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## Mathematic Strategies For Teaching Problem Solving: The Influence Of Teaching Mathematical Problem Solving Strategies On Students' Attitudes In Middle School

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MATHEMATIC STRATEGIES FOR TEACHING PROBLEM SOLVING:  
THE INFLUENCE OF TEACHING MATHEMATICAL PROBLEM SOLVING STRATEGIES  
ON STUDENTS' ATTITUDES IN MIDDLE SCHOOL

by

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A thesis submitted in partial fulfillment of the requirements  
for the degree of Master of Education  
in the School of Teaching, Learning and Leadership  
in the College of Education  
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## **ABSTRACT**

The purpose of this action research study was to observe the influence of teaching mathematical problem solving strategies on students' attitudes in middle school. The goal was to teach five problem solving strategies: Drawing Pictures, Making a Chart or Table, Looking for a Pattern, Working Backwards, and Guess and Check, and have students reflect upon the process. I believed that my students would use these problem solving strategies as supportive tools for solving mathematical word problems. A relationship from the Mathematics Attitudes survey scores on students' attitudes towards problem solving in mathematics was found. Students took the Mathematics Attitudes survey before and after the study was conducted. In-class observations of the students applying problem solving strategies and students' response journals were made. Students had small group interviews after the research study was conducted. Therefore, I concluded that with the relationship between the Mathematics Attitudes survey scores and journal responses that teaching the problem solving strategies to middle school students was an influential tool for improving students' mathematics attitude.

## **ACKNOWLEDGMENTS**

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## CHAPTER 1: INTRODUCTION

### Rationale

The 2011-2012 school year was a year of great change for me. In that year, I transferred to a new school and moved up a grade level from sixth to seventh grade. With the change of grade came a change of curriculum. Florida had recently adopted the Next Generation Sunshine State Standards (NGSSS, 2007) and the Common Core State Standards (CCSS, 2010). These standards came with grade specific topics that the previous seventh grade students had not been taught. This was a new challenge for me, but at the same time was a good chance to expand my repertoire of mathematical teaching techniques. I wanted to continue researching and working with my students to help them become better problem solvers. To do this I reflected upon my teaching practices and how they related to influencing problem solving strategies in my classroom.

During the 2010-2011 school year, I noticed my students struggled with higher-order word problems. Students would either complain that the mathematics was too hard or they would give up reading the problem. Some of the reasons they gave up were not understanding the vocabulary being used or not comprehending the text of the word problems. I also observed other students taking the numbers that they found in a math word problem and carrying out an incorrect mathematical operation, thus coming to an incorrect answer. Despite my continued efforts to conduct teacher instructed lessons on how to problem solve, there were many instances where I found my students struggling. By the end of the school year I was exhausted with the

fight of students' negative attitudes on problem solving. This struggle prompted me to seek out more influential teaching strategies for mathematical problem solving.

Also during the same 2010-2011 school year, I observed that students' attitudes were very important in the problem solving process. If the student was disagreeable towards the problems or the methods, then he/she was less likely to give a response, correct or incorrect. By focusing on the students' attitudes during the problem solving process, I hoped to gain a new understanding into how the students liked to learn and apply their mathematical skills. To influence the teaching of my students, I must first understand how they feel about the subject matter and how they learn best to actively engage them in the learning process. Therefore, I administered a pre and post survey on mathematical problem solving to create a better understanding of students' attitudes towards the mathematical problem solving process. Students' input into the teaching process made this a more meaningful experience for both them and me.

In the 2010-2011 school year, the Florida Comprehensive Assessment Test (FCAT) which is a means of evaluating student achievement, was made more difficult for students. There was an advertised increase in the content rigor of the test. Questions that used to be mild to moderate in complexity were changed to moderate to high in complexity. The test was mainly comprised of higher-order thinking skills taken from the NGSSS. In mathematics, higher-order thinking skills commonly include two to three step word problems. These tend to be very difficult for students to dissect and solve independently. With the changes in FCAT, and standardized testing becoming more rigorous, I began to look for a teaching method to

implement during the fall of 2011 that would scaffold student learning. I focused my research on strategies in which students could learn to solve mathematical word problems. I wanted to base my research on Vygotsky's Zone of Proximal Development (ZPD). Vygotsky (1978) defined ZPD as the space between the actual developmental level to the level of potential development, as determined through problem solving with help from the teacher and peers. This model directed my research in that the teacher scaffolded information to the student, and then the students collaborated with each other. Students' potential for solving mathematical word problems was guided through teacher instruction and classroom practices with peers.

The teacher-guided instruction was intentionally focused upon using five set strategies for mathematical problem solving. Stanic and Kilpatrick (1988), in alignment with Pólya "recognized that techniques of problem solving need to be illustrated by the teacher, discussed with the students, and practiced in an insightful, non-mechanical way" (p.42). Vygotsky (1978) and Pólya (1981) both shared theory that techniques need to be "scaffolded" by the adult (teacher) for the students. It was this scaffolding technique that was used to illustrate, practice, and apply the mathematical problem solving skills.

Teachers have many obstacles in teaching problem solving. Students need to be good readers as well as good mathematicians. According to Montague (2005), when students are given strategies and a process to make mathematical problem solving less complicated, then they could learn those strategies and become successful problem solvers. My justification for completing this action research was to teach my students the tools, processes, and strategies needed to solve any mathematical problem. My goal of this action research was to coach my students to feel

more confident and appreciate the tools that help them to be more successful with mathematical problem solving.

My purpose and position was to successfully coach, efficiently guide, and influence positively the teaching of my students how to problem solve. I wanted to enhance my students' problem solving skills by teaching them useful strategies. Introducing problem solving strategies to students and letting them explore which were best for the problem is one way to help students become better problem solvers. The strategies that I taught were drawing pictures, making a chart or table, looking for a pattern, working backwards, and guess and check. Before and after teaching these strategies I had the students take a survey on their attitudes towards problem solving. This gave students the control and discretion to use whichever method they liked best.

In my mathematics classroom, past students had difficulty solving word problems. Students needed to learn how to solve mathematics word problems successfully. Through introducing the students to using these strategies that I have identified, they became better mathematical problem solvers. My justification for this study was to reflect on my teaching abilities of mathematical problem solving and determine its influence. I have gained a new understanding of my students' attitudes towards problem solving and learned how to influence their ability to problem solve.

### Research Questions

Therefore, the goal of this study is to answer the following questions:

1. What problem solving strategies do students choose to use in solving mathematics problems in the classroom?
2. How do students decide what initial strategy to use or not use?
3. What is the influence of teaching mathematics problem solving strategies on middle school student attitudes in mathematics?

### Conclusions

I taught the five strategies for mathematical problem solving to my students in order for them to become more proficient problem solvers. I learned through my own research and other research articles the importance of giving students support during the problem solving process. I used the strategies as a tool that students could apply to any mathematics problem in the future.

For this study, I planned to observe the students in class during the process of practicing problem solving strategies. I planned for students to write in their student journals about the problem solving practices and reflect upon their own learning processes. I planned exit interviewing students about the entire problem solving study, to gather more data about their attitudes towards problem solving. The Mathematics Attitudes survey was planned to gauge students' attitudes towards mathematics, problem solving, and learning strategies for problem solving.

Chapter 2 includes the research for problem solving, strategies, and ZPD. Chapter 3 explains the methodology used in this action research, including its design, setting and participants, procedures, data collection, and data analysis. Chapter 4 includes the results of this action research, including both qualitative and quantitative data, and the analysis of the data. Chapter 5 concludes my action research, describing the positive and negative outcomes of this study, along with possible improvements and implications for future studies involving teaching problem solving strategies.

## CHAPTER 2: LITERATURE REVIEW

### Introduction

Problem solving is a very complex process in which students need to be properly supported and coached. During this literature review, included research will convey the importance of using problem solving strategies and how they can assist with student learning and attitude towards mathematics.

First, research will be included regarding a mathematical problem, its definition and how it relates to today's classroom. It is important to lay the foundation of a definition in order to start the problem solving process correctly. Secondly, a brief overview of literature related to the history of problem solving will be laid out. It is important to note the origin of problem solving and how it has evolved into today's problem solving. Next the Zone of Proximal Development (ZPD) is explained for theoretical framework for this research study. The importance of problem solving is also noted, along with teacher's beliefs about problem solving. Both of these views weigh heavily on the amount of problem solving opportunities students receive in the classroom today. An important aspect of this action research is students' attitudes towards mathematics. Therefore, research that describes the importance of students' attitudes for mathematical problem solving success and future success in mathematics courses is included. Lastly, students need to have the ability to influence their own problem solving. Therefore, research included shows that when students are influentially supported on how to use strategies when problem solving, they have greater success.



### Defining a Mathematical Problem

According to Lambdin (2003), a problem is defined as a situation in which disequilibrium and perplexity occur. A mathematical problem causes a student to become uncomfortable when they cannot find a solution. When individuals encounter a problem and find themselves in an uncomfortable situation, if they do not have the means to change it, they do not overcome the situation (Jausovec, 1993). It is in this instance that students realize what they have encountered is not an exercise in mathematics, but rather a mathematical problem.

Jausovec (1993) defined each problem by three components: an undesired initial situation, a desired end situation, and an obstacle in the middle of both. Every student must encounter these three parts in a mathematical problem or otherwise it is considered a mathematical exercise. There is a significant difference between a mathematical exercise and a mathematical problem. A mathematical exercise involves reading the directions and using one to two steps to solve the exercise. The mathematical problem does not always present itself with a cut and dry solution at the surface. The student has to delve into the problem in order to think of a process with which they will be able to solve the problem. Mathematical problems have a higher complexity level of thinking than mathematical exercises from a workbook or textbook. In mathematical word problems students also must be able to identify these three parts in order to find a solution.

Frobisher (1996) defined a mathematical problem as “the original condition presenting the problem through its appropriate data to a goal which must be reached by the problem solver,

and the path from the original situation to the end solution to be found by the problem solver” (p.298). It is important to note that Frobisher also describes the three parts in his definition just like Jausovec (1993). Students sometimes believe that mathematical word problems have low complexity. Some students believe that they can answer any mathematics question with a one-step mathematical procedure. As a result, Cotic & Hodnik (2002) found that the students come to believe that any problem can be solved without finicky mental effort, and when the way to the answer is not immediately apparent, the students are easily persuaded that the solution cannot be found. Mathematical problems can be solved, but they may not always be immediately obvious. Students need to learn that because the answer may not come from a one-step procedure that they need to continue to try to solve for the answer. This mindset of the students is the difficulty with problem solving in today’s classroom setting.

### History of Problem Solving

Stanic and Kilpatrick (1988) trace problem solving back to early civilization, suggesting that the early Egyptian, Chinese, and Greek writings laid the foundation for problem solving. American education began to develop and take shape in the early 20<sup>th</sup> century. One of the great American philosophers of education was John Dewey. It was clear in Dewey’s view of education and schooling that problems and problem solving were critical. What we refer to as problem solving Dewey called reflective thinking. Dewey was forward in his thinking for mathematics. He believed in thinking critically about learning and the process involved. It is this reflective thinking that laid the foundation for what would become modern day problem solving.

A deeper understanding of mathematics did not occur until “the art of discovery”. In 1969, Pólya (1981) created a more comprehensive view of problem solving. To Pólya problem solving was a practical art, like horseback riding, skating, or playing the French horn, which one learns with practice. Pólya was quick to note that problem solving was not something you quickly picked up, but rather you had to learn it over a period of time. The learning for problem solving had to be scaffolded for the learner to become independent. He was one of the first to point out that teaching problem solving is possible and he devised a plan for others to succeed with the process.

“In Pólya’s (1981) formulation, the teacher is the key. Only a sensitive teacher can set the right kind of problems for a given class and provide the appropriate amount of guidance” (Stanic & Kilpatrick, 1988, p. 42). Pólya was quick to point out that students need help to develop problem solving skills and it needs to be taught effectively.

Stanic and Kilpatrick (1988) used the analogy of teaching to art, “that no one can program or otherwise mechanize teaching; it remains a human activity that requires experience, taste, and judgment just like art” ( p. 41). The art of teaching is in the skill of the teacher, and that is where learning transpires from. If the teacher is not good at the art, then the student will never complete the masterpiece with that teacher.

Lester (1977) conducted mathematical problem solving, metacognition, and the assessment of higher-order thinking in mathematics. In 1977, he worked on the Mathematical Problem Solving Project (MPSP). Since problem solving is viewed as an important part of

mathematics, it should be analyzed so that influential instructional techniques can be developed. He researched and found that problem solving skills needed to be effectively taught to students.

Schroeder and Lester (1989) explained that since the role of problem solving is to develop students' understanding of mathematics, teaching via problem solving is the most appropriate approach. They argued that advocates of this approach consider problem solving not as a topic, but rather as a pedagogical position. This approach has come to be referred to today as teaching through problem solving (NCTM 2003). His research has a profound influence on mathematical curriculum in today's classroom. The keyword in his research was teaching through problem solving. Giving students the problems to work through, rather than randomly solving problems helps students develop a better understanding of problem solving. It has continued to shape what problem solving in the classroom looks like, and what teachers need to do in order to influence the teaching process for problem solving. A teachers' influence can be provided through scaffolding information. A method of how to scaffold information from the teacher to the student is called the Zone of Proximal Development.

### Zone of Proximal Development

Vygotsky (1978) discovered a method of teaching in which the teacher scaffolds the information to the students. Vygotsky's support system of scaffolding student learning is called the Zone of Proximal Development (ZPD). Vygotsky defined ZPD as the distance between the student's developmental level and their level of potential development, as guided by the teacher and peers. This system allows teachers to instruct students at their level and work up to a higher

independent level of complexity. Teachers supply students with the tools, such as learning strategies, that they need to learn the subject matter, and then gradually take away any teacher assistance for the students. This allows the students to master the skills and become totally independent.

In ZPD, the teacher and the student work on a task, such as problem solving, that the learner is not able to perform independently due to the complexity level. After time practicing the skill, the learner will be able to perform the same task without assistance from the teacher (Doolittle, 1997). This is a model that involves instruction from the teacher to the student by first starting with the student's current knowledge of the subject matter. Starting at the student's knowledge base is crucial. Teachers should not start any higher than the basics of what the student knows, or else the process will not be successful. Students need to work towards the goal of mastery with teacher scaffolding for assistance. Once the teacher has determined what knowledge base to start from, then instruction begins. The teacher instructs the student to reach their full potential which is their ZPD. This is not as simple as the theory may sound.

During the process of achieving independent mastery of the skill, there is continuous scaffolding for the student through the learning process. Davis and Miyake (2004) indicate that scaffolding represents the support a learner is given by the teacher, to attain a goal otherwise unachievable. The teacher needs to continuously support the student up to the point of what the teacher within the ZPD. The teacher needs to be educated on the difference between levels of complexity and what effective mastering the skill is (Jacobs, 2001). If the teacher's expectations are not laid out for the student they may not reach ZPD. If the teacher does not have a solid

concept of what ZPD is, then the process may not go smoothly. The key to ZPD is the teacher. Then the instruction may be successfully scaffolded by the teacher in order for the student to reach full mastery of the skill. When this is done then the student has achieved their ZPD.

When students' potential for solving mathematical word problems is guided through teacher instruction and classroom practices with set expectations then the student will reach their ZPD for problem solving. Every student who goes through the scaffolding process must have a guide map of what they are learning and what they must master. Vygotsky's teaching method theory demonstrates that solid teaching techniques need to be effectively scaffolded by the teacher (Jacobs, 2001). It is this scaffolding technique that will give students the knowledge for becoming successful independent problem solvers.

### Importance of Problem Solving

Being a 21<sup>st</sup> century learner requires students to be critical thinkers and problem solvers. Some students would benefit from instructional strategies for problem solving. Like the parable, if you teach a man to fish he can fish for a lifetime. Likewise, if you teach a student how to problem solve, they can do it for a lifetime.

“Taking seriously the notion that problem solving is for everyone, means studying children in a variety of situations and providing examples to teachers of what children can do when an attempt is made to link subject matter to experience” (Stanic & Kilpatrick, 1988, p. 45). Students need opportunities to make connections between real-world applications and mathematics. Students enjoy mathematics more when there are connections to their favorite

basketball player or their favorite musician. These are real-life instances where students learn to apply their skills to their lives. Students should be able to apply what they are learning in school to become productive citizens of society. Hiebert and Wearne (1993) wrote that such tasks as problem solving can promote students' conceptual understanding, their ability to reason mathematically, their ability to communicate mathematically, and to capture their interest. Capturing a student's interest is necessary to learning. If the problems are applicable to real life, it might be easier for the student to understand the problem. Giving students relevant problems provides meaning to mathematical concepts.

The National Research Council (1989) found that it is not the memorization of mathematical skills that are important, but the self-assurance that one knows how to find and use mathematical tools in problem solving. Students build this confidence through the process of creating, constructing, and discovering mathematics. When this becomes part of a student's everyday routine they are more proficient and able to develop, carry out, and execute their plan. Helping students to become better problem solvers is not only a fundamental part of mathematics learning, but also across content areas and grade levels. This skill is an ongoing process that students need to develop at their own pace. The hope of teaching through problem solving is to have students continue to use problem solving skills throughout their life.

### Teachers Beliefs about Problem Solving

Teachers in today's classrooms have moved from traditional teaching practices to using applications of mathematical thinking. Lester (1994) wrote about the shift from teaching problem

solving to the emphasis now on teaching through problem solving. This has happened in conjunction with the problem based learning movement that is a student-centered approach for teaching more complex, realistic content. Taplin (2010) wrote that problem solving has been recommended to be the organizational tool around which the mathematics curriculum should reside. Also NCTM (2003) strongly supports that problem solving should drive the mathematics curriculum.

According to Lambdin (2003), “to be able to solve problems, one must have deep, conceptual understanding of the mathematics involved; otherwise one will be able to solve only routine problems” (p. 7). Teachers believe that students need to have the background knowledge to solve not just routine problems, but also complex higher order thinking problems. To prepare students for the future and the problems that they will encounter, students need to learn mathematics through problem solving.

“Problem-solving instruction that emphasizes conceptual understanding can significantly help children meet the challenges of the general education classroom” (Xin & Jitendra, 1999, p. 223). Many teachers are using problem solving mapping to aid instruction in problem solving. Being able to make a concrete illustration of these abstract mathematical problems can assist students of all levels.

Teachers know and believe that they have to make the subject matter of mathematics relevant to their students. “A primary tenet of teaching through problem solving is that individuals confronted with honest-to-goodness problems are forced into a state of needing to connect what they know with the problem at hand” (Lambdin, 2003, p. 7). Good teachers know



their students' needs and address them. Students need a connection to the problem in order to construct meaning of the problem.

“Learning through problem solving develops understanding” (Lambdin, 2003, p. 7). It is through this belief that teachers continue to influence learning for all students to gain understanding. “When students appreciate the underlying structures of mathematics, their self-confidence soars and they are more willing to tackle challenging problems” (Lambdin, p. 10). Students' attitudes towards mathematics are the key to students' future in mathematics.

#### Student Attitudes toward Mathematics

The term attitude is used “similarly to beliefs, whereas others see it in a less cognitive sense—more akin to emotions” (McLeod, 1992, p. 692). A middle school student's attitude toward a subject matter can tend to be more emotional than cognitive. Students remember their past experiences with mathematics and continue to feel that way when there is no change in their learning results. Whether they are positive or negative towards mathematics greatly affects their performance.

Students' attitudes towards the subject of mathematics can be somewhat disappointing at times. Their attitudes come from an early preconception that mathematics is very difficult and not fun. “Most adults' attitudes to mathematics come from their experiences of mathematics in school when they were children” (Sparrow & Hurst, 2010, p. 18). It is this math attitude that continues with the child for life. It is a serious issue in today's American classrooms that needs to be addressed.

“It is clear that many people (children and adults) have negative attitudes towards mathematics, and these attitudes are seen as hindering mathematical learning and engagement” (Hemmings, Grootenboer, & Kay, 2010, p. 692). Students do not leave their attitudes at the door. Their attitudes continue to follow them wherever they go in mathematics. Students with negative attitudes continually perpetuate the cycle of hindering their learning process. If the student has a negative attitude and negative math experiences, then they could become adults with the same problem.

It is very important to foster positive attitudes towards mathematics during adolescent years. “This transition that occurs is important because this is the time when children either develop an eagerness to learn or begin to devalue education and disengage from the learning process which influences their motivation and their academics” (Wentzel, 1997, p. 411). Middle school is a time when students’ emotions and attitudes are amplified. Students either fully engage in the learning process, or completely disengage and become involved in other activities. The reason students do this is because of their emotions from past and present experiences with mathematics. Students need to have more positive mathematics experiences to want to engage in the learning process. Understanding can give students confidence and keep them engaged. Teachers need to provide these positive math experiences with understanding and purpose. “Understanding leads students to see mathematics in a positive light—as a subject that makes sense because it is logical and connected” (Lambdin, 2003, p. 7). If students understood mathematics with a deeper understanding, this may lead them to a positive attitude towards mathematics.

To promote a positive attitude, the teaching needs to be intentional and have a purpose to achieve this. “From experience, the key factors in achieving positive emotional responses are: variety of experiences, clarity of purpose, and success and understanding for children” (Sparrow & Hurst, 2010, p. 19). Giving students clarity of a lesson’s purpose allows for understanding. Providing students with an assortment of experiences gives conceptual meaning to future mathematical problems.

Another way to promote positive attitudes towards mathematics is to keep the content applicable to the students. “It is also suggested that children may become more engaged in mathematical learning if the mathematics is embedded in a context that is relevant to them” (Sparrow & Hurst, 2010, p. 19). When students are presented mathematical word problems about things that they have an interest in, they are more likely to positively connect to the problem. It is this connection that allows them to give an extra effort in finding a solution.

By simplifying instruction for students, they are better able to understand the content on their level. It is important to think about the comprehension level of students, so as not to overwhelm or make the students anxious. That does not promote a positive environment and those students could develop a poor attitude towards mathematics.

It is imperative to foster a positive environment for the students in the mathematics classroom to promote future learning. Students’ attitudes should not be overlooked. “Students who are anxious, bored, fearful, or simply believe that mathematics is unimportant, are likely to avoid the study of mathematics” (Furner & Bermen, 2004, p. 81). Negative feelings towards

mathematics can be avoided. Students can be engaged in learning, students can be successful in mathematics, and students can like mathematics.

When students come into the classroom with a negative attitude this presents a setback to the teacher. “These students often have very low confidence in their mathematical abilities, which extends as far as them saying ‘we can’t do mathematics!’ This then becomes the real challenge; the main emphasis of any teaching has to be diverted from teaching the mathematics content to giving the students confidence in their mathematical skills” (Metje, Frank, & Croft, 2007, p. 81). Students need confidence to learn and teachers need to be cognizant to this need. Before undertaking any type of learning, first the students need to have confidence building activities in which the student can feel successful. These confidence building activities will provide a basis for a student’s future success in mathematics.

When students feel that they are never going to be good at mathematics and continually receive failing scores on their tests and quizzes this affirms to them that they are a failure; however there is hope for coming out of this failure situation. “Breaking the ‘Failure Cycle’ when teaching mathematics has to be one of the key objectives, as repeated failure often results in a negative attitude and low confidence towards mathematics and this often leads to an avoidance of the subject” (Metje, Frank, & Croft, 2007, p. 81). Students need to experience something on their level and have baby steps towards success in mathematics. One way to do this is with accommodating students’ different learning styles with the class lessons. Furner and Berman (2004) wrote about the importance to design positive practices in mathematics classes, to point out that everyone makes mistakes and to make the math appropriate to the students. By

including everyone in the class in this type of environment the positive experiences will increase with students' attitudes also increasing about the subject of mathematics.

When starting the process to eliminate the bad attitudes from the classroom, it may seem an overwhelming and daunting task. "The first step for any educator to eliminate the mathematics anxiety is to become aware of it and its relevance to good teaching as good teaching seems to eliminate the fear of mathematics" (Seaman, 1999, p. 7). Good teaching will eradicate students' fears and anxieties if done so in a manner that is relevant and appropriate for the learner.

If negative mathematical attitudes are not eradicated from the classroom, students can suffer severely. "Studies have shown that negative mathematical attitudes and poor achievement and/or engagement with mathematics are related" (Hemmings, Grootenboer, & Kay, 2010, p. 692). Teachers need to be aware of this relationship and continue to promote positive mathematical attitudes in the classroom. If negative attitudes continue, students can disengage and not further their education in advanced mathematics courses. "The strongest predictor of participation in advanced mathematics courses was students' attitude towards mathematics" (Ercikan, McCreith, & Lapointe, 2005, p. 5). Even in advanced mathematics courses, students' attitudes play a key role in how they participate and learn mathematics. This is not a problem for just middle school classrooms, but rather all levels of mathematics courses.

When positive attitudes in mathematics are fostered this yields greater gains in mathematical learning. "The findings from other studies point to a significant and positive relationship between attitude towards mathematics and mathematics attainment" (Hemmings,

Grootenboer, & Kay, 2010, p. 692). This is evidence that teachers need to foster positive learning to push students into attaining mathematical knowledge. Negativity cannot breed positivism; only positivism can breed positivism.

When students leave the classroom they should be leaving with a positive attitude. “Quality math instruction should provide the students with two things: a challenge and a feeling of success at having accomplished something” (Cotic & Zuljan, 2009, p. 307). It is this feeling, or rather, attitude of success that will give students the confidence to continue to be successful in mathematics.

### Strategies for Problem Solving

“Strategies are groupings of actions, mental or physical, designed to solve a problem” (Biddlecomb & Carr, 2010, p. 2). There are many strategies that students can use to find the correct answer. Students need to know these strategies and utilize them. “In learning mathematics, the students should have the opportunity to discover by themselves a way to reach the solution to the problem” (Cotic & Zuljan, 2009, p. 300). Students should learn how to properly use strategies for problem solving. With the background knowledge of mathematical problem solving strategies, students are better able to solve any problem that may arise.

“John Dewey pointed out that the best way to gain deeper understandings of a subject is to search for better methods to solve problems” (Stanic & Kilpatrick, 1988, p. 43). These better methods or strategies help students to complete the mathematics problem solving process. By focusing on methods students can learn various ways of overcoming any mathematical obstacle.

Teachers instructing students on the various strategies of problem solving promote learning on a higher level of thinking.

“Research indicates that when teachers explicitly teach strategies, this instruction appears to have a positive impact on children’s numerical knowledge” (Biddlecomb & Carr, 2010, p. 6). The keyword here is explicitly. When teaching instructional strategies to solve mathematical word problems the results are positive. Teachers need to teach the strategies fully in order for the students to internalize them and make them become background knowledge. Students may not know the value of the new strategies until they apply them to a mathematical word problem and have success in finding the solution.

After teaching various strategies to the students, the teacher should promote mathematical discourse when presenting a word problem to the class. “It is important for the teacher to challenge and encourage the students towards independent search of various paths to the solution by discussing and comparing these in class” (Cotic & Zuljan, 2009, p. 300). By having mathematical discourse, students will have more knowledge of how to use the strategies. Having in class discussions of the different strategies illustrates to the students that there is not just one way to solve a mathematical problem. “This helps the students develop intuition and creativity, convergent and divergent thought, as well as to acquire the ability to plan and evaluate” (Cotic & Zuljan, 2009, p. 300). Students need these skills to further their mathematical problem solving abilities. This type of learning is important for the 21<sup>st</sup> century student to know how to think differently about a given problem.

There are many strategies and tools to help students. One strategy for visual learners is the use of manipulatives. “Manipulatives—physical materials to support learning such as blocks or tiles—are ubiquitous in early years educational settings across cultures” (Manches, O’Malley, & Benford, 2010, p. 622). Manipulatives are helpful to students in visualizing what they are reading in the word problem. They are able to concretely look at the problem and physically manipulate the materials into finding a solution. “The use of physical materials to support young children’s education can be traced back to education pioneers such as Fröbel and Montessori” (Manches, O’Malley, & Benford, 2010, p. 623).

Other strategies that are used for problem solving are drawing pictures, making charts, working backwards, and guess and check (Rickard, 2005). Students who are visual learners will benefit from the strategy Drawing Pictures. This makes the problem more concrete and real for the student. Making charts is a method that is good for organizing data to find a solution. Working Backwards is sometimes a good strategy when the problem presented does not offer a forward solution. Lastly, guess and check is always an excellent strategy to use even after you have already used a previously mentioned strategy. It never hurts to go back and check your work when solving mathematical word problems.

Mathematical problem solving strategies are taught with the instructional purpose to produce positive results. A similar study to mine was conducted in a seventh-grade middle school mathematics class in Maryland on the influence of using problem solving strategies. This study found very positive results with the students’ motivation towards problem solving. “Learning problem-solving strategies has positively influenced the students’ attitudes towards



solving more challenging problems in my classroom” (Shears, 2005, p. 9). This study showed that teaching students strategies that would aid in the process of problem solving had a positive influence on the students’ motivation. Shears (2005) also indicated that problem-solving strategies would be valuable for all students to learn. Shears would take measuring tools such as an attitudinal survey, exit tickets, observations, and interviews to find a trend in students’ motivations. She used this triangulation of data to find a trend in her students’ motivations in mathematics. This is a good study which shows how positive teaching and strategies helped the students become successful problem solvers.

These strategies are not meant to overload the students’ learning capacity. There are meaningful skills that every student should receive from their teacher. Quality mathematics instruction “should equip the students with declarative and procedural knowledge and skills and allow them to gradually grow independent” (Cotic & Zuljan, 2009, p. 307). Students equipped with these skills will have more knowledge of how to independently solve mathematical word problems.

### Conclusion

Problem solving is the foundation for a stronger understanding of mathematics. After researching the history and importance of problem solving it is evident that there is more of a need for influential teaching strategies and practices. Students can have success with mathematical problem solving and feel positive about themselves and their results. Both teachers and researchers need to work together to help alleviate this problem of a negative mathematics

attitude. Although problem solving is for everyone, this study will focus primarily on seventh grade mathematics students in middle school. In the next chapter the procedures of the study will be further explained, and how the data was collected and analyzed will be discussed.

## CHAPTER 3: METHODOLOGY

### Introduction

The purpose of this study was to determine how teaching specific problem solving strategies would influence students' attitudes towards problem solving in mathematics. In the past I had used different methods of instruction for my students to problem solve. I was not always pleased with the results of the methods that were used for teaching problem solving. I felt that many times the methods being used were not helpful in scaffolding the students learning processes. Students were not able to easily apply these methods to different mathematical problems. I wanted to find a method of scaffolding instruction to the students that would be meaningful and improve students' attitudes towards mathematical problem solving. I wanted my students to remember this method and apply it in the future to any mathematical word problem. I also wanted my students to master the method, so if needed, they would be able to teach this method to others.

I found the teaching method through the mathematician Pólya (1981). It involves the use of four problem-solving steps (understanding the problem, devising a plan, carrying out the plan, and looking back), and problem-solving strategies. After research into his methods for problem solving, there were, among others, five common strategies: drawing a picture, looking for a pattern, guess and check, making a list, and working backwards. These problem solving strategies were used as the teaching methods for the study. I believed that this five strategy approach would be the right number of strategies to instruct the students. My purpose was to use

these methods with the classroom curriculum as a tool that would be beneficial to the students' mathematics attitudes.

### Design of the Study

My research was action research based. Action research is any systematic inquiry conducted by teachers that involves gathering information about the ways in which their particular schools operate, the teachers teach, and the students learn (Gay, Mills, & Airasian, 2009). The goal of this action research was to reflect upon my teaching practices to create a positive change in the classroom environment. My research could be viewed as practical action research (Gay, Mills, & Airasian) as it contributed to my professional development, reflective teaching practices, and improvement of my school. The goal of teaching problem solving strategies was to learn how my classroom teaching methods influence my students' attitudes towards mathematics. In order to collect data I used a variety of strategies, which included both qualitative and quantitative data collection and analyses.

This study examined the following questions:

1. What problem solving strategies do students choose to use in mathematics problems in the classroom?
2. How do students decide what initial strategy to use or not use?
3. What is the influence of teaching mathematics problem solving strategies on middle school student attitudes in mathematics?

Table 1 shows each question, the evidence used to support each question, and whether the evidence is classified as quantitative or qualitative data. The examples of evidence will be explained further in detail.

Table 1: Research Questions, Evidence, and Evidence Classifications

	<b>Question</b>	<b>Evidence</b>	<b>Evidence Classification</b>
1	What problem solving strategies do students chose to use in mathematics problems in the classroom?	Student journals, in-class observations, and student interview questions	Qualitative
2	How do students decide what initial strategy to use or not use?	Student journals, in-class observations, and student interview questions	Qualitative
3	What is the influence of teaching mathematics problem solving strategies on middle school student attitudes in mathematics?	Mathematics Attitudes Survey, student journals, in-class observations, and student interview questions	Quantitative & Qualitative

### Setting and Participants

#### *School Setting*

The setting of my study was a suburban school in Central Florida that was given a grade of A for the 2010-2011 school year. At the time the research began, the school consisted of 1522 students, 43% Caucasian, 42% Hispanic, 8% African American, and 6% Asian/Pacific Islander, and 0.51% American Indian. The school consisted of 13% Language English Proficiency (LEP) students, 13% Exceptional Student Education (ESE) students, and 41% of students received free or reduced lunch.

### *Participants*

The study consisted of students from one seventh grade advanced mathematics class. Students were placed in this class by achieving a level 4 or level 5 on the mathematics part of the 2011 Florida Comprehensive Achievement Test (FCAT). Of this class of twenty-one students, only fifteen participated fully in the study. The entire classroom used the same strategies and instruments. Of the 16 students that began the study, qualitative data from 15 were analyzed. One student took a three week leave of absence from school before finishing the study. The student's data was incomplete; therefore her data was not included. The study included one Hispanic male, three Hispanic females, two African American females, five Caucasian males, and four Caucasian females. The ages of the students were twelve (12 students) and thirteen (3 students) years old. Of those fifteen students in this study, only one student was labeled as ESE with disability and four students received free or reduced lunch. None of the students in this study qualified for the LEP program or for the gifted program.

### *Classroom Setting*

The classroom itself was organized with four rows of six desks equidistant from each other. The classroom included two whiteboards, one of which was used daily in this study for the students to lead and share discussion on problem solving strategies. The classroom also included a projector and document camera that were connected to the teacher computer. There was a sound system within the classroom in which I used the microphone daily. Students also had access to a classroom set of calculators, as well as reference and reading material about mathematics.

### *Procedures*

After receiving IRB approval (see Appendix A), the procedures for the research study began in September 2011. Students were administered the Mathematics' Attitudes Survey as a pre-survey to the study. The Mathematics' Attitudes Survey was modified and used with permission from Pierce, Stacey, and Barkatsas (2007) as shown in Appendices B and C. The modifications made to the survey were eliminating the last section of the survey about technology, because this study did not relate to technology. The survey helped to identify the students who were less confident with using problem solving strategies and identify the areas where mathematics attitude needed improvement.

It was also during the first week of the study that each student was given a math student journal. Each student was required to take notes, answer problems, and write reflective journals in the notebook. The notes were from lessons of strategies to assist them in problem solving. The strategies that were taught were drawing pictures, making a chart or table, looking for a pattern, working backwards, and guess and check. Students numbered the pages of their journals for future reference when referring to problem solving strategies. Examples of students' problem solving strategies used are in Appendix D.

Every week for the first five weeks, the students would receive a lesson on a problem solving strategy. After the strategy notes were written in the student's journal, the student would problem solve using that strategy. This was included after the strategy notes to keep the consistency of the strategies used and notes together. The problem would be answered individually, but would be reviewed with the whole class. After discussing the problem with the

class, each student would write a reflective journal on the following page about problem solving. Student journals were prompted with questions such as, “What did you learn about problem solving today? What do you know about problem solving? How do you feel about problem solving? What do you want to learn about problem solving?” These questions helped students reflect on their practices. Examples of students’ reflections can be found in Appendix E. Table 2 presents the order of instruction and problems by week, including strategy taught and problems, group work, and independent work with page numbers involved in the textbook.



Table 2: Order of Instruction and Problems

<b>Week</b>	<b>Strategy Taught &amp; Problem</b>	<b>Group Work</b>	<b>Independent Work</b>
1	Drawing a picture. Problem: At a party, there were 5 couples including the host and hostess. Each person shook everyone's (except their partner's) hand once. How many handshakes were there altogether?	Holt McDougal Florida Mathematics Course 3 Textbook Page 20, #1, 15	Holt McDougal Florida Mathematics Course 3 Textbook Page 21, #51
2	Looking for a pattern. Problem: A farmer has horses, goats, and chickens on his farm. The number of horses is double the number of goats. The number of chickens is 5 times the number of goats. The animals have a total of 44 legs. Find the number of goats, horses and chickens on the farm.	Holt McDougal Florida Mathematics Course 3 Textbook Page 39, #18, 34	Holt McDougal Florida Mathematics Course 3 Textbook Page 39, #35
3	Guess and check. Problem: Copy the figure below and place the digits 1, 2, 3, 4, and 5 in these circles so their sums across and down are the same. Is there more than one solution?	Holt McDougal Florida Mathematics Course 3 Textbook Page 44, #38, 60	Holt McDougal Florida Mathematics Course 3 Textbook Page 44, #61
4	Making a list. Problem: Find the median of the following test scores: 73, 65, 82, 78, 93, 82, 54, 100, 99	Holt McDougal Florida Mathematics Course 3 Textbook Page 46, #13, 31	Holt McDougal Florida Mathematics Course 3 Textbook Page 46, #32
5	Working Backwards Problem: Anna, Bernard, and Clara had different number of stamps at first. Then Anna gave Bernard 12 stamps. Bernard gave Clara 10 stamps and Clara gave Anna 4 stamps. In the end they all had 20 stamps each. How many stamps did each of them have at first?	Holt McDougal Florida Mathematics Course 3 Textbook Page 75, #15, 28	Holt McDougal Florida Mathematics Course 3 Textbook Page 75, #29

If there were any absences, the absent student would make up the work the next class by copying the notes and completing the mathematics word problem on their own. I would then discuss the work and ask if there were any questions. After the student asked questions they would write their reflective journal for that lesson. There was only one student whose long term absence required them to be removed from the study.

The journals were well kept by students as a means of on-going formative assessment. The journals contained problems that the students completed on their own and the strategies taught in class. The journals were kept in the classroom and I read the journals once a week. At the end of the study the journals were collected to be analyzed for themes of the students' attitudes and understanding of problem solving strategies. Also at the end of the study students completed the post Mathematics Attitudes Survey and were given exit interviews. The exit interviews were conducted with a small group of at least two other students. The questions can be found in Appendix F. Each student answered every question with a written response and then shared orally some of their responses with their peers. After completing the post Mathematics Attitudes Survey and exit interview questions, students wrote about their mathematics attitudes in their student response journals. Examples of these responses can be found in Appendix G.

### Data Collection

The data collected in this study was both qualitative and quantitative. The qualitative data included observations of the students' response journals weekly while the study was being conducted. This was to note any misconceptions in the lessons and give me a means of informal

assessment of the weekly learning objectives being met. I also made notes and observations during class, taking note of how students were problem solving and what they were doing to come to an answer.

At the end of this study qualitative data was gathered from the students through interviews. They were given an exit interview by me who was conducted with a small group of two to four students. Students were encouraged to answer all seven questions and discuss the study with their peers and myself. The exit interview questions were:

1. How helpful are the problem solving strategies that we have discussed in class? Why or why not?
2. Which problem solving strategy have you used the most? Why?
3. Do you feel that you are becoming a better problem solver? Why or why not?
4. Do you feel confident when approaching problems? Why or why not?
5. What types of obstacles have you had when solving problems?
6. How have you overcome these obstacles when solving problems? Why or why not?
7. Would you recommend any of these strategies to another student to use? Why or why not?

At the end of the study I collected the students' response journals to form a final evaluation of the quality of their work. Their journals were well kept and had notes about problem solving strategies, problems solved using problem solving strategies, and weekly reflections. At this time, the reflection questions were also analyzed.

The quantitative data included scores from the pre and post Mathematics Attitudes Surveys. The Mathematics Attitudes Survey was based on the Likert scale scores of 1 as totally

disagree, 2 as partially disagree, 3 as uncertain, 4 as partially agree, and 5 as totally agree. This survey was comprised of three different areas of mathematics, including mathematics behavior, mathematics confidence, and mathematics engagement.

### Data Analysis

Data collected was analyzed to help answer the following research questions:

1. What problem solving strategies do students choose to use in solving mathematics problems in the classroom?
2. How do students decide what initial strategy to use or not use?
3. What is the influence of teaching mathematics problem solving strategies on middle school student attitudes in mathematics?

A triangulation of data, including both quantitative and qualitative was used for analysis. In Design of the Study, Table 1 can be found to reference again. The triangulated data from student journals, in-class observations, and student interview questions were used to determine what problem solving strategies the students used on mathematics problems in the classroom. I looked for themes to make connections between the research questions and collected data. This data also assisted in answering question 1: What problem solving strategies do students choose to use in mathematics problems in the classroom?

The triangulated data from student journals, in-class observations, and student interview questions were used to determine what initial strategy students choose to use or not use. I looked

for themes to make connections between the research questions and collected data. This data also assisted in answering question 2: How do students decide what initial strategy to use or not use?

Quantitative and qualitative data were used to triangulate the data from mathematics attitudes survey, student journals, in-class observations, and student interview questions. I looked for themes to make connections between the research questions and collected data. This data was used to answer question 3: What is the influence of teaching mathematics problem solving strategies on middle school student attitudes in mathematics? The relationship between the pre and post statements in the mathematics attitudes survey was then calculated. This was done to establish the trend of students' attitude towards mathematical problem solving.

In the next chapter an analysis of the collected data will be shared as the results of this study. This will include the triangulated data from mathematics attitudes survey, student journals, in-class observations, and student interview questions.

## CHAPTER 4: RESULTS

### Introduction

This study was conducted during the fall of 2011. Its purpose was to answer the following questions:

1. What problem solving strategies do students chose to use in mathematics problems in the classroom?
2. How do students decide what initial strategy to use or not use?
3. What is the influence of teaching mathematics problem solving strategies on middle school student attitudes in mathematics?

During the first nine weeks of the seventh grade Pre-Algebra curriculum by Holt McDougal (2007), students used their problem solving strategies to solve mathematical word problems. The goal in this research was to see how teaching mathematical problem solving strategies would influence students' attitudes in mathematics and problem solving.

Data for this study was collected quantitatively and qualitatively. Qualitative data included journal entries from students, in which students wrote about problem solving strategies that they learned and how these influenced them and informal, in-class observations of how students' problem solved were also taken qualitatively. Students completed quantitative

Mathematics Attitudes Surveys before and after the research study was conducted to obtain their opinions about problem solving.

The three research questions were included as central points for evaluation of the influence of problem solving teaching. The three questions were included in Table 1, which was also shared in Chapter 3. The following results allowed me to answer these questions about the students' attitudes from having learned problem solving strategies. Research questions 1 & 2 will first be discussed. The qualitative data collected from student journals and in-class observations will be discussed. Then, student interview questions and answers will be shared and discussed. Lastly, research question 3 will be analyzed with the quantitative data from the Mathematics Attitudes Survey.

### Evidence for Research Question 1

The first question was “What problem solving strategies do students choose to use in mathematics problems in the classroom?” Evidence for this question was provided from the student journals, in-class observations, and student exit interview questions. All of this evidence was classified as qualitative data.

From the student journals data was collected regarding which problem solving strategy students used in the classroom (see table 3 for journal responses for question 1). After three weeks of learning problem solving strategies, one student wrote that he liked using the strategy of drawing a picture best. After four weeks of the study, four students wrote in their journals that guess and check was the easiest method, four students wrote that they would use guess and check

in the future, and three students wrote that guess and check was their favorite strategy for problem solving. After five weeks of learning problem solving strategies, thirteen out of fifteen students wrote in their journals that they would use lists and charts strategy in the future. After seven weeks of learning problem solving strategies, six of the fifteen students wrote that they would use working backwards in the future. One student wrote that he liked working backwards as the best method overall. Only two students wrote that they did not like to use working backwards. Four students wrote that guess and check was still their favorite method of problem solving. After eight weeks of learning problem solving strategies three students wrote that their favorite method of problem solving was guess and check. Of the five strategies that were learned, the students wrote that they would at least use one of them in the future.

Table 3: Journal Responses for Research Question 1

<b>Week</b>	<b>Total</b>	<b>Draw a Picture</b>	<b>Look for a Pattern</b>	<b>Guess &amp; Check</b>	<b>Make a List</b>	<b>Work Backwards</b>	<b>No response</b>
3	15	1	0	0	0	0	14
4	15	0	0	4	0	0	11
5	15	0	0	0	13	0	2
7	15	0	0	4	0	6	5
8	15	0	0	3	0	0	12

From the in-class observations I observed that students used all of the five problem solving strategies in the classroom. The most used strategy amongst the students was guess and check. The second most used strategy used in the classroom was drawing a picture. Students said that these were easy to understand and use, so that is why they utilized them.



From the student exit-interview questions it was evident that students had a preference of what strategies they used in the classroom. The second student interview question was, “Which problem solving strategy have you used the most? Why?” All of the students answered guess and check, except for one student, who answered working backwards. The reasons for using guess and check were “it’s the easiest for me”, “it’s simple to understand”, “I guess and check a lot”, and “it’s the most versatile”. Other students responded with “if I don’t know what strategy it is I put guess and check”. This was a common practice for students to put guess and check as a last resort. The students didn’t always know when guess and check was an acceptable response and would record their answer as guess and check if none of the other strategies fit.

The seventh and final interview question was, “Would you recommend any of these strategies to another student to use? Why or why not?” Fourteen out of fifteen students said that they would recommend these strategies. Reasons for recommending them were, “they are helpful”, “I would recommend problem solving strategies to people who are having problems with solving a problem”, “I would recommend these strategies to other students, because it was helpful for me so I would figure that the strategies would help them”, “they are easy to learn, plus I like them”, “I understand how to answer the problems because of them”, “it’s useful”, “it makes life easy”, “they help your grades”, “with them you can solve any problem”, and “they can be helpful to other people”. The one student that would not recommend them said that “I would not recommend them because I don’t understand them completely myself.” Overall students gave praise to using strategies when solving mathematical word problems.

The triangulation of this data shows common themes of what problem solving strategies students used in the classroom. From the student journals, classroom observations and student interviews the students said that they were using all five strategies (drawing a picture, making a chart, looking for a pattern, guess and check, and working backwards). From the student journals, classroom observations, and student interviews most of the students preferred to use guess and check as their favorite problem solving strategy. A more in depth reaction towards these themes will be discussed further in Chapter 5, the conclusion section of this research.

### Evidence for Research Question 2

The second question was “How do students decide what initial strategy to use or not use?” Evidence for this question was provided from the student journals, in-class observations, and student exit interview questions. All of this evidence was classified as qualitative data. Evidence for question 2 can be found in Appendix E.

From the student journals it was observed that students initially chose whatever strategy seemed to be the easiest to use when solving the problem. After multiple experiences with problem solving, students wrote that they had a preferred problem solving strategy. Students then would use the preferred strategy more often than the rest, if applicable.

From the in-class observations I observed that students used all of the strategies for problem solving. I also observed that the students did have a tendency to overuse or misuse some of the strategies. The students commonly overused guess and check as a preferred method. Students would tend to overuse guess and check, because they said that it was easy, and not

difficult to use. The students' initial choice seemed to be based on difficulty level of applying the problem solving strategy to the problem. After reading the word problem, when students would decide which strategy to use, they would choose by which one they thought was the easiest to apply to the word problem.

From the student exit-interview questions it was observed that students talked about their confidence in approaching a problem, and the obstacles that came with initially solving a problem. The fourth interview question was, "Do you feel confident when approaching problems? Why or why not?" Eight students said during the interviews that yes they were confident. Some of their reasons were, "they're really easy", "I have practiced and know how to solve most of the time", "I know that I have problem solving strategies if I get stuck", "we have practiced them a lot", "now I'm smarter", "we go over the different strategies more often and more thoroughly", and "I know how to do most of them". The other half of the class said that they were only confident depending on the question. Seven students responded with, "it depends if the question is hard or not", "for some of them I do because I'm not as good at some of the strategies as others", and "it depends on what type of numbers you are using". Those students felt more confident in certain situations of problem solving than others. Overall the students said that they had more confidence now since they learned the different problem solving strategies to use in mathematics.

The fifth interview question was, "What types of obstacles have you had when solving problems?" Four students said that they had no obstacles. Six students wrote that they got confused when they didn't know what strategy to use. One of those students wrote, "Sometimes I

don't know what strategy to use so I just guess". Three students wrote that they didn't know what to do at first and struggled starting to solve a word problem. One student reflected upon how he struggled at first when "learning the strategy work backwards, because (he) worked forwards" all the time. Another student wrote that, "I had problems when I made a small miscalculation or was over thinking things".

The sixth interview question was, "How have you overcome these obstacles when solving problems? Why or why not?" Most of the students answered this question saying that trying harder, using problem solving strategies, and practicing more math word problems. Other responses were, "asking questions and getting help from the teacher", "trying to simplify the problem", "by learning strategies and it doesn't take me that long", "I just try my best and answer it with my best guess if I don't know what it is", "I used all the strategies and saw which one made the most sense" and "I look back at my work and try to make sense of what I did and I go over my steps". All of the students recognized that using the strategies was an answer to overcoming their obstacles.

The triangulation of this data shows common themes of how students decide what initial strategy to use or not to use. From the student journals and classroom observations, and student interviews the students said was that it was easy to find a strategy to use. From the student journals and classroom observations it was observed that students used their favorite strategy first. Their favorite strategy was not necessarily the best one for the problem; rather it was the easiest one for the student to use. From the exit interview questions it was observed that students might get stuck initially and then have to take another look at the problem to find a strategy that

would work. A more in depth reaction towards these themes will be discussed further in Chapter 5 the conclusion section of this research.

### Evidence for Research Question 3

The third question was “What is the influence of teaching mathematics problem solving strategies on middle school student attitudes in mathematics?” Evidence for this question was provided from the student journals, in-class observations, student exit interview questions, and the Mathematics Attitude Survey. This evidence was classified as qualitative and quantitative data. Evidence for question 3 can be found in Appendix G.

From the student journals it was observed that students wrote before instruction that they knew nothing about problem solving strategies, and they wanted to learn more about them. At the end of the study students chose what to write in their journals about learning problem solving strategies. Students’ responses ranged from “I have a higher confidence, I feel like I can answer any question that has to do with problem solving” to responses like, “Well at first I didn’t like math at all. It was super hard for me. Now math is still hard, but now I know about problem solving strategies and that makes it easier.” Overall the responses were positive from the students. I believe this was a positive environment for the students to learn problem solving strategies.

From the in-class observations I observed that students were hesitant about problem solving before the study, and did not understand what problem solving strategies were. During the study I observed students begin to grow confident in their skills and have a more positive

attitude. At the end of the study, I observed that most of the students had an improved attitude towards mathematical problem solving.

From the student exit-interview questions it was observed that students felt they were better at being a problem solver. The third interview question was, “Do you feel that you are becoming a better problem solver? Why or why not?” Many of the responses were “yes”, and some of the responses were a “little bit”. The reasons varied between students. Some of the reasons were, “I’m getting more answers right”, “I understand it more than I did before”, “we are practicing it in class”, “we are practicing it all the time”, “I understand the problems better with the problem solving strategies”, “my grades have been really good so far”, “I get the answer quick and easy”, and “I understand how to answer the problems.” Some of the responses from students that said they were a little bit better problem solvers were, “it’s hard” and “the strategies are helpful to use when you don’t know what to do”. Overall the students evidenced that they were becoming better problem solvers because they know and use the strategies for mathematical problem solving.

The fourth interview question was, “Do you feel confident when approaching problems? Why or why not?” Eight students said during the interviews that yes they are confident. Some of their reasons were, “they’re really easy”, “I have practiced and know how to solve most of the time”, “I know that I have problem solving strategies if I get stuck”, “we have practiced them a lot”, “now I’m smarter”, “we go over the different strategies more often and more thoroughly”, and “I know how to do most of them”. The other half of the class said that they were only confident depending on the question. Seven students responded with, “it depends if the question

is hard or not”, “for some of them I do because I’m not as good at some of the strategies as others”, and “it depends on what type of numbers you are using”. Those students felt more confident in certain situations of problem solving than others. Overall the students said that they had more confidence than before they learned the different problem solving strategies to use in mathematics.

The triangulation of this data shows common themes of what students’ attitudes towards Mathematics Problem Solving before and after instruction of strategies. From the student journals, classroom observations, and student interviews, the students said they were becoming more confident and better problem solvers. The reasons for this varied, but most of the students agreed that the strategies helped and gave them confidence. A more in depth reaction towards these themes will be discussed further in Chapter 5 conclusion section of this research. The Mathematics Attitude Survey was also observed for this question and the results of this survey follows this section.

#### Mathematics Attitudes Survey Scores

Of the 16 students that began the study, qualitative data from 15 were analyzed. One student took a three week leave of absence from school before finishing the study. The student’s data were incomplete; therefore their data were not included.

The qualitative data collected included three different subscales of mathematics: mathematics behavior (MB), mathematics confidence (MC), and mathematics engagement (ME). Mathematics behavior was assessed with five questions, mathematics confidence was assessed

with six questions, and mathematics engagement was assessed with four questions, for a total of fifteen questions. The survey questions were answered with the following Likert scale:

- Score of 1 was given if the student totally disagreed with the statement;
- Score of 2 was given if the student partially disagreed with the statement;
- Score of 3 was given if the student was uncertain of their opinion of the statement;
- Score of 4 was given if the student partially agreed with the statement; and
- Score of 5 was given if the student totally agreed with the statement.

A copy of the Mathematics Attitudes survey can be found in Appendix C.

Table 4 shows the Mathematics Attitudes survey scores for the first subscale mathematics behavior. The first subscale for mathematics behavior had five statements as listed. The scores for the pre and post survey are given from the fifteen students who were surveyed. The change in the number of students' responses from pre and post survey is given. Lastly, the percentage difference between the pre and post survey scores is given.



Table 4: Mathematics Attitudes Survey Scores for Mathematics Behavior

Statement		Total	5	4	3	2	1
1. I focus in mathematics class.	<b>Pre</b>	15	5 (33%)	8 (53%)	1 (7%)	1 (7%)	0 (0%)
	<b>Post</b>	15	8 (53%)	6 (40%)	1 (7%)	0 (0%)	0 (0%)
	<b>Change</b>	0	+3	-2	0	-1	0
	<b>Difference</b>	0	+20%	-13%	0%	-7%	0%
2. I make an effort to respond to mathematics questions the teacher asks.	<b>Pre</b>	15	6 (40%)	5 (33%)	1 (7%)	3 (20%)	0 (0%)
	<b>Post</b>	15	5 (33%)	6 (40%)	2 (13%)	1 (7%)	1 (7%)
	<b>Change</b>	0	+1	+1	+1	-2	+1
	<b>Difference</b>	0	+7%	+7%	+7%	-13%	+7%
3. If I make mistakes in a mathematics problem, I work until I find the correct solution.	<b>Pre</b>	15	0 (0%)	10 (67%)	3 (20%)	2 (14%)	0 (0%)
	<b>Post</b>	15	5 (33%)	7 (47%)	3 (20%)	0 (0%)	0 (0%)
	<b>Change</b>	0	+5	-3	0	-2	0
	<b>Difference</b>	0	+33%	-20%	0%	-14%	0%
4. If I can't do a mathematics problem, I keep trying different strategies.	<b>Pre</b>	15	5 (33%)	2 (13%)	5 (33%)	3 (20%)	0 (0%)
	<b>Post</b>	15	6 (40%)	4 (27%)	3 (20%)	2 (13%)	0 (0%)
	<b>Change</b>	0	+1	+2	-2	-1	0
	<b>Difference</b>	0	+13%	+14%	-13%	-7%	0%
5. If I can't do a mathematics problem, I seek help to solve the problem.	<b>Pre</b>	15	4 (27%)	7 (47%)	2 (13%)	1 (7%)	1 (7%)
	<b>Post</b>	15	10 (67%)	3 (20%)	1 (7%)	0 (0%)	1 (7%)
	<b>Change</b>	0	+6	-4	-1	-1	0
	<b>Difference</b>	0	+40%	-27%	-6%	-7%	0%

Of the mathematics behavior statements, three of five statements had more significant changes than the other two statements. Those with significant changes were statement one with a class mean increase of 8%, statement four with a class mean increase of 9%, and statement five with a class mean increase of 16%. The two statements with less significant differences were statement two with a class mean decrease of 2% and statement three with a class mean increase of 3%. Also statement two had seven students (47%) not change their scores and statement three had six students (40%) not change their scores.

The first statement of the Mathematics Attitudes survey, “I focus in mathematics class”, eight students scored themselves the same on the pre and post survey. The other students had increases or decreases from their pre survey score to their post survey score. Three students’ scores went up from a 4 to a 5, one student’s score went up from a 3 to a 5, and another student’s score went up from a 2 to a 4. Only two students scores went down, one student’s score went down from a 5 to a 4 and another student’s scores went down from a 4 to a 3.

The fourth statement of the Mathematics Attitudes survey, “If I can’t do a mathematics problem, I keep trying different strategies”, six students scored themselves the same on the pre and post survey. The other students had increases or decreases from their pre survey score to their post survey score. One student’s score went up from a 4 to a 5, two students’ scores went up from a 3 to a 5, two students’ scores went up from a 3 to a 4, and another student’s score went up from a 2 to a 4. Only three students’ scores went down, one student’s score went down from a 5 to a 4, one student’s scores went down from a 5 to a 3, and another student’s scores went down from a 4 to a 3.

The fifth statement of the Mathematics Attitudes survey, “If I can’t do a mathematics problem, I seek help to solve the problem”, two students scored themselves the same on the pre and post survey. The other students had increases or decreases from their pre survey score to their post survey score. Six students’ scores went up from a 4 to a 5, one student’s score went up from a 3 to a 5, one student’s score went up from a 1 to a 5, and another student’s score went up from a 3 to a 4. Only four students’ scores went down, two students’ score went down from a 5

to a 4, one student's score went down from a 5 to a 3, and another student's scores went down from a 2 to a 1.

Table 5 shows the Mathematics Attitudes survey scores for the second subscale mathematics confidence. The first subscale for mathematics behavior had five statements as listed. The scores for the pre and post survey are given from the fifteen students who were surveyed. The change in the number of students' responses from pre and post survey is given. Lastly, the percentage difference between the pre and post survey scores is given.

Table 5: Mathematics Attitudes Survey Scores for Mathematics Confidence

Statement		Total	5	4	3	2	1
6. I have a mind built for mathematics.	Pre	15	4 (27%)	2 (13%)	7 (47%)	1 (7%)	1 (7%)
	Post	15	3 (20%)	5 (33%)	3 (20%)	1 (7%)	3 (20%)
	Change	0	-1	+3	-4	0	-2
	Difference	0	-7%	+20%	-27%	0%	-13%
7. I can get good grades in mathematics.	Pre	15	9 (60%)	4 (27%)	0 (0%)	1 (7%)	1 (7%)
	Post	15	10 (67%)	3 (20%)	1 (7%)	0 (0%)	1 (7%)
	Change	0	+1	-1	+1	-1	+0
	Difference	0	+7%	-7%	+7%	-7%	0%
8. I know what to do with difficult problems in mathematics.	Pre	15	0 (0%)	9 (60%)	2 (13%)	1 (7%)	0 (0%)
	Post	15	3 (20%)	10 (67%)	4 (27%)	1 (7%)	0 (0%)
	Change	0	+3	+1	+2	0	0
	Difference	0	+20%	+7%	+14%	0%	0%
9. I know how to solve mathematics word problems.	Pre	15	5 (33%)	7 (47%)	1 (7%)	1 (7%)	1 (7%)
	Post	15	5 (33%)	8 (53%)	2 (13%)	0 (0%)	0 (0%)
	Change	0	+1	+2	+1	-1	-1
	Difference	0	+13%	+14%	+6%	-7%	-7%
10. I know strategies that can help me solve mathematic word problems.	Pre	15	3 (20%)	6 (40%)	4 (27%)	1 (7%)	1 (7%)
	Post	15	11 (73%)	4 (27%)	0 (0%)	0 (0%)	1 (7%)
	Change	0	+8	-2	-4	-1	-1
	Difference	0	+53%	-17%	-27%	-7%	-7%
11. I am confident with my mathematics skills.	Pre	15	4 (27%)	6 (40%)	2 (13%)	3 (20%)	0 (0%)
	Post	15	7 (47%)	5 (33%)	1 (7%)	2 (13%)	0 (0%)
	Change	0	+3	-1	-1	-1	0
	Difference	0	+20%	-7%	-6%	-7%	0%

Of the mathematics confidence statements, four of the six statements had considerable changes. Those with significant changes were statement eight with a class mean increase of 9%, statement nine with a class mean increase of 7%, statement ten with a class mean increase of 31%, and statement eleven with a class mean increase of 11%. The two statements with less significant differences were statement six with a class mean decrease of 6% and statement seven

with a class mean increase of 3%. Also statement six had seven students (47%) not change their scores and statement seven had eleven students (73%) not change their scores.

The eighth statement of the Mathematics Attitudes survey, “I know what to do with difficult problems in mathematics”, nine students scored themselves the same on the pre and post survey. The other students had increases or decreases from their pre survey score to their post survey score. Three students’ scores went up from a 4 to a 5, one student’s score went up from a 3 to a 4, and another student’s score went up from a 2 to a 4. Only one student’s scores went down from a 3 to a 2.

The ninth statement of the Mathematics Attitudes survey, “I know how to solve mathematic word problems”, ten students scored themselves the same on the pre and post survey. The other students had increases or decreases from their pre survey score to their post survey score. One student’s score went up from a 3 to a 5, one student’s score went up from a 2 to a 4, and another student’s score went up from a 1 to a 3. Only two students scores went down, one student’s score went down from a 5 to a 4 and another student’s score went down from a 4 to a 3.

The tenth statement of the Mathematics Attitudes survey, “I know strategies that can help me solve mathematic word problems”, three students scored themselves the same on the pre and post survey. The other students had increases or decreases from their pre survey score to their post survey score. Five students’ scores went up from a 4 to a 5, two students’ scores went up from a 3 to a 5, one student’s score went up from a 2 to a 5, one student’s score went up from a 1 to a 5, and two students’ scores went up from a 3 to a 4. Only one student’s scores went down from a 5 to a 4.

The eleventh statement of the Mathematics Attitudes survey, “I am confident with my mathematics skills and strategies”, and seven students scored themselves the same on the pre and post survey. The other students had increases or decreases from their pre survey score to their post survey score. Four students’ scores went up from a 4 to a 5, and two students’ scores went up from a 2 to a 4. Only two students scores went down, one student’s score went down from a 5 to a 4 and another student’s score went down from a 3 to a 2.

Table 6 shows the Mathematics Attitudes survey scores for the third subscale mathematics engagement. The first subscale for mathematics behavior had five statements as listed. The scores for the pre and post survey are given from the fifteen students who were surveyed. The change in the number of students’ responses from pre and post survey is given. Lastly, the percentage difference between the pre and post survey scores is given.

Table 6: Mathematics Attitudes Survey Scores for Mathematics Engagement

<b>Statement</b>		<b>Total</b>	<b>5</b>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>
12. I am interested to become skilled at new strategies in mathematics.	<b>Pre</b>	15	3 (20%)	3 (20%)	5 (33%)	3 (20%)	1 (7%)
	<b>Post</b>	15	4 (27%)	6 (40%)	1 (7%)	2 (13%)	2 (13%)
	<b>Change</b>	0	+1	+3	-4	-1	+1
	<b>Difference</b>	0	+7%	+20%	-26%	-7%	+6%
13. I get rewarded for my efforts in mathematics.	<b>Pre</b>	15	2 (13%)	3 (20%)	6 (40%)	1 (7%)	3 (20%)
	<b>Post</b>	15	6 (40%)	8 (53%)	1 (7%)	0 (0%)	0 (0%)
	<b>Change</b>	0	+4	+5	-5	-1	-3
	<b>Difference</b>	0	+27%	+33%	-33%	-7%	-20%
14. Learning mathematics is fun for me.	<b>Pre</b>	15	3 (20%)	1 (7%)	5 (33%)	5 (33%)	1 (7%)
	<b>Post</b>	15	4 (27%)	5 (33%)	1 (7%)	3 (20%)	2 (13%)
	<b>Change</b>	0	+1	+4	-4	-2	+1
	<b>Difference</b>	0	+7%	+26%	-26%	-13%	+6%
15. I feel accomplished when I solve a mathematic word problem.	<b>Pre</b>	15	8 (53%)	4 (27%)	0 (0%)	1 (7%)	2 (13%)
	<b>Post</b>	15	12 (80%)	2 (13%)	0 (0%)	0 (0%)	1 (7%)
	<b>Change</b>	0	+4	-2	0	-1	-1
	<b>Difference</b>	0	+33%	-14%	0%	-7%	-7%

Of the mathematics engagement statements, two of the four statements had significant changes. Those with significant changes were statement thirteen with a class mean increase of 44% and statement fourteen with a class mean increase of 70%. The two statements with less significant differences were statement twelve with a class mean increase of 10% and statement fifteen with a class mean increase of 15%. Also statement twelve had four students (33%) not change their scores and statement fifteen had ten students (67%) not change their scores.

The thirteenth statement of the Mathematics Attitudes survey, “I get rewarded for my efforts in mathematics”, and only one student scored themselves the same on the pre and post survey. The other students had increases or decreases from their pre survey score to their post survey score. Four students’ scores went up from a 4 to a 5, two students’ scores went up from a

3 to a 5, four students' scores went up from a 3 to a 4, one student's score went up from a 2 to a 4, two students' scores went up from a 1 to a 4, and another student's score went up from a 1 to a 3. Only one student's scores went down from a 5 to a 4.

The fourteenth statement of the Mathematics Attitudes survey, "Learning mathematics is fun for me", and five students scored themselves the same on the pre and post survey. The other students had increases or decreases from their pre survey score to their post survey score. One student's score went up from a 4 to a 5, one student's score went up from a 3 to a 5, three students' scores went up from a 3 to a 4, one student's score went up from a 2 to a 4, and another student's score went up from a 2 to a 3. Only three students' scores went down. One student's score went down from a 5 to a 4, another student's score went down from a 3 to a 2, and one student's score went from a 2 to a 1.

The next chapter includes comparisons and recommendations. Comparisons include how the research questions, triangulated data, and literature measure up to each other. Also included are recommendations and improvements that are being considered for teaching problem solving strategies in the future.



## CHAPTER 5: CONCLUSIONS

### Introduction

The focus of this study was to determine the influence of teaching middle school students problem solving strategies and how this influenced their attitudes. During the first nine weeks of the school year, the course three Holt McDougal Math curriculum was taught. Students learned this new curriculum and five specific strategies for problem solving. They took notes about problem solving and wrote reflections on their problem solving process in their student response journals. Students applied the five problem solving strategies in class when solving mathematical word problems. The goal of this research was to see if students' attitudes would positively change after learning strategies to use when problem solving.

Qualitative and quantitative data were collected during this research. The Mathematics Attitudes survey was given before and after the study was conducted. The pre and post survey results were compared. Student response journals were both collected and analyzed. These journals contained students' reflections, which assisted in drawing conclusions of students' personal beliefs and attitudes about problem solving.

Lastly, in-class observations I conducted also assisted in drawing conclusions of students' learning. These observations were made in class during problem solving lessons, during class practice of problem solving strategies, and during the students' small group interviews.

### Conclusions for Research Question 1

The first question was “What problem solving strategies do students choose to use in mathematics problems in the classroom?” Evidence for this question was provided from the student journals, in-class observations, and student exit interview questions. All of this evidence was classified as qualitative data.

There were connections made during this research from the student journals, classroom observations and student interviews from the students. The students used the strategies for solving mathematics problems in the classroom. They were open to trying and learning the strategies. Along the way, the students found their own preferences for which strategies they liked best and how best to use the strategies.

From this study it can be concluded that most of the students preferred the method of guess and check. In the students’ journals, over half of the students wrote at least once that they preferred the method of guess and check. As a response to why this was the preferred method, they would respond that it was the easiest one for them to use. . “In learning mathematics, the students should have the opportunity to discover by themselves a way to reach the solution to the problem” (Cotic & Zuljan, 2009, p. 300). Students had the opportunity to solve the problems with the method that they felt was most appropriate. Students chose the method that they were most comfortable with, though it may not have been appropriate for the problem.

Classroom observations made during the study also suggested that guess and check was the method most often used. Students would use it in class and I informally assessed that it was

used the most out of the five strategies that were taught. “It is important for the teacher to challenge and encourage the students towards independent search of various paths to the solution by discussing and comparing these in class” (Cotic & Zuljan, 2009, p. 300). Students were asked in class why they chose a certain strategy and were asked to discuss how they came to that conclusion. Sometimes students were asked to check their work and see if another strategy would work better. The student’s thought process was challenged and they checked their work to gain a better understanding of how to appropriately solve the problem.

Lastly, the exit interview question about” which strategy have you used the most” was answered by fourteen out of fifteen students with guess and check. It was the easiest and most simple strategy for the students to understand. “Research indicates that when teachers explicitly teach strategies, this instruction appears to have a positive impact on children’s numerical knowledge” (Biddlecomb & Carr, 2010, p. 6). Students demonstrated this by using the strategies to help them answer the mathematical word problems correctly. I noted that even though guess and check may have been the most often used, the students might have overused it due to the name of the strategy. Students would incorrectly report because they guessed how to solve the problem, therefore they were using guess and check. In some of these cases I found that the students reporting using guess and check, when they actually were working backwards to find the solution. In these cases, there needed to be more clarification regarding the distinctions between problem-solving strategies. This idea will be addressed in more detail in the recommendations section of this chapter.

## Conclusions for Research Question 2

The second question was “How do students decide what initial strategy to use or not use?” Evidence for this question was provided from the student journals, in-class observations, and student exit interview questions. All of this evidence was classified as qualitative data.

There were connections made during this research from the student journals, classroom observations and student interviews from the students. Students responded in their journals that “whatever strategy seemed to be the easiest to use when solving the problem”, was how they initially chose. It was common for students to do whatever they felt comfortable with. “This helps the students develop intuition and creativity, convergent and divergent thought, as well as to acquire the ability to plan and evaluate” (Cotic & Zuljan, 2009, p. 300). By allowing the students to come up with their own decision they were independently using the strategies. What had been scaffolded information from the teacher was not being utilized independently by the student. Davis and Miyake (2004) wrote that scaffolding represents the support a learner is given by the teacher, to attain a goal otherwise unachievable. The goal became achievable when the students were comfortable using the strategies. If students were not comfortable with a strategy they tended not to use it. This feeling of discomfort was from the student not knowing how to properly implement the strategy. Students were encouraged to utilize their notes until they were experts of using strategies.

After multiple experiences with problem solving, students wrote that they had a preferred problem solving strategy to use. Students then would use the preferred strategy more often than

the rest. This preferred strategy would then usually become their initial strategy to use for every problem, unless they found that it was easier to solve the problem with a different strategy. Rickard (2005) wrote about other strategies that are used for problem solving are drawing pictures, making charts, working backwards, and guess & check. One strategy does not work for all problems, which is why there are more than one strategy for problem solving. The students often wrote in their journals that they felt comfortable or that it was easier with their preferred strategy and that is why they initially picked it. Classroom observations confirmed that the students' initial strategy was the same as observed in the journals. The students would use whatever initial strategy they felt comfortable with or was the easiest to them. This strategy then became their default to solve most of their problems, unless they found that another strategy would be easier to solve the particular problem. Quality mathematics instruction "should equip the students with declarative and procedural knowledge and skills and allow them to gradually grow independent" (Cotic & Zuljan, 2009, p. 307). While instruction was equipping them to use strategies independently, some students needed further instruction how to appropriately use them. Students at the independent stage should be able to use the strategies and use them appropriately. While other students wanted more of a challenge in learning more strategies for problem solving. This idea will be addressed in more detail in the recommendations section of this chapter.

In the exit interviews the students answered questions about their initial strategy and the obstacles that they had to overcome in using their initial strategy. Vygotsky's (1978) theory of scaffolding information played a major part in how students decided to use an initial strategy.

Information of strategies had been scaffolded to help students find the one that worked best for them. If it didn't work they continued trying different strategies until they found one that worked. If they couldn't solve the problem, then they were able to talk about it with a classmate to find out what strategy would be best to solve the problem. "Learning through problem solving develops understanding" (Lambdin, 2003, p. 7). The students found this to be true. Working with a peer helped in the process of learning how to problem solve. Discussing the possible ways to solve a problem helped the students develop a deeper understanding.

In conclusion, the students' initial strategy was often pre-chosen before the problem was read and comprehended. Fourteen out of fifteen students responded that they preferred to use guess and check. There was a case for contentment with the strategy that leads these students to choose this strategy first. Their initial strategy decision was chosen out of ease and comfort for them. Shears (2005) wrote how problem-solving strategies would be valuable for all students to learn. While it was valuable for the students to learn these strategies, not using them appropriately devalues them also. Students did not choose what they thought would necessarily be best, but what they felt comfortable with. This was an area of problem solving that will be addressed in the recommendations for future use of teaching these strategies later in this chapter.

### Conclusions for Research Question 3

The third question was "What is the influence of teaching mathematics problem solving strategies on middle school student attitudes in mathematics?" Evidence for this question was provided from the student journals, in-class observations, student exit interview questions, and

the Mathematics Attitude Survey. This evidence was classified as qualitative and quantitative data.

Given the evidence we have, it can be concluded that before receiving instruction on strategies some of the students were unaware of problem solving strategies and some of the students felt that they did not know how to solve mathematical word problems. “Learning problem-solving strategies has positively influenced the students’ attitudes towards solving more challenging problems in my classroom” (Shears, 2005, p. 9). In this study it was also observed from students who wrote about this in their journals and expressed confidence in their Mathematics Attitudes Surveys. “Understanding leads students to see mathematics in a positive light—as a subject that makes sense because it is logical and connected” (Lambdin, 2003, p. 7). Students had a clear understanding of what was being taught which made the strategies for problem solving logical to use. Students learned what each strategy was and how to use it.

The evidence collected at the conclusion of the study shows that after learning the instructional strategies, students’ attitudes improved. Students became more comfortable with problem solving, as was shown by their preference for using the strategy guess and check. “From experience, the key factors in achieving positive emotional responses are: variety of experiences, clarity of purpose, and success and understanding for children” (Sparrow & Hurst, 2010, p. 19). Enough positive experiences had occurred in which students knew the purpose for succeeding with problem solving therefore students attitudes were influenced positively.

Learning was scaffolded to the students which increased their Zone of Proximal Development (ZPD) for problem solving. “Studies have shown that negative mathematical

attitudes and poor achievement and/or engagement with mathematics are related” (Hemmings, Grootenboer, & Kay, 2010, p. 692). Students did not experience a decline in attitude, rather they experienced an increase in mathematics confidence and engagement. This increase in their ZPD likewise created an increase in mathematics engagement for problem solving. With the increase in engagement came the increase in students’ confidence with problem solving. “Quality math instruction should provide the students with two things: a challenge and a feeling of success at having accomplished something” (Cotic & Zuljan, 2009, p. 307). Students were presented with the challenge of learning strategies and their attitudes towards mathematics were positively influenced. The triangulated data shows that students were more comfortable and knowledgeable about the problem solving strategies, so their confidence and attitudes improved.

### Recommendations

There are three main parts of this study that should be considered as recommendations for future use. These recommendations include the appropriate number of problem solving strategies to teach, the appropriate amount of time to practice using problem solving strategies, and continuing to apply and learn new problem solving strategies.

One of the criticisms that came from students was the number of problem solving strategies. Some students wanted more problem solving strategies, while others wanted less. I chose to only focus on five problem solving strategies, due to the amount of time available for the action research study. Some of the students that reported wanting more strategies said this because “it might be more helpful”, or “might have been helpful on previous problems if they



knew more strategies”. Other students didn’t see the need to learn five because the one they used the most was guess and check.

The reason why the other problem solving strategies were not introduced was because the ones selected for this study were the top five types of problem solving strategies that have been used by other researchers. I would not change the number of strategies given to the students. If middle school students are given too many strategies and information they might become overwhelmed and confused. However if middle school students are given only one strategy, then they might not be challenged and might be left unprepared. Most of the students found that the five selected strategies were helpful and an appropriate number of strategies. When teaching problem solving strategies in the future, I am planning to continue to use the five strategies used in this study.

Another recommendation regards time allotted to practice the problem solving strategies. The average instructional time spent every week on learning a new strategy was thirty minutes. The average time spent practicing problem solving strategies every week was thirty to forty minutes. More time should have been given for problem solving practice in the classroom. Practice was often done through an in-class activity. With every practice the students gained more confidence and knowledge of how the problem solving process works. If more time had been allotted, the students would have had more opportunities to practice with the problem solving strategies and more application time. Giving students more time with this process would in turn help the students become more confident problem solvers.

As a result of this study, students quickly became experts on the five problem solving strategies that were taught and applied in the classroom. After the students mastered these five strategies they were constantly asking if there were additional strategies out there for them to learn. Some students said that they wanted additional strategies because those might be helpful in solving mathematics problems that they otherwise would not be able to solve. Other students thought that the five strategies were enough to master their problem solving. I would recommend encouraging students to find additional strategies that can be learned and mastered through independent study. It would be a good extension of this study to continue learning additional strategies. Some students wanted to learn additional strategies to become better problem solvers and that would be a great opportunity for them to do an independent study.

### Final Discussions

It is the my opinion that teaching problem solving strategies was found to be a very influential solution to increase students' confidence and ability to solve mathematical word problems. It did prove to be a positive experience for me, as I was able to instruct and observe students using these problem solving strategies independently.

The purpose of this research was not to create a new teaching method, but rather to see how teaching problem solving strategies would influence middle school students. Students were instructed and given the tools to be successful problem solvers. In the end, it proved to be an influential tool for teaching middle school mathematics.

There are many different ways to teach and instruct students in the ways of mathematical problem solving. Teaching strategies to students is one way to help them become better problem solvers. Teaching five different problem solving strategies was just one of the many ways mathematical problem solving could have been accomplished. This study has shown that teaching strategies to students influences their processes of becoming better problem solvers.

In conclusion, students used and applied their problem solving strategies to solve mathematical word problems. If problem solving strategies can help students become better problem solvers, as it did during this action research study, then it is my opinion that it is a valid method of instruction for any middle school mathematics classroom.

## **APPENDIX A: IRB OUTCOME LETTER**



University of Central Florida Institutional Review Board  
Office of Research & Commercialization  
12201 Research Parkway, Suite 501  
Orlando, Florida 32826-3246  
Telephone: 407-823-2901 or 407-882-2276  
[www.research.ucf.edu/compliance/irb.html](http://www.research.ucf.edu/compliance/irb.html)

### Approval of Exempt Human Research

From: **UCF Institutional Review Board #1**  
**FWA00000351, IRB00001138**

To: **Kelly L. Klingler**

Date: **August 10, 2011**

Dear Researcher:

On 8/10/2011, the IRB approved the following activity as human participant research that is exempt from regulation:

Type of Review:	Exempt Determination
Project Title:	Mathematics strategies for effectively teaching problem solving: The effects of teaching mathematical problem solving strategies on students' attitudes in middle school.
Investigator:	Kelly L. Klingler
IRB Number:	SBE-11-07794
Funding Agency:	
Grant Title:	
Research ID:	n/a

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Kendra Diamond Campbell, MA, JD, UCF IRB Interim Chair, this letter is signed by:

Signature applied by Joanne Muratori on 08/10/2011 12:38:52 PM EDT

A handwritten signature in black ink that reads "Joanne Muratori".

IRB Coordinator

**APPENDIX B: PERMISSION FROM AUTHOR OF MATHEMATICS**

**ATTITUDE SURVEY**

RE: A scale for monitoring students' attitudes to learning mathematics with technology.

[Back to messages](#) |  

□ Kaye Stacey

To kelly.klingler@knights.ucf.edu, Robyn Pierce

7/27/11 

[Reply](#) 

Hi Kelly,

You are welcome to use our scale, but I wonder if it is right for your purpose. The scale is correctly named: it is about learning mathematics with technology.

With best wishes,

Kaye

**Kaye Stacey**

Foundation Professor of Mathematics Education

Melbourne Graduate School of Education | 234 Queensberry St (Room 348) | University of Melbourne | Vic 3010 Australia

| m: +61 417399 745 | f: +61 3 8344 3742 | [www.education.unimelb.edu.au/~kayecs](http://www.education.unimelb.edu.au/~kayecs)

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**From:** kelly.klingler@knights.ucf.edu [mailto:kelly.klingler@knights.ucf.edu]

**Sent:** Wednesday, 27 July 2011 1:09 AM

**To:** Kaye Christine Stacey

**Subject:** A scale for monitoring students' attitudes to learning mathematics with technology.

Dear Dr. Stacey,

I am writing to ask for permission to use your instrument "Mathematics and Technology Attitudes Scale" from your article "A scale for monitoring students' attitudes to learning mathematics with technology". I am a public school teacher in Orlando, Florida. I will be conducting an action research thesis this Fall with one of my middle school mathematics classes as a requirement for completion of my masters program at the University of Central Florida. I will be teaching strategies for solving mathematical word problems and will be measuring students' attitudes with a pre and post Likert scale assessment. I would like your permission to use your instrument with my students to collect data on their attitudes of mathematics. Thank you for your time.

Sincerely,

Kelly Klingler

## **APPENDIX C: MATHEMATICS ATTITUDES SURVEY**



**Subscales:** mathematics behavior (MB), mathematics confidence (MC), and mathematics engagement (ME). **Directions:** Fill in the bubble with the answer you agree with most. The scale is listed below.

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1- Totally disagree    2-Partially disagree    3- Uncertain    4- Partially agree    5- Totally agree

---

1. I focus in mathematics class. (MB)  
 1  2  3  4  5
2. I make an effort to respond to mathematics questions the teacher asks. (MB)  
 1  2  3  4  5
3. If I make mistakes in a mathematics problem, I work until I find the correct solution. (MB)  
 1  2  3  4  5
4. If I can't do a mathematics problem, I keep trying different strategies. (MB)  
 1  2  3  4  5
5. If I can't do a mathematics problem, I seek help to solve the problem. (MB)  
 1  2  3  4  5
6. I have a mind built for mathematics. (MC)  
 1  2  3  4  5
7. I can get good grades in mathematics. (MC)  
 1  2  3  4  5
8. I know what to do with difficult problems in mathematics. (MC)  
 1  2  3  4  5
9. I know how to solve mathematic word problems. (MC)  
 1  2  3  4  5
10. I know strategies that can help me solve mathematic word problems. (MC)  
 1  2  3  4  5
11. I am confident with my mathematics skills and strategies. (MC)  
 1  2  3  4  5
12. I am interested to become skilled at new strategies in mathematics. (ME)  
 1  2  3  4  5
13. I get rewarded for my efforts in mathematics. (ME)  
 1  2  3  4  5
14. Learning mathematics is fun for me. (ME)  
 1  2  3  4  5
15. I feel accomplished when I solve a mathematic word problem correctly. (ME)  
 1  2  3  4  5

**APPENDIX D: STUDENTS' JOURNALS OF PROBLEM SOLVING  
STRATEGIES**

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(A) The answer is  $1\frac{1}{6}$

$$\begin{array}{r} \boxed{1\frac{1}{6}} \\ 5 \overline{) 305} \end{array} \quad 1 \cdot \frac{1}{6}$$

I used Guess and Check

(B) The answer is 1.45

$$\begin{array}{r} 1.45 \\ 45 \overline{) 61} \end{array} \quad \boxed{1.45}$$

I used Guess and Check

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## Journal

A:  $\frac{\cancel{1.5}}{\cancel{3.5}} = \frac{\cancel{x}}{\cancel{98}}$  guess & check

$$\frac{3.5x}{3.5} = \frac{147}{3.5} = \boxed{42}$$

The radio tower is 42 meters long.

B:  $\frac{\cancel{24}}{\cancel{56}} = \frac{\cancel{x}}{\cancel{42}}$  guess & check

$$\frac{56x}{56} = \frac{1,008}{56} = \boxed{18}$$

Kim's friend's shadow is 18 inches long.

## **APPENDIX E: STUDENTS' REFLECTIONS FROM JOURNALS**

# Problem Solving

When I do problem solving, I often use guess & check. I reason I use guess & check is because it is the most easy, most efficient, and most used in my life. So I would most likely do guess & check in the future.

I have learned many things about problem solving. Drawing a picture, looking for a pattern and making a list are some strategies you would use in problem solving. Just to name a few! I feel that problem solving is easy.

# Journal

1. Problem solving strategies help me because they help me better understand the problem/question.

2. I feel that I am becoming a better problem solver because I understand the problems better with the problem solving strategies.

3. One obstacle that I had when I was solving problems was that I was solving the problem and didn't know what strategy I was using.

4. I would recommend these strategies to other students because it was helpful for me so I would figure that the strategies would help them.

# Journal

With problem solving it is very easy to come up with the answer. You can use, draw a picture, look for a pattern and guess and check. Guess and check was the newest one we just learned.

With it you don't have to do much work, in my opinion. You just guess and then check your answer.

Yes I use guess and check all the time and I will still use it because it is the most common way to do problem solving. We have learned how to draw a pic., look for a pattern and guess and check. I feel really good about problem solving.



## **APPENDIX F: STUDENT INTERVIEW QUESTIONS**

1. How helpful are the problem solving strategies that we have discussed in class? Why or why not?
  
2. Which problem solving strategy have you used the most? Why?
  
3. Do you feel that you are becoming a better problem solver? Why or why not?
  
4. Do you feel confident when approaching problems? Why or why not?
  
5. What types of obstacles have you had when solving problems?
  
6. How have you overcome these obstacles when solving problems? Why or why not?
  
7. Would you recommend any of these strategies to another student to use? Why or why not?

## **APPENDIX G: STUDENT ATTITUDES POST STUDY FROM JOURNALS**

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1 Attitude to me is the way you act around people. My math attitude is if I don't get it I study and I ask my sister to review me by asking questions. If you don't you will get frustrated and you will have a hard time answering the questions. I have a higher confidence, I feel like I can answer any question that has to do with problem solving.

12 Pg

Problem Solving is getting harder and harder. I don't get ratios and I am not good at fractions. I like problem solving in a group. I like it that way because more brains are better than one. Also I am not very good at math so working with others helps a lot.

I have learned about, drawing pictures, looking for patterns, guessing and checking and making lists and charts. Problem solving is hard I don't get half of it.

① To me my attitude is fair. I don't show off in math and I don't talk back. But I do not like math it is my least favorite subject and I don't think I will ever need math.

② If you have a good attitude in math, it motivates you to do better. If you have a bad attitude, you start to ignore it and you get bad grades.

③ Well at first I didn't like math at all. It was super hard for me. Now math is still hard but now I know about problem solving strategies and that makes it easier.

# Journal

13

1. Attitude is the way you act. Math attitude is the way you act towards math (I think).

2. It is important to have a good attitude about math because it could change your grades in math.

3. Learning problem solving strategies have made me like math more and make it easier to learn math.

(13)

1. My attitude is confident sometimes. Other times I feel like I can't do it. But mostly I'm confident.

2. Because it makes you feel better. Also you get better grades. I get better grades because of this.



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