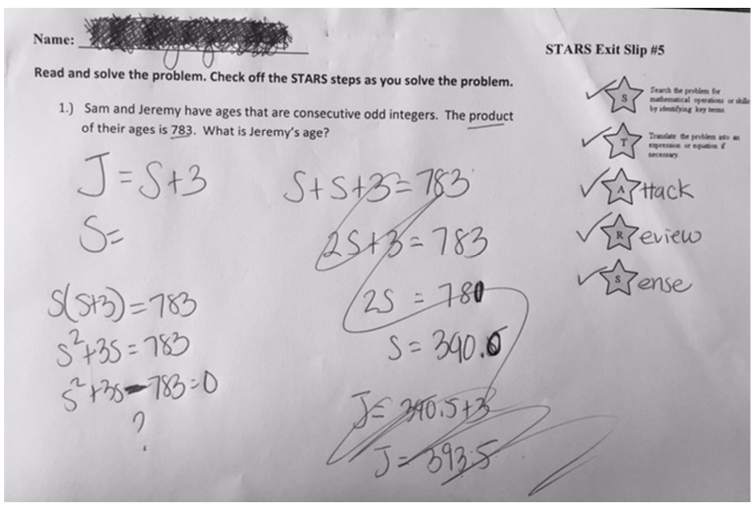

Figure 5.4. Student Exit Ticket showing the use of the *STARS* mnemonic strategy as a checklist to monitor the problem-solving process.

In Figure 4, the student used the *STARS* mnemonic strategy to monitor his/her problem-solving process and realized that the first answer (the one scratched over) did not make "sense." The student made two mistakes. The first was a conceptual error, identifying a consecutive odd integer as "S+3" when the correct expression was "S+2." The student made a second conceptual error by translating the equation to "S+S+3=783," where "S" is Sam's age and "S+3" is Jeremy's age. The student underlined the word “product” but translated this into “+” in his/her original equation. The student solved the equation and noticed that S=390 was not a reasonable answer for a person’s age. This student then crossed out the first work and started the problem again. This time, the student correctly identified “product” as “multiplication” but still incorrectly translated the consecutive odd integer value as “S+3.” Despite this mistake and the resulting incorrect answer, the student received partial credit for his/her work because he/she was able to formulate a quadratic equation based on a conceptual error.

Improving metacognition is vital for students to be successful with the Common Core Algebra curriculum. Students who actively reflect on and analyze the outcome of their problem-solving process and procedures in the “Sense” step are better able to determine if their answer is reasonable in the context of the problem (Impecoven-Lind & Foegen, 2010). Further, students can use the steps in the *STARS* mnemonic strategy to go back and correct their thinking about the problem. The curriculum and Common Core Algebra Regents Exam uses real-life examples, so their answers have real-life implications. Teachers therefore need to train students to go beyond a simple procedural review of the problems to analysis of their answer in relation to the goal of the problem.

Teachers’ Perception of Student Mathematical Problem Solving

Students with disabilities who are exposed to high-quality and differentiated instruction learn more and perform better on tests (Darling-Hammond, 2000; Goldhaber & Brewer, 2000; Krawec & Montague, 2014). Teachers who understand the mathematics curriculum and have practice with implementing strategies that improve student learning will be more positive about their teaching and continue to instruct with more effective strategies. Teacher B reported that she understood how the *STARS* mnemonic strategy targeted her students' deficits, and that she saw students make improvements in problem solving while using the strategy (June 2017). Before the intervention study, Teacher B claimed that she was aware of the importance of problem solving in mathematics and had noted the increase in mathematical word problems in textbooks. She acknowledged, however, the lack of instructional support for teaching problem solving (June 2017). While problem solving content was available, support to incorporate problem solving in the classroom was limited (Van Garderen, Scheuermann, & Jackson, 2012). The discrepancy between content and instructional support contributed to both teachers' sentiments that teaching problem solving was difficult.

Teacher participants reported that the *STARS* mnemonic strategy instruction was beneficial for students' mathematical problem solving. Teacher A attributed her students' success with the strategy and her ability to effectively teach it to the coaching and planning sessions. This prompted her to think about how mathematical learning has changed since she was in school. Teachers often hold pre-existing beliefs about problem solving and mathematical performance based on how they learned mathematics (Ernest, 1989). This prompts teachers to view student learning as a passive reception of knowledge (Little & Anderson, 2016). Integrating the *STARS* mnemonic strategy with the new Common Core Algebra curriculum required teachers to adjust instruction to include more problem-solving strategies (Sowder, 2007). Teachers had to shift their thinking about mathematical learning in order to employ teaching practices that are more aligned with Common Core Algebra's emphasis on the problem-solving process. Teacher B reported, "I actually saw how they did more work with *STARS* than before so I know they are learning and getting the practice they need" (June 2017). Teachers were more inclined to teach using the strategy because it targeted cognitive skills that were required for students to be active and engaged in problem solving. Teachers who implement instructional strategies aligned with how curriculum requires students to think and learn tend to view student learning more positively (Kane et al., 2016).

Theoretical Implications

Teachers who demonstrate confidence in their teaching and model appropriate learning strategies are more likely to have students who replicate the strategies (Kane et al., 2016; Krawec & Montague, 2014). Bandura (1977) asserts that much of learning occurs through observation so teachers who are cognizant of their problem-solving demonstrations have a significant impact on how students mirror, repeat, and apply new knowledge. Moreover, students who have teachers with high self-efficacy about their ability to teach mathematics tend to score higher on standardized tests compared to students with teachers with low self-efficacy (Goddard et al., 2000; Lee et al., 2011). This is because teachers with high self-efficacy are more able to support students' metacognitive skills, help students apply their thinking to real-world problems, and expand on student understanding (Zee & Koomen, 2016). The coaching sessions provided teachers with the guidance and practice they needed to be more self-efficacious. Their students thus observed teachers who were confident and knowledgeable about instruction and student learning.

Feedback from the coaches provided teachers with the opportunity to reflect and improve instruction (Darling-Hammond et al., 2009; Kane et al., 2016; Krawec & Montague, 2016). An important component to increasing teacher self-efficacy is offering a non-threatening, supportive environment in where teachers may discuss and receive feedback on instruction. Positive teacher learning experiences improves professional knowledge and skills and ensure that teachers continue their effective instruction (Bray-Clark & Bates, 2003; Darling-Hammond et al., 2009). Newer teachers, especially teachers of students with disabilities, benefit from skilled teachers who know how to integrate effective strategies. When the strategy is the main component of planning and instruction, teachers can increase self-efficacy and by extension student learning. The coaching sessions allowed teachers to plan lessons with teacher coaches before they attempted to implement the strategy in their instruction. This likely helped the teachers implement the *STARS* mnemonic strategy more effectively.

Understanding how individual student learning and instruction can be tailored for student-centered learning is another method of increasing teacher self-efficacy and student achievement. Problem solving is a complex process that requires students to engage in cognitive activities (Suriyon et al., 2013; Tate & Rousseau, 2007), but not all students demonstrate the same strengths and weaknesses. Teachers who are aware of students' prior knowledge and deficits are more equipped to design lessons that improve knowledge and expand students' application of new knowledge (Christie, 2005; Confrey, 1994). The *STARS* mnemonic strategy helped teachers diagnose and analyze student learning in order to determine where students needed instructional support. This emphasizes that student learning is highly individualized, and that teachers can use the *STARS* mnemonic strategy to design and prepare lessons that target each students' learning needs. Teachers who view learning as a more individualized process will be better able to scaffold learning for their students by adapting instruction to include the necessary learning skills so that all students can reach the same goal.

Implications for Practice

The intervention study was limited in sample size, but the study revealed results that can be applied to teacher instruction and student learning for mathematical problem solving. Although no statistical differences between the comparison and intervention groups were found in the proportion of students who passed the Common Core Algebra Exam, the surveys and focus groups yielded possible areas to improve instruction and student learning.

Instructional Support

The coaching session played a critical role for the effective implementation of the *STARS* mnemonic strategy instruction. As Darling-Hammond et al. (2009) suggested, instructional support is necessary for newer teachers to understand and implement effective teaching practices. Instructional support for mathematics, which prepares teachers to focus on mathematical understanding and reasoning, can transform teacher instruction to reflect best practices for student learning. Research suggests that the efficacy of an instructional method is enhanced when there is a means to implement it effectively and with integrity (Krawec & Montague, 2014; Moyer-Packenham et al., 2011). The coaching sessions provided this support and should be expanded to include more teachers, both newer and veteran teachers, to make a greater impact on teacher instruction.

Professional learning opportunities are a critical component of any evidence-based teaching intervention (Darling-Hammond et al., 2009; Krawec & Montague, 2014). The consistent monitoring, modeling, feedback, and coaching in this study not only ensured implementation fidelity but also provided teachers with the confidence to incorporate effective strategies with their mathematics lessons. It also increased the likelihood that teachers remained supportive of and enthusiastic about the intervention (Barlow et al., 2014; Bray-Clark & Bates, 2003; Krawec & Montague, 2014; Krawec et al., 2016). The consistent collaboration among teachers and the modeling of the *STARS* mnemonic strategy within the context of the given class topic ensured implementation fidelity.

Changing Student Perception about Problem Solving

The *STARS* mnemonic strategy helped students shift their thinking about mathematical problem solving. Prior to the intervention, students saw problem solving as a rigid procedure that included certain rules and steps that had to be followed if they wanted to arrive at the correct answer (Sowder, 2007). The Common Core Algebra curriculum does not reflect this type of mathematical knowledge and thinking but, rather, emphasizes adaptive thinking, sense-making, and perseverance with the problem-solving process (Krawec et al., 2016). The *STARS* mnemonic therefore helped to modify student views on problem solving to reflect the skills required for the Common Core Algebra curriculum.

Students who use the *STARS* mnemonic strategy will have the tools necessary to help them improve and strengthen their cognitive skills so they can successfully problem solve. The strategy targets their cognitive deficits of attention, memory, and metacognition by prompting them to initiate and persist through the problem-solving process. It acts as a support system that can lead to successful problem solving. When students have the support of this strategy, they are more likely to access and apply their knowledge to increase their chances of solving problems correctly. Even if students obtain incorrect answers, their use of the strategy can help them show their thought process and possibly be are awarded points for attempting the problem with appropriate mathematical knowledge. This may increase student scores and thus student passing rates on the Common Core Algebra Regents Exam. If more students can pass this exam at the end of their ninth grade year, it can increase the number the number of students on track to graduate from high school in four years.

In addition to increased instructional support for teachers to span the entire school year, students should be taught this strategy earlier. This will allow students more time to practice and rehearse strategy implementation over all units in the Algebra curriculum. More rehearsal and repetition can lead to increased internalization of strategy so students become more fluid and capable of problem solving absent of written prompts.

Limitations

There are several limitations to this study, including sample size, contamination, intervention length, and the threat of the experimenter. The intervention study sample included only 2 teachers and 44 student participants, with only 43 exam scores recorded. The number of teachers eligible to participate in the intervention study was restricted to the criteria from Chapter 4 and by the number of teachers available within the school setting. Similarly, the sample sizes of the comparison groups from 2015 and 2016 and the intervention study group from 2017 may have restricted the analysis of exam results. The small sample size for student exam results could have affected the result from the chi-square test of independence.

A larger sample of teachers and students might reveal more information about the usefulness of the *STARS* mnemonic strategy instruction. Moreover, both teachers knew the teacher coach (experimenter effect) prior to the intervention. They had also worked with the teacher coach in some capacity before the start of the intervention either as a co-teacher or a mentor (non-coaching role). This prior relationship may have enhanced or hindered the teachers' willingness to share their experiences with the teacher coach during the coaching sessions, as well as during the survey and focus groups. Teachers' support for the teacher coach for this study may also have caused the teachers to be unusually invested in the implementation of the intervention.

Recommendations for Future Research

The intervention study was implemented at the end of the school year, starting approximately two months before the administration of the Common Core Algebra Regents Exam. Implementing the intervention earlier in the school year would provide more time for teachers to instruct using the *STARS* mnemonic strategy. It would also allow students more time to practice using the strategy. The eight Essential Skills Review Classes were conducted approximately once every week and ended three class days before the end of the school year. This may not be have been enough time to adequately measure the impact of the *STARS* mnemonic strategy on instruction and student mathematical problem solving. The timing of the intervention could have also jeopardized the integrity of the intervention: The start of the intervention coincided with the beginning of the school's emphasis on Regents Exam preparation. This could have meant that students were learning test preparation strategies outside of their Algebra classes and Essential Skills Review Classes.

Darling-Hammond et al. (2009) noted that the most effective teacher instructional development programs offered substantial contact hours, ranging from 30 to 100 hours in total, spread over a period of 6 to 12 months. Programs with this length and these contact hours are more likely to show a positive, significant impact on teacher instruction and student achievement than are shorter ones. Teacher participants met with the teacher coach for approximately 16 hours, in addition to a few hours of informal coaching sessions. This is far below the 30-hour minimum Darling-Hammond et al. (2009) recommended. Starting the intervention earlier in the school year would increase teachers' opportunities to have more coaching and planning sessions and therefore more hours for mentored support and feedback. Although teachers were generally positive about the coaching and planning sessions, they claimed that attending the sessions as scheduled was difficult due to other school commitments and requirements during the last two months of the school year. Starting coaching and planning sessions at the beginning of the school year can increase the chances that the sessions become a routine part of teachers' schedules. Other research further suggested that newer teachers receive continuous and targeted instructional support for up to three years past their initial teaching assignment (Corcoran et al., 2003; Supovitz & Turner, 2000). The *STARS* mnemonic strategy instruction could have a more significant impact on teacher instruction and student learning if it is expanded and continued into the following school years.

Future research should also attempt to reduce possible diffusion. The student participants in this study were required by the school to attend an after-school study hall four times a week beginning one month before the Common Core Algebra Regents Exam. Some students were placed in a study hall with a different, non-Algebra, mathematics teacher and other students who did not participate in the intervention study.

This may have caused diffusion, as students were free to discuss strategies and receive help from another mathematics teacher. Other students may have been placed in a study hall with a non-mathematics teacher who may not have helped them. In addition, some students may not have been assigned a study hall due to their participation in school sports; some practices and games occurred during the school's mandatory study hall period. These students would not have had the additional mathematics support their peers received. A request was made to the school's data and scheduling manager to place students in the same study hall to reduce discrepancies in student experience there. Not all accommodations could be made, however, due to student and teacher scheduling and classroom availability.

Increasing the student sample size also could yield more reliable results. The student passing rate for 2017 was higher than for 2016, but the passing rate was the same when compared to scores for 2015. The chi-square test of independence showed that the result was not significant. This could be due to the small sample size. Increasing the number of teachers could also provide more insights into the intervention. Only two teachers participated in the intervention, and this may limit the perspectives on the effectiveness of the strategy. Further expanding the study can also reveal additional areas for teacher and student support in the Common Core Algebra curriculum.

Conclusion

This intervention study examined the impact of the *STARS* mnemonic strategy instruction on teacher experiences and student learning as demonstrated by passing rates on the Common Core Algebra Regents Exam. While the 2017 students passing rate was not statistically different when compared with similar student passing rates from the previous two years, qualitative evidence suggested that students benefited from the *STARS* mnemonic strategy instruction. It prompted students to initiate the problem-solving process and encouraged them to persevere, monitor their thinking, and complete problems. It also supported teachers in their development of teaching practices aimed at helping students become proficient problem-solvers.

The literature and intervention study indicated that newer special education teachers who teach Algebra, and newer teachers in general, are best supported with coaching that helps them improve their instructional practice. Teachers learn about teaching strategies in their preparation programs but have little practice in planning lessons and implementing the lessons with these strategies. The *STARS* mnemonic strategy intervention provided a much-needed opportunity for instructional support, thus increasing special education teachers' ability to instruct students effectively with a problem-solving strategy targeting their cognitive deficits. The teachers who participated in the intervention study were thus more able than before to target the skills their students needed to pass the Common Core Algebra Regents Exam.

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APPENDIX A. NEEDS ASSESSMENT TEACHER SURVEY

I. General Teaching Experience

1. Do you currently hold a teaching certification?
    a. Yes
    b. No

2. If you answered yes in Question #1, what is your area of certification?

____

3. What is the highest degree that you have obtained?
    a. Bachelor's degree
    b. Master's degree
    c. Post-graduate degree (MD, JD, Phd, EdD, etc)

4. Do you currently teach in the content area of your certification?
    a. Yes
    b. No

5. How many years have you been a teacher?
    a. Less than 1 year
    b. 1-4 years
    c. 5-10 years
    d. More than 10 years

6. How many years have you been teaching at your current school?
    a. 0-3 years
    b. 4-6 years
    c. 7-9 years
    d. 10 years or more.

II. Teacher Preparation (Credentials) prior to teaching

1.) In fulfilling your requirements to become a teacher in New York State did you: *(Mark only one)*
  a. Attend full-time teacher preparation program:
    1. If so, which program and institution___________________________________
  b. Attend a part-time teacher preparation program:
    2. If so, which program and institution___________________________________
  c. Attend an alternative certification program (TFA, Teaching Fellows, Empire Fellows, etc.).

        3. If so, which program and location of coursework
    d. Other (please explain):____

2.) How long did it take you from start to finish to fulfill your requirements to begin full time teaching?
    a. 0-1 year
    b. 2-3 years
    c. 3-4 years
    d. 4-5 years
    e. More than 5 years

3.) How did you obtain certification to teach in New York State?
    a. University recommended for certification, undergraduate
    b. University recommended for certification, graduate
    c. University-based alternative routes (TFA, Teaching Fellows, Peace Corps Fellow, etc)
    d. Transcript Review (Direct Application)
    e. Other (please specify):____

4.) Prior to teaching, did you have a career in a non-education related field? If yes, please specify your career and length:
    a. Yes (please specify and # of years)_____________________________________
    b. No

5.) To satisfy your teaching requirement for certification, did you teach your own classroom without another teacher present? (If you went through an alternative teaching program, select yes).
    a. Yes
    b. No

6.) How much actual time did you spend student teaching as part of your teacher preparation prior to becoming a full-time teacher
    a. 0-20 hours
    b. 21-40 hours
    c. 41-60 hours
    d. 61-80 hours
    e. Greater than 80 hours

7.) In thinking about your preparation prior to becoming a full-time classroom teacher, to what extent do you agree or disagree with the following statements about your program?

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

a. My program lacked a sense of coherence among courses and between courses and field experiences
b. What I learned in methods courses reflected what I observed in my field experiences or in my own classroom.
c. My program articulated a clear vision of teaching and learning
d. The faculty in my program shared experiences relevant to classroom teaching.

8.) In your preparation to becoming a full-time classroom teacher, to what extent do you agree or disagree with the following statements.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

a. I studied stages of child development
b. I develop strategies for handling student behavior
c. I develop specific strategies for teaching English Language Learners
d. I develop strategies for teaching students with disabilities
e. I develop strategies for teaching students from diverse racial and ethnic backgrounds.
f. I develop strategies for setting classroom norms
g. I learned how to fill out Individual Education Plans
h. I learned how to participate in and contribute to an Individual Education Plan meeting.

III. Teacher Instructional Quality:

1.) In your current school setting to what extent do you agree or disagree with how much influence you have over the following areas of planning and teaching:

(1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

a. I select textbooks and other instructional materials
b. I select content, topics, and skills to be taught
c. I select specific teaching techniques that help students understand content

d. I differentiate curriculum for struggling students

2.) To what extent do you agree with the following statements

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

a. I am able to adjust daily lessons to help all students learn
b. I am able to adjust lessons “on the spot” when students struggle
c. I am able to apply theoretical concepts and ideas underlying mathematical applications
d. I am comfortable facilitating student math learning in large groups
e. I am comfortable facilitating student math learning in small groups
f. I am able to use technology (calculators or computers) to help facilitate learning
g. I am comfortable with using manipulatives or models to demonstrate abstract concepts
h. I am familiar with typical difficulties students have with Algebra
i. I can effectively design and execute math lessons that reflect the diversity of learning and learning styles
j. I study and/or analyze student math work
k. I am familiar with New York State Standards for middle and high school algebra
l. I am familiar with the types of questions that are on the Algebra Regent’s Exam.

IV. Teacher Knowledge of Special Education

1.) Approximately how many courses did you take in undergraduate and/or graduate school on special education?

a. 0-2 courses
b. 3-5 courses
c. 6-8 courses
d. More than 8 courses

2.) To what extent do you agree with the following?

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

a. I am able to work with students with learning disabilities

b. I am able to use what I learned in school about learning disabilities to help students learn
c. I am able to properly attribute student misunderstandings to specific learning differences
d. I am able to use a variety of strategies to help students with disabilities master content.
e. I understand how disabilities affect students in class.
f. I am familiar with students' related services and how this might affect their learning
g. I understand that students can use multiple strategies to reach the same solution
h. I understand how testing accommodations may affect a student's outcome on state and local exams
i. I am able to collaborate with both general and special education teachers regarding special education issues.

APPENDIX B. NEEDS ASSESSMENT TEACHER FOCUS GROUP QUESTIONS

1.) Describe your experience with your specific teacher education program?

2.) How well has your university/college prepared you to be an effective classroom teacher?

3.) Describe your experience working with students with disabilities.

4.) Describe the teaching techniques and strategies that are the most effective for you and your students.

5.) Describe some of the different student learning styles and how you adjust lessons to benefit the different styles.

6.) What are the relative strengths and weaknesses of state, standardized tests?

7.) What coursework have you taken that has made you successful in teaching math?

8.) How do you stay updated in teaching mathematics (professional development, coursework, etc.)?

Additional questions were asked during the focus group based on teachers' responses.

APPENDIX C. NEEDS ASSESSMENT STUDENT SURVEY

I. Student Information

1.) What grade are you currently in?
   a. 9th Grade
   b. 10th Grade
   c. 11th Grade
   d. 12th Grade

2.) Do you have an IEP or a 504 plan?
   a. Yes
   b. No

3.) Which math class are you taking?
   a. Foundations of Algebra 1 of 2 (Teacher XXX)
   b. Foundations of Algebra 1 of 2 (Teacher XXX
   c. Foundations of Algebra 2 of 2 (Teacher XXX)
   d. Integrated Algebra (Teacher XXX)
   e. Integrated Algebra (Teacher XXX)
   f. Integrated Algebra (Teacher XXX)
   g. Integrated Algebra (Teacher XXX)
   h. Integrated Algebra (Teacher XXX)

II. Student beliefs on learning

1.) To what extent do you agree with the following statements
   (1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

a. I have struggled with math in previous years
b. I struggle with math this year
c. I have had good math teachers in the past
d. I look forward to coming to math class everyday
e. I know what is expected of me in math class everyday
f. The math class is structured in a way that is good for my learning
g. I can ask questions and get the answers/explanations
h. I am able to get tutoring before and/or after school

III. Student Perception of Teaching Practices

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

1.) My teacher is able to design lessons that are easy to follow
2.) My teacher designs lessons with hands-on activities
3.) My teacher expects nothing less than my best work
4.) My teacher encourages students to use their prior knowledge
5.) My teacher challenges me in class
6.) My teacher understands how I learn
7.) My teacher is aware of who is doing well and who is not doing well in class
8.) My teacher reaches out to me when they know I do not understand
9.) My teacher makes me feel like I can do math
10.) My teacher explains the same concept in different ways
11.) My teacher gives me a good amount of work to do on my own
12.) My teacher praises me for doing well
13.) My teacher does not feel that I can learn
14.) My teacher sometimes confuses me
15.) My teacher gets frustrated with my learning abilities

APPENDIX D. NEEDS ASSESSMENT STUDENT FOCUS GROUP QUESTIONS

1.) What do you like best about Math? What do you like least about Math?

2.) What makes you feel successful in math?

3.) Have you ever had a really bad experience with math? If so, what happened?

4.) What types of activities or strategies does your teacher use in class that make you feel like you can do math? Are there activities or strategies that do not work well for you?

5.) What could teachers do to help students with in math?

6.) How well do you feel prepared for the Integrated Algebra Regents exam at the end of the year?

Additional questions were asked during the focus group based on student responses.

APPENDIX E. TEACHER EVALUATION RUBRIC

Planning and Preparation			
Rating	1 (Ineffective)	2 (Effective)	3 (Highly Effective)
Essential Skills Review Lesson with *STARS* Mnemonic Strategy	Teacher designed the lesson that covered the Essential Skills Review content but did not use the *STARS* mnemonic strategy as the primary mode of instruction. Students not able to use the *STARS* mnemonic strategy to solve independent practice problems and the exit ticket.	Teacher designed the lesson that covered the Essential Skills Review content and introduced the *STARS* mnemonic strategy. The teacher connected the *STARS* mnemonic strategy to one example in the lesson. Some students can use the *STARS* mnemonic strategy to help them solve independent practice problems and the exit ticket.	Teacher designed the lesson that adequately covered the Essential Skills Review content and introduced the *STARS* mnemonic strategy. The teacher connected the *STARS* mnemonic strategy to all examples in the lesson. All students were able to incorporate the *STARS* mnemonic strategy to solve independent practice problems and the exit ticket.
Teacher Use of Supporting Materials	Teacher does not refer to posters, anchor charts, word walls, etc., to remind students about the *STARS* mnemonic strategy during the lesson.	Teacher occasionally refers to posters, anchor charts, word walls, etc. to remind students about the *STARS* mnemonic strategy during the lesson.	Teacher frequently refers to materials, such as posters, anchor charts, word walls, etc. to remind students about the *STARS* mnemonic strategy during the lesson.
Instruction			
Rating	1 (Ineffective)	2 (Effective)	3 (Highly Effective)
Warm Up Problem	Teacher does not use a warm up problem and the teacher does not connect it to the *STARS* strategy	Teacher uses a warm up problem specific to the Essential Skills Review content. Teacher does not connect with the *STARS* strategy.	Teacher uses a warm up problem specific to the Essential Skills Review content and connects it to the *STARS* mnemonic strategy.

Instruction (cont.)			
Rating	1 (ineffective)	2 (effective)	3 (highly effective)
Introduction to Mnemonic Strategy	Teacher does not introduce the *STARS* mnemonic strategy and does not explain how students can use the strategy to solve problems.	Teacher introduces the *STARS* mnemonic strategy and explains to students how they can use the strategy to solve problems. Teacher gives a brief review of each step in *STARS* just once.	Teacher introduces the *STARS* mnemonic strategy and explains to the students how they can use the strategy to solve problems. Teacher gives a thorough review of each step in *STARS* more than once.
Demonstration of Mnemonic Strategy	Teacher does not demonstrate how the *STARS* mnemonic strategy can be used to help students solve problems.	Teacher demonstrates how the *STARS* mnemonic strategy can be used to help students solve problems from the Essential Skills Review content by providing one example.	Teacher demonstrates how the *STARS* mnemonic strategy can be used to solve problems from the Essential Skills Review content by providing more than one example.
Student Practice with Mnemonic Strategy with Teacher Guidance	Teacher does not provide guided practice for students to use the *STARS* mnemonic strategy.	Teacher provides one opportunity for students to practice using the *STARS* mnemonic strategy immediately after initial demonstration.	Teacher provides multiple opportunities for students to practice using the *STARS* mnemonic strategy immediately after initial demonstration.
Independent Student Practice with Mnemonic Strategy	Teacher does not provide students with the opportunity to independently practice using the *STARS* strategy. Teacher does not encourage students to use the *STARS* mnemonic strategy.	Teacher provides students with the opportunity to independently practice using the *STARS* strategy. Teacher monitors student work but does not encourage students to use the *STARS* mnemonic strategy.	Teacher provides students with the opportunity to independently practice using the *STARS* strategy and encourages students to use the *STARS* mnemonic strategy verbally. Teacher verbally praises students who use the strategy.

Instruction (cont.)			
Rating	1 (ineffective)	2 (effective)	3 (highly effective)
Exit Ticket/Check for Understanding	Teacher does not collect an exit ticket to asses if students are using the *STARS* mnemonic strategy to solve problems.	Teacher collects an exit ticket to assess if students are using the *STARS* mnemonic strategy to solve problems. Teacher does not collect an exit ticket of a problem unrelated to the Essential Skills Review content after Lessons #3, 5, and 8.	Teacher collects an exit ticket to assess if students are using the *STARS* mnemonic strategy to solve problems. Teacher collects an exit ticket of a problem that is not related to the Essential Skills Review content after Lessons #3, 5, and 8.
Timing	Teacher does not use appropriate pacing and timing to properly introduce and practice content.	Teacher uses appropriate pacing and timing to properly introduce and practice content using the *STARS* mnemonic strategy, but does not adjust lesson based on student learning.	Teacher uses appropriate pacing and timing to introduce and practice content using the *STARS* mnemonic strategy. Teacher adjusts lesson based on student learning.

APPENDIX F. SAMPLE LESSON PLANS

<table>
<tr><th colspan="4">Essential Skills Review Class Lesson Plan #1</th></tr>
<tr>
<td>Content Area:
Common Core Algebra</td>
<td colspan="2">Topic:
Solving Equations</td>
<td>Purpose:
To build our cognitive skills and practice using the STARS mnemonic strategy to help us initiate and persist through mathematical problem solving.</td>
</tr>
<tr>
<td colspan="2">Aim: How can we use the STARS strategy to help us remember how to set up and solve an equation from a word problem?</td>
<td colspan="2">Do Now (10 min):
Skills Review:
Part 1: Combine like terms
1.) $2x + 2x$
2.) $7m - 3m + 2p - p$

Part 2: Distribute
1.) $3(2 - 5x)$
2.) $7 - (4x + 1)$</td>
</tr>
<tr>
<td colspan="2">Lesson (approx. 15 min):
We are going to use a mnemonic strategy to help up set up and solve math equations from word problems. A mnemonic strategy is a device, such as a formula, rhyme, or an acronym, that is used as an aid in remembering something important.

“We use mnemonics in math to help us trigger our thinking about a problem. It not only helps us solve the problem, but it helps us start the problem. Many of us look at a problem and have no idea where to begin. Therefore, we get stuck without even writing anything down and then immediately ask for help.
“The mnemonic we will use to help us remember how to set up and solve equations is STARS.” *Put this on the board for everyone to see. Point to the posters in the classroom

Search the problem for mathematical operations or skills by identifying key terms.
Translate the problem into an expression or equation if necessary.
Attack the problem by solving for the unknown variable.
Review the solution by substituting it back into your equation.
Sense. Does your answer make
</td>
<td colspan="2">Questions/Comments:

What types of mnemonic strategies have you used in math before? How about other subjects? (Feel free to brainstorm with students mnemonic strategies and have a student write them down on chart paper in the class). Some mnemonic strategies could include “FREEPA,” “In 1492, Columbus sailed the ocean blue,” etc.

About one-fifth of the students in these Algebra classes went to KIPP STAR Middle School. A reference to this the middle school should be made to make the mnemonic more impactful.

Hand out student cutout of the STARS mnemonic to glue into student notebook.</td>
</tr>
</table>

sense? Once students see this on the board and have glued the sheets into their notebooks, the teacher will ask one student to read “S”, “T”, “A”, “R”, “S”, etc.	But what does all of this mean? Have students do a think, pair, share. And then share out with the entire class (max 1 minute). Re-explain that this device is to help students remember the process in how to solve a problem
In order for us to do the first step, we have to know key math terms. For today, we are going to focus on the following key terms “is equal to” “is the same as” “does not equal to”	
So we are talking about equivalency. One side of an equation has the same value or does not have the same value as the other side. When we see these phrases, we must immediately think of the equal sign. Therefore, we need to be able to read the problem (part “S” of STARS) and pick out the key terms.	Give a Green handout of these terms. Ask students, “what ‘symbol’ do you think these phrases correspond to in math?” If students not get it, point to the “equal”
It is our goal by the end of today that everyone can read a problem and when they see any of these three key terms, they know they are supposed to set up an equation. Example 1: Twice the sum of 3 and a number is the same as 10. What is this number?	Demonstrate how to search for key terms in a problem. “What does ‘twice’ mean? What does ‘sum’ mean? What does ‘is the same as’ mean?” Underline these words and annotate the problem with the mathematical operations. Cross off “S”. Then demonstrate to students how you will “translate” the sentences into the equation, “$2(3+x)=10.$" Be careful here, explain that when you see “twice the sum of, or three times the difference of, things like that, then you are multiplying the mathematical operations that are in a parenthesis. Now that you have completed “T” of STARS, make sure to cross off “T.” Ask students, “What am I doing to S, T, A, R, and S” as I moved through the problem? Why do you think it is important to cross off the steps?” “Attack the problem.” This is solving for your variable.

	Cross off "A." When students get "$x = 2$ ", complete the "R" (Review) step. This is substitution. Cross off "R." Move to "S." Spend some time. Ask students, "Do you think x=2 is a reasonable answer? If you are multiplying a value inside the parenthesis by 2, to get the number ten, then the value inside this parenthesis has to be less than ten (but greater than 0. If the value inside the parenthesis is less than zero, then you will get a negative number when you multiply by 2." If the value inside the parenthesis is greater than 10, then you will get a number greater than 10 when you multiply it by 2. It I this type of thinking that students need to have when they do the "sense" step and monitor their thinking. "Why is it important for us to ask ourselves if our answer makes sense?"
Guided Practice (~5 min): 1.) 4 is increased by 6 times a number. The solution is 70. What is this number?	**Independent Practice (~15 min):** 1.) Four times a number is then subtracted by 5. The solution is the same as 39. Find the value of this number. 2.) Twice the sum of 3 and a number is equivalent to -18. Determine this number algebraically. 3.) Triple a number is the same as twice the same number added to 27. What is this number? 4.) The opposite of the sum of a number and 8 is equivalent 11. Find this number.

<table>
<tr>
<td>Closing (5 min):
Summarize lesson. Ask students to review the Aim and verbally explain the steps to STARS with their seat partner.

Exit Ticket
Triple a number added to 4 is the same as 19. What is this number?</td>
<td>Differentiations:
Classifying equations
Clarifying questions (“why do we do this?”
Organizer of inverse operations
Key terms organizer.</td>
</tr>
<tr>
<td>Additional Last Minute Notes:</td>
<td></td>
</tr>
</table>

<table>
<tr><th colspan="3">Essential Skills Review Class Lesson Plan #2</th></tr>
<tr><td>Content Area:
Common Core Algebra</td><td>Topic:
Solving Equations</td><td>Purpose:
To build our cognitive skills and practice using the STARS mnemonic strategy to help us initiate and persist through mathematical problem solving.</td></tr>
</table>

<table>
<tr><td>Purpose (2 min): How can we use the STARS strategy to help us remember how to solve word problems that involve multiplying or dividing by a fraction?

Aim: How do we translate word problems that have a fractional multiplier?</td><td>Do Now (5 min):
Skills Review:
Multiply the fractions:
3.) $\frac{1}{2}\left(\frac{3}{5}\right)$
4.) $\frac{4}{7}\left(\frac{2}{3}\right)$</td></tr>
<tr><td>Lesson (10 min total):

A: Recall the STARS strategy from the last time we did a review day. Have students go through their notebook and look at the acronym “STARS”. Have five students (one for each letter) give the entire class an explanation of each letter in “STARS.”

Have one student explain how we used “S” to help us identify key terms that indicate we are working with an equation.

Put this on the board for everyone to see

• Search the problem for mathematical operations or skills by identifying key terms.
• Translate the problem into an expression or equation if necessary.
• Attack the problem by solving for the unknown variable.
• Review the solution by substituting it back into your equation.
• Sense. Does your answer make sense?

Go over a word problem to review how we used parts STARS.
1.) Twenty four is added to three times a number. This value is the equivalent to six times the same number. Determine this number algebraically.</td><td>Questions/Comments:

Go over the explanation for why this is an important strategy to use.

We are using this strategy because it gives us a roadmap to solve a problem. Problem solving is a process and STARS helps us know that we are going through the right steps to get a good answer. At the same time, it is helping us improve our attention to important details, it helps us activate our memory about math, and it makes us aware of our own problem solving and thinking. If we do this well, we will improve in math.”

What does “S” stand for in “STARS?”

What resource can we use to help us “search” for key words?</td></tr>
</table>

Now, we will be working with similar word problems; however, these word problems include fractions. (Pass out half sheet with common words/phrases that indicate fractions). Have students read out these words to gain exposure. 1.) Example: 50 is equivalent to one-fifth of a number added to 12. Determine algebraically the value of this number. 2.) A bicycle is on sale for two-thirds of its original price. The final price of the bicycle includes the sales price and a	(Teacher Models the rest of the steps.) Demonstrate how to use the STARS strategy with the first example problem. Physically show students how to use "S", underline the key terms, "equivalent," "one-fifth," "added to," etc. Annotate what these words mean in terms of mathematical operations. Cross off "S". Then demonstrate to students how you will "translate" the sentences into the equation, "$50 = \frac{1}{5}x + 12.$" Now that you have completed "T" of STARS, make sure to cross off "T." Ask students, "What am I doing to S, T, A, R, and S" as I moved through the problem?" -Get them to come up with the answer that you are crossing it off. Ask students, "Why do you think it is important to cross off the steps?" Once everyone understand how we got to the the equation, then demonstrate how to "Attack the problem." This is solving for your variable. Encourage students by telling them that they know how to do this problem and they are successful with it. Cross off "A." When you arrive at "$x = 190$", complete the "R" (Review) step. This is substitution. Cross off "R." Go onto "S." Spend some time. Ask students, "Do you think 190 is a reasonable answer? Why or why not?" "Based on your equation, 190 works, but why?" "When you take $\frac{1}{5}$ of 190, should you get a smaller number or a bigger number?" Process with students, why "S" is an important

$10 delivery fee. If the final price is $364, then how much was the original price of the bicycle?	step. Explain that most students usually do steps such as “S,” “T,” and “A” and a small fraction of students do “R.” Ask students, “Why is it important for us to ask ourselves if our answer makes sense?” If time permits, repeat STARS strategy with this problem. Be careful, students may pick the variable “o” for original price. This may confuse students to think it is a 0, so guide students to picking another variable, maybe “p.” Circle or underline “two-thirds,” “of,” “final price,” and “includes.” Like the last example, make sure to annotate what these words mean in terms of mathematical operations. Ask students, “When I finish the first step, what should I do?” Cross off “S.” Translate the equation. If students are doing well, have them translate it for you. Make sure students know that “includes the $10 shipping fee looks like “+10.” The equation should be “$\frac{2}{3}x + 10 = 364$ Ask students, “When I finish the first step, what should I do?” Cross off “T.” Then solve the problem. Ask students, “When I finish the first step, what should I do?” Cross off “A” Ask students, what comes after ‘S,’ ‘T,’ and ‘A,’ ? Review by substituting your answer in to the equation. Finally, go over the “S” step with students. Does your answer make sense? Why or why not? “Original price is supposed to be higher than the final price since the bike is on sale. If you were to buy something on sale, you are paying less than the original price.” “What would happen if you solve for a variable that has a smaller value than 394?”

Guided Practice (~5 min): Have students attempt this problem. Make sure they use STARS. Encourage them to use it. Kaylah sold tickets to a very expensive Broadway show. Each ticket's final price was \$105. If the final price is three quarters of the original price, how much was the original price?	**Independent Practice (~10 min):** 1.) Seneca is a small town outside of Albany, New York. According to the U.S. Census, four-fifths of the total population in 2015 was considered middle-class. If 22,000 people were middle class, then what was the total population in 2015? 2.) One half of a number added to 15 is the same as twice the same number. 3.) Rachel bought a discounted flat screen TV for a final price of \$675. The final price of the flat screen TV included the discount price and a one-time delivery fee. The discount was three-quarters the original price of the TV and the delivery fee was \$60. Determine the original price. 4.) A recipe for a wedding cake requires 8 full cups of flour. Benny has a problem: He could only find his one-third cup measuring cup. How many times would Benny have to use his one-third cup measuring cup to fill the recipe's requirement of 8 cups of flour? 5.) Alvin is planning on inviting a few friends over for a dinner party. He wants to serve his famous mashed potatoes. The recipe calls for each serving to include $^7/_8$ cups of potatoes. He has a total of 10 potatoes. Not including himself, how many people can he serve with 10 potatoes?
Closing (5 min): The freshman class at Albert High School is planning a ski trip in January. There are 236 students in the class who turned in permissions slips and liability waivers for the ski trip. This represented five-sixths of the entire freshman class. How many students are in the entire freshman class?	**Additional Differentiations:** Use Key terms list. Reference it multiple times throughout the lesson.
Additional Last Minute Notes:	

<table>
<tr><th colspan="3">Essential Skills Review Class Lesson Plan #3</th></tr>
<tr><td>Content Area:
Common Core Algebra</td><td>Topic:
Function Notation</td><td>Purpose:
To build our cognitive skills and practice using the STARS mnemonic strategy to help us initiate and persist through mathematical problem solving.</td></tr>
</table>

<table>
<tr><td>Aim (2 min): How do we use the STARS strategy to help us write, interpret, and solve linear functions?</td><td>Do Now (5 min):
Tyrell is starting an exercise program at the gym. He hires a trainer that charges $25 for the first introductory session. The trainer then charges $15 for each, one-hour session, after the introductory session. The gym's contract states that a member who wishes to have personal training must spend at least $100 included the introductory session. How many hours must Tyrell work with his Trainer to follow the gym's contract?</td></tr>
<tr><td>Lesson (15 min total):

Put this on the board for everyone to see

1.) Search the problem for mathematical operations or skills by identifying key terms.
2.) Translate the problem into an expression or equation if necessary.
3.) Attack the problem by solving for the unknown variable.
4.) Review the solution by substituting it back into your equation.
5.) Sense. Does your answer make sense?

1.) An internet company charges a one-time installation fee of $30 and a $22 monthly service charge. Write an equation for T(m), the total cost of charges for, m months. If T(m) = $228. How many months was Michael billed for?</td><td>Questions/Comments:

Have students quietly in pairs discuss why we use this strategy. After one minute is up (put a timer on), call on two students to share their students' responses (as students are discussing, go up to two students and let them know you will call on them). In the one minute, go up to pairs and say that they will share their responses (do this instead of cold-call).

Ask students (pick them a head of time) to share out how the mnemonic is helping them keep track of their work.

Ask students to think silently about this problem? What do you notice? How is this problem different from other linear functions we have worked with thus far? What numbers are important? What does T(m) and m represent?

There are two parts to this problem: 1) writing a function in function notation and 2) solving it.
Students need to understand that function notation: T(m) and m. Review this if necessary.

Use STARS to demonstrate how to write the problem. Search the problem for key terms.</td></tr>
</table>

2.) A local district park is improving its swimming pool by replacing the pool lights with new, florescent lights. The lights are supposed to be brighter to increase lifeguard's visibility of the swimmers at night. The pool must first be drained of its water. If the pool initially holds 20,000 gallons of water and can be drained at a rate of 250 gallons per minute, how many minutes will it take for the pool to be drained so that there is no water left? Write an equation for this function using *G(m)* as the number of gallons in the pool and *m* for the number of minutes.	Some of the key terms in this problem is "installation fee" (initial value, 30) and "monthly service charge" (rate of change, 22). Since T(m)= 228, we write 228 = 22m+30. For this problem ask students, "what exactly is the problem asking us to find? Is it the total cost or is it the number of months? Have students solve the problem. Model the review and sense part This problem is a bit tricky. First, it is a decreasing function. So how will this look in the equation? Is the rate of change positive or negative? What word tells you this? Model the "search" step of STARS. Go over strategies to scratch out parts of the equation that is not important (first two sentences). The word "drained" indicates this is a decreasing function. "Initially holds" is the initial value. G(m) is the total number of gallons of water in the pool. In this case, G(m) has to be 0 because the problem says to find "m" when there is no water. "No water" means G(m)=0. Model this thinking. Then ask a student to give the function. 0=20000-250m. Some students may write 0=250m+20000 because 20000 is the number of gallons of water in the pool but they have the 250m incorrect. Solve this problem with them and model the review and sense step? Does it make sense m equals a negative number?

Guided Practice (~5 min):	**Independent Practice (~10 min):**
1.) Andy has \$310 in his account. Each week, *w*, he withdraws \$30 for his expenses. Write an equation, *T(w),* to represent the amount of money Andy has in his account. Find *w* if *T(w)* = 40.	1.) iTunes charges a new customer an initial \$6 fee to use a gift card. They charge an additional \$4 for every movie, *m,* thereafter. *C(m)* represents to total charges. Ken is a new iTunes user and has a gift card worth \$50. How many movies can he download using his gift card? 2.) A college bookstore charges \$60 for yearly membership. Each book, *b*, that Michelle will purchase costs \$125. Write an equation where *C(b)* represents her total charges, including the yearly membership fee. How many books can Michelle buy if her total charges, including the membership fee is not to exceed \$700? Explain your answer. 3.) Caitlin has a movie rental card that is initially worth \$175. Each movie rental costs \$3.00. Write an equation to define *A(n)*, the amount of money on the rental card after *n* rentals. Caitlin rents a movie every Friday night. How many weeks in a row can she afford to rent a movie, using her rental card only? Explain how you arrived at your answer.
Closing (5 min): 1.) Determine the zeros of the function $f(x) = (x+2)^2 - 25$ are	**Additional Differentiations:**
Additional Last Minute Notes:	

<table>
<tr><th colspan="3">Essential Skills Review Class Lesson Plan #4</th></tr>
<tr><td>Content Area:
Common Core Algebra</td><td>Topic:
Solving Linear Equations</td><td>Purpose:
To build our cognitive skills and practice using the STARS mnemonic strategy to help us initiate and persist through mathematical problem solving.</td></tr>
</table>

<table>
<tr><td>Aim (2 min): How do we use the STARS strategy to help us remember how to solve linear function word problems?</td><td>Do Now (5 min):
Skills Review:
Solve for the variable. Only an Algebraic solution will be accepted.

5.) $6x - 4 = -28$

6.) $64 = 4.5x + 10$</td></tr>
<tr><td>Lesson (10 min total):

Recall the STARS strategy from the last time we did a review day. Have students go through their notebook and look at the acronym “STARS”. Have five students give the entire class an explanation of each letter in “STARS.”

Have one student explain how we used “S” to help us identify key terms that indicate we are working with an equation.

Put this on the board for everyone to see

6.) Search the problem for mathematical operations or skills by identifying key terms.
7.) Translate the problem into an expression or equation if necessary.
8.) Attack the problem by solving for the unknown variable.
9.) Review the solution by substituting it back into your equation.
10.)Sense. Does your answer make sense?</td><td>Questions/Comments:

Ask students, “Why do you think we are using this strategy to help us problems solve?”
- Anticipated student responses:
“To help us start a problem”
“So that we can solve problems.”
“So that we can earn points.”
If students do not hit on the points on “initiate problem,” “persist in problem solving,” or to use our “cognitive skills” and “memory,” then have this discussion with them.

“We are using this strategy because it gives us a roadmap to solve a problem. Problem solving is a process and STARS helps us know that we are going through the right steps to get a good answer. At the same time, it is helping us improve our attention to important details, it helps us activate our memory about math, and it makes us aware of our own problem solving and thinking. If we do this well, we will improve in math.”</td></tr>
</table>

1.) Mario paid \$44.00 in taxi fare from the hotel to the airport. The cab charged \$2.25 for the first mile plus \$3.50 for each additional mile. How many miles was it from the hotel to the airport?	Demonstrate how to use the STARS strategy with the first example problem. Physically show students how to use "S", underline the key terms, "equivalent," "one-fifth," "added to," etc. Annotate what these words mean in terms of mathematical operations. Ask students, "what algebraic concept does this problem represent?" Now that students have identified this problem as a "linear function," ask a student to give the general equation for a "linear function." Say, "now that we know this is a linear function, our equation should look like "$y = mx + b$" The ask students, "what does "m" and "b" represent?" Tell students, "identify the numbers in the problem that corresponds with 'm' and 'b.'" Cross off "S". Demonstrate to students how you will "translate" the sentences into the equation to represent the situation., "$44.25 = 2.25m + 3.50.$" Now that you have completed "T" of STARS, make sure to cross off "T." Ask students, "What am I doing to S, T, A, R, and S" as I moved through the problem? It is just like the other day." Ask students, "Again, why is it important for us to cross off each step." Proceed to "A" when everyone is ready. Cross off "A" when completed." When you arrive at "$x = 18$", complete the "R" (Review) step. This is substitution. Ask students Cross off "R." Move to "S.", "Is 18 a reasonable answer?" "What if I said she rode a taxi for 10 miles? How much money would she pay? What if she rode the taxi for 20 miles? How much money would she pay? Since \$44 is in between the

2.) A website offers a discount for buying songs. If one song is bought at the full price of \$1.29, then each additional song is \$.99. State an equation that represents the cost, *C*, when *s* songs are downloaded. Sandy figured she would be charged \$52.77 for 52 total songs? Justify your answer.	price for 10 and 20 miles, and it is closer to the calculation for the 20 miles, then 18 miles would make sense. Ask, "Why is it important for us to ask ourselves if our answer makes sense?" If time permits, repeat *STARS* strategy with this problem. Since the problem gives students a variable, C, then students must use this variable. Tell students this or they will get one point off on the exams. Ask: "Does this problem resemble a linear function? Why or why not?" Since it does, ask students to identify the "m" and the "b." Ask students, "When I finish the first step, what should I do?" Cross off "S." Translate the equation. Note that the first part of the problem identifies the "m" and the "b." \$52.77 is the total cost. The equation should be "$52.77 = .99s + 1.29$. Ask students, "When I finish the first step, what should I do?" Cross off "T." Then solve the problem. Ask students, "When I finish the first step, what should I do?" Cross off "A" Move to "R". The answer should work. Cross off "R." Finally, go over the "S" step with students. Students will get "$s = 52$" but "s" stands for the number of songs at the discounted price. "The "+1.29" means that she has to buy one song at the full price first to get the other 52 songs at .99. So in reality, she has 53 songs." So the total \$52.77 is the charge for 53 songs.

Guided Practice (~5 min):	Independent Practice (~10 min):
1.) Julio works as a computer technician every Saturday. He worked for five hours and his total wages earned last Saturday was $148.75. Determine algebraically how much he gets paid for every hour he works.	6.) Robin spent $17 at an amusement park for admission and rides. If she paid $5 for admission, and rides cost $3 each, what is the total number of rides that she went on? 7.) Alexander paid for a plumber to fix his sink. The plumber charges an initial fee of $35.50 and $28.60 for each hour of work. The plumber charged a total of $207.10. How many hours did the plumber work?
Closing (5 min): 1.) A cell phone company charges $60.00 a month for up to 1 gigabyte of data. The cost of additional data is $0.05 per megabyte. If *d* represents the number of additional megabytes used and *c* represents the total charges at the end of the month, write a linear function that can be used to determine a user's monthly bill. How many additional megabytes did a Raquel use if her total charges for June were $60.75.	**Additional Differentiations:** Use color coding: Green for initial value and red for rate of change. Use book marks and posters with the *STARS* mnemonic on it as a reference.
Additional Last Minute Notes:	

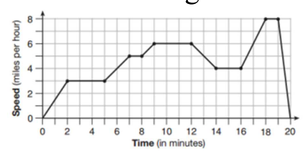
Essential Skills Review Class Lesson Plan #5

Content Area:	**Topic:**	**Purpose:**
Common Core Algebra	Function Notation	To build our cognitive skills and practice using the STARS mnemonic strategy to help us initiate and persist through mathematical problem solving.

Aim (2 min): How do we use the STARS strategy to help us write, interpret, and solve linear piecewise functions?

Do Now (5 min):

1.) The graph below represents a jogger's speed during her 20-minute jog around her neighborhood.



1.) Describe the jogger's speed from 0 minutes to 2 minutes.

2.) Describe the jogger's speed from 9 minutes to 12 minutes.

Lesson (15 min total):

Put this on the board for everyone to see

11.) **S**earch the problem for mathematical operations or skills by identifying key terms.
12.) **T**ranslate the problem into an expression or equation if necessary.
13.) **A**ttack the problem by solving for the unknown variable.
14.) **R**eview the solution by substituting it back into your equation.
15.) **S**ense. Does your answer make sense?

3.) According to the United States Postal Service (in 2014), the total cost of mailing first-class letters up to one ounce is 50 cents. Each additional ounce will incur an additional 2 cents to the total cost.

a.) On the grid below, draw a piecewise step function to model the relationship *C(s)*, the total cost of sending a first-class letter and *s*, the weight of the letter in ounces.

Questions/Comments:

Quick 2 minute match game. On the quizlet website, have one student demonstrate the steps on the board.

Ask students, "could the cost to send mail be 51 cents? Why or why not?"

Why does it make sense that a letter cannot cost 51 cents?
Guide students to understand that once you go over the first ounce, even the smallest bit, will make it "jump" to 52 cents.

So how will this look on a graph? Will I be drawing an increasing graph? A graph with no slope? Undefined slope?

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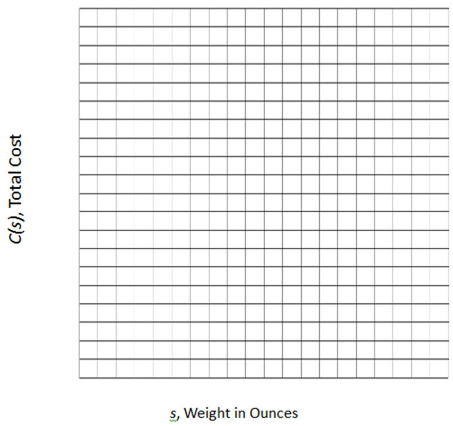
<tr>
<td>


b) Write the equations for the first three “steps” to the piecewise function. Make sure to give the proper domains.

c) What is the total cost to mail a first-class letter that weighs 3.5 ounces? What is the total cost to mail a first-class letter that weighs 7 ounces? Justify your answers.
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*Lesson from day before went over open and closed circles. Refer back to it when necessary.

Model how to write the different steps. From the steps, demonstrate the translate portion of the STARS strategy. And then attack the problem.

Answer Part C by attacking the problem. Note that attacking the problem for this looks a little different. We are not performing many mathematical procedures but rather reading our graph, and our equations.
Demonstrate how to look for your answer on the graph and the equations you made. Even if your answer is incorrect, if you obtain your answer from your graph or equations despite it being wrong, you can still earn 1 point show demonstrating your knowledge.
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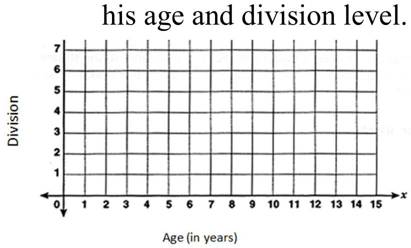
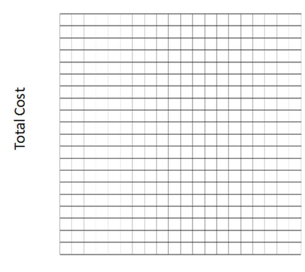
<td>
Guided Practice (~5 min):

1.) Morgan can start wrestling at age 5 in Division 1. He remains in that division until his next odd birthday when he is required to move up to the next division level. Make a graph to show his age and division level.



a.) Write a piecewise step function for this relationship up until Morgan’s 13^{th} birthday.
b.) What division will Morgan participate in when he is 9 years old? What division will he participate in when he is 12 years old? How do you know?
</td>
<td>
Independent Practice (~10 min):

a.) Jamala is at a carnival where it costs $20 for admission and each ride costs $4. She does not spend money on food, drinks, or souvenirs. Make a graph to show the amount of money Jamala has left once she enters the carnival and go on rides.



b.) Write a piecewise step function for the relationship in your graph?
c.) How much money will Jamala have left after riding three rides?
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</table>

Closing (5 min):	Additional Differentiations:
1.) Sam and Jeremy have ages that are consecutive odd integers. The product of their ages is 783. What is Jeremy's age?	Some students will need additional scaffolding for graphing. Some worksheets should have the axis already labeled. The Regents exam makes the students label but for now it is ok if some students have them labeled.
Additional Last Minute Notes:	

Essential Skills Review Class Lesson Plan #6		
Content Area: Common Core Algebra	**Topic:** Systems of Linear Equations	**Purpose:** To build our cognitive skills and practice using the STARS mnemonic strategy to help us initiate and persist through mathematical problem solving.

Aim (2 min): How do we use the STARS strategy to help us write, work through and solve a system of linear equations word problem?

Do Now (5 min):

1.) Complete the sentence by inserting either the word "POSITIVE" or "NEGATIVE" to make the statement true. Then complete the four mental math problems below.

a.) If you multiply a positive number by a negative number, the product will be ___________________.

b.) If you multiply a negative number by a negative number, the product will be ___________________.

c.) If you divide a positive number by another positive number, the quotient will be ________________.

2.) Determine whether each product will be positive or negative. Write it down. Then multiply.

$-4(8) =$	$(-3)(-2) =$
$(7)(3) =$	$(9)(-2) =$

Lesson (15 min total):

Put this on the board for everyone to see

16.) **S**earch the problem for mathematical operations or skills by identifying key terms.

17.) **T**ranslate the problem into an expression or equation if necessary.

18.) **A**ttack the problem by solving for the unknown variable.

19.) **R**eview the solution by substituting it back into your equation.

20.) **S**ense. Does your answer make sense?

Questions/Comments:

Each pair of students will be given 10 square cards. Five yellow cards will have the letters, S, T, A, R, and S, written on the front. Five blue cards will have one of the steps written on each of them. All cards will be faced down. Students will play the game "memory" by flipping over a yellow card first. Then they have to flip over a blue card. If the blue card description matches the step of the letter on the yellow card, then that student will take the pair and count it as a point. If a student flips a blue card that does not match the yellow card's letter, then they will flip it back over and it is the other student's turn. They will play this game over and over again for about 4 minutes.
Once the 4 minutes is up, have students share out their experiences with the *STARS* strategy.

Example Problem #1: On Friday, Ms. Cruz bought six belts and eight hats for \$140. A week later, at the same prices, Ms. Saporito bought nine belts and six hats for \$132. Determine the cost one belt and one hat.	Model the problem-solving process by using *STARS*. Say, "I know the first step of *STARS* is S, which stands for search. I will search for the key terms. When I read, the problem, there does not seem to be any words that stick out other the goal of the problem: to find the cost of the belts and hats. I am going to define my variables. But what are my variables? Finding the cost of one belt and one that is my goal, these must be what I am solving for. I will let B equal the cost of one belt and H equal the cost of one hat." Ask students "why is it best to label the variables as B and H and not x and y?" Set up the equation. Go on the "T:" translate. Say, 'The first sentence says Ms. Navarro bought 6 belts and 8 hats for \$140' So, this should be translated as "6B+8H=140.' I also know that another teacher, Ms. Speer bought nine belts and six hats for \$132. This then should translate 9B+6H=132." But the equations right under each other and align the variables. $6B + 8H = 140$ $9B + 6H = 132$ Ask questions for clarification. This part is where most students struggle so it is ok to spend some time going over the translation part. Go on the "A:" Attack. Most students know what to do from here because they have demonstrated mastery here. But just go over in case you need it. Demonstrate the attack part by solving (for bother variables. Go on the "R:" Review. This is a good opportunity to make a mistake on purpose. Some students with solve for one variable and stop. Demonstrate that some students get one variable, and look over their work but do not recognize that they need to solve for the other variable. The "Sense" part is similar to the review, but in this case, some students may get a negative answer. Ask "why should we be alarmed if one

<table>
<tr><td></td><td>of our variables is equal to a negative number?" Have discussion with students about this.</td></tr>
<tr><td>Guided Practice (~5 min):
1.) The school that Stefan goes to is selling tickets to a choral performance. On the first day of ticket sales the school sold 3 senior citizen tickets and 1 child ticket for a total of $38. The school took in $52 on the second day by selling 3 senior citizen tickets and 2 child tickets. Find the price of a senior citizen ticket and the price of a child ticket.</td><td>Independent Practice (~10 min):
1.) Jack bought 3 slices of cheese pizza and 4 slices of mushroom pizza for a total cost of $12.50. Grace bought 3 slices of cheese pizza and 2 slices of mushroom pizza for a total cost of $8.50. What is the cost of one slice of mushroom pizza?
2.) The equations $5x + 2y = 48$ and $3x + 2y = 32$ represent the money collected from school concert ticket sales during two class periods. If x represents the cost for each adult ticket and y represents the cost for each student ticket, what is the cost for each adult ticket?
3.)</td></tr>
<tr><td>Closing (5 min):
1.) Last night, Mr. Donaldson took his wife to dinner at a Mexican restaurant. She got ordered taco and one soda and it cost $2.10. Mr. Donaldson ordered 2 tacos and 3 sodas which cost him $5.15. How much did each taco and soda cost?</td><td>Additional Differentiations:
#2 on the Independent practice already has the equation written out. If students are struggling with the translation part, direct them to #2 to complete first.</td></tr>
<tr><td>Additional Last Minute Notes:
Students have had a few systems of equations questions on the spiral review section of the homework assignments within the past three weeks. Many have demonstrated that they can solve but need the prompting to write the equations. Do not feel worried about showing them how to calculate, focus on the searching and translating parts.</td><td></td></tr>
</table>

Essential Skills Review Class Lesson Plan #7		
Content Area: Common Core Algebra	**Topic:** Operations with Exponents (Growth and Decay)	**Purpose:** To build our cognitive skills and practice using the STARS mnemonic strategy to help us initiate and persist through mathematical problem solving.

Aim (2 min): How do we use the STARS strategy to help us write, work through, and solve Growth and Decay problems?	**Do Now (5 min):** 1.) Which expression is equivalent to $3^3 \cdot 3^4$? a. 9^{12} b. 9^7 c. 3^{12} d. 3^7 2.) Some bank account accrues interest every year. Jim puts money in an account but does not deposit or withdraw money from the account The equation $y = 5000(1.02)^x$ represents the value, *y*, of one account for a period of *x* years. What does 1.02 represent in the context of this situation?
Lesson (15 min total): Put this on the board for everyone to see 21.)**S** 22.)**T** 23.)**A** 24.)**R** 25.)**S** Ask students immediately after the Do Now, "What do you think about when you see the word "STARS?" Example Problem #1: Kathy deposited money in an account that accrues interest at a rate of 14% per year. The initial deposit was \$21,000. Write an equation that represents the value, *v(t)*, in the account after *t* years. How much money will Kathy have after 3 years? Why is your answer greater than \$21,000?	**Questions/Comments:** Do this after you ask the question to the left: Tell each pair of students to write or draw about their experience with the strategy. Choose three groups to share their experiences and feelings. Make sure to ask students why they felt this way. The key term here is "accrues interest." When you model the STARS mnemonic strategy, make sure that students understand that "accrues" means increasing, but it does not mean to add. It means to multiply each time. Give students the general equation for a Growth and Decay Problem: $y = ab^x$, where a is the initial value and b is the rate. Now go on to the translate step. When you translate this, anticipate that some students will translate the rate to be

<table><tr><td>Accrued Interest Rate</td><td>Multiplier</td></tr><tr><td>1%</td><td>1.01</td></tr><tr><td>2%</td><td>1.02</td></tr><tr><td>7%</td><td>1.07</td></tr><tr><td>14%</td><td>1.14</td></tr><tr><td>19%</td><td>1.19</td></tr><tr><td>20%</td><td>1.20</td></tr><tr><td>54%</td><td>1.54</td></tr></table> Example Problem #2: Some banks charge a fee on savings accounts that are left inactive for an extended period of time. The equation $y = 5000(0.98)^x$ represents the value, y, of one account that was left inactive for a period of x years. The account is checked after 5 years and 7 years. What is the difference in money from 7 years in comparison to 5 years? <table><tr><td>Decay (Decrease)</td><td>Multiplier</td></tr><tr><td>1%</td><td>0.99</td></tr><tr><td>2%</td><td>0.98</td></tr><tr><td>7%</td><td>0.93</td></tr><tr><td>15%</td><td>0.85</td></tr><tr><td>20%</td><td>0.80</td></tr><tr><td>30%</td><td>0.70</td></tr><tr><td>54%</td><td>0.46</td></tr></table>	"14." But this is inaccurate. Because we are accruing interest, the 14% is always added to the 100% of what is in the account. So 14% interest is represented as 100% + 14%. But in decimal form it is "1.14." 1.14 is what you put in for b. Anticipate this to be a problem for students. Put up the chart on the left. Have students fill in the "multiplier" for each percentage of accrued interest. So the equation is $v(t) = 21000(1.14)^t$ Go on to the "A" step: Attack. Have students identify the t. The problem says that the time in years is 3. Substitute this in for t and solve. Go on to the "R" step: Review. Demonstrate here how you can spot check to make sure that your equation is set up correctly. You may even want to write out the components to the equation and verify that the numbers are in the correct place. The "Sense" part is similar to the review, but in this case, ask the question, "If you are accruing interest, then you are gaining money. Why would it make sense for your answer to be more than $21000? What do you think happened if you got a number than is less than 21000? Would this be possible in this situation? Ask students, "How is this problem different from the previous example that we just completed?" "What about the multiplier?" Model the search step. In this case, the multiplier and the equation is already given. "But why is the multiplier less than 1?" Discuss with students why this is the case. Go over this Also, the question is asking students to do something more than just solve for y. It is asking students to find the difference from 5 years and 7 years. Put this table (to the left) on the board for students to see and fill out. For decay

<table>
<tr><td></td><td>functions, we are using a multiplier that is less than one. Explain why (every year, the population is 81% of the previous years population).

Attack the problem. Use a calculator for this step. Review the problem and spot check the equation to make sure the year is in the place of the exponent.
For Sense, ask “if we are decreasing, then should we expect the population to be less or more than 5,000? Does your answer make follow this logic?

Review, once you find the value for after 5 years, we also have to find the value after 7 years. You also have to subtract them.

Sense: Some students make get a negative number. Ask why negative numbers does not make sense here. Some students may subtract the value for 5 years from the 7 years thus making it negative. But it should be the other way around. Ask why.</td></tr>
<tr><td>Guided Practice (~5 min):
2.) Rhonda deposited $3000 in an account in the Merrick National Bank, earning 4.2% interest, compounded annually. She made no deposits or withdrawals. Write an equation that can be used to find B, her account balance after t years.</td><td>Independent Practice (~10 min):
4.) The value, y, of a $15,000 investment over x years is represented by the equation $y = 15000(1.2)^{\frac{x}{3}}$. What is the total amount of money after a 6-year investment? What is the profit (total amount minus the initial value)?
5.) Adrianne invested $2000 in an account at a 3.5% interest rate compounded annually. She made no deposits or withdrawals on the account for 4 years. Determine, to the nearest dollar, the balance in the account after the 4 years.</td></tr>
<tr><td>Closing (5 min):
1.) The population of Henderson City was 3,381,000 in 1994, and is growing at an annual rate of 1.8%. If this growth rate continues, what will the approximate population of Henderson City be in 5 years?</td><td>Additional Differentiations:
For the independent work, give the problems with the equations to struggling students. Have them practice the review and sense step. Most of the questions from the Regents exam give the equation.</td></tr>
<tr><td>Additional Last Minute Notes:</td><td></td></tr>
</table>

<table>
<tr><th colspan="3">Essential Skills Review Class Lesson Plan #8</th></tr>
<tr><td>Content Area:
Common Core Algebra</td><td>Topic:
Quadratic Functions</td><td>Purpose:
To build our cognitive skills and practice using the STARS mnemonic strategy to help us initiate and persist through mathematical problem solving.</td></tr>
</table>

<table>
<tr><td>Aim (2 min): How do we use the STARS strategy to help us write, work through, and solve quadratic function problems</td><td>Do Now (5 min):
1.) What values of x will make the equation
$(x+2)(x-5)=0$, true?

2.) What method would you use to factor the expression, x^2-36?</td></tr>
<tr><td>Lesson (15 min total):
Put this on the board for everyone to see. Do not define the steps. Students hopefully would have internalized the steps. But just put it on the board to prompt them to think about the steps.

26.)S
27.)T
28.)A
29.)R
30.)S</td><td>Questions/Comments:

Instruct students to reflect on their learning in class. Specifically ask students to write down in their notebook how they have grown as a problem-solver. What part of the STARS mnemonic strategy is the most useful for you when you problem solve?

Bring the class together after 4 minutes and discuss which part was helpful. Teacher may want to model how the discussion should sound like. Example l: “I really thought Sense was the most helpful step for me because….”</td></tr>
<tr><td>Example Problem #1:
Amy solved the equation $x^2+x-35=0$ She stated that the solutions to the equation were 7 and -6. Do you agree with Amy's solutions? Explain why or why not.</td><td>Students first need to recognize that this is a quadratic equation. When they attempt the search step, they may realize that there they do not need to identify any key terms but they need to identify the concepts. Also, the problem asks students to explain whether Amy is right or wrong. This still requires them to solve the problem and do mathematical operations.

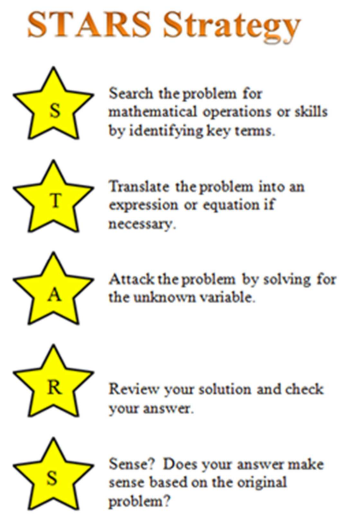
Students can either 1) factor the equation and solve or 2) substitute the 7 and -6 into the equation.
So for this problem, the Search and Translate steps are not very helpful. Students rather have to search the problem to determine what the concept.</td></tr>
</table>

Example Problem #2: Clara is solving quadratic equations algebraically. She comes across the equation $x^2 = 16x - 28$. What is the first step Clara needs to do in order to solve this quadratic equation knowing that she cannot use her graphing calculator? Next, demonstrate to Clara the steps she needs to complete in order to solve this quadratic equation.	Have the students Attack the problem depending on which way they choose. Demonstrate both ways of the attacking the problem. For the Review and sense steps, instruct students to re-read the problem and make sure that they understand that this problem is a quadratic. Students already have a good sense that quadratics sometimes have two solutions. Ask them why most quadratics have two solutions. The STARS mnemonic strategy for this problem will be a little different, but similar to example problem #1. For "S" and "T," the equation is already given, so we can check off "S" and "T." Even though we crossed off the "S," the key term quadratic equation should initiate the students' memory about how to solve quadratics. It may be helpful to point out that there are two parts to the problem: say what her first step is and then solve the problem. Because this is a quadratic (and the problem says it is), students should be able to move the 16x-28 over to the other side. Ask students why they must do this? Students should indicate they need to factor. When students read "quadratics" they automatically need to think about setting the equation equal to zero and then factor. Once the students establish the thinking to move the terms overs to the left to set the equation equal to zero, then they must factor. Demonstrate how to factor if needed. You may want to start the students off with the first part of factoring but gradually let them finish it on their own.

Guided Practice (~5 min):	**Independent Practice (~10 min):**
3.) The function $r(x)$ is defined by the expression $x^2 + 3x - 18$. Determine the zeros of $r(x)$. *For this problem, model the "S" step and explain to students that "zeros" is a key term for the students to factor and set the equation equal to zero.	6.) Mr. Lucas is teaching his students to solve quadratic equations. He presents the equation $8m^2 + 20m = 12$ to his class. Markie says to the class, "You have to use the quadratic formula because the coefficient of m^2 is greater than 1." Explain and show how Markie can use another method to solve this quadratic equation. 7.) Jocelyn claims that there are two solutions to the equation $f(x) = 3x^2 - 3x - 6$. Is she correct? Explain why or why not by showing how to algebraically solve for the solutions. 8.) Manuel is trying to algebraically determine the *x-intercepts* of the graph with the equation $x^2 - 6x = 0$. What should be his first step? Help Manuel determine the *x-intercepts*. 9.)
Closing (5 min): 1.) Donna wants to make trail mix made up of almonds, walnuts and raisins. She wants to mix one part almonds, two parts walnuts, and three parts raisins. Almonds cost $12 per pound, walnuts cost $9 per pound, and raisins cost $5 per pound. Donna has $15 to spend on the trail mix. Determine how many pounds of trail mix she can make. [Only an algebraic solution can receive full credit.]	**Additional Differentiations:**
Additional Last Minute Notes: For this lesson, most of the equations have already been set up. But students can still "attack," "review" and make "sense." This is a good opportunity to reinforce these skills. Also, it is a great opportunity to explain to students that STARS may not always work in the same way as the other Essential Skills Lessons. The problems in this lesson are trying to get students to explain their thinking, which is very much a metacognitive skill.	

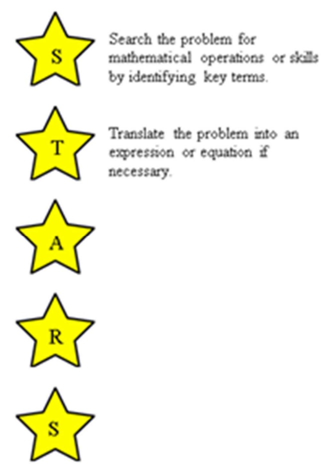
APPENDIX G. STUDENT EXIT TICKETS

Essential Skills Review Day Lesson #3: Exit Ticket
Directions: Solve the problem. Make sure to show all your work.



Determine the zeros of the function $f(x) = (x+2)^2 - 25$

Essential Skills Review Day #5: Exit Ticket
Directions: Solve the problem. Make sure to show all your work.



1.) Sam and Jeremy have ages that are consecutive odd integers.

The product of their ages is 783. What is Jeremy's age?

Essential Skills Review Day #8: Exit Ticket
Directions: Solve the problem. Make sure to show all your work.

1.) Donna wants to make trail mix made up of almonds, walnuts and raisins. She wants to mix one part almonds, two parts walnuts, and three parts raisins. Almonds cost $12 per pound, walnuts cost $9 per pound, and raisins cost $5 per pound. Donna has $15 to spend on the trail mix. Determine how many pounds of trail mix she can make. [Only an algebraic solution can receive full credit.]

APPENDIX H. STUDENT SATISFACTION SURVEY

Teacher Name: ___________________________

Class Period:__________

How much do you agree with the following statements?

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. My teacher understands how I learn.	1	2	3	4	5
2. My teacher teaches me how to use strategies to solve a math problem.	1	2	3	4	5
3. My teacher uses strategies that are easy to use.	1	2	3	4	5
4. I like using the strategies my teacher teaches me.	1	2	3	4	5
5. I think the strategies my teachers teach me help me learn.	1	2	3	4	5
6. My teacher uses written or oral explanations as well as visuals to help me learn.	1	2	3	4	5

APPENDIX I. STUDENT FOCUS GROUP QUESTIONS

Possible Student Discussion Questions: Post-Intervention

1.) Explain the steps in the *STARS* mnemonic strategy.

2.) When do you use the *STARS* mnemonic strategy?

3.) How does the *STARS* mnemonic strategy help you solve math problems?

4.) Why do you think this is a strategy that your teacher taught you?

5.) Describe your problem-solving experience when you use the *STARS* mnemonic strategy. Does it make you feel successful? Does it make you feel unsuccessful?

Additional Questions:

AQ1: How successful do you feel in problem solving?

AQ2: How satisfied are you with your learning how to problem solve?

AQ3: How successful were you in problem solving for math before learning about the STARS

mnemonic strategy? What challenges did you face when you problem-solved?

AQ4: How do you think the STARS mnemonic strategy helped you problem-solve?

AQ5: What do you think about your teacher's ability to teach you how to problem solve?

AQ6: Why do you think problem solving is important?

APPENDIX J. TEACHER SATISFACTION SURVEY

How much do you agree with the following statements?

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. The coaching sessions were helpful in planning lessons that use the STARS mnemonic strategy.	1	2	3	4	5
2. The coaching sessions were helpful in practicing the delivery of lessons that use the STARS mnemonic strategy.	1	2	3	4	5
3. I am able to communicate concerns about instructional strategy with my coach.	1	2	3	4	5
4. I believe the STARS mnemonic strategy is a good strategy to teach my students.	1	2	3	4	5
5. I think my students improved their mathematical performance because of the STARS mnemonic strategy.	1	2	3	4	5
6. I plan on using the STARS mnemonic strategy in my other math classes.	1	2	3	4	5

APPENDIX K. TEACHER FOCUS GROUP QUESTIONS

Possible Teacher Discussion Questions: Post-Intervention

1.) How do you think the STARS mnemonic strategy improved students' problem-solving skills?

2.) Explain how you felt using the STARS mnemonic strategy as a teaching method?

3.) Describe some of your students' success when using STARS?

4.) Describe some of you students' areas of difficulty when using STARS?

5.) Do you plan on using the STARS mnemonic strategy in the future? Why or why not?

6.) How do you think the coaching sessions helped you improve your instruction?

7.) What do you think was the most effective part of the coaching sessions?

Additional Questions:

Curriculum Vitae
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EDUCATION

- 2014 – 2018 **The Johns Hopkins University**
  Doctor of Education – Special Education
  Dissertation: "The Impact of *STARS* Mnemonic Strategy Instruction on Algebra Test Scores for Students with Deficits in Math"

- 2010 – 2012 **St. John's University**
  Master of Science in Education – Adolescent Math and Special Education

- 2009 – 2010 **Columbia University**
  Master of Arts – East Asian Languages & Cultures

- 2005 – 2009 **University of Notre Dame**
  Bachelor of Arts – History & Japanese (with Honors)

WORK & LEADERSHIP EXPERIENCE

- July 2016 – Present **St. John's University** Queens, NY
  Adjunct Instructor and Teacher Coach
  - Design and instruct graduate level courses focusing on the implementation of research- and evidence-based teaching strategies for mathematics, science, social studies, and English as a Second Language.
  - Coach and mentor approximately 30 new career teachers and school leaders every year.
  - Evaluate and provide feedback to teachers and school leaders.
  - Lead a team of three Adjunct Instructors in designing and implementing master's level courses to meet New York State Teacher Certification Standards.

- July 2012 – Present **KIPP NYC College Prep High School** Bronx, NY
  Founding Mathematics and Japanese Teacher, New Teacher Mentor
  - Develop and implement yearly curriculum in Mathematics, Special Education, and Japanese.
  - Evaluate teacher instruction through meaningful coaching and feedback.
  - Set learning and instructional goals.

- Analyze student performance data and design instructional interventions to meet goals.

- August 2010 – June 2012 **NYC Department of Education** New York, NY
  Special Education-Math Teacher, Sheepshead Bay High School & Vanguard High School
  - Successfully designed and taught Algebra and Geometry courses
  - aligned to Common Core State Standards.
  - Worked collaboratively with mentor teachers and administrators.

MASTER'S LEVEL COURSES TAUGHT

EDU 9704: Research Methods in Collaborative Partnerships for General, Special, and Inclusive Educational Settings
EDU 9706: Curriculum Adaptation and Modification Planning for Students w/Exceptionalities
EDU 9711: Education of Exceptional Individuals in Education
EDU 9726: Curriculum and Instructional Design for Students w/Exceptionalities in Math, and Science, and Social Studies
EDU 9742: Formal and Informal Educational Assessments for Individuals w/Exceptionalities

PRESENTATIONS, PANEL DISCUSSIONS, and WORKSHOPS

"PechaKucha: Revolutionizing Knowledge Sharing in the Classroom and On-Line." Teaching Narratives Symposium: Sharing Innovative Pedagogies, Queens, NY, May 2018.

"Preparing Beginning Teachers to Teach Mathematics in Inclusive Classrooms." Presented at the National Alliance for Public Charter Schools Conference, Washington, DC, June 2017.

"Awareness Through Film: *At Eye Level*." Panel Discussion at the ReelAbilities Film Festival, New York, New York, March 2017.

CERTIFICATES

NYS Professional Teaching Certificate—Mathematics (Grades 7-12)
NYS Professional Teaching Certificate—Students w/Disabilities-Math Concentration (Grade 7-12)
NYS Autism Certificate
Japanese – Advanced Proficiency