USING A GRAPHIC ORGANIZER TO PROMOTE PROBLEM-SOLVING SKILLS IN A SECONDARY MATHEMATICS CLASSROOM

By

CASSIDY FULLER

A THESIS PRESENTED TO THE GRADUATE SCHOOL OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN EDUCATION

UNIVERSITY OF FLORIDA

2009
To my mom who has always stood by me and motivated me to be a better student and person.
ACKNOWLEDGMENTS

I would like to thank Dr. Stephen Pape for his guidance and motivation and Dr. Tim Jacobbe for his support and understanding. I would also like to thank Karina Hensberry for helping me stay focused and my brother for his encouragement. Last but certainly not least, I would like to thank my mother for knowing all the right words to say and keeping me grounded.
# TABLE OF CONTENTS

ACKNOWLEDGMENTS .................................................................................................................. 4

LIST OF TABLES .......................................................................................................................... 7

LIST OF FIGURES ....................................................................................................................... 8

ABSTRACT ..................................................................................................................................... 9

CHAPTER

1 INTRODUCTION ...................................................................................................................... 10

2 REVIEW OF LITERATURE ....................................................................................................... 12

   How Students Learn ................................................................................................................ 12
   Learning Mathematics ........................................................................................................... 12
   Experts versus Novices ......................................................................................................... 16
   Problem Solving .................................................................................................................... 19
   Graphic Organizers ............................................................................................................... 30
      Graphic Organizers in Reading ......................................................................................... 31
      Graphic Organizers, Mathematics, and Reading .............................................................. 33
   Summary of Literature .......................................................................................................... 38

3 METHODS AND PROCEDURES .............................................................................................. 40

   Participants ............................................................................................................................ 40
   Instrumentation ..................................................................................................................... 40
   Procedure and Data Collection ............................................................................................ 42
   Data Analysis ......................................................................................................................... 43

4 RESULTS .................................................................................................................................. 46

   Research Question 1 ............................................................................................................... 46
   Research Question 2 .............................................................................................................. 47
   Student Work ......................................................................................................................... 48
   Student Attitudes .................................................................................................................... 58
   Summary of Findings ............................................................................................................ 60

5 CONCLUSIONS ....................................................................................................................... 63

   Discussion ............................................................................................................................... 63
   Limitations .............................................................................................................................. 64
   Implications for Future Research ......................................................................................... 66
APPENDIX

A  PRETEST .................................................................................................................. 67
B  POSTTEST .................................................................................................................. 68
C  GRAPHIC ORGANIZER .................................................................................................. 70
D  INTERVIEW PROTOCOL ............................................................................................... 71
E  PRETEST AND POSTTEST INTERVIEW RESPONSES .............................................. 72

LIST OF REFERENCES ...................................................................................................... 75

BIOGRAPHICAL SKETCH ................................................................................................. 79
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-1</td>
<td>Problem-solving processes rubric used when coding students’ written responses</td>
<td>45</td>
</tr>
<tr>
<td>4-1</td>
<td>Pretest Interview, Pretest, and Posttest Problem-Solving Processes Scores and the Number of Students that Achieved that Score</td>
<td>48</td>
</tr>
<tr>
<td>4-2</td>
<td>Comparing problem-solving success and process score change from pre to post test.</td>
<td>51</td>
</tr>
</tbody>
</table>
TABLE OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-1</td>
<td>Participant 5’s pretest.</td>
<td>52</td>
</tr>
<tr>
<td>4-2</td>
<td>Problem 1 from participant 5’s posttest.</td>
<td>53</td>
</tr>
<tr>
<td>4-3</td>
<td>Problem 2 from participant 5’s posttest.</td>
<td>54</td>
</tr>
<tr>
<td>4-4</td>
<td>Participant 17’s pretest problem 1.</td>
<td>55</td>
</tr>
<tr>
<td>4-5</td>
<td>Participant 17’s posttest problem 2.</td>
<td>56</td>
</tr>
<tr>
<td>4-6</td>
<td>Participant 20’s pretest problem 1.</td>
<td>57</td>
</tr>
<tr>
<td>4-7</td>
<td>Participant 20’s posttest problem 2.</td>
<td>58</td>
</tr>
</tbody>
</table>
Abstract of Thesis Presented to the Graduate School of the University of Florida in Partial Fulfillment of the Requirements for the Master of Arts in Education

USING A GRAPHIC ORGANIZER TO PROMOTE PROBLEM-SOLVING SKILLS IN A SECONDARY MATHEMATICS CLASSROOM

By

Cassidy Fuller

December 2009

Chair: Stephen Pape
Major: Mathematics Education

A problem is a task “for which the student does not have a readily accessible mathematical means by which to achieve that resolution” (Schoenfeld, 1989, p. 88). By solving problems and facing challenges, students can start to gain expert characteristics, like metacognitive awareness, and reduce their novice mistakes. Increasing a student’s problem-solving strategies can help reduce novice mistakes. Like problem solving, graphic organizers have been used to increase understanding of concepts and bridge the gap between prior knowledge and incoming information. In this study a graphic organizer was designed using Polya’s (1985) problem-solving phases and Schoenfeld’s (1987) questioning techniques to promote problem-solving success and increase problem-solving processes in student solutions. Students’ success and process scores increased significantly by using a graphic organizer. During interviews, students reported that the graphic organizer made them slow down when solving the problems, causing them to avoid minor mistakes and errors. It was concluded that a graphic organizer can be used beyond text comprehension in reading and can promote problem-solving skills and increase problem-solving success in a secondary mathematics classroom.
CHAPTER 1
INTRODUCTION

Mathematics has a reputation of being one of the less popular subjects in school. Many students give up and do not feel like they are able to succeed at mathematics once they have had a bad experience. One explanation for this could be the way mathematics is currently taught in schools. The National Council of Teachers of Mathematics' (NCTM, 2000) Principles and Standards for School Mathematics states, “Students’ understanding of mathematics, their ability to use it to solve problems, and their confidence in, and disposition toward, mathematics are shaped by the teaching they encounter in school” (p. 16-17). Students tend to see problems as having only one right answer and only one right way to find that answer. This is a common misconception and a cause of mathematics anxiety in students (Schoenfeld, 1987).

Problems by their very nature cause confusion and doubt (Lambdin, 2003). For this reason alone, students hesitate to attempt to find a solution. Problem-solving methods and strategies give students the tools to feel confident when trying unfamiliar problems. This does not mean that students will not have difficulty; problem solving in a mathematics classroom is often a situation where students struggle to find a solution (Hiebert, 2003). NCTM’s (1980) An Agenda for Action, said that problem solving fosters conceptual understanding and learning mathematics with such an understanding increases students’ ability to transfer knowledge (National Research Council (NRC), 2000). It has nearly been thirty years since this call to action and problem solving is still not found in most classrooms. Students cannot afford the implementation of problem solving to be delayed any longer.
Word problems are often included in problem solving activities. Students’ anxiety increases toward mathematics when reading comprehension within a problem is also required (Brennan & Dunlap, 1985). Students have difficulty decoding mathematical word problems. Decoding involves translating between words, symbols, numbers, letters, and graphics. In this research study, the use of a graphic organizer was used to help bridge the gap between mathematics and reading within word problems was explored. Graphic organizers increase understanding and require students to break down a problem into manageable pieces and slow down the problem-solving process (Braselton & Decker, 1994). Furthermore, graphic organizers may support problem-solving techniques and students’ abilities to think through the individual steps of a problem as suggested by Polya (1985).

This study examines the impact of a graphic organizer on students’ problem-solving processes and success on word problems. The graphic organizer created for this study uses Polya’s (1985) and Schoenfeld’s (1987) problem-solving method and questions that have been shown to help improve students’ mathematical thinking and understanding. In this study, a pretest and posttest were created to test the students’ abilities to problem solve before and after being introduced to the graphic organizer. The researcher investigated how the problem-solving graphic organizer affected student achievement in a high school mathematics classroom and if the students’ were able to break down the problem and devise a solution more clearly when using the graphic organizer. The research questions for this study were:

1. How does using a graphic organizer that includes problem-solving methods influence student achievement on word problems?

2. How will the use of the researcher’s graphic organizer influence students’ use of Polya’s four stages of problem solving?
CHAPTER 2
REVIEW OF LITERATURE

How Students Learn

It is important for educators to understand how students learn in order to effectively teach them. It is imperative that students are developing a conceptual understanding of the content instead of memorizing and reiterating information on homework assignments, exams, and other assignments. In order to learn effectively, students need to find a balance between conceptual understanding and procedural knowledge.

Learning Mathematics

Mathematics is one of the few content areas in which it is socially acceptable to admit failure. Many students have a negative outlook toward mathematics because they feel that they are unable to succeed and cannot improve their mathematics skills. Students’ mathematical confidence can change and certain teaching strategies can foster this change. The National Research Council’s (NRC, 2005) *How Students Learn* focuses on three well-established principles of learning and points out that mathematics is rarely taught in a way that makes use of these principles.

Instead of connecting with, building on, and refining the mathematical understandings, intuitions, and resourcefulness that students bring to the classroom (Principle 1), mathematics instruction often overrides students’ reasoning process, replacing them with a set of rules and procedures that disconnects problem solving from meaning making. Instead of organizing the skills and competences required to do mathematics fluently around a set of core mathematical concepts (Principle 2), those skills and competencies are often themselves the center, and sometimes the whole, of instruction. And precisely because the acquisition of procedural knowledge is often divorced from meaning making, students do not use metacognitive strategies (Principle 3) when they engage in solving mathematics problems (p. 217).
In order to learn mathematics successfully, a student needs to have mathematical proficiency. Mathematical proficiency has five components, or strands:

- **conceptual understanding**—comprehension of mathematical concepts, operations, and relations
- **procedural fluency**—skill in carrying out procedures flexibly, accurately, efficiently, and appropriately
- **strategic competence**—ability to formulate, represent, and solve mathematical problems
- **adaptive reasoning**—capacity for logical thought, reflection, explanation, and justification
- **productive disposition**—habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one’s own efficacy” (NCR, 2001, p. 116).

The five strands are interdependent and interwoven. In order to have success within mathematics a student needs to possess and use all five.

Learning mathematics needs to be fixed in an understanding of the nature of a problem and on a student’s own reasoning and strategy development so that the student feels personally involved in the problem. If it is learned in any other way, solving problems will depend on procedural fluency and the ability to recall memorized rules and facts (NRC, 2005) without integrating the other four strands. Learning that is embedded in a student’s understanding of a problem or concept increases the likelihood of transfer. Transfer of knowledge is defined as “the ability to extend what has been learned in one context to new contexts” (NRC, 2000, p. 51). Teachers hope that students will be able to transfer their learning beyond the classroom and apply their strategic competence to a variety of problems (NCR, 2001). Knowledge transfer
shouldn’t stop after the knowledge has transferred from one problem to the next and from one school year to another, it should also continue between school and home and from school to the work place (NRC, 2000). This type of transfer will increase the amount of prior knowledge a student has and therefore make it easy for them to solve problems when faced with unknown situations in and outside of the classroom.

“All learning involves transfer from previous experience” (NRC, 2000, p. 68).

Principle 1 focuses on building students’ prior knowledge and engaging them in the classroom so that students will start to see mathematics as more than just procedures and computation. Building on students’ prior knowledge helps increase engagement in the classroom and can also act as a source of transfer. With more prior knowledge comes the ability to see multiple entry points into a problem. Problems that have multiple strategies can engage more students in the classroom by making each student feel like their strategy has meaning and value in the classroom. When students believe that several correct methods exist for a given problem, their eagerness to develop strategies for problem solving will increase (NRC, 2005).

Principle 2 focuses on how equally important it is for students to understand and see the link between procedural knowledge and conceptual understanding. When learning, students build on their previous knowledge and have to condense this knowledge in order to organize new concepts and procedures. This process creates networks of understanding that are organized into paths that begin with an informal concrete understanding of a concept that is soon condensed into a more abstract idea (NRC, 2005). When students are engaged in a learning activity, they must connect their “informal knowledge and experience to mathematical abstraction” (NRC, 2001, p. 9).
When students represent their solution strategies in a more general way, they increase the probability of positive transfer and decrease the chance of a previous strategy being used inappropriately (NRC, 2000).

Transfer can be improved by students becoming more aware of themselves as learners. Metacognitive approaches to instruction increase the degree to which transfer occurs without the use of explicit prompting (NRC, 2000). Principle 3 highlights how influential students’ previous experiences can be when solving mathematical problems. When students are aware of how they monitor themselves while solving a problem and reflect on their solution strategies, they will be more effective as they approach unfamiliar problems. Self-monitoring involves a student using adaptive reasoning to examine if their explanation of the answer is correct and valid. This can include going back and rechecking each of the steps used to solve the problem. Other examples of self-monitoring include drawing a picture to help clarify understanding of known and unknown information and self-questioning to ensure the strategy will likely lead to a correct solution. Another tool that helps students learn is “debugging” a wrong solution. “Debugging” involves realizing where the error occurred, why it is an error, and how it is able to be corrected (NRC, 2005). After these self-monitoring techniques are learned and used, a knowledge base is formed that can be accessed and built upon when solving new problems. Being metacognitively aware when solving a problem is a difficult ability to learn but it can change the way students solve problems.

Integrating metacognitive instruction and emphasizing the importance of understanding all aspects of the solution strategy of a problem, enhances student achievement and the ability to learn independently (NRC, 2000). Kramarski, Mevarech,
and Arami (2002) state that a major element of metacognitive instruction is to train students to reason mathematically by creating and answering the following questions and ideas:

a) comprehending the problem (e.g., “What is the problem all about?”);

b) constructing connections between previous and new knowledge (e.g., “What are the similarities/differences between the problem at hand and the problems you have solved in the past? and why?”);

c) using strategies appropriate for solving the problem (e.g., “What are the strategies/tactics/principles appropriate for solving the problem and why?”; and in some studies also

d) reflecting on the processes and the solution (e.g., “What did I do wrong here?”; “Does the solution make sense?”). (p. 228)

The metacognitive instructional tools of self-monitoring and “debugging” are just a few of the ways to help students become better problem solvers. Being able to recognize problem schemas combined with metacognitive awareness will elevate all students’ understanding. Experts in mathematics and other content areas use problem schemas to attempt new and unfamiliar problems. By introducing students to strategies and tools that experts use when problem solving, like recognizing schemas, they have an opportunity to internalize these expert traits and reduce their novice mistakes.

**Experts versus Novices**

Understanding the thought process and problem-solving skills that an expert uses can help educators instill expert characteristics into their novice students. Educators do not expect their students to be experts in any content area but examining what it means to be an expert on a subject allows teachers to see what successful learning looks like (NRC, 2000). Knowing this, teachers can use strategies that increase successful learning.
Novices work on the basis of surface features of a problem while experts are able to make inferences and identify principles that go deeper than surface structures (Langan-Fox, Albert, & Waycott, 2000). There is a limit to the amount of information that people are able to hold in their short-term memory. Short-term memory can be enhanced by chunking information together that has a familiar pattern (NRC, 2000). According to Chi, Feltovich, and Glaser (1981), “knowing more” means having more conceptual chunks in memory, more relations or features defining each chunk, more interrelations among the chunks, and efficient methods for retrieving related chunks and procedures for applying these informational units in problem-solving contexts. Experts use this technique and organize knowledge in terms of schemas (Langan-Fox et al., 2000). Marshall (1995) defines schemas as vehicles of memory, allowing organization of an individual’s similar experiences in such a way that the individual

- can easily recognize additional experiences that are also similar, discriminating between these and ones that are dissimilar;
- can access a generic framework that contains the essential elements of all of these similar experiences, including verbal and nonverbal components;
- can draw inferences, make estimates, create goals, and develop plans using the framework; and
- can utilize skills, procedures, or rules, as needed when faced with a problem for which this particular framework is relevant (p.39).

These schemas invoke sensitivity to patterns of meaningful information that are not available to novices and help guide how problems are represented and understood (NRC, 2000).

Experts’ knowledge is “conditionalized” to include an understanding of the contexts in which the information will be useful. Most traditional forms of curricula and
instruction do not aid students in forming conditionalized knowledge. Textbooks often give students laws of mathematics but do not include how they can be useful in solving problems. One way for students to learn when, where, and why to use the knowledge they are learning is through solving word problems that require students to use appropriate concepts. This will help them learn about conditions of applicability (NRC, 2000) and strengthen their adaptive reasoning. An important aspect of applicability is recognizing problem types and being able to retrieve the existing schemas related to that type of problem. Novice students can have the necessary knowledge but not the ability to understand when and how to apply that knowledge to unfamiliar problems.

During the process of learning, becoming fluent at recognizing types of problems is necessary. Fluent retrieval does not always mean performing faster on a task. Most experts spend more time trying to understand problems before jumping into working the problem out. As mentioned earlier, the amount of information a person can remember and process in a short period of time is limited, therefore fluency in certain aspects of a task can ease the processing of new information included in that task (NRC, 2000).

It is critical for students to be able to metacognitively monitor their knowledge while learning. If a student is able to evaluate their solution strategy and decide that they do not understand or are lacking information, they can save themselves from straying away from the goal. Being able to monitor the current level of understanding and decide when it is not adequate will aid students in taking the necessary steps to remedy the situation and not limit their current level of knowledge (NRC, 2000).

The characteristics of expertise need to be considered as parts of a whole. They are interconnected and when analyzed as a whole, can help teachers understand what
it means to be a successful learner and part of being a successful learner is being an effective problem solver. Problem solving is a tool that every expert possesses and can utilize in different and unknown situations. Equipping students with the tools to be an effective problem solver will increase their expert traits and decrease their novice mistakes when solving problems.

**Problem Solving**

A mathematical problem for any student is defined by Schoenfeld (1989) as "a task (a) in which the student is interested and engaged and for which he wishes to obtain a resolution, and (b) for which the student does not have a readily accessible mathematical means by which to achieve that resolution" (p. 88). A task that relies on routines and memorized algorithms should be referred to as an exercise. All three principles from the NRC (2005) emphasize the importance of challenging students to increase their learning, therefore using problems instead of exercises can increase student learning.

Problem solving has been defined in many different ways. For the purpose of this study, problem solving will be defined as "a form of inquiry learning where existing knowledge is applied to a new or unfamiliar situation in order to gain new knowledge" (Hammouri, 2003, p. 571) where inquiry learning is based on student’s questions. In *An Agenda for Action*, the importance of problem solving was emphasized by the National Council of Teachers of Mathematics (NCTM, 1980). NCTM (1980) raised awareness on how vital problem solving is in the classroom and the need to make problem solving the focal point of school mathematics. When problem solving is implemented in the classroom, students’ focus shifts from memorizing mathematical facts and procedures to developing a conceptual understanding of the mathematical concepts (Lesh &
Zawojewski, 2007; NCTM, 2000; Schoenfeld, 1987). This fosters an environment that focuses on learning for understanding rather than just rote exercises (NRC, 2005). Obtaining a connection between procedural and conceptual knowledge increases students’ understanding and problem solving is a vehicle that helps create this connection. Problem solving also incorporates the use of a student’s adaptive reasoning when determining whether the procedure used was appropriate and strategic competence when the solution strategy is monitored for effectiveness (NCR, 2001).

Before NCTM stated that the curriculum needed to be reformed, George Polya introduced the term “modern heuristic” to describe the art of problem solving (Schoenfeld, 2007). Heuristic is an adjective for experienced-based techniques that help promote problem solving and learning. Heuristic methods, or heuristics, are used to arrive at a solution that is close to the best possible solution. The method of trial and error can be seen as a common heuristic. Polya (1954) compared learning mathematics to the discovery of mathematics. Instead of teachers giving a clear cut solution to the students, they need to see all additional steps and work that goes into solving a problem. Polya emphasized that students’ experience with mathematics have to be consistent with the way mathematics is done. This process includes being given a problem and going through a process of trial and error until an appropriate solution strategy is found.

Polya’s (1985) heuristic for problem solving includes four phases that students must go through in order to effectively solve a problem: (1) understanding the problem; (2) devising a plan; (3) carrying out the plan; and (4) looking back (p. xvi-xvii). Understanding the problem emphasizes that students need to fully understand the given
information and goal of the problem. Without fully comprehending these characteristics of the problem, students may choose inappropriate solution strategies (Schoenfeld, 1987) or feel helpless and unable to solve the problem. Polya (1985) lists a few questions a problem solver should ask at this phase, “What is the unknown? What are the data? What is the condition?” (p. xvi).

Finding the connection between what is given and what is being asked in the problem is important in phase two, devising a plan. Polya (1985) suggests thinking of similar problems to help aid the problem solver in finding the connection and when the connection is found, a plan should then be constructed before attempting to solve the problem.

Carrying out the plan is a phase that exists in most students’ solution strategies but it is important to understanding that carrying out a plan involves more than doing computational procedures. The problem solver needs to check each step and question if the plan that was chosen is the best for that problem (Polya, 1985). Checking each step ensures that there are no errors and allows for constant “debugging” (NRC, 2005). Questioning the plan and deciding if it was the best choice may include attempting different strategies and periodically going back to devise a new plan. If problem solvers do not include this process in their solution strategies they can end up on a wild mathematical goose chase that wastes lots of valuable time (Schoenfeld, 1987).

Reflecting upon and examining the solution is the basis for phase four, looking back. This is one of the most neglected steps in Polya’s (1985) problem-solving method yet the most important. When Polya discusses the importance of the looking back phase he says, “by looking back at the completed solution, by reconsidering and
reexamining the result and the path that led to it, they could consolidate their knowledge and develop their ability to solve problems” (p. 14-15). Looking back at the problem also opens up an opportunity to improve and stimulate students’ creative thinking skills (Krulik & Rudnic, 1994).

These four phases should be used to help students “think about, reflect on, and interpret problem situations” (Lesh & Zawojewski, 2007, p. 768) rather than a step-by-step guide when a student is stuck while solving a problem. Engaging in all four steps will improve understanding and benefit students' problem-solving skills (Polya, 1985) and increase their mathematical proficiency.

Having students implement Polya’s problem-solving process can decrease instances of carelessness and misunderstandings (Jacobbe, 2008). Jacobbe gave 29 students in a mathematics education course for elementary school teachers the following problem:

Write an equation to represent the relationship between the number of professors and the number of students.

There are six times as many students as there are professors at this university. Use S for the number of students and P for the number of professors. (p. 391)

Seventy-nine percent of the students answered incorrectly. During the following two months, the students were shown Polya’s problem-solving process and were given numerous problems to exercise the method with an emphasis on looking back at the answer and checking for reasonableness of the solution. After two months had passed, a second problem was given to the students:

Write an equation using the variables C and U to represent the following statements:
There are eight times as many people in China as there are in the United States, use C to represent the number of people in China and U to represent the number of people in the United States (p. 391).

During the two month period between the first and second problem, the students continued learning about elementary school mathematics methods and the initial problem was never discussed. Eighty six percent of students answered the second question correctly when using Polya’s four step process. The results showed that having students look back at the solution process would help students reflect on the solution and also “debug” their solution of any errors.

Polya’s problem-solving method requires students to reflect on their solutions and the strategies used to arrive at those solutions. This process supports the development of students’ metacognitive skills and adaptive reasoning. Like problem solving, metacognition was a big buzzword in the 1980s. To clear up some of the confusion of the term, Schoenfeld (1987) describes metacognition as “three related but distinct categories of intellectual behavior:

1. Your knowledge about your own thought process. How accurate are you in describing your own thinking?

2. Control, or self-regulation. How well do you keep track of what you’re doing when (for example) you’re solving problems, and how well (if at all) do you use the input from those observations to guide your problem solving actions?

3. Beliefs and institutions. What ideas about mathematics do you bring to your work in mathematics, and how does that shape the way that you do mathematics?” (p. 190).

Schoenfeld’s different aspects of self-regulation resemble Polya’s problem-solving method. Schoenfeld (1987) relates self-regulation to management. The different aspects of management include “(a) making sure that you understand what a problem is all about before you hastily attempt a solution; (b) planning; (c) monitoring, or keeping
track of how well things are going during a solution; and (d) allocating resources, or
deciding what to do, and for how long, as you work on the problem” (p. 190). In his own
problem-solving courses, Schoenfeld (1987) uses three questions to probe students
while they engage in problem solving: What (exactly) are you doing? (Can you describe
it precisely?) Why are you doing it? (How does it fit into the solution?) How does it help
you? (What will you do with the outcome when you obtain it?) (p. 98). These questions
force students to monitor their strategies and make sure they are still answering the
question that was originally posed.

To describe how important it is to regulate oneself, Schoenfeld (1987) compared
novices (students) and an expert (a mathematician) while they solved a problem. The
students were given a problem to do in twenty minutes and most of them spent the
entire time on a “wild goose chase” (p. 193). They read the problem and then
proceeded to explore one strategy the entire time and never stopped to ask themselves
if they were going in the right direction or if they should try a different strategy. A
mathematician, whose focus was not on Geometry, was given a geometry proof to do in
twenty minutes. He spent the majority of his time thinking about what to do rather than
pursuing a particular solution strategy. When he did try a solution strategy he would
evaluate if he felt that it was going in the right direction and if he was not he would go
back and analyze the problem again. In this situation, the students actually had a
greater advantage when it comes to having knowledge about the presented problem
because their problem relied heavily on their recent prior knowledge but yet it was the
mathematician that successfully solved the problem. This was attributed to the
mathematician’s self-regulation while solving the problem which is a characteristic of an efficient problem solver.

Cognitive and metacognitive behaviors are important when problem solving but the role of each behavior during the problem-solving process can become confusing. Generally, metacognition involves choosing, planning, and monitoring what is to be done and cognition is more involved in the processing of information. Artzt and Armour-Thomas (1992) examine the two behaviors in a study involving seventh-grade students. In order to code the observed behaviors, Artzt and Armour-Thomas created a framework for the protocol analysis that would distinguish between different metacognitive and cognitive episodes of problem solving observed during the group work. The episodes were based on a synthesis of the problem-solving steps identified by Polya (1985) and Schoenfeld (1987). Although Schoenfeld’s framework was used as the main starting point, the episodes were altered to fit the needs of the study. During the coding process each of the eight problem-solving episodes (read, understand, analyze, explore, plan, implement, verify, watch and listen) was categorized as cognitive or metacognitive even though it was understood that the two behaviors can coexist during an episode. But for the purpose of the study, the behavior that was most predominate was used to code that episode.

The episodes that had cognitive and metacognitive as the predominate behaviors were explore, implement, and verify. Understand, analyze, and plan had more metacognitive behaviors. The read episodes were mostly cognitive, and the watch and listen episode was not assigned a cognitive level.
Although the students were working in groups, their cognitive levels were coded individually. Of all the groups, 171 behaviors were coded as metacognitive and the episodes that the behavior appeared the most in were exploring and understanding episodes. Interestingly, the only group that did not solve the problem had the lowest percentage of metacognitive behaviors and the highest percentage of cognitive behaviors. This shows a correlation between the use of metacognitive strategies and student achievement.

Similarly, 159 behaviors were coded as cognitive and 96 were in the exploring category and 38 were in the reading category. All of the episodes occurred intermittently throughout the group work. Therefore, there is no step-by-step process of solving a problem, each step has to be revisited and reevaluated through the solution strategy. Exploring (cognitive and metacognitive together) was the behavior that was seen most in the group work. The exploratory phase led the way for the creation of plans, implementing of plans, analysis, and back to more exploration and implementation episodes. This process is similar to the way the expert mathematician solved the unfamiliar problem in Schoenfeld’s (1987) observations and plays an important role in successful problem solving. Polya’s (1985) problem-solving phases occur in a similar way. Each phase can be revisited and reevaluated to better understand the problem, strategy, and solution. This study also shows that there is a relationship between the use of cognitive and metacognitive behaviors that is necessary for student’s problem-solving efforts to result in a solution in group work but this conclusion can be expanded to individual student work since the analysis was done on an individual basis.
To further investigate the need for metacognitive behaviors to solve a problem, Lucangeli and Cornoldi (1997) developed a research study that was aimed at seeing what type of knowledge and awareness was activated in students when confronted with mathematical tasks. The Emmepiu’ mathematics test was administered and accompanying it was a researcher constructed metacognitive test. In addition to finding the answer to the problems, the students were asked questions concerning their prediction, planning, monitoring, and evaluation skills. The predictions were considered positive if the outcome matched the prediction. For planning, the students were asked to state what operations they were going to use to solve the problem and the specific order. For monitoring, the students picked the strategies to perform the chosen operations in the planning phase and to keep track of the execution of these strategies. Evaluation mirrored the prediction operation in that they were to state if they thought they correctly solved the problem. When the test was administered, students were asked to answer the prediction and planning items before beginning to solve the problem. During the process of solving the problem, the students were asked to describe the strategies used to monitor the performance. Once they were finished they evaluated their solution.

The use of metacognitive processes positively related to mathematical achievement. This relationship was stronger for tasks that were less automated (e.g., problem solving and geometrical tasks). In both grade levels the problem solving and geometrical tasks required students to use metacognitive abilities while predicting, planning, monitoring, and evaluating their solution. Therefore when students perform automatised arithmetic operations, they are not exercising as much metacognitive skills
as they do when they are problem solving. The students have performed the procedural operations before and do not have to think about their solution strategy as much. This is because they are familiar with the steps that are necessary for the task, unlike the problems that required the students to problem solve in order to reach a solution.

Although problem solving does not consist of only word problems, word problems are often used in classrooms to facilitate problem-solving skills. Teong (2003) examined the influence of explicit metacognitive training on forty 11 to 12-year-old low achieving students' problem-solving success. Teong implemented a problem-solving method that is similar to Polya's (1985) and Schoenfeld’s (1987) methods. The CRIME strategy was used to facilitate problem-solving skills where CRIME stood for Careful reading, Recall possible strategies, Implement possible strategies, Monitor, and Evaluation. The study consisted of a two-phase design, an experimental design and a case study design. In the experimental design students completed a word-problem test and in the case study design students did problems while prompted to do a think aloud exercise that were video-recorded. The children were split up into two groups: one group had explicit metacognitive training using the CRIME acronym and the other group solved problems without the CRIME strategy. The students were given the two evaluations following an equal number of instructional sessions. The results from the individual test showed that the children in the CRIME group outperformed those that did not use it on word-problems. It was also shown that “the ability to know when and how to use metacognitive behaviours when they are needed are important determinants to successful word-problem solving” (p.53).
Word problems cause difficulty for students because they require mathematical problem-solving skills and reading comprehension. Pape (2004) aimed to develop a description of the behaviors that middle school students exhibit while they solve word problems. Students participated in a Think Aloud Stimulus that consisted of eight word problems while the researcher probed students to explain their solution processes aloud. The data was coded according to problem-solving behavior (direct translation approach and meaningful approach), success, and type of error.

Students who “recorded the given information, exhibited greater use of the context, and provided explanations and justifications for their mathematical steps solved more problems, committed fewer errors of understanding, and preserved the elements and structure of the problems better when recalling the problems” (p. 208). Therefore students who engaged in strategies to understand the problem, Polya’s (1985) first phase, were able to translate the text of the word problem into mathematical terminology and use their strategic competence to arrive at a solution. Successful students in the study showed evidence that they translated and organized the given information from the problem by rewriting it on the paper. They also supplied an explanation for their mathematical steps and justified their solutions. Hence, students who engaged in all four of Polya’s (1985) phases were more successful.

All experts are efficient problem solvers. The ability to be able to approach problems in a variety of ways, while accessing prior knowledge and schemas is not easily learned by novices but can be acquired over time. A potential method to help students make the transition between being a novice and becoming an expert is using graphic organizers. Graphic organizers can catalyze the process of gaining qualities of
an expert (Langan-Fox et al., 2000) and increase metacognitive behaviors which are shown to influence student achievement (Artzt & Armour-Thomas, 1992; Lucangeli & Cornoldi, 1997). This could be attributed to the visuospatial arrangement of words or statements that connect key conceptual relationships in graphic organizers (Horton, Lovitt, & Bergerud, 1990). This arrangement helps novices form a schema similar to those of experts.

**Graphic Organizers**

There have been a variety of terms used to describe the graphic display of information including graphic organizers, structured overviews, concept maps, flow charts, and tree diagrams. Much research was done in the early 1960s by Ausubel that focused on organizing prior knowledge so that new knowledge could easily be assimilated. Learning occurs when the cognitive structure can expand and strengthen while incorporating new information (Kim, Vaughn, Wanzek, & Wei, 2004). Advanced organizers facilitate knowledge acquisition from prose and provide a framework for relating existing knowledge to new material (Ausubel & Fitzgerald, 1961). Ausubel's research concluded that advanced organizers have the potential to link prereading information with a reader's existing schemata (Ausubel, 1960).

Ausubel believed that advanced organizers were effective in enhancing reading comprehension. Although his work seemed promising, it was criticized by many for lacking the proper experimental controls (e.g., Frase, 1975; McEneany, 1990). For example, McEneany (1990) found the assumption of unfamiliarity with the to-be-learned material was unfulfilled and seeing that acquiring knowledge of new materials was one of the preconditions of Ausubel's research. This raised a question for many. Although this speculation loomed in researchers' minds, further studies revealed that advanced
organizers were associated with increasing learning and retention (Corkhill, 1992; Luiten, Ames, & Ackerson, 1980; Stone, 1983).

The shift in the terminology depended on the current use of the organizer. Advanced organizer was one of the first terms used for graphic representations of information but others developed over time. Merkley and Jefferies (2001) describe the terminology transformations as the use shifted from just prereading prose passages in Ausubel’s research to being an outline format, the name changed from advanced organizer to structured overview. Once structured overviews were adapted to being used for prereading, during-reading, and postreading tasks the terminology changed again to graphic organizers. Novak and Gowin (1984) adapted graphic organizers to develop schemas, or concept mapping, as a metacognitive tool for learning that would emphasize the importance of labeling links between concepts. For the purpose of this study, a graphic organizer is defined as a visual representation of information that guides the user and enables them to better understand the given problem.

**Graphic Organizers in Reading**

Most of the research on graphic organizers is in the area of reading and reading comprehension. All of Ausubel’s research was based on using organizers for comparative and expository texts. Mayer (1984) examined reading as a process of storing and taking in information and believed that graphic organizers could be used to display connections among the incoming information.

In order to better understand the use of graphic organizers, Kim et al. (2004) did a synthesis of research that focused on graphic organizers and their effects on students’ reading comprehension. Most of their studies they examined were based on students with a learning disability (LD), who used graphic organizers to assist in learning from
expository text. The 21 studies that were chosen included a total of 848 students with LD and used one of four types of graphic organizers including semantic organizers, cognitive maps with a mnemonic, cognitive maps without a mnemonic, and framed outlines. Each organizer served the basic purpose of helping students comprehend reading passages. The treatments that used semantic organizers found that the students demonstrated significantly higher scores on research-developed comprehension measures than students in comparison groups. The students with LD slightly surpassed regularly developing students. The three treatments that used cognitive maps with a mnemonic outperformed those using conventional reading techniques on a reading comprehension test. The seven studies that used cognitive maps without a mnemonic were associated with higher comprehension scores than comparison conditions (i.e. typical reading instruction). The two studies that used framed outlines also showed positive effects on students’ reading comprehension. No significant differences across elementary to secondary grades were found when analyzing the effects of the graphic organizers on reading comprehension. Kim et al. (2004) concluded “the effects of graphic organizers on the reading comprehension of students with LD revealed overall beneficial outcomes across the studies” (p. 114).

The connection between the use of graphic organizers and reading was strong but researchers still wanted to know if the use of the graphic organizer extended beyond just comparative and expository texts. Horton, Lovitt, and Bergerud (2001) investigated the effectiveness of graphic organizer for content area classes at the secondary level. Three classes in middle school science, three in middle school social studies, and three in high school social studies participated. Eight students out of the combined nine
classes were considered to have a LD, and the high school social studies class contained nine remedial students. Two reading passages were chosen for the study. These passages came from the assigned textbook and were chosen by the researchers. The graphic organizers were created by the researchers for the two passages in a hierarchical format that is similar to an outline. The students were given an incomplete diagram with directions of how to complete the graphic organizer. The experiments included various ways of testing and comparing the effectiveness of students' self-study techniques and use of the graphic organizer. Self-study techniques included “making a diagram or outline, writing short sentences of main ideas, formulating and answering questions, defining key terms using the glossary, or any other self-study strategy as long as they worked independently, and attempted to produce a written product” (Horton, Lovitt, & Bergeurd, 2001, p.15). The experiments showed that the graphic organizers produced significantly higher performance than self-study techniques for students with a LD, remedial students, and regular education students.

Prior research supports a positive impact of graphic organizers in the classroom when the content is related to reading a text. Graphic organizers were also shown to increase comprehension in other content areas such as science and social studies (Horton, Lovitt, & Bergerud, 2001; Kim et al., 2004). Although these studies include multiple content areas, the relationship between graphic organizers and mathematics was not addressed.

**Graphic Organizers, Mathematics, and Reading**

Reading and mathematics are content areas that are not mutually exclusive. Mathematics instruction often assumes that the learner has typical language skills (Ives
& Hoy, 2003). In addition, mathematics is one of the most difficult content areas to read. This is due to the number of concepts that exist per word, sentence, and paragraph in mathematics texts. Reading mathematics requires the reader to switch between different types of vocabulary and translate between words, symbols, letters, numbers, and graphics (Braselton & Decker, 1994). Maffei (1973) indicated that reading teachers were more successful at teaching students how to solve mathematical word problems than mathematics teachers because of the high level of reading that is involved. Textbooks used in the curriculum further complicate a student’s ability to read mathematics. The mathematics content is appropriate for grade level but the reading level of the text is often one to three years above the reader's level (Brennan & Dunlap, 1985). One way to close the gap between students’ reading level and mathematics achievement is the use of graphic organizers (Braselton & Decker, 1994).

In their action research project, Braselton and Decker (1994) designed a graphic organizer that included five steps: restating the question, deciding what information is necessary to solve the problem, planning the mathematics to perform, doing the mathematics, and asking oneself if the answer is reasonable. These five steps are very similar to Polya’s (1985) problem solving heuristic. When Braselton and Decker designed their graphic organizer they realized how important the layout and design were because the strength of the graphic organizer lies in its ability to help the learner construct the relationship between the information in the story problem and organize that information so it supports the learners’ acquisition of knowledge. They chose to use a rhombus shape organizer because it highlighted for the students that they all start with the same information and end with the same conclusion. The graphic organizer was
used with Braselton’s fifth grade class who had previously used the keyword search strategy to solve word problems. Braselton began by teaching her students how to read word problems as meaningful passages. Once she felt like the students understood the basics of problem solving, she introduced and modeled the graphic organizer for the students by solving a few example problems and performing think-aloud exercises with them. The think-aloud exercises involved vocalizing each step that the problem-solver goes through when trying to find the solution of the problem. Braselton soon progressed to using guided practice and eventually independent practice allowing the students to use the graphic organizer individually while solving problems.

After using the organizer for several days and having the opportunity to apply it to multiple problems, Braselton and Decker noticed that the students showed noticeable improvement in problem solving. The key seemed to be the systematic approach to analyzing the problems and providing a framework to act as an initial point when trying to solve a problem. The most effective aspect of the graphic organizer was the ability to slow the students down. It made them stop and evaluate the problem and look ahead to the solution strategy instead of rushing into it, similar to Polya’s (1985) heuristic. Braselton and Decker (1994) stated “by using strategies that integrated both language and mathematics skills we can increase students’ abilities to function as independent problem solvers” (p. 281). Graphic organizers can be used to support reading in mathematics and they can also be used to do more computational and procedural mathematical operations.

In higher-level secondary education it is difficult to avoid teaching procedural knowledge due to the content in the curriculum. There are numerous operations that
students are expected to be able to execute. Graphic organizers rely on visual/spatial reasoning and can easily be applied to higher-level mathematics. Most of the procedural knowledge that is embedded in mathematics relies heavily on the construction of patterns. Graphic organizers are a vehicle for recognizing and processing those patterns. In their review of approaches to teaching mathematics, Ives and Hoy (2003) show that a graphic organizer can be used to teach operations such as positive and negative integer exponents and solving systems of three linear equations with three unknowns. Using the graphic organizer, students are able to learn the conceptual foundation that lies beneath the procedural computations. Once students get comfortable with using this type of visual representation to relate concepts, they can begin to generalize it for themselves and apply it to other seemingly procedural processes (Ives & Hoy, 2003).

In order to support their previous findings, Ives (2007) investigated the effectiveness of using a graphic organizer to teach secondary students with LDs to solve systems of linear equations. A two-group comparison was used; the graphic organizer group consisted of 14 students where 10 had been diagnosed with a LD and the control group consisted of 16 students, 11 of which had a LD. The graphic organizer was a two by three array of rectangular cells with Roman numeral column headings. Typically, when solving a system, the student would work from one cell to another in a clockwise direction. The top row of the graphic organizer is used to combine equations so that unknowns can be eliminated until an equation that includes just one unknown is left.
Before students were allowed to see the graphic organizer they were given a prerequisite skills test including solving linear equations in one unknown and combining linear equations. Following the preassessment, the classroom teacher began a unit that taught students how to solve a system with multiple unknowns. The control group was taught without the use of the graphic organizer while the treatment group used the graphic organizer during instruction.

After the instructional unit was over, each group received a teacher-generated assessment that was used as an outcome variable to test for group differences in mean scores. They also received one version of a content skills test constructed by the researcher that tested their conceptual understanding of the procedural knowledge used to solve systems of linear equations with multiple unknowns. Between two and three weeks after the first content skills test, a second version was administered to both groups.

The conceptual portion of the content skills test showed that students in the treatment group had a stronger conceptual foundation for solving linear equations than the students in the control group on both content skills tests. Therefore the conceptual understanding that the treatment group demonstrated in the first test was carried over weeks later on the second content skills test. The retention of knowledge that these students showed is crucial when learning mathematics because of the scaffolded structure that it possess. Mathematical concepts build on top of each other. For example, in order to understand how to solve a system of linear equations, a student must be able to understand how to solve one step linear equations. Retaining prior
knowledge will help increase students’ ability to transfer their knowledge to new material and create a conceptual understanding of content. This conceptual understanding

**Summary of Literature**

Understanding how students learn is essential when trying to effectively teach. Blending procedural knowledge and conceptual understanding in the curricula will promote students to make more connections and allow for transfer between concepts and increase adaptive reasoning (NRC, 2005). Problem solving promotes conceptual understanding and strategic competence by encouraging students to explore concepts and ideas beyond equations and algorithms and giving them the tools to formulate, represent, and solve problems. An increase in conceptual understanding will aid in the students’ transfer of knowledge to other classes, home, and work (Lesh & Zawojewski, 2007; NCTM, 2000; Schoenfeld, 1987).

It is apparent that students retain knowledge better when it is scaffolded and builds onto their prior knowledge (NRC, 2000; 2005). Graphic organizers help build that bridge between new and incoming information (Mayer, 1984; Novak & Gowin, 1984) and support strategic competence. Graphic organizers cause the students to slow down and really think about the problem and try to relate it to similar problems they have seen (Braselton & Decker, 1994). This will lead to less errors and more meaningful solution strategies (Jacobbe, 2008). The metacognitive skills embedded in problem solving (Schoenfeld, 1987) and the use of graphic organizers (Langan-Fox et al., 2000) can help a novice exemplify expert qualities in a shorter period of time. The graphic organizer promotes students to reevaluate and revisit the problem-solving phases which is a process that experts undergo when problem solving (Artzt & Armour-Thomas, 1992; Schoenfeld, 1987). Although teachers do not expect their students to be experts at
mathematics, having these metacognitive and problem-solving skills will make them a better student in all content areas. The use of graphic organizers has been linked to an increase in reading comprehension in various content areas. The present study aimed to show a stronger connection between graphic organizers and mathematic problem solving. The goal of the study was to create a research-based graphic organizer that incorporated problem-solving methods in order to increase problem-solving success in a high school classroom.
CHAPTER 3
METHODS AND PROCEDURES

The study took place in an Algebra II honors high school classroom at a university developmental laboratory school. The school serves approximately 1,150 students in kindergarten through twelfth grade. Of the student body the demographics/ethnicity is comprised of 24% African-American, 51% Caucasian, 16% Hispanic, 3% Asian, and 5% multi-racial. The gender of the students is 48% female and 53% male (http://www.pky.ufl.edu/aboutPK/demographics.php).

Participants

The students in the Algebra II honors class consisted of eleven 11th graders, twelve 10th graders, and one 9th grader. Twelve of the students were male and 12 were female. All students were selected for the honors course based on performance during the previous school year. None of the students were known to have a LD. The participants were all under the age of 18 and parental consent was given by a parent or guardian to participate in the study. All 24 students consented to being a part of the whole class pre and post tests, and 8 students volunteered to participate in the individual interviews.

Instrumentation

Two data sources were used in the study: (1) pre and post tests and (2) individual interviews. The pre and post tests consisted of two word problems each selected from released items on state and international assessments: Florida Comprehensive Assessment Test (FCAT, 2005; FCAT, 2006), Program for International Student Assessment (PISA, 2006), and National Assessment of Educational Progress (NAEP, 2005). The pre and post test questions were similar in content and difficulty
level. The two FCAT questions had the MA.C.2.4.1 as the benchmark, a moderate difficulty level, and similarity as the content focus. Also, 17 percent of students answered each question correctly. The specific statistics on the PISA and NAEP questions were not available but each was reviewed by several mathematics educators who determined that they were similar in content and difficulty level. All of the questions were approved by the classroom teacher and deemed appropriate.

The first problem on the pretest was selected from the FCAT (2006) and involved using similar triangle properties to find the length of an unknown side. The second problem on the pretest was selected from NAEP (2005) and required the students to determine how many years it would take for a car’s value to depreciate to half the cost of its original value (see Appendix A).

The first problem on the posttest was selected from PISA (2006) and required the students to find the better deal when comparing two pizzas with different diameters and price. The second problem was selected from the FCAT (2005) and required the students to use the given information about the similar triangles to determine an unknown side (see Appendix B).

The intervention and posttest used a graphic organizer that was created by the researcher. The graphic organizer was displayed in a rhombus shape with the word problem situated in the middle of the rhombus. This shape of the graphic organizer was inspired by the graphic organizer used by Braselton and Decker (1994). The graphic organizer has four different steps in which the students engaged. These four steps reflect Polya’s (1985) four phases problem solving. The graphic organizer also contains Schoenfeld’s (1987) three questions that encourage the student to think deeper about
what they are looking for and what they are doing. The graphic organizer used in this study can be found in Appendix C.

The individual interviews were conducted with eight of the students. The students were asked a set of predetermined questions including: “What are your initial feelings when given a word problem?” and “How difficult did you find the given problems?” A full list of the prepared questions can be found in Appendix D. These questions were designed to give the researcher a better understanding of the students’ attitudes toward word problems and also their feelings about the problems specifically on the pre and post tests. In addition, students were asked to indicate their perception of the graphic organizer and whether they felt it helped them understand and solve the problems.

**Procedure and Data Collection**

The entire study took place over four 50-minute class periods. Before the four questions for the pre and post test were finalized, a pilot study was conducted to judge the difficulty level of the questions. Students in a comparable Algebra II honors class at the same school were given eight questions, and the questions that produced the most variability in answers were used for the pre and post tests. The pretest was given to the class. Students were encouraged to show all their work and record any thoughts they had while solving the problem. Following the pretest, 8 students were interviewed individually. During the audio taped semi-structured interviews, the students were asked to explain the steps they took to solve each problem. In addition to the preplanned interview questions, students were asked questions dependent upon their explanations.

The researcher presented the graphic organizer to the students during the class period following the pretest administration. The researcher had an informal and unscripted conversation with the class introducing the graphic organizer, explaining the
reasons it is useful, and how to use it. The four steps of Polya’s (1985) problem-solving method and Schoenfeld’s (1987) self-monitoring questions were presented and explained to the students. The students were told that the graphic organizer helps them slow down and examine each aspect of the problem before getting lost in a mathematical goose chase. The students were also told how the graphic organizer can decrease anxiety toward word problems and help them justify their reasoning and solution strategies. To help the students understand how to use the graphic organizer, the researcher did two think aloud examples with the class. During the think aloud examples, the researcher demonstrated to the students how one would think through a problem when using the graphic organizer, making sure to use each step of the problem-solving process. The students were allowed to ask questions about the graphic organizer and were also encouraged to help think through the problem with the researcher.

The students took the posttest the class period after the intervention. The questions were presented on the graphic organizer and the students were encouraged to use the graphic organizer to their advantage. Similar to the pretest, the same eight students were individually interviewed after the test. The same sets of questions were asked during the posttest interview as the pretest interviews, with the addition of the student perception questions.

**Data Analysis**

The students’ solutions were rated for accuracy and student success rates were compared. The students’ solution strategies and methods were also examined. The researcher coded each student’s solutions from the pre and post tests using a rubric (see Table 3-1) adapted from a rubric from Stenmark and Bush (2001, p.46). According
to Polya (1985), when solving mathematical problems effectively, the solver should go through four different stages: understanding the problem, devising a plan, carrying out the plan, and looking back. Each of these stages was broken down into two components. The researcher examined the students’ written responses to the problems and decided whether they achieved each component of the four different stages. If the student successfully demonstrated one of the characteristics of that stage he or she received a point toward their final overall score for that problem. Each problem had a possible score of 8 points, for a total of 16 points. The researcher then compared the final process score for the pre and post tests to see if there was an increase, decrease, or no change.

Although the students were instructed to show all their work on the pretest, the likelihood that they did is low. For this reason, the pretest individual interviewers were also coded using the rubric in Table 3-1. The researcher listened to the students’ description of their solution method and assigned points based on their verbal communication of their solution process. This score was then compared to the students’ posttest processes scores.
Table 3-1. Problem-solving processes rubric used when coding students’ written responses.

<table>
<thead>
<tr>
<th>Problem-Solving Processes Rubric</th>
<th>Subtotal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restating the Problem (Understanding the Problem)</td>
<td></td>
</tr>
<tr>
<td>▪ Student rephrased the problem (1)</td>
<td></td>
</tr>
<tr>
<td>▪ Student correctly identified the known and unknown information</td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>Devising a Plan</td>
<td></td>
</tr>
<tr>
<td>▪ Student selects an appropriate strategy (1)</td>
<td></td>
</tr>
<tr>
<td>▪ Student explains the plan (1)</td>
<td></td>
</tr>
<tr>
<td>Carrying out the Plan</td>
<td></td>
</tr>
<tr>
<td>▪ Student carries out given plan (1)</td>
<td></td>
</tr>
<tr>
<td>▪ Student finds the correct solution (1)</td>
<td></td>
</tr>
<tr>
<td>Looking Back</td>
<td></td>
</tr>
<tr>
<td>▪ Student checks steps of the plan (1)</td>
<td></td>
</tr>
<tr>
<td>▪ Student assesses if the solution is correct and appropriate for</td>
<td></td>
</tr>
<tr>
<td>the problem (1)</td>
<td></td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER 4
RESULTS

The results of this research study will examine the impact of the graphic organizer on problem-solving success and use of Polya’s four stages of problem solving. The first research question will be based on the students’ achievement scores from pretest to posttest. The second research question will be investigated through the use of the problem-solving rubric created by the researcher. Information gained through the individual interviews will supplement this analysis and help explore the attitudes of the students toward problem solving and the graphic organizer used in this research study.

**Research Question 1**

To examine whether the use of the graphic organizer affected student problem-solving success on word problems, a t-test was performed to compare students’ scores on the pre and post test. Students’ scores on the posttest ($M = 1.33, SD = 0.565$) were significantly higher than students’ achievement scores on the pretest ($M = 0.25, SD = 0.442$), $t(23) = 7.399$, $p < .001$.

More specifically, 3 out of the 24 students in the class answered the first question correctly on the pretest and 4 of the 24 students answered the second question correctly. All together on the pretest, 6 students scored 1 out of 2 possible points and 18 students scored no points. These results are contrasted significantly by the outcome on the posttest.

Seventeen of the 24 students answered the first question on the posttest correctly, and 15 students answered the second question correctly. One student scored no possible points, 14 students scored 1 out of 2 possible points, and 9 students scored 2 out of 2 possible points.
When comparing the pre and post test scores the following was revealed. None of the students decreased in their scores, and 6 students’ scores remained the same. Eighteen students’ scores, however, increased from pre to post test. Of the 18 students, 7 increased their scores from 0 to 1, 2 increased their scores from 1 to 2, and 9 increased from 0 to 2.

**Research Question 2**

To examine whether the graphic organizer affected students’ use of Polya’s (1985) four stages of problem solving, a t-test was performed to compare students’ processes scores on the pre and post test using the rubric in Table 3-1. Students’ problem-solving processing scores on the posttest ($M = 8.75$, $SD = 3.011$) were significantly higher than students’ processes scores on the pretest ($M = 2.88$, $SD = 3.011$), $t(23) = 7.832, p < .001$.

More specifically, on the pretest 15 students scored between 0 and 3 points and 9 scored between 4 and 7 points. On the posttest, 3 students scored between 0 and 3 points, 3 students scored between 4 and 7 points, 15 students scored between 8 and 11 points, and 4 students scored between 12 and 16 points (see Table 4-1).

Comparing the pre and post test scores, students used more of the problem-solving stages when using the graphic organizer than prior to using the graphic organizer. To be more precise, 22 students increased their score, 2 decreased their scores (by two and three points), and no students had the same score.

Although the students were prompted to show all their work, students may have not written all the steps taken to solve the problem on the pretest and the rubric used to assess the pretest was closely aligned to the format of the graphic organizer. Therefore, in order to increase the validity of the results for research question 2, the 8 individual
interviews for the pretest were coded using the rubric in Table 3-1 and compared to the posttest processes scores. The 8 students’ problem-solving processing scores when using the graphic organizer ($M = 9.75$, $SD = 2.121$) was significantly higher than their processes scores determined from the interviews prior to using the graphic organizer ($M =5.75$, $SD = 1.282$), $t(7) = 3.802$, $p = .007$. The posttest process score was used instead of the posttest interview process score because the students simply read off of their graphic organizer during the posttest interview. In contrast, during the pretest interviews students added additional information to their solution strategy when verbally asked to explain their solution. As a result of being able to better recognize the students’ strategies from the interview, 7 of the 8 students increased their process score from the interviews prior to using the graphic organizer to the posttest (see Table 4-1).

Table 4-1. Pretest Interview, Pretest, and Posttest Problem-Solving Processes Scores and the Number of Students that Achieved that Score.

<table>
<thead>
<tr>
<th>Test Scores</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Pretest Interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>15</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>4-7</td>
<td>9</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>8-11</td>
<td>0</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>12-16</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

**Student Work**

In order to get a better understanding of how the graphic organizer impacted the students’ solutions, a few students’ work will be examined in more detail. Participant 5 scored no points on the pretest and increased to 2 out of 2 points on the posttest. The work the student gave on the pretest was minimal. For question one, there is no work or
answer shown and for question two the given information was restated and there was an attempt to create an equation to solve the problem but the student did not follow through with the plan or produce an answer. Participant 5 was one of the students who were interviewed after completing the test. During the interview, the student showed improvement in the process score by providing evidence of using certain problem-solving phases on the pretest, even though there was no work written on the actual test. For example, for problem 1 the student mentioned subtracting 360 from the given three numbers in the problem and using the Pythagorean Theorem as solution strategies she considered but none of these possible plans were written on the test. Since there was no work written on the test for problem 1 the student received no points when assessed using the problem-solving method rubric and 3 points out of 8 on problem 2. However when coding the individual interview, participant 5’s process score increased to 4 out of 8 points. On the posttest, participant 5 scored 2 out of 2 points. For problem 1 and 2 the student received 6 points out of 8 for their problem-solving process. Figure 4-1 shows participant 5’s solutions from the pretest and Figures 4-2 and 4-3 display the posttest solutions. Participant 5 showed considerably more work on the posttest than the pretest. Each step was well thought out and explained. In contrast to the pretest where there was no effort made to try and solve the problems on paper. Although the student used the wrong area formula for the circular pie, a plan was devised and carried out and the correct solution was produced.

Participant 17 scored the same on the pre and post test. On the pretest, the student answered problem 2 correctly but showed little work. It appears that the student calculated 20% of $30,000 and arrived at $24,000 left over and then calculated 20% of
$24,000 and so on until realizing it takes four years to get below $15,000. This is what it seems like the student is doing but all he has written on his paper is a list of numbers and the answer. Therefore the student received only two points for carrying out the plan and finding the correct solution. On the posttest, the student answered problem 1 correctly and received 7 out of 8 process points. The student was able to actively engage in each of the four problem-solving stages. The only point he didn’t receive was due to not explaining why the 24 inch pizza was a better deal. When using the graphic organizer, the student showed more work and the researcher was able to follow the solution easily and see clearly what the student’s thought process was when solving the problem. Figure 4-4 and 4-5 shows participant 17’s pretest problem 2 and posttest problem 1 respectively.

It is important to emphasize when problem solving that the process is more important than the outcome. The process and the act of solving the problem will help students succeed on future problems. Participant 20 kept the same score from the pre to post test. The student was unable to get the correct answer on problem 1 on the pretest (see Figure 4-6). The Pythagorean Theorem was written down but nothing was done with it. Needless to say, the student scored no points for the problem-solving methods on problem 1. Participant 20 was also unable to find the correct solution for problem 2 on the protest (see Figure 4-7). When comparing the strategies of the two problems, in the posttest problem the student was able to identify the known and unknown information, devise a plan, and carry out the plan. Although the problem was not answered correctly, the student scored four points for the problem-solving strategies. Although the pre and post test problems were not answered correctly, the
student was able to increase the amount of work shown from pre to post test, therefore showing more of their thought process allowing the researcher to better understand their method.

When comparing the problem-solving success and process scores, 17 students increased their success and process score when using the graphic organizer (see Table 4-2). This correlation is significant and shows that using the graphic organizer can help students increase their success when solving problems and also improve their solution strategy explanations.

Table 4-2. Comparing problem-solving success and process score change from pre to post test.

<table>
<thead>
<tr>
<th>Problem-solving success score</th>
<th>Problem-solving process score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease</td>
<td>Decrease</td>
</tr>
<tr>
<td>No change</td>
<td>0</td>
</tr>
<tr>
<td>Increase</td>
<td>2</td>
</tr>
</tbody>
</table>
Problem 1.) An engineer wanted to approximate the width of a river. She placed markers at point A and point B to represent the average width of the river. She also placed 3 other markers along the riverbank and measured the distances shown in the diagram below.

Based on the diagram, what was the width of the river, in feet (ft), from point A to point B.

Figure 4-1. Participant 5's pretest.
Problem 1:
A pizzeria serves two round pizzas of the same thickness in different sizes. The smaller one has a diameter of 12 inches for $12 dollars. The larger one has a diameter of 24 inches for $24 dollars.

Which pizza is a better value? Why?

What are you doing?
Why are you doing it?
How does it help you?

area of the pizzas
\[ A = \pi d \]
Small: \[ A = \pi (12) \]
Large: \[ A = \pi (24) \]

then subtract \$24 - \$12 = \$12 difference

to find the diff. of the areas

Restate the question
1st

Look back
4th

Find the

2nd

Devise a plan

Find diff. of the areas
1st

Figure 4-2. Problem 1 from participant 5’s posttest.
Problem 2:
An architect is using isosceles triangles in the design of a bridge. In the diagram below all line segments represent the steel beams needed to build this section of the bridge. Line segment $\overline{HA}$ is parallel to line segment $\overline{DB}$. $\triangle DEC$ is similar to and congruent to $\triangle AFG$.

Determine the length, in feet, of $\overline{EC}$.

What are you doing?
Why are you doing it?
How does it help you?

2nd

3rd

4th

Carry out the plan

Look back

Devise a plan

Restate the question

$EC = 2.5\text{ ft}$

Figure 4-3. Problem 2 from participant 5’s posttest.
Problem 2.) A car costs $30,000. It decreases in value at the rate of 20 percent each year, based on the value at the beginning of the year. At the end of how many years will the value of the car first be less than have the initial cost? 4 years

24,000
19,200
15,360
12,288

Figure 4-4. Participant 17’s pretest problem 2.
A pizzeria serves two round pizzas of the same thickness in different sizes. The smaller one has a diameter of 12 inches for $12$ dollars. The larger one has a diameter of 24 inches for $24$ dollars.

Which pizza is a better value? Why?

Find area of both pizza sizes:
- 12-inch: \( \pi r^2 \) = \( 3.14 \times (6^2) \)
- 24-inch: \( \pi r^2 \) = \( 3.14 \times (12^2) \)

Find pizza per dollar:
- 12-inch: \( \frac{113.04}{12} \)
- 24-inch: \( \frac{452.16}{24} \)

Amount of pizza per dollar:
- 12-inch: \( \frac{113.04}{12} \) in\( ^2 \) per dollar
- 24-inch: \( \frac{452.16}{24} \) in\( ^2 \) per dollar

Answer: 24-inch pizza has a better value.
Problem 1: An engineer wanted to approximate the width of a river. She placed markers at point A and point B to represent the average width of the river. She also placed 3 other markers along the riverbank and measured the distances shown in the diagram below.

Based on the diagram, what was the width of the river, in feet (ft), from point A to point B.

\[ a^2 + b^2 = c^2 \]

Figure 4-6. Participant 20’s pretest problem 1.
Figure 4-7. Participant 20’s posttest problem 2.

**Student Attitudes**

Students’ attitudes toward problem solving and the graphic organizer were revealed through the individual interviews. Although this was not a research question in
the beginning of the study, the researcher thought the students’ attitudes were important to discuss. During the interviews following the pretest, the researcher asked the students how they felt about word problems. All 8 students said they did not like word problems. The three main reasons why the students did not like word problems were that they made them nervous, they required more work than other problems, and it is hard to pick the needed information out of the problem. The students who were nervous said looking at the problem as a whole makes it seem more complicated, which causes anxiety when trying to solve the problem. The students who believed that the word problems were more work felt that word problems don’t give them all the tools necessary to solve the problem and he or she is left to find strategies to solve the problem without help. Students who struggled also mentioned that word problems require too much time to solve, and if they can’t figure the problem out by looking at it for a few minutes they usually skip it and go on to the next problem.

It is pretty clear that none of the students that were interviewed liked word problems. Overall, they felt like they were hard, complicated, and took too much time. It seemed as if the students were unsure how to approach word problems therefore they get frazzled right from the start.

During the posttest interviews, the students were asked how they felt about the graphic organizer and whether they thought it was useful to them while working on the given word problems. Some of the students felt like the graphic organizer was unnecessary. The students felt that it cluttered the page and made them do extra steps. Because the graphic organizer takes up the entire page to include all four problem-solving phases, students felt confused by the amount of information on the page and
limited by the amount of space they could use. Students did not like that the graphic organizer made them do extra steps on paper that they would normally do in their head. Therefore using the organizer slowed the students down and caused them to write more. This was hard for them because they were not used to writing out and explaining their mathematical steps. Separating parts of the solution strategy into one of the four phases on the graphic organizer required extra thinking that was not desired by the students.

Although these students felt strongly about the graphic organizer interfering with their work, there were students that saw positive aspects within the organizer. Students felt like it gave them more structure and organized their thoughts well. Participant 5, who indicated being nervous when given word problems, liked that the graphic organizer helped break down the problems instead of dealing with all the information at once and getting frazzled. Some students said they already go through these four phases when solving a problem, hence using the graphic organizer did not negatively affect them when they were working.

The 8 students’ attitudes were mixed about liking the graphic organizer but they all said that they felt that they would rather do the problems without the organizer. Their reasons varied from not liking it, having it slow them down, and simply not being familiar with the format of the graphic organizer (see Appendix E for a transcription of the interviews).

**Summary of Findings**

The graphic organizer was created to foster problem-solving skills and success. During the research study, the students were instructed on how the organizer should be used only once. Although the amount of time they were exposed to the graphic
organizer was limited, the students’ achievement scores increased from pre to post test and the increase was significant.

Increasing student achievement is important but developing students’ solutions to include more detail is equally as important. This study also examined the effect of the graphic organizer on the students’ use of problem-solving methods. In order to assess this, the researcher created a rubric that characterized each stage of Polya’s (1985) four-stage problem-solving process. The process scores increased when using the graphic organizer when comparing the written test scores and the individual interviews. The students provided more evidence of using Polya’s four phases when required to solve the problem using the graphic organizer.

During the individual interviews, the students revealed their dislike for word problems. Most of them thought that they were time consuming and complicated. The students also felt more hesitant to attempt a word problem than a computational problem. Word problems often require the students to translate from words to symbols and vice versa. The translation process of solving a word problem causes the students to become confused and overwhelmed. Graphic organizers help aid students while decoding (Braselton & Decker, 1994).

Although the achievement and problem-solving method scores increased tremendously when using the graphic organizer, the students’ reaction to the graphic organizer was not that favorable. A few students felt that the organizer cluttered the page and confused them more when solving the problem although they succeeded more when using the graphic organizer. They felt they had to stop and think about the graphic organizer instead of just thinking about the mathematics. The students were
used to doing a lot of the mathematics in their head; therefore the graphic organizer slowed them down and made them think more instead of just doing what they are used to which is finding the correct answer. However, this was the main objective of the graphic organizer, to get the students to slow down and think about each step of the problem.

All of the students stated that they would have rather done the problems without the graphic organizer but some students did find it useful. They felt like it helped them structure their thoughts and relieve some of the stress that they feel when faced with a word problem. They were able to focus on sections on the problem, rather than getting frazzled by looking at it as a whole. A student said that he/she normally goes through these stages in their head when solving a problem so they didn’t feel uneasy using the graphic organizer. Although the students’ feelings were negative toward the graphic organizer, it helped them develop their solution strategies in a clear and organized way. They did not like that it slowed them down but slowing down caused the students to develop a clear solution strategy and lead them to more successful solutions.
CHAPTER 5
CONCLUSIONS

Discussion

Students’ productive disposition to mathematics tends to be negative. Most students feel they are unable to succeed; therefore there is no reason to try. During this study, the students’ dislike for word problems was very apparent. With the use of the graphic organizer, the students were able to slow down and not be overwhelmed by the amount of information the word problems contained.

When finding the solution, the students used their prior knowledge to construct new ideas and strategic competence to use those new ideas to formulate, represent, and solve the problem. Building onto prior knowledge increases the likelihood of retention and gets the student motivated to learn if they feel like they already have some idea of what to do. Combining procedural and conceptual knowledge, graphic organizers help bridge prior knowledge and new incoming information (Ausubel, 1960; Mayer, 1984; Novak & Gowin, 1984). During the pretest, many students said that they felt they could do the problem but couldn’t remember an appropriate method to use. When the graphic organizer was used this did not seem to be as big of an issue, even though the problems were similar in content. The graphic organizer helped them use their prior knowledge to solve the unfamiliar problem.

Continuing this process on new and unfamiliar problems causes the students to stay aware of methods they’ve used in the past and how and when to apply those methods in the future. Metacognitively monitoring their solution strategies when problem solving can help students develop qualities of an expert (Langan-Fox et al., 2000; Schoenfeld, 1987). Many of the students thought the graphic organizer slowed them
down and made them think about the problem. This prevented the students from going on a mathematical wild goose chase (Schoenfeld, 1987) and increased their awareness of their solution strategies.

Although all phases are important, successfully engaging in the first phase of Polya’s problem-solving method can reduce translation errors when solving word problems (Pape, 2004) and engaging in the fourth phase can reduce the amount of careless mistakes and misunderstandings made while solving a problem (Jacobbe, 2008). The posttest data showed an increase in student achievement and an increase in the number of students who rephrased the problem, identified the known and unknown information, checked back over their work, and made sure the solution answered the problem. The use of the graphic organizer also helped the students increase their adaptive reasoning by justifying their work (NCR, 2001). Participating in each of Polya’s (1985) four problem-solving phases, increased their understanding of the problem and helped them explain their solution strategy more clearly. The graphic organizer may have also helped foster the metacognitive and cognitive behaviors that are needed to successfully solve a problem (Artzt & Armour-Thomas, 1992) by giving the students a structured and organized way to explore the possible problem.

**Limitations**

There were several limitations to this research study, but the most detrimental was the close alignment between the rubric and the format of the graphic organizer. The rubric used to code the pre and post tests had Polya’s (1985) four stages outlined as did the graphic organizer. Therefore this could have affected the process scores from the pre and post test.
The sample of the students chosen could have also affected the reliability of the quantitative data. The sample size was only 24 students and the class was an honors course. Had the sample been larger and included students from regular Algebra II classes, the data would have been more generalizable. The number of students who participated in the individual interviews was also low. If the number has been larger, the pretest process score data could have been more precise.

The lack of time available for the study also limited the research. The classroom in which the study took place had a curriculum that they needed to follow. Therefore taking more than three class periods would have hindered the normal class schedule. The limited time used for the study caused the students’ exposure to the graphic organizer before the posttests to be restricted. The study required time for the pilot study, whole class pretest, posttest, intervention, and individual interviews following the tests, therefore taking up four class periods from the classroom teacher. Hence the researcher had only one day to introduce, explain, and model the graphic organizer to the class. When the students received the posttest, they recognized the graphic organizer but weren’t as comfortable as they could have been given more time before the test.

Finally, the lack of familiarity with the students’ prior knowledge could have limited this study. The questions chosen for the pre and post tests were taken from standardized tests, were similar in content and complexity, and functioned well on a pilot study class. However, without fully understanding the students’ background knowledge, the researcher cannot say that the students were unfamiliar with all the concepts that were tested. This could have skewed the pre or post test scores.
Implications for Future Research

The graphic organizer used in this study was not well received by the students. This could have been because of the lack of time the students were able to interact with the organizer before being tested. It could have also been a result of the structure of the organizer. With less clutter and more space for the students to work, the organizer may have been received more positively. An important question arises from this study. What qualities should a graphic organizer have in order to be successfully accepted by students? There has been little research on how to effectively design and create a graphic organizer although understanding what is needed to make it useful in the classroom is a necessary key that is still missing.

Even though Polya’s (1985) four stages of problem solving are useful when dealing with a variety of problems, the question of whether or not the graphic organizer is useful when dealing with geometric problems arose from the study. Students felt like it was difficult to describe how they carried out their plan when most of their work was done on the geometric figure that was present in the problem.

Despite the resistance to the graphic organizer by the students, the quantitative data collected in the study show that the Polya (1985) and Schoenfeld (1987) inspired graphic organizer helped increase student achievement and problem-solving skills. Through the use of problem solving, students can start to develop a conceptual understanding and metacognitive awareness and no longer be afraid to approach unfamiliar problems and situations in and outside of the classroom.
Problem 1.) An engineer wanted to approximate the width of a river. She placed markers at point A and point B to represent the average width of the river. She also placed 3 other markers along the riverbank and measured the distances shown in the diagram below.

Based on the diagram, what was the width of the river, in feet (ft), from point A to point B.

Problem 2.) A car costs $30,000. It decreases in value at the rate of 20 percent each year, based on the value at the beginning of the year. At the end of how many years will the value of the car first be less than half the initial cost?
Problem 1:
A pizzeria serves two round pizzas of the same thickness in different sizes. The smaller one has a diameter of 12 inches for $12 dollars. The larger one has a diameter of 24 inches for $24 dollars.

Which pizza is a better value? Why?
Problem 2:
An architect is using isosceles triangles in the design of a bridge. In the diagram below all line segments represent the steel beams needed to build this section of the bridge. Line segment $\overline{HA}$ is parallel to line segment $\overline{DB}$. $\triangle DEC$ is similar to and congruent to $\triangle AFG$.

Determine the length, in feet, of $\overline{EC}$.

What are you doing?
Why are you doing it?
How does it help you?
APPENDIX C
GRAPHIC ORGANIZER

1st
Restate the question

2nd
Devise a plan

3rd

4th
Look back

What are you doing?
Why are you doing it?
How does it help you?

Carry out the plan
APPENDIX D
INTERVIEW PROTOCOL

The following are initial questions in this open-ended interview. Additional questions will be asked depending upon students’ responses.

Interview questions for pre and post tests:
1.) Talk about your reaction to the given problems.
2.) Explain how you solved the problems.
3.) Can you tell me why you solved it that way?
4.) How did your solution strategies help you to solve the problems?
5.) What did you find difficult or easy about the problems?
6.) Can you think of another way to solve the problems?

Questions for posttest interview only:
1.) Talk about your reaction to the graphic organizer.
2.) Do you think it helped you solve the problem?
3.) Would you prefer solving a problem with or without the graphic organizer?
Pretest Interview: Feelings about Word Problems

*Participant 5:* I get nervous I really don’t like word problems. I kinda get stressed out sometimes so I don’t really look at each step one by one.

*Researcher:* Why do you get nervous?

*Participant 5:* If you look at the whole thing it seems more complicated than it actually is sometimes.

*Participant 3:* it’s more work so I don’t like it. I’m going to have to solve it more on my own. They [word problems] don’t give me the tools I need to make it easier.

*Participant 12:* I don’t want to read it. I don’t like reading. It depends on what kind of problem it is. Sometimes I skip over them and go to them at the end because I don’t feel like doing them.

*Participant 24:* I hate them.

*Researcher:* Why do you hate them?

*Participant 24:* I’ve always hated them I do not find them fun.

*Participant 8:* Ah man I’m going to have to make a formula and solve something.

*Researcher:* So you don’t have a good feeling about word problems?

*Participant 8:* Not if I read it the first time and don’t get it.

*Participant 1:* I don’t like the hard ones. That is how I react. If it’s hard I don’t like it.

*Researcher:* What makes it hard?

*Participant 1:* Whenever it’s complicated and hard to understand.
Participant 23: I struggle on word problems a lot. It’s hard to pick out the information you need and don’t need. They are actually really hard for me and it takes quite a bit of time to do them.

Participant 9: I don’t necessarily like them but I’ll do them.

Posttest Interview: Attitude toward Graphic Organizer

Participant 3: I think it makes it more confusing because it clutters your page you don’t have freedom to do stuff wherever you want to

Participant 23: For me it was extra steps. I do a lot of stuff in my head. For the second problem I did it in my head and then had to go through and fill out the steps. It is extra work but it does keep your stuff organized when you look at it. For the second one, for my work I just did it on here [points to diagram in problem] because I did it in my head.

Participant 1: I’m not used to using a graphic organizer. I just do it in my head or on paper. This is new. It slowed me down I had to go out and actually write stuff down that I would usually wouldn’t really need to I go straight to the actual equations and slowing down is a bad thing.

Participant 9: I found it kind of confusing. I work better when I work it out but when I have to put it in separate categories it is kind of confusing.

Participant 5: It was organized and structured. In ways it did help solve the problem because when I look at the problem I freak out and get frazzled instead of breaking it down so it helps break it down.

Participant 24: umm I guess it was good because this is how I do it anyways.

Participant 8: I had a headache because I’d seen a lot of writing but then I was like “ohhh interesting.” So I liked it.
Participant 12: It helped a little bit but I found it harder to write out what I was going to do just because it's hard to explain what you're going to do with math just because I pretty much think it up in my head but it helped me understand it a bit more because I read through it more to write down everything.
LIST OF REFERENCES


Cassidy Fuller was born in Dallas, Texas in 1987. She grew up in Richmond, Virginia with her brother, Austin and mother, Julie. Before entering fourth grade, her family moved to Orlando, Florida. She graduated with honors from Colonial High School in 2005 as salutatorian of her class. She went on to attend the University of Florida in Gainesville, Florida.

From an early age, Cassidy made fake tests and gave them to an imaginary class; she knew she wanted to be a teacher. In high school, Cassidy had the realization that she loved mathematics and from then on she knew that is what she wanted to teach. While at the University of Florida, she studied mathematics. Although it was difficult, she graduated in the summer of 2008 with cum laude.

Although her minor gave her some teaching experience, she knew that she was not ready for her own classroom. Therefore Cassidy decided to go to graduate school to get her Master of Arts in Education in mathematics education.

The program at the College of Education was more than she had expected. The faculty and students in the program really inspired her and gave her the tools to feel prepared for her own teaching career and opened her up to the world of problem solving.

Cassidy plans on teaching in a high school mathematics classroom. Although she has heard the horror stories of a first year teacher, the University of Florida has equipped her with the tools and confidence that she needs to be successful.

The future holds a lot of possibilities but with the support of her family and friends, Cassidy is prepared to take on whatever challenges life puts in her way. Besides, after an undergraduate degree in mathematics and finishing her thesis, anything is possible!