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Using the Four Square strategy to enhance math problem-solving

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USING THE FOUR SQUARE STRATEGY TO ENHANCE MATH PROBLEM-SOLVING

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Abstract

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This study examined whether the use of the Four Square problem-solving strategy would improve the math problem-solving performance of students who receive supplemental services for language arts literacy and mathematics from a basic skills teacher or a special education teacher. The Four Square strategy was used in conjunction with the enVision math series. It was also used during all problem-solving lessons. Students' growth in math problem-solving was measured using the enVision problem-solving pre- and post-test and the Measure of Academic Progress Test (MAP). Students showed growth on the enVision test. The students showed work when solving problems instead of just selecting one of the available answer choices and were able to increase the number of questions correct on the assessment. Students did show growth on the MAP test. They were able to close the gap between other students in the sixth grade who receive supplemental services for language arts literacy and mathematics from a basic skills teacher. The results indicate that the Four Square strategy can be a useful way to enhance students' problem-solving skills. The Four Square strategy allowed students to take ownership of their problem-solving skills and to improve these skills throughout the study.

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Chapter 1

Introduction

In today's schools students are expected to do more than just perform basic computation in math. They are expected to be able to solve word problems. Students are required to read word problems that can, for some, be challenging because of their reading difficulties. As students get older often math struggles can relate back to reading struggles in the classroom.

Often students seem overwhelmed by the words and can at times give up before even attempting to solve a word problem. Solving a word problem requires students to read the word problem multiple times and then think before starting to complete the problem. A student needs to understand what has been read, which may require a student with reading difficulties to reread the word problem. Next comes the task of using the information the student is given in the word problem in order to answer the question. Sometimes a word problem requires more than one answer, as well as an explanation regarding how the problem was solved is also required.

Most math series teach problem-solving, but all the questions in the chapter require a student to solve the same type of problem. Yet, that is not how life works. In the real world there is usually more than one way to approach finding the answer. When I have to solve a problem I usually start with a picture in my head no matter what the question is and then move on to solve the problem even if a picture is not necessary. Just the use of a picture in my head makes me feel I am able to tackle the word problem.

In order for students to successfully read a word problem they must have a grasp of math vocabulary and reading skills that determine what the word problem is really asking the students to do. Word problems do not always have a clear question that ends with a question mark but instead will use an imperative sentence to communicate what the student needs to do in order to solve the problem. Each student must look closely at the problem to ensure that the word problem is not just asking for more than a number answer.

One way to help students improve their math problem-solving skills is to teach them to use a graphic organizer to assist in the organization of the information stated in the word problem. The Four Square problem-solving technique allows the student to organize information presented in the word problem in a list format in the "What I Know" (WIK) section of the four boxes. The "Question" box allows the student to list each question or command stated in the word problem. The student is then able to make a plan on how to solve the problem before beginning to complete the work in the "Work" square. The student then has a defined work space to complete all computation and/or list to solve the problem. The final box allows the student to write his answer in a given area and proved space to write a sentence to go along with the final answer. The Four Square problem-solving technique allows the student to reread the problem a minimum of three times before beginning to solve the problem.

Given the difficulties with word problems that some students experience and the possibility that a reading strategy may help them be more successful, the research question to be examined in this study is: Will the use of the Four Square problem-solving technique improve the word problem-solving performance of sixth grade students who receive supplemental services through basic skills and special education for both reading and math?

The use of a Four Square problem-solving technique may assist students identified as having difficulties with math problem-solving by giving them a strategy to use when solving word problems. This technique will increase the student's willingness to effectively attempt to solve word problems by identifying the known information and the question and/or command that the word problem states. It is hypothesized that these students will also see an increase in beginning and end of the year math assessment scores compared to the previous school year.

Most forms of math assessment are no longer just a large quantity of given computation problems students need to solve. High stakes testing like the New Jersey Assessment of Skills and Knowledge (NJ ASK), district wide assessments such as Measure of Academic Progress (MAP Testing), and end of the chapter tests now require students to read word problems. This requires the student to read the word problem and then understand what the question is asking before being able to show if he/she knows how to perform a math skill. As students get older the number of students who are identified as having math difficulties also have been identified as having reading difficulties.

Problem-solving is an important skill for all people to learn not because it is a skill you need to learn to be successful in any math class. Word problems help students to begin to develop the skills needed in order to meet challenges they face in everyday life outside of school. When faced with a math word problem or a problem outside of math class, either at home or in school, a student needs to be able to take in the important information and organize it in a way that will allow the student to reuse the information to make a decision or react to a situation in an appropriate manner. Also, math problem-solving allows students to see that there may be more than one answer to a problem. There are many strategies for students to use when solving a problem depending on the type of student they are. Some students need a more visual way to solve a problem either literally, on paper, or visually, in their mind, while other students may do better using a method that allows the student to use words instead of a picture or both pictures and words.

Since students will be using problem-solving skills throughout their life, it is important for them to find ways to willingly approach math problem-solving while in school. The increase reading demands on students outside of reading class in school can turn many students off to the learning process. It is important for students to realize that reading word problems becomes easier with practice just like reading a book becomes easier with practice. Students are encouraged to improve their reading fluency by rereading books. By rereading a story a student's reading rate increases, his understanding of what is being read increases, and his familiarity with words improves. Reminding students of the importance of rereading outside of the reading class will help all students approach the task of solving a word problem.

Teaching problem-solving skills in math class with a word problem requires a teacher to stress to students they should not just jump into the meat of the problem first and find an immediate answer, but instead they need to stop and think before taking the first step. The first reading of a word problem allows the student to just become familiar with the necessary information and what you might be looking for when solving the problem. The second reading of a word problem allows a student to identify the information that is stated in the problem. The third reading allows the student ensure that he identified the question he needs to solve. The fourth or final reading allows the student to make sure he answered the question completely.

For some students the lack of success in the classroom leads to a sense of apathy when it comes to school. The student is willing to write any answer down to say that all his work has been completed. As teachers we need to find ways to help students find success and then work on building from this success. One way to help students when solving word problems during math classes is the use of a graphic organizer. Just by giving students a tool to organize the information from a word problem, students are able to start to identify information into their language. Students do not have to use full sentences; they can identify a number and its label that is in the word problem. Once students realize this one number was used to solve the word problem they can start to become more open to finding more information in the word problem, and identifying what the question in the word problem is.

Students are required to do large quantities of reading not just during language arts classes, but also during science, social studies, and math. In order for students who struggle with reading skills to find success it is important that they receive instruction in strategies that prove to be beneficial. Without a useful strategy that can assist the students in their problem-solving skills many of them will often give up and not attempt to solve word problems. It is important that the students realize that math vocabulary can be key in identifying they correct operations and pulling in out of the problem into a graphic organizer can help students to see what the math terminology is asking them and not become overwhelmed by the terms.

Problem-solving also allows students to develop personal strengths when It has been shown that the use of graphic organizers assist students outside of the language arts classroom. Breaking up the problem-solving process into defined steps may assist a student and help him to not give up before even starting to solve the word problem. In math graphic organizers have helped students to find possible solutions and given the students an organized way of communicating how the answer was achieved (Zollman 2009). The Four Square graphic organizer does this. It gives students a chance to organize the information that is given in the word problem, identify everything the question is asking them to find, a place to complete the math computation and/or list development, and a spot to clearly convey the answer and any explanation that is needed.

Chapter 2

Literature Review

Background on Math Learning

The National Mathematics Advisory Panel (2008) has found that the use of real-world problems for upper elementary and middle grade students has a positive impact on certain types of problem-solving. In order for students with learning disabilities and students identified as low-achieving to develop the ability to apply mathematics skills to novel problems and to solve word problems the use of explicit systematic instruction can improve the students' performance for solving word problems. This requires the teacher to explain and demonstrate specific strategies. Students need to think aloud about each decision they are making as they solve problems, and have the chance to ask and answer questions. As school districts in New Jersey transition to the Common Core Content Standards (2010), it is important for students to be able to analyze the problem to locate a starting point and gain insight into the problems solution.

Problem-solving requires students to apply math skills to real world situations (Rutherford-Becker & Vanderwood, 2009). Word problems can be broken into a variety of categories and assess a variety of skills depending on what the student is being asked to do to solve the word problem.

Word problems can be broken into subgroups based on the strategy a student needs to use to solve the problem. Students are required to compare, change, combine, or equalize when completing problem-solving tasks (Vilenius-Tuohimaa, Aunol & Nurmi, 2008). These four types of problems may also be presented with consistent language or inconsistent language. Consistent language presents information which allows a student to just solve a word problem based on the operation stated in the word problem. Inconsistent language requires students to look past the relational terms used in the word problem and perform another operation in order to solve the problem (Pape, 2004).

The use of word problems allows students to think strategically and develop reasoning skills that move beyond classroom mathematics. This shift in assessment outcomes means that a student must use reading skills when problem-solving. There has also been an increase in difficulty with what a word problem is asking students to do to solve word problems. Problem-solving is now often requiring students to perform more than one operation, integrate across math skills, and the use of a more realistic presentation when solving mathematical word problems (Fuchs, Fuchs & Prentice, 2004).

In order to solve a story problem a student needs to understand the words and then turn the words into a mathematical representation. These skills are linked to verbal comprehension which is determined by reading skills (Jordan, Hanich & Kaplan, 2003). Many students' errors are based on not understanding the word problem, which can also be a lack of background knowledge. The errors students experience are for a variety of reasons. Students can have language deficiencies, a lack of necessary skills to coordinate the necessary skills, poor conceptual and procedural math knowledge, and ineffective reading strategies (Pape, 2004). All of these deficiencies lead a student to the inability to effectively approach a word problem and begin to solve the word problem.

Math Difficulties/Disabilities

Due to the increased requirements to use math application to assess students' math skills, not just computation, it is important to look at the link between math and reading difficulties. Most of the research has been focused on reading difficulties and does not look at how these difficulties affect older math students. The studies regarding problem-solving have primarily been limited to one-step problems that typically involve addition and subtraction at the earlier grades. This can explain why there are fewer students who are identified as having both math and reading difficulties in the younger grades. Problem-solving requirements become more difficult and demanding for students after second and third grade (Fuchs & Fuchs, 2002; Fuchs, Fuchs & Prentice, 2004). Students who have academic difficulties can be broken into three distinct categories. There are students with just reading difficulties, just math difficulties, and finally there are students who have both math and reading difficulties. Students who have just the reading difficulties are able to make progress on computational skills (Jordan, Hanich & Kaplan, 2003). Approximately 20% of students in schools receive math and/or reading services from special education or Title I teachers (Thurber, Shinn & Smolkowski, 2002).

Students who only have math difficulties appear to be able to improve their math skills by using their reading skills that are strengths for them (Jordan, Hanich & Kaplan, 2003). Jordan, Hanich, and Kaplan (2003) completed a longitudinal study on 180 students who started the study in 1999 were evaluated for this study. The children who participated in the study for its entirety involved 46 students who had only math difficulties, 42 children with reading and math difficulties, 45 children with only reading difficulties, and 47 children who had normal achievement. Students were given seven mathematical tasks to complete. Addition and subtraction problems were separated on exact calculation of arithmetic combinations, approximate arithmetic, forced retrieval of number facts, and written computation. The other tasks were story problems, place value, and calculation principles. Students with only math difficulties take advantage of their reading strengths to compensate for math difficulties, while students with only reading difficulties appear to use their mathematical skills to compensate for reading and verbal weaknesses. The comprehension of the words presented in the word problem and translating these words into the appropriate mathematical representation is what causes students with both mathematical and reading difficulties a large challenge when solving word problems.

Fuchs & Fuchs (2002) used students who scored 90 or higher on an individually administered intelligence test and it was reported by their special education teacher that the student had a mathematics disability. The students were then given the *Test of Computational Fluency*. Students who scored 1.5 standard deviations below the national normative mean were included in the mathematics disability sample. The students were then given oral reading portion of the *Comprehensive Reading Assessment Battery.* Any student who scored 1.5 standard deviations below the national normative mean were identified as having a mathematics disability co-morbid with a reading disability. Students were administered word problems that could be identified in one of three categories. Arithmetic story problems that required the students to only add or subtract with answers less than 10. Complex story problems were problems found in the third-grade curriculum involving shopping list problems, halving problems, pictograph problems, and buying bag problems. Real-world problem-solving measured the application of math skills to realistic situations. The administration of the story problems was done in three sessions where all word problems were read aloud to the students. The results were converted to percentages and then compared based on disability status, task requirements, and performance dimension. Effect sizes were found by subtracting the difference of the mathematics disability group and the students who have a co-morbid mathematics and reading disabilities. Students who have both math and reading difficulties do not grow as quickly in math as their peers (Fuchs & Fuchs, 2002). This can be because a student with both math and reading difficulties may have preexisting deficits that are more serious both in math and reading (Fuchs, Fuchs & Prentice, 2004). Students with both math and reading difficulties have a decreased working memory, lower verbal skills, and auditory-perceptual skills (Fuchs & Fuchs, 2002).

When students independently read word problems there is a process that all students must complete in order to solve the problem. Students who struggle to successfully solve word problems experience errors due to reading issues. Errors can often be tied to a student not completely understanding what the word problem is asking the student to solve. Students lack the necessary reading strategies and have an inability to coordinate the necessary skills to solve the problem. After the student has read a word problem he needs to be able to put the problem into a real-world scenario, which allows the student to put the problem into everyday language and understand what is being asked (Pape, 2004).

Once the problem can be broken down into everyday language the student can break the problem into the smaller parts and organize the information. This organized information can help the student to determine if the problem is using consistent language or inconsistent language (Pape, 2004). Some problems will give key phrases that let a student know which operation has to be performed and the student can start work immediately. However, this is not always the case as students move to higher grades and begin to perform more complex task to solve math problems. When a problem uses the term “times” and the student does not need to multiply this is an example of inconsistent language. The student cannot just react to the numbers in the word problem and the term “times.” The student must first understand if the problem is asking him to split the given into a smaller amount by dividing.

Intervention Methods for Problem-Solving

There are a variety of interventions that can be used when attempting to solve math problems. A student can use a strategy-based intervention or a conceptual model-based approach. Strategy-based intervention identifies steps students need to follow in order to work through the word problem. The use of a strategy-based intervention can often lead students to better understanding of a conceptual model (Alter, Brown, & Pyle, 2011). A conceptual model-based approach has students identify the parts the problem and what piece is missing. An example is factor x factor = product. No matter the model that is selected it is important to use the technique in a consistent manner and to have good beginning and ending data to measure the success of the intervention. It is important that the intervention that is used in the classroom enhances the mathematical problem-solving skills of the students in the classroom.

Intervention for math problem-solving can occur in a variety of ways. Instruction can happen in the whole group setting, small group, or the use of a self-regulated learning strategy. The use of schema-based instruction has students classify problems into different types and use a specific plan to solve the problem. Fuchs and Fuchs (2005) completed three individual studies for all three types of interventions using third grade students in 24 different classes. The classes were divided into four groups for 16 weeks of instruction. All students received the minimum instruction of the basal textbook and the district curriculum. Six classes were part of the control group. Another six classes were assigned experimenter-designed instruction without an explicit attempt to develop broader schemas to enhance math problem-solving. The next group of six classes was assigned experimenter-designed schema-based instruction. The last group of six classes was given experimenter-designed schema-based instruction with full problem-solution instruction. At the end of the study it was determined that students who have math disabilities as young as eight or nine can benefit from mathematical problem-solving instruction. Secondly students need to have a strong foundation in rules for problem solution for mathematical problem-solving instruction; meaning the students should practice the same type of problems with limited changes to the word problem until the skills are mastered. Another conclusion is the need for explicit instruction on how to connect a new problem to a previously learned problem type. The final two conclusions involve the benefit to students with disabilities. Students who have disabilities benefit from the combining of strategies. The second study combined the explicit instruction of the whole group with the use of a self-regulated learning strategy. Students with disabilities benefit from whole-group instruction where they are able to learn from nondisabled classmates, but they also benefit from small-group tutoring where students are able to receive instant feedback to correct errors or there is a lack of understanding.

The use of a strategy-based intervention has been shown to help students increase their problem-solving accuracy and on-task behavior. Alter, Brown, and Pyle (2011) studied three self-contained students who were classified as having emotional and behavioral disorders. Students received 15-minute instruction that used a more focused scripted lesson. After the additional lesson students had 15 minutes to independently complete five word problems on a worksheet. During the scripted sessions students were asked about their thinking process and identify a problem-solving strategy they were using. Students could select from Draw a Picture, Guess and Check, and Making a Table or Chart in order to solve the word problems. Although the students failed to achieve the instructional or mastery levels of 80% and 90% respectively the students were found to have increased their on-task behaviors and problem-solving accuracy. On-task behavior was determined to be occurring when students had their eyes on the paper and working on the assignment. Problem-solving accuracy was measured when parents were given points for clearly writing a problem-solving strategy, correctly found and labeled solution to the problem, use of the correct basic facts or choosing the correct operation, and underlining the key mathematic vocabulary in the word problem.

Alter, Brown, and Pyle (2011) have described a shift in mathematics instruction. It is no longer about just getting the correct answer when problem-solving. Mathematics education is about the process and the thinking that students need to do in order to reach an answer. As teachers become more comfortable with the shift in educational goals set forth by the NCTM, students and teachers can become better communicators of their own mathematical thinking when solving word problems.

A conceptual model-based approach to problem-solving has the student turn the word problem into parts of an equation and then proceed to find the solution to the problem. Xin and Zhang (2009) had three students who were in fourth- or fifth-grade. These students were at risk for or already classified has having a mathematics disability. Students were instructed individually after school by research assistants who were trained in the conceptual model-based approach. Students are taught to first decide if the problem is an equal group or multiplicative compare. Then, students place the information into a conceptual model diagram and once that is done the model is changed into a mathematical equation that the student understands. Finally the student solve for the unknown quantity. The use of the conceptual-model based approach that stressed algebraic expression of mathematical relations showed an improvement in arithmetic problem-solving skills and increased the students' pre-algebra knowledge. The students also began to generalize problem-solving skills.

Cognitive strategy instruction focuses on the cognitive and metacognitive processes, strategies and mental activities that are used to facilitate learning and improve the performance of students. Students with learning disabilities typically have not developed the strategies that are needed for mathematical problem-solving or have difficulty selecting the correct strategy needed to solve the problem. *Solve It!* is an intervention strategy that has students paraphrase problems into their own words and visualize the problem. Students are able to complete the following seven cognitive processes by reading, paraphrasing, visualizing, hypothesizing, estimating, computing, and checking when solving word problems. The metacognitive process of self-regulation is taught through the use of self-instruction, self-questioning, and self-monitoring when problem-solving (Montague, Enders & Dietz, 2011).

Montague, Enders, & Dietz (2011) looked at the use of *Solve It!* as an intervention strategy of eighth grade mathematics classrooms in Florida for students identified with a learning disability or as low achieving. There were eight intervention schools, which had 319 student participants, and 16 comparison schools, which had 460 students participate. Classrooms that participated in the study were inclusive math classrooms which tended to have a higher percentage of learning disabled students. Seven CBMs of math problem-solving form the *Solve It!* were given using the item response theory methods so equivalent difficulty levels were achieved. *Solve It!* has scripted lessons, class charts, student cue cards, and practice problems that were modeled after the Florida Comprehensive Assessment Test. Classrooms where *Solve It!* was used received three days of intensive instruction by the general education teacher followed by weekly problem-solving practice that began in October. Students in the comparison group received classroom instruction only that followed the district mandated "pacing guide" that linked the textbook to the Florida State Sunshine Standards. The CBMs were given six times prior to the intervention to determine a baseline and then monthly for progress monitoring. The comparison group four times before the intervention began as a baseline and then given three additional times. Students who received the *Solve It!* intervention strategy made significantly greater growth in mathematical problem-solving than the comparison group students who received classroom instruction based on the districts mandated "pacing guide". The greater growth was not just attribute to average-achieving students, but also to students identified as having a learning disability. Students with a learning disability did score lower than their peers who received the intervention, but these same learning disabled students scored higher than all ability groups in the comparison schools on the CBMs.

Four Square

Four square is a graphic organizer that can be used across the curriculum to assist students when processing information. It can be used to assist in reading comprehension skills, organizing ideas for writing, and organizing information to complete math problem-solving task. According to Brunn (2002), “The four-square lessons reflect a research-based paradigm, which incorporates interactive, direct instruction followed by a meaningful and relevant period of practice and application.” The four square graphic organizer is easy to make out of a piece of paper with simple folds that create lines to assist students in creating the defined blocks to self-organize once the strategy is taught. Students are able to create a visual representation of the content presented. It also allows student to activate prior knowledge and brainstorm ideas. The four square technique can benefit all students no matter their ability level (Cockrum & Markel, 2007; Zollman, 2009).

Zollman (2009) studied ten classroom teachers in third, fourth, and fifth grades. Approximately 240 students took part in the research that was completed. The teachers taught a modified four square writing graphic organizer developed by Gould and Gould in 1999. The class was instructed as a whole on using graphic organizers when answering open responses for problem-solving. Students were then placed in cooperative groups to complete the graphic organizer and solve a problem before completing the graphic organizer on their own. When completing the four square graphic organizer students were able to identify possible solutions and provide clear justifications when explaining answers. A 12 point rubric was used to assess student’s skills when solving for perimeter and are. The average third grade had a perimeter pretest score of 6.90 and a posttest score of 9.50. The area pretest scores averaged 6.30 and rose to 9.10 on the posttest. Fourth grade perimeter pretest scores averaged 4.95 and increased to 6.65 on the posttest. Their area pretest average was 4.71 and rose to 5.76. Fifth grade students saw an increase on perimeter assessments from 4.70 to 6.89. The average area pretest score of 4.81 rose to 7.90 on the posttest.

Teachers noted other benefits that are not typically measured. Students who would not usually provide any written work for problem-solving questions were now writing partial answers to the problem. The four square strategy allowed teachers to follow the student's thinking and assisted the teachers in developing two-way communication with the students. At the beginning of the research five of the ten teachers said they were somewhat uncomfortable teaching problem-solving before using the four square strategy. When the study was completed, two teachers said they were somewhat comfortable teaching problem-solving to students and the other eight teachers were very comfortable teaching problem-solving.

This study will be using a modified version of Zollman's Four Square technique. Instead of having five sections for students to complete we will be using four sections. As previously stated, when students get older problem-solving involves multi-step problems as well as problems asking more than just one question in one problem. The use of the four square strategy allows students to incorporate the use of cognitive and metacognitive strategies. Students are required to read, paraphrase, hypothesize, compute, and check, as well as self-instruct, self-question, and self-monitor as the problem-solving process is completed (Montague, 1992). As students identify the known information they need to read, reread, and paraphrase the information that is written into the What I Know (WIK) and the question squares of the strategy. This also allows the students to self-instruct and self-question as the information is written. In the work square students are given a chance to hypothesize, estimate, compute, and check as cognitive strategies require students to do. Students are also able to begin the metacognitive process of self-monitoring. When an answer does not match an estimate or “gut feel” (hypothesis) of the correct answer students are able to correct and reread the information that is presented in the WIK and question squares. The answer square allows students to finish the self-monitoring to ensure the entire question has been answered.

Summary

Mathematics assessment has transitioned from pure computation to application through problem-solving. A student has to be able to apply the skills taught when reading a word problem. This requires the student to process the information given, what the word problem is asking the student to do, as well as identify any information that might be missing. Many students who struggle academically both in mathematics as well as reading can become easily discouraged and overwhelmed by the problem-solving process. The use of a four square graphic organizer can assist students in processing the given information, identifying what the word problem is asking the student to do, and the additional information they may have to find in order to solve the word problem. The purpose of this study is to see if the use of a four square graphic organizer will improve the problem-solving skills of sixth grade students who receive supplemental services through basic skills teachers and special education teachers for reading and mathematics.

Chapter 3

Methodology

Setting and Participants

This study examined the use of a four square problem-solving strategy to assist sixth grade students who receive supplemental services through a basic skills instructor or special education teacher to increase the students' performance on assessments given during the school year.

The setting was a sixth grade general education classroom in a small, urban, K-12 school district in southern New Jersey. The school district is identified as a Title 1 (Basic Skills) school district. There are three buildings. All sixth grade students are located in the third through sixth grade building. Basic skills services and in class support services are provided for 45 minutes of a 90 minute block of mathematics by certified staff. The first 45 minutes of class the students receive instruction from the special education teacher while the general education and basic skills teachers provide supportive services. The second 45 minutes is when students complete class assignments.

There were 19 students in the classroom. All students participated in the instruction of the four square strategy and used the strategy when solve word problems during whole group instruction. Of the 19 students, 9 students receive supplemental services in the general education classroom. One student is eligible for special education services for specific learning disability, and receives in class support services for both language arts literacy and mathematics. Eight students have been determined eligible to receive basic skills services for both language arts literacy and mathematics. An additional three students are eligible for basic skills services for language arts literacy.

Students are determined eligible for basic skills services based on the student's prior school year score on the New Jersey Assessment of Skills and Knowledge (NJ ASK). A score below 200 makes a student eligible for basic skills services.

Three students were new to the school district this school year and a fourth student entered the school district in the middle of the previous school year and do not have both pre- and posttest scores from last school year. The fourth student did take the NJ ASK 5 in the district, so their score was used to determine that she was eligible for basic skills services. Ten of the students scored a minimum of 200 on the NJ ASK 5 Mathematics Assessment, which meant they were not eligible to receive basic skills services.

Materials

The four square strategy was used in combination with the enVision Math textbook series. EnVision Math is a kindergarten to sixth grade textbook series that is aligned to multiple state curriculum content standards. The textbook series deepens conceptual understanding by making meaningful connections for students. The program delivers a strong, sequential visual/verbal connection. This is done through the 20 topics (chapters) that are at each grade level. At the end of each topic there is a problem-solving lesson. During each of these lessons new problem-solving skills are introduced to the class (i.e., try a simpler problem, make an organized list, guess and check, etc.). These skills can be introduced in a variety of formats, but not in one consistent way throughout the learning process.

All students received a pretest assessment, which was part for the school's math textbook series, the first week of school. Later in September the Measures of Academic

Progress (MAP Test) was administered to evaluate each students overall present level of performance. The MAP Test is a 53 question, multiple choice mathematics assessment that is given using a computer and is used as a benchmark test within the school district. Students are assessed on number and operations, geometry and measurement, patterns and algebra, data analysis, probability and discrete mathematics, and mathematical processes. Number and operations assesses the student's calculation skills and the student's ability to construct meaning for numbers. Geometry and measurement assesses the student's ability to identify geometric terms, compare objects, and measure geometric objects using customary measures and elapsed time. Patterns and algebra assesses the student's ability to extend patterns and solve problems with missing addends and factors. Data analysis, probability, and discrete mathematics assess the student's ability to read and interpret tables and graphs, determine the chance of a selected result will happen, determines the number of possible combinations for a given set, and follows and describes a practical set of directions for numerical operations. Mathematical processes assess the students ability to problem solve and communicate their problem-solving and reasoning. Both forms of assessment are completed individually in whole class format.

Students were then introduced to the four square format (figure 1) as a strategy to assist them when solving word problems. Students were asked what they would do first if they needed to build a birdhouse. Before the students began the discussion the four square strategy was placed on the board for all students to see. The strategy was used to guide the class's discussion in the importance of setting a plan before just jumping into a project without thinking. Some students felt it was important to read the directions first and then make a list of the supplies that are needed to make the birdhouse. As a class it was discussed why it was important to read through the directions (word problem) and then make a list of the necessary supplies (What I Know). Students were then asked how they would determine that they had a list of all the supplies that they need to build the birdhouse. It was determined that the directions would need to be reread to make sure everything was written on the supply list. Students were then asked how they would know if the birdhouse was made correctly. Students said they would refer to a picture (Question) of the birdhouse to make sure that the birdhouse looked like the picture. Students then talked about having a work area to make the birdhouse where they could make changes to their plan before finishing the final product. Students were told that this is the same process for word problems. Students were then asked how they would let people know they were finished making the birdhouse. After a brief discussion it was determined that it would be best to display the birdhouse for people to see, so everyone knows you are done making the birdhouse. As a class we discussed that we need to do the same thing for a word problem and this can be done by writing the answer in a complete sentence that refers to the question the word problem is asking.

The four square strategy is an organizational strategy. The first step in the four square procedure for the students is to identify the mathematical information that is stated in the word problem. Once the mathematical information is identified the student needs to locate the question and/or command that is stated in the word problem. The students then have an area to complete work where mathematical computations and/or charts can be completed. The final section gives the student a place to clearly identify his answer and assure that all parts of the question/command have been completed. The four square strategy is used in conjunction with the mathematics textbook.

What I Know (WIK)	Question
Work	Answer

Figure 1 Four Square Strategy Format

During the six cycles word problems were used for warm ups. A warm up is a five minute review of previously learned skills that happens before the day's mathematics lesson is presented to the class. The word problems that were used from the supplemental resource book, *Daily Word Problems: Grade 6*. This resource book is correlated to state standards and presents a variety of problem-solving skills that are needed for students to become a good problem-solver.

Procedure

Before being introduced to the four square format students participated in a discussion of the importance of planning for completing a project. Students stated it was important to know what a person is making, as well as knowing all the supplies that are needed to complete the project.

The four square format was then handed out to students. The students were introduced to the "What I Know" (WIK) section. They were told that this is where the given mathematical information form a word problem is written. The "Question" section was introduced next. Students were told to write any part of the word problem that told them what needed to be in the answer. This could be a question and/or command that is written in the word problem. The "Work" section was introduced afterwards. Students were told that this is where any work that needs to be done to solve a problem. The work can involve the student writing an equation, calculations, charts, etc. Finally the students were introduced to the "Answer" section. Students were told to write complete sentences that stated their answers to the question and/or command in this section. Charts and/or tables are to be recopied into this section so they are neat and easier to read.

At the end of the second marking period the MAP test was administered to determine a new overall RIT score, as well as Mathematical Processes score range. The MAP test is a 53 question computerized multiple choice test completed three times each year. It measures students' progress towards the curriculum standards. The RIT score is found by using the individual item's difficulty value to estimate the student achievement. The Mathematical Processes score measures a student's ability to complete problems solving task, as well as the student's ability to communicate connections and reasoning when completing the problem-solving task.

Anytime a word problem or problem-solving strategy was taught in class the first and second marking periods the four square strategy was used in the whole class setting. At the start of the third marking period students began completing two word problems during the warm up period of the math class, which was gone over as a class using the four square strategy. This was done for four days. On fifth day the two word problems were completed independently and reviewed by the researcher to determine areas of need to be addressed during the next five day period when completing the next round of word problems. This was done for a period of six five day periods.

At the end of the six cycle period a posttest was given. Questions on the posttest were similar to the questions on the pretest, but did not use the same numbers as the pretest. The pretest was five multiple choice questions. Question number one assessed the student’s math skills. Questions two through four assessed the student’s strategies and reasoning skills. The fifth question assessed the student’s communication skills when problem-solving. The posttest was five multiple choice questions that were given the second half of the mathematics class.

Data Collection

All word problems were presented in a whole class setting. When the word problems were collected each was analyzed to determine if the student earned the five possible points for each word problem. This means each student could earn possibly ten points per cycle. The first point was given if the student identified the information the word problem stated. The second point was awarded for identifying the question the word problem stated. Students who showed work to solve the problem were given a third point. The fourth point was given when the student identified his answer. A fifth point was given when the student’s answer was the correct answer.

Chapter 4

Findings

Summary

In this study a sixth grade class was used to determine if the use of a four square problem-solving strategy would increase the students' math problem-solving performance. There were 19 students in the study, nine of whom receive supplemental services for mathematics and language arts literacy in the general education setting. Student scores from September on the MAP Test (Measure of Academic Progress Test) were compared to their scores on the same test given in February. The MAP Test is a standardized test taken on the computer independently. In addition student growth on the math assessment for the enVision Math Program at the beginning of the year and end of the year was evaluated.

The study consisted of the use of a four square problem-solving strategy that was used anytime a problem-solving task was presented during mathematics instructional time throughout the school year. There were also six cycles during which word problems were completed on a daily basis. One cycle consisted of four days solving two word problems as a class and on the fifth day students solved the two word problems on their own. The fifth day of the cycle gave students time to use the four square problem-solving strategy independently. At the end of the six cycles students completed the problem-solving section of the enVision math series posttest. Students' overall pretest and posttest scores were compared. Additionally, student completion of each part of the four square strategy was examined. A student earned a point for identifying the What I Know (WIK), Question, showing work, and having the correct answer.

Individual Results

Table 1 is a summary of the mean for each group of students on the enVision pretest versus posttest and change. It also shows the mean for the MAP Test in September versus February and the mean change for each group. Each group saw growth on the enVision pre- and post-tests of a growth of 0.8. Students who do not receive supplemental services doubled the growth of the students who received supplemental services. The students also showed growth on the MAP Test between the fall and winter administration of over 6 RIT points, which is 196% increase compared to the mean growth of the norm group. There was only a one-tenth of a point growth difference between the students who do receive supplemental services and those who do not receive the services.

Table 1 Results for Pre- and Post- Testing

Group	enVision Pre	enVision Post	Change	MAP Fall	MAP Winter	Change
Supplemental Services	1.7	2.2	0.5	206.6	213	6.2
No Services	1.6	2.6	1.0	214.4	220.7	6.3
Total	1.6	2.4	0.8	210.7	217.1	6.3

Figure 2 illustrates the scores for each student on the problem-solving pretest. On the enVision pretest only two students showed any work to indicate they thought about the information given in the question and what the question was asking. On the posttest five of the nine students showed work on at least four of the five questions on the posttest. One of the remaining students only showed work for two of the questions, but the student indicated the information given in the problem and the question for four of the questions. Only one student did not show any work or prethinking before selecting an answer on the posttest.

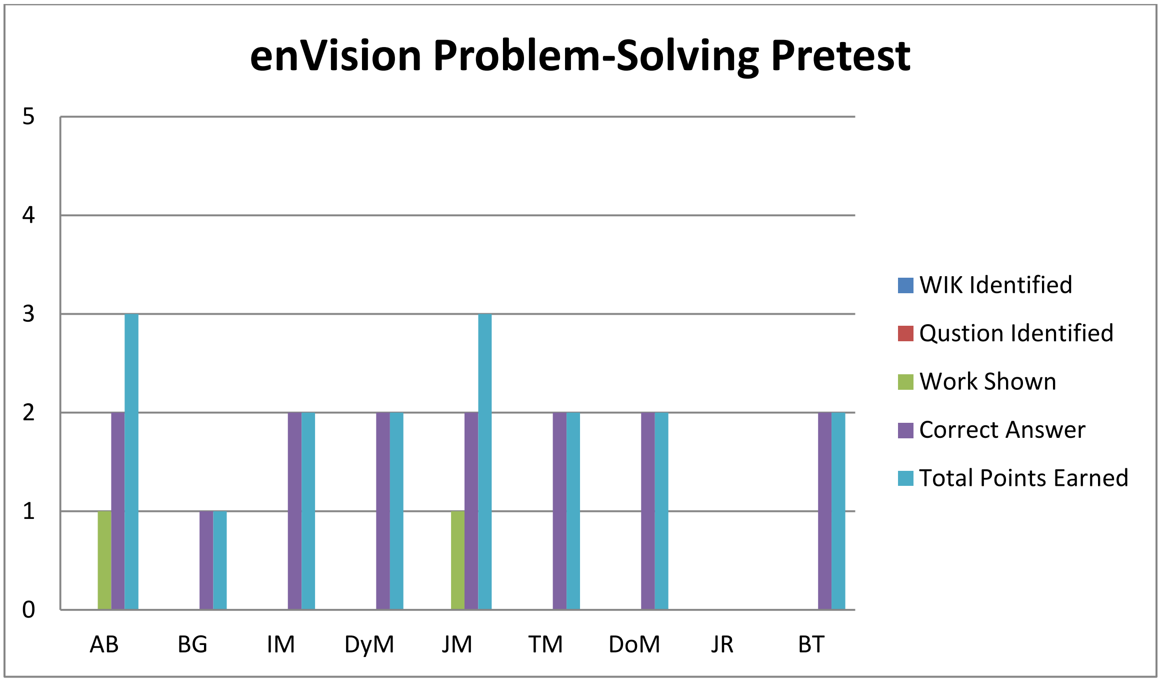

Figure 2 Results on the Problem-Solving Pretest

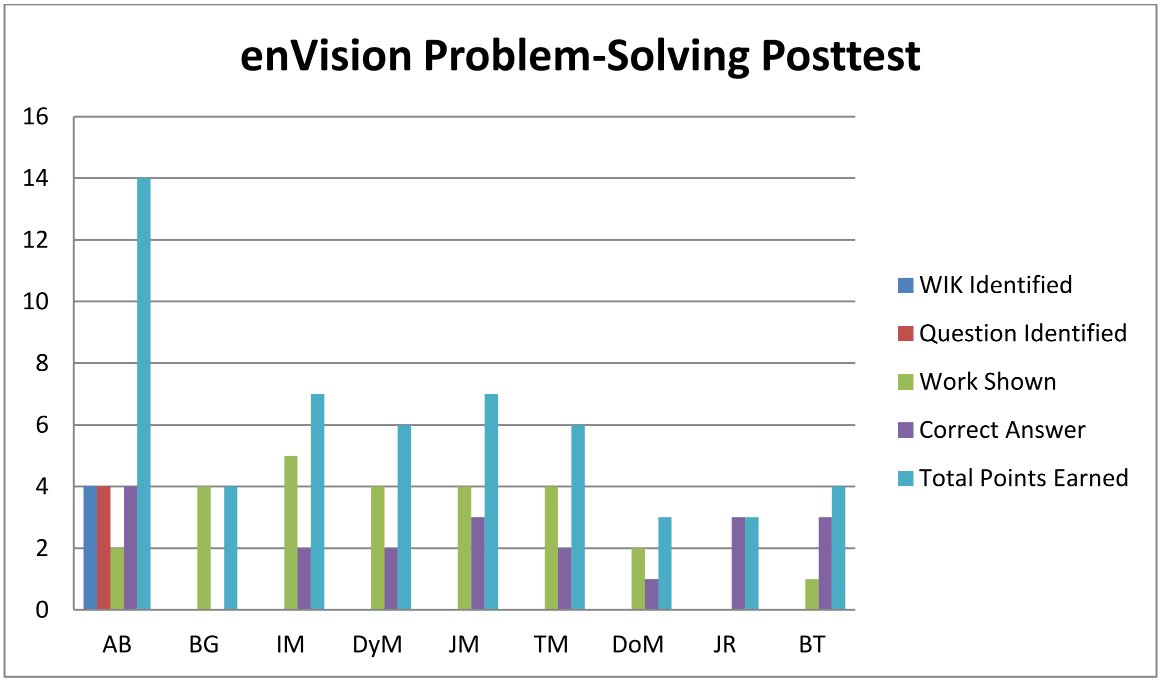

Figure 3 Results on the Problem-Solving Posttest

Figure 4 shows fall and winter MAP Test RIT scores for each student who receives supplemental services. According to the Northwest Evaluation Association, who created the MAP Test, the fall mean score for sixth grade students across the nation in 2011 was 219.6 and the winter mean score for sixth grade students was 222.8. This is an increase of 3.2 points. Students who received supplemental services improved their winter RIT score by 6.2 points, which is almost double what the Northwest Evaluation Association indicates for growth between the fall and winter MAP Tests. Four of the students had an increase of 9 or more points between their fall and winter RIT scores. Two students saw a decrease of their RIT scores between the fall and winter.

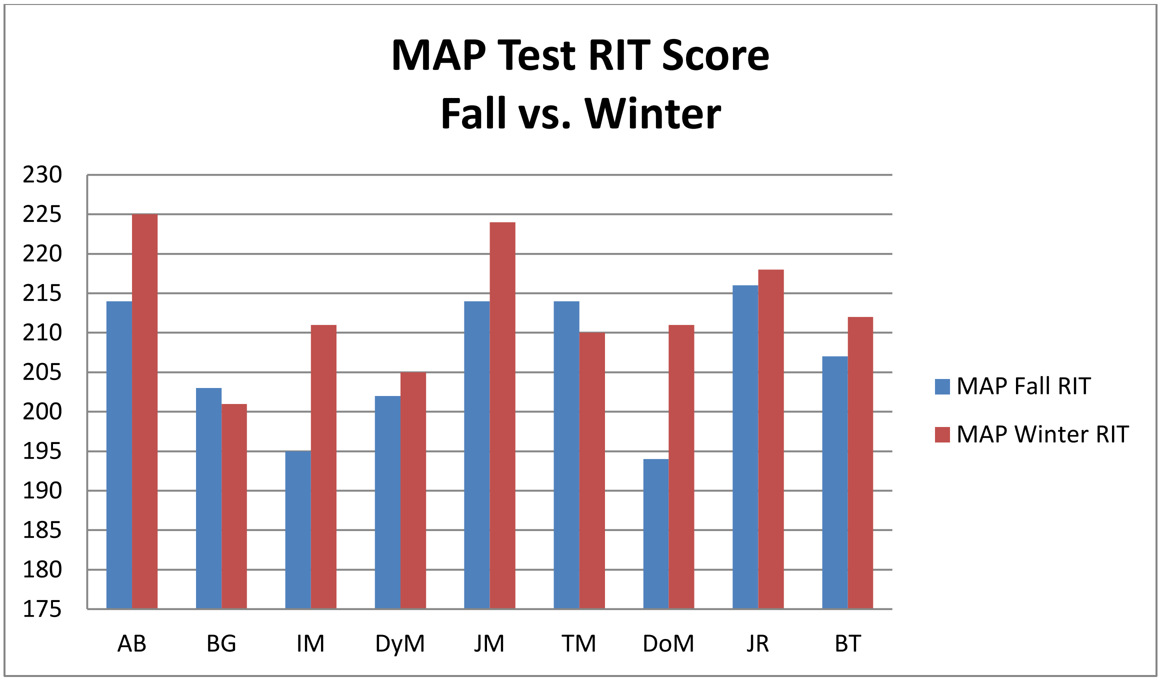

Figure 4 MAP Test RIT Score Fall vs. Winter

Figure 5 compares the mathematical process RIT score for the fall and winter MAP Test for the students who receive supplemental services. Eight of the nine students saw an increase of their mathematical processes scores between the fall and winter administration of the MAP Test. Three of the eight students had an increase of over 20 points for this part of the assessment. The other five students had an increase above 3.2 points which is the indicated growth for students at the 50th percentile.

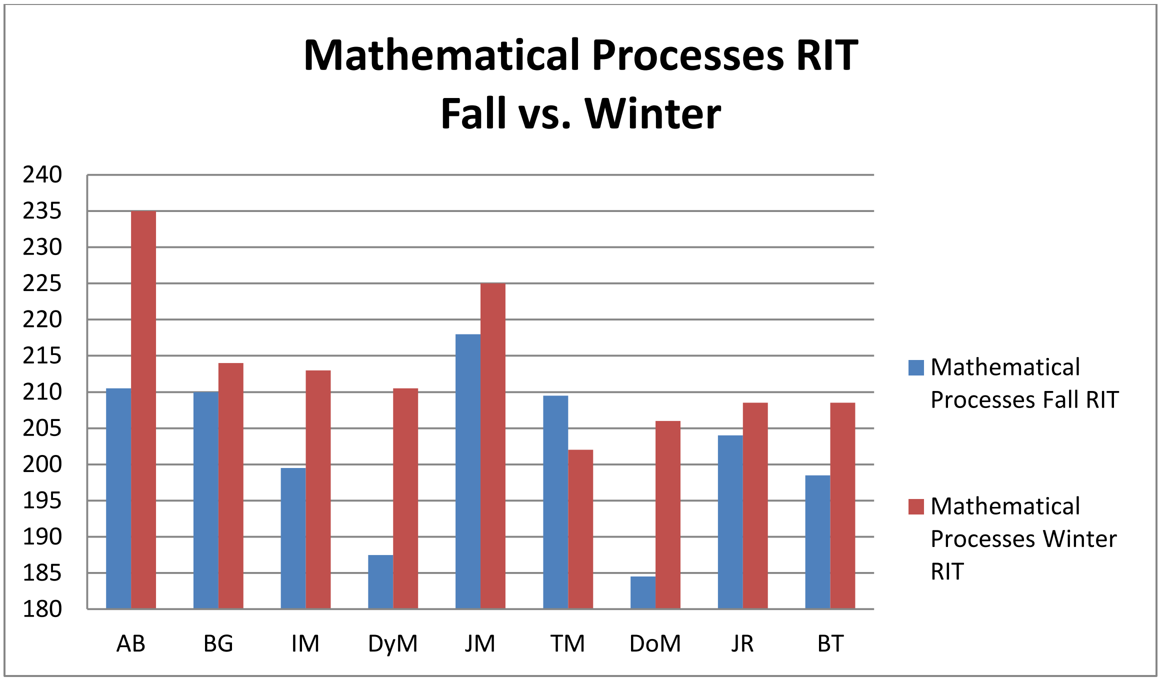

Figure 5 Mathematical Processes RIT Fall vs. Winter

<u>Cumulative Review</u>

Figure 6 compares the students who receive supplemental services for language arts literacy and mathematics to the rest of their peers in their classroom on the enVision pre- and posttests. There were five multiple-choice questions on the pretest and five multiple-choice questions on the posttest. The pretest was given in September. No students indicated the information the word problem stated or what the question was asking on the pretest. On the pretest the students averaged showing work on less than one problem. The mean score for correct answers was less than two correct responses for the entire class. Out of a possible 20 points on the pretest the mean score was 2.21. The posttest was given in April. On the posttest three students indicated the information given in the word problem and identified the question being asked. The posttest showed some growth in all areas that were assessed. Identifying of the information given in the word problem and the question that was asked increased to a mean score of 0.56 for each.

The mean score for showing work on the posttest was 2.56. On the posttest the correct answer was selected for a mean score of 2.06. The posttest total mean was 5.72 out of a possible 20 points.

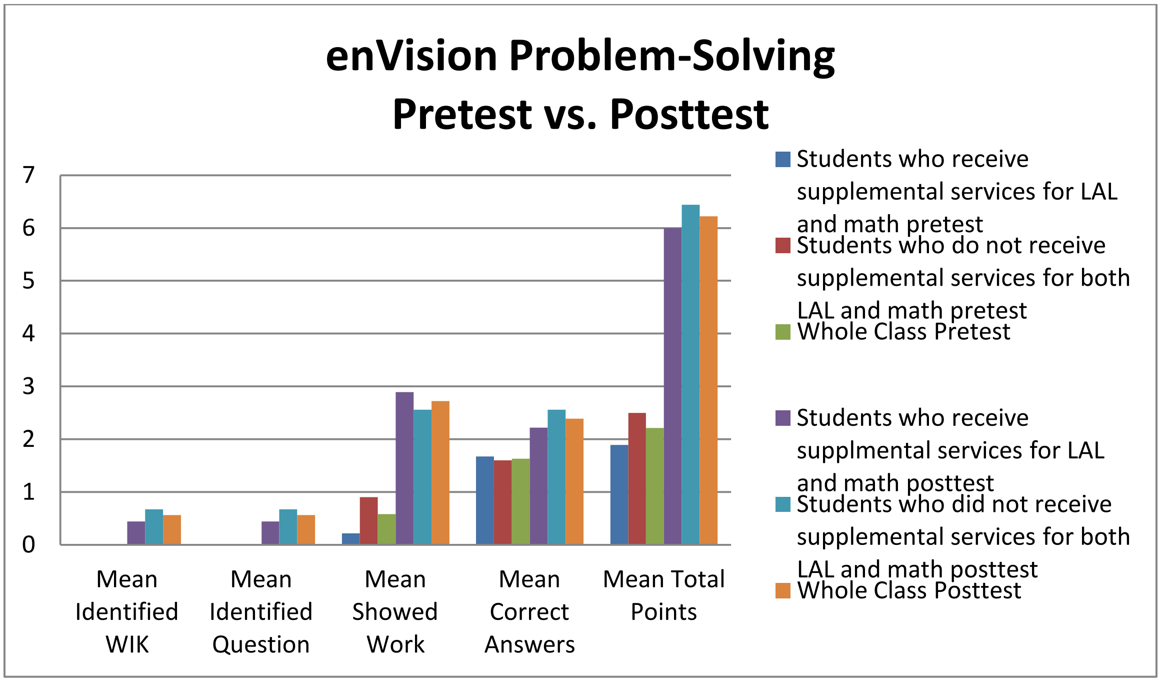

Figure 6 Problem-Solving Pretest vs. Posttest

Figure 7 compares the overall results of the MAP Test for the students who used the four square strategy and receive supplemental services for language arts literacy and mathematics to students who did not use the four square strategy and receive supplemental services for language arts literacy and mathematics versus the entire sixth grade, which includes special education students in self-contained classes. The fall MAP Test was administered during the month of September. The mean fall MAP RIT score for the students who used the four square strategy was 206.6. The mean fall MAP RIT score for the students who did not use the four square strategy but receive supplemental services from a basic skill instructor for language arts literacy and mathematics was 207.7. The mean fall MAP RIT score for all sixth grade students was a 209.8. The winter MAP Test was administered during the month of February. The students who used the four square strategy and receive supplemental services for language arts literacy and mathematics had a winter MAP RIT mean score of 213. The students who receive supplemental services for language arts literacy and mathematics, but did not use the four square strategy had a winter RIT score on the MAP Test of 214.5. The entire sixth grade had a winter MAP RIT of 218.1.

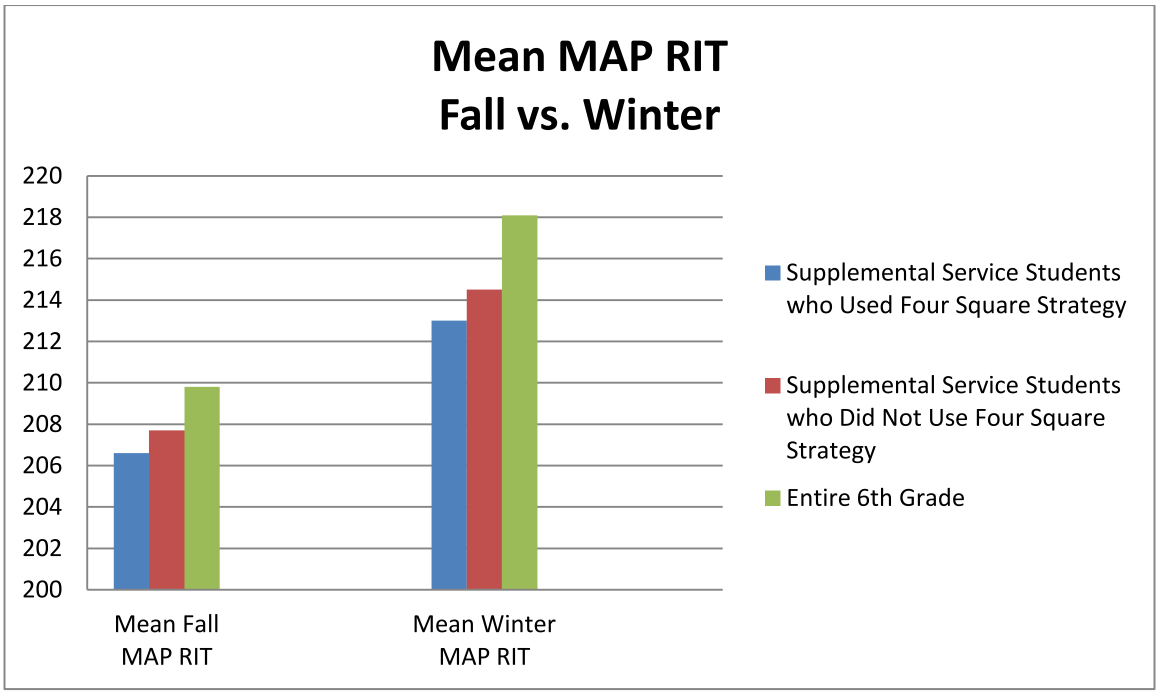

Figure 7 Mean MAP RIT Fall vs. Winter

Figure 8 shows a comparison of the overall mathematical processes score for students use the textbook used by the general education classrooms. It also compares the students who receive supplemental services for language arts literacy and mathematics who used the four square strategy and those who did not use the strategy during problem-solving instruction. Students who used the four square strategy who receive supplemental services in both language arts literacy and mathematics had a mean fall RIT score of 202.4. The students who did not use the four square strategy had a mean fall

RIT score of 208.6. The mean fall RIT score for mathematical processes for all sixth graders who use the enVision Math Program was 211. The students who received instruction on the four square strategy and receive supplemental services had a mathematical processes mean winter RIT score of 213.6. Students who did not receive instruction on the four square strategy and receive supplemental services for both language arts literacy and mathematics had a mathematical processes mean winter RIT score of 213.9. The mathematical processes winter RIT mean score for the entire sixth grade who receives mathematics instruction using the enVision Math Program was 219.8.

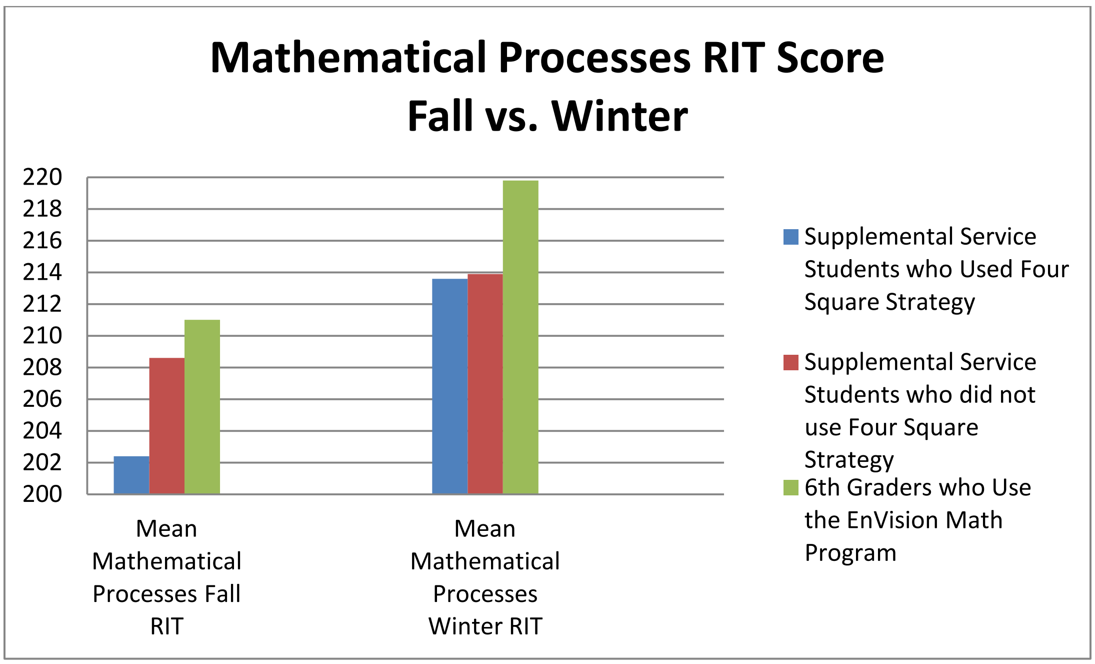

Figure 8 Mathematical Processes RIT Score Fall vs. Winter

Chapter 5

Summary, Conclusions, and Recommendation

In this study the effectiveness of the Four Square problem-solving strategy for solving math word problems was examined for students who receive supplemental services for language arts literacy and mathematics. Nine students were chosen to be followed because they received supplemental services from either a basic skills teacher or a special education teacher in the general education setting. The study compared the growth of the students receiving supplemental services with problem-solving instruction using the Four Square strategy to students who did not receive supplemental services. The final groups each contained nine students.

The nine students who receive supplemental services were taught to use the Four Square strategy were given a pretest and posttest for the enVision math program. The enVision math program is a kindergarten to sixth grade math series that is used in the general education classes. Of the nine students who receive supplemental instruction through a basic skills instructor or special education teacher all but three of the students showed an increase of correct problem-solving questions between their enVision posttest in fifth grade and their enVision posttest taken in sixth grade. Eight of the nine students saw an increase in the number of questions students provided work in order to solve the problem.

Besides being a consistent way for students to solve word problems and problem-solving task in the classroom, the Four Square problem-solving strategy allows the students to organize the information given before completing the problem. It also requires the students to read the problem more than one time to ensure that they identify all the important information in the problem. This also allows each student time to think before reacting. When the students have time to think they are able to feel confident about their problem-solving actions. Also this strategy does not give the student an out of saying I don't know. When students read word problems independently they were always able to identify at least one piece of information that was given.

It was hypothesized that the use of the Four Square problem-solving strategy may assist students identified as having difficulties with math problem-solving by giving them a strategy to use when solving word problems. This strategy may increase the student's willingness to effectively attempt to solve word problems by identifying the known information and the question and/or command that the word problem states. It was also hypothesized that these students would also see an increase in beginning and end of the year math assessment scores compared to the previous school year on the enVision math program.

The use of the Four Square problem-solving strategy proved to increase the problem-solving skills of the students who received supplemental services for language arts literacy and mathematics compared to their peers in the other two sixth grade classes who received supplemental services for language arts and mathematics. The use of the Four Square strategy assisted in the growth of students' mathematical processes RIT on the MAP test from fall to winter. At the end of the study the students mathematical RIT on the MAP test were compared to students in the other two sixth grade classes who did not receive problem-solving instruction using the Four Square strategy. As indicated by Figure 8, the students who received instruction on the use of the Four Square strategy were able to close the approximate six point difference with the students who receive supplemental services and did not use the Four Square strategy and their 11.2 point growth was double the growth of the other two sixth grade students who receive supplemental services. The group's growth was also greater than the average of all sixth grade students who receive math instruction using the enVision math program. When comparing the mathematical process RIT to the overall MAP RIT the students who received instruction in the Four Square problem-solving strategy had a higher mathematical process RIT mean than the overall MAP RIT.

Two students experienced a decrease in MAP scores and one student stayed the same. One possible reason for this is that the posttest in fifth grade was taken the last week of May and the posttest in sixth grade was taken the first week in April. This eight week shift means not all of the material was covered before the sixth grade posttest was given. Three students did not show any growth from the pretest in sixth grade to the posttest. While it appears the Four Square strategy did not increase the students' accuracy because the students' mean accuracy increased by less than one question; it did help with the students' willingness to show work on the posttest, which indicates students were thinking about what the problem was asking and not just circling an answer. When students did not have enough room where the problem was located three students got another piece of paper and one student used the back of the paper to work out problems.

The hypothesis that students would improve their pretest to posttest growth on the enVision diagnostic test between fifth and sixth grade was not supported for students who received supplemental services instruction for language arts literacy and mathematics. One possible reason for this result could be that the students completed the posttest approximately eight weeks later in fifth grade. However, as a class, the Four Square strategy did lead to a larger growth rate in sixth grade than in fifth grade. In fifth grade there was no growth shown and in sixth grade there was growth of approximately one more question correct. Most students increased the amount of work shown even if this did not increase the number of questions correct on the assessment.

In the classroom this study has shown that the consistent use of a problem-solving strategy improves the students' ability to solve math word problems. In most, if not all, math programs there is a problem-solving strategy (i.e., try a simpler problem, make an organized list, etc.) but each of these strategies requires students to approach problem-solving in a different manner and only practices one strategy at a time. The Four Square problem-solving strategy allows students and teachers to approach problem-solving in a consistent manner. Often students who struggle in the classroom need consistency, which is what the Four Square strategy gives. Students must identify "What I Know" (WIK) and the question before even attempting to answer the problem, which can often eliminate some of the concerns when answering a word problem. The hypothesis that the students would improve their problem-solving skills was supported using the standardized MAP test. Eight of the nine students saw growth for their mathematical processing score between the fall and the winter. The four students who showed the greatest growth were the students who consistently used the Four Square strategy when problem-solving with other students in the classroom. Also three of those same students consistently volunteered in class to identify the WIK, question, and solve the problems when the class reviewed any word problems as a whole. It is believed that this allowed these students to build their confidence in their own abilities when problem-solving, in the large class setting.

One limitation of the study is the age of the students. Many sixth grade students have already established habits when problem-solving. Students who receive supplemental services through basic skills and special education often have established ineffective problem-solving habits that hinder their ability to answer questions. They often feel they are unable to complete a task that requires thinking and trying. Another limitation is to determine if the students will use the Four Square strategy after this school year if it is not used during problem-solving instruction.

The results of the current study were similar to those found by Zollman (2009) for students in third to fifth grade. Zollman found that third through fifth grade students benefited from the use of the Four Square strategy for problem-solving for perimeter and area. Achievement for mathematical problem-solving increased from 22 percent to 64 percent. The completion of the Four Square graphic organizer can lead students to a possible solution. Students were more willing to show work before answering word problems. Also, when students were completing the Four Square graphic organizer it allowed for the students to clearly express their thought process to a teacher at a quick glance since the students need to write the WIK and question into the graphic organizer.

Many of the students found their own way to modify the Four Square strategy when there was more than one word problem on the page. Instead of making a replica of figure 1 they would highlight the WIK with one color highlighter or underline it one time. They would then use another highlighter to underline the question. If they did not have a highlighter many of them would then circle the question to distinguish it from the WIK. This also gave them a larger work area to complete the mathematical operations.

Future research on the use of the Four Square strategy for students in more restrictive placements is necessary. Will the Four Square strategy assist these students to attempt problem-solving prior to a teacher reading the word problem? Will the Four Square strategy help students who are in second grade or younger when problem-solving, especially if problem-solving in younger grades is most often one step problems? Examining the results of sixth grade students who have been using the Four Square strategy for more than just one school year should be done also.

Based on the results of this study the use of a consistent strategy for problem-solving is beneficial for all students. A consistent strategy allows for all students to speak the same language and approach problem-solving in a similar manner. Students who struggle to read word problems are able to organize the information in a concise way and then start to solve the problem and they are not overwhelmed by excess words and/or information given in the word problem. The Four Square strategy allows theses students to find success in the classroom by feeling more comfortable with the information they know and willingly volunteering to complete the Four Square graphic organizer in the large group setting. The graphic organizer also allowed students who exhibit more math and language arts proficiencies to think about how they achieved there answer. These students were able to better explain to their classmates how an answer was achieved than just giving the answer to their peers.

Conclusion

This study examined whether the Four Square problem-solving strategy would assist students who receive supplemental services for language arts literacy and mathematics from a basic skills teacher or a special education teacher. Students showed growth on a standardized measure. They were able to close the gap between other students in the sixth grade who receive supplemental services for language arts literacy and mathematics from a basic skills teacher. This was achieved through the consistent use of the Four Square problem-solving strategy. Ninety percent of the word problems solved during whole group instruction were solved using the strategy and when students worked independently they were encouraged to use the strategy. The Four Square strategy allowed students to take ownership of their problem-solving skills and to improve these skills throughout the study.

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