Sponsoring Committee: Dr. Richard Grove, Moravian College
Dr. Camie Modjadidi, Moravian College
Ms. Carly Worman, Upper Perkiomen School District

From Trash to LIT: Problem Solving in a 7th Grade Classroom

Amanda Giangiobbe

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ABSTRACT

This qualitative research study examined the effects of creating and building a classroom environment that is conducive to math problem solving as well as a step-by-step approach to solving word-based math problems. The participants were seventh grade students in the general education classroom who receive mathematics instructions on a daily basis for fifty minutes. During the time, students learned problem-solving strategies to help them when solving word based math problems. Students were provided with daily warm-up word problems that activated students' prior knowledge, built on students' current computation levels and understandings and became more complex over the span of the action research project. Each warm-up provided a step-by-step approach through the use of a questioning organizer to slow down the problem-solving process and to encourage students to consider all of their options for solving a math-based word problem. Students began solving the problem presented to them on their own before collaborating with others on their strategies and solutions. Teacher scaffolding was only provided during the time when students worked collaboratively and not when individual students were reading, processing, completing the organizer and designing a strategy for solving. Students enjoyed the daily routine of being presented with word problems and being challenged to discuss their reasoning behind their answers and strategies for solving. At the end

of this action research project, it was clear from the triangulation of data, that students felt more confident in their ability to begin solve word-based math problems as a result of the guided question organizer and the ability to engage in discourse with their peers on their strategies for solving.

ACKNOWLEDGEMENTS

In school, my grade partner consistently refers to me as a squirrel, as I am always jumping from one topic to the next, discussing content and lessons that are far in the future and constantly throwing our conversations off it's track. On a weekly basis I find myself sending my grade partner an e-mail of what the next week will look like, the subject heading always reading, "Next Week: I'm Squirreling." My grade partner knows these are my tendencies and he when I take on this role; he turns to me, smiles and says, "G, you're squirreling." Then, we both laugh and I will regain my focus. My grade partner has to constantly bring me back to the moment we are in and although he appreciates the "squirrel" tendencies I have, he knows that I am always able to ring it in, as he knows I am only trying to provide the best instruction and learning opportunities for my students.

Therefore, I want to thank every person who saw me squirrel and helped me to regain my focus through my action research project. My journey since this action research process began has been exactly that of a "squirrel." It was hard for me to narrow in on a topic, constantly questioning whether or not the topic I picked would be the topic of me. It was even harder to narrow in specifically on a topic each time I went to read an article that sparked my interest or made me reconsider the topic I had chosen and to question if I should move in a different direction. I suppose that is inevitable, because as a teacher, I am always yearning

to do better, to learn more, and to better my practice in the classroom that I am constantly being pulled in so many directions to enhance what I can do to make a different in the lives of my students. I now know that this process is all about believing in yourself and your ability to hone in on a topic, to invest in it, to carry it out and to make a difference in the classroom by reflecting on the practice and re-vamping it as I saw fit for my students and their learning.

This study would not have been possible without the motivated and willing students in my seventh grade class. For that, I thank my students for their willingness to bring 110% of their effort to my classroom on a daily basis. I appreciate all of you and how much you care about your education and learning. I admire how much you all believe in yourself and your ambitions to always do better.

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Thank you to every professor I’ve had the pleasure of working with at Moravian College. The time, effort and guidance you have provided me with over the last two years has shaped the teacher I am in the classroom and the teacher I aspire to be. Thank you to my cohort, you were my rock and I wish you nothing but well in your future endeavors.

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TABLE OF CONTENTS

List of Figures

RESEARCHER STANCE

School was never easy for me; every grade I earned required hours of studying, days of memorizing flash cards and late nights at the kitchen table with my mother quizzing me on countless pages of information. When the day came to take the test, as long as there were no curve balls in terms of the information being asked, I did well. I received good grades and my studying strategies were working in all of my subjects except for math class. It seemed almost impossible to predict what types of questions a math test would present. It seemed that every time I would have a math test, I could memorize the different formulas, carry out the rote skills required and get half way through the assessment before hitting a wall. On each test, there would always be a handful of word problems that required me to apply my learned knowledge from the tested unit, and even worse, there were problems that required me to dabble into previously learned and test material that I had not looked at since the being tested on it. I never knew how to tackle the word problems successfully.

I would panic when I came across the word problems, because I lacked the confidence in myself when it came to my ability to understand the problem and apply the skills necessary to solve it correctly. I would begin to feel the grade slowly slip away from me when I approached a problem I did not recognize. I had never felt confident in my ability to think outside of the box and come up with solutions to problems in my own way. I was the type of student that did well if I was shown how to do something, to follow a series of pre-determined steps; I was never the type of student who could develop my own problem-solving strategies and be creative with solving problems. I was never the type of student who came up with an alternative way to explain the problem, let alone solve a problem in a different way.

When beginning a problem, I had always been taught to underline key words, circle the numbers in the word problem and to use “problem solving” strategies to solve. The highlighting of key words and circling of numbers was the easy part. In fact, if someone were observing my test-taking strategies, I would without a doubt pass given my ability to doodle around the key words and numbers. It would appear to an outsider that I knew what I was doing, but if they were to hear the rattled thoughts running through my mind, as I finished underlining and circling and neared the end of the problem, they would think differently. This was my downfall; this is where the rubber met the road for me in terms of my ability to do well on assessments that required me to problem solve. I always wondered why some of my friends were able to do well with these types of problems. What did they have going on in their brains that I did not have? How could I become better at problem solving and be just like them? How could I transition from “book smart” grades to “problem solving smart?” I was never able to bridge that gap as a public school student, until I was forced to face the SAT test in order to apply to college.

My admissions counselor told me that I had to continue to take the SAT test until I was able to break 500 in each section. This may sound rather easy; score 1000 points out of a possible 2400 points, how hard could it be? For me, it was extremely difficult. Despite all of the honors courses that I took in my high school, my grades reflected, my hard work, but the SAT revealed my continuing struggles to problem solve. I had to have my parents hire a tutor to work with me. The tutor was able to help me use key words to identify what I knew and to identify patterns in the questions, which ultimately helped me to bring up my score for college admissions. The tutor I worked with and the SAT test taught me that it was not my skills that were lacking, but rather it was my ability to work through the questions being asked of me and to use problem-solving strategies appropriately.

When attending Moravian as an undergraduate, I studied history and had planned on becoming a middle or high school social studies teacher. After passing the PRAXIS test, I was able to apply for teaching positions and landed a middle school position at a local private school, where my whole world opened up. I was asked to teach both Social Studies and Math, which meant placement in a co-taught Algebra class and my own 7th grade math class. While teaching at the private school, I had to find a way to make up for the small income I was receiving and began a tutoring business. I began working with eight to ten students a week, who requested, mostly tutoring in math. I was able to teach myself the content and then teach them. Also during this time, I was able to take and pass the Middle School Mathematics Praxis exam and became certified to teach math in grades 6-8. As I continued to work with students, I consistently noticed that they, too, struggled with word problems. They seem largely to have been given the same strategies I had been given, namely to underline and circle important words and numbers, but they seemed to stop at the same point I did. They shut down. They could not synthesize the information in a way that made sense to them, nor could they apply appropriate problem solving strategies. They rarely asked questions about the problem, and they, rarely checked the validity of their answers before moving on. This troubled me, as they reminded me of myself just a short time ago, lacking the confidence to push through their struggles and develop the skills to be successful at problem solving. During my tutoring sessions, I would prompt the students I worked with to draw pictures, think about topics they had studied and question the familiarity of the topic presented to them. I would advise my students to look for patterns, to make organized lists, to even guess and check, but still they struggled to really understand and develop these problem-solving skills. I began to wonder why. Then, I realized they were probably never shown the ways to appropriately carry them out, which is why they did not utilize them when problem solving.

After finishing my first year of teaching in the private school, I applied for a new position at a local public school and was hired as a 6th grade math teacher.

Now, in my fourth year of teaching there, I still see the same lack of confidence and inability for my students to apply problem-solving strategies. It is first nature for me to draw pictures, to make lists, to check my answers and to struggle through the problem before finally figuring it out, but with my students this is usually not the case. When they are presented with word problems, they instantly feel unequipped to handle them. They begin to complain about problem complexity and state the problems are too hard and that they are not good at math, which I know not to be the case.

The more I work with the students in my classroom now, the more I see an instant look of defeat in their eyes when they come across a word problem. I see students who make up operations based on poor understanding of the words in the problem because they are not able to put the terms into the context of the question, stemming from their inability to actually understand what the question is asking. I see little to zero grit when it comes to persevering through a word problem. The students must think reading it once is enough and that if they cannot get it right away, then they do not "get it."

I begin to wonder, how can I change the thinking of my students with regard to their ability to successfully solve word problems? What type of strategies could I put in place to help students see that they can solve a word problem, no matter how complex it may be with the right skills? How can I give my students grit, motivation and drive to work through a word problem? Are there steps that should be followed each time they attack a word problem? How can I help them break down a word problem, so that they see the full picture of what they know, what they are solving for and to be successful when explaining how they arrived at their answers? These questions have led me to my research project and I am more motivated than ever to help my students become more equipped to deal with complex word problems. I want to make my students competent word problem solvers, no matter what they may face.

My belief is that I can do anything that I set my mind to and that I can accomplish anything that I really feel motivated to do. I learned through my own education that hard work pays off and that when it pays off, the feeling is simply amazing. It would be great if my students could feel this as well in everything that they do.

Ultimately, my action research project implemented a problem solving teaching technique that helped to build students confidence when they solve word problems. My action research project provided students with a place to begin the problem solving process. I wanted my students to be aware of the problem solving strategies they had at the tips of their fingers and to use them more often when problem solving. In order to do this, I had to make sure that my students understood how the graphic organizer was designed, that they were engaged with the organizer and were taught how to successfully use the guiding questions to help them solve. Once my students were able to see how successful they could be with their organizer of questions, on top of their learned problem solving strategies, they became more confident in their ability to deal with any word problem they faced, instead of always feeling defeated by them. My research project sought to answer the question: What are the observed and reported experiences on the motivation and success of seventh grade math students when properly implementing and modeling a problem solving graphic organizer?

LITERATURE REVIEW

Imagine yourself as a student in a mathematics classroom. Now, be prepared to solve your first word problem. Are you ready? Do you remember what it feels like to solve a word problem? What steps do you have to carry out to solve a word problem? Is there only one way to solve a word problem, no matter what the question may ask? When was the last time you did math? Do not panic; remember to use your 'problem solving skills' to guide you. Remember to read carefully. The problem is as follows:

Kate bought a fizzy drink and a mars bar for $1.20. Sophie went to the same shop and bought a fizzy drink and 2 mars bars for $1.55. How much is a fizzy drink in that shop?

Did you arrive at an answer? What was the first step you carried out to solve this problem? Did you plan or organize a way to go about solving this plan? Did you sketch out a picture of this problem to help make better sense of it? Were there any questions you asked yourself about parts of this word problem to help you solve?

The problem posed above is considered to be a real-world problem, one that requires careful reading and the ability to use and build upon previously learned knowledge in order to appropriately solve and arrive at the correct answer. Recent studies have shown that most students, no matter the grade level, have a difficult time solving problems that they would otherwise solve successfully if the problem posed to them were more algorithm-based than word-problem based (Seifi, Haghverdi, Azizmohamadi, 2012). The reason for this is rests in the fact that, children make more errors when solving word problems than solving comparable number problems, such that solving word problems demands mathematical computations along with other kinds of knowledge including linguistic knowledge, which are required for understanding the problems (Seifi, Haghverdi, Azizmohamadi, 2012; Cummins, Kintsch, Weimer, 1988).

Word Problems

Literature has provided a key term for these two types of problems: routine problem solving and non-routine problem solving. Non-routine problem solving requires a much more complex level of thinking, as students have to use both their basic learned knowledge and basic “routine” problem solving to be successful (Schoenfeld, 1992; Stanic & Kilpatrick, 1989). For example, routine problem solving would be demonstrated when a student uses information learned in isolation to solve a problem, such as addition or such as subtraction, whereas a non-routine problem would require a student to use both an addition and subtraction in tandem, despite each of the skills being introduced to the student individually. Currently, math instruction in the classroom is far too focused on the covering of content related to arithmetic and is more highly involved in computation skills, rather than giving students the opportunity to apply their learning and use diverse problem strategies to solve math problems. Therefore, the question, as well as the problem posed and presented to teachers in the mathematics classroom setting becomes, how can both routine and non-routine problems be tackled in such a way that no matter what the word problem states, students possess the ability to work through and solve problems successfully?

In order to address this issue, one must first understand the struggles that students in our classrooms are facing when solving math word problems, as well as understand the recent literature that speaks to the strategies that have proven to benefit students when becoming competent and independent problem solvers. A study conducted with 58 teachers in one middle school showed that students in grades 6^{th} through 8^{th} grade experienced difficulty in representing and understanding word problems, making a plan to solve a word problem, understanding the vocabulary used in the word problem, drawing on background knowledge to solve the problem, utilizing higher level thinking skills to make sense of the problem, validating the reasonability in their given answer, and simple computation errors (Seifi, Haghverdi, Azizmohamadi, 2012). In this study, more than half of the students struggled with representing and understanding the problem. In addition, teachers in this study also indicated that students had a difficult time devising a plan to solve, once having read the word-problem, and cited that many students lacked the meaning of different vocabulary used in the given word problem (Seifi, Haghverdi, Azizmohamadi,).

Teachers who reflected on student difficulty when problem solving stated that "39% of student struggle with word problems rested in text difficulties, 26% of student struggle with word problems rested in unfamiliar context within the problem, 17% of student struggle with word problems occurred because students used the inappropriate strategies to solve, and 12% of student struggle with word problems rested in language factors (Seifi, Haghverdi, Azizmohamadi, 2012, p. 2925). It is clear that there are a number of difficulties that students face when problem solving.

So, when are students supposed to learn how to problem solve? When is this skill taught within the mathematics curriculum? Unfortunately, students are not generally taught specifically how to problem solve at any grade level and problem solving is not always a "skill" that they are taught. Students may not be shown how to problem solve, but they are expected to know how to do so. Problem solving is just like any other subject taught in school; it needs to be modeled and developed (Sheperd, & Sakashita, 2009).

The National Council of Teachers of Mathematics (2000) expects that students should be able to analyze and evaluate the strategies of others, which involves communicating their thinking to the teacher or the peers around them. The National Council of Teachers of Mathematics (2006) clearly define the standard to which students grade kindergarten to grade eight are responsible in achieving, which is that students must posses a wide-range of strategies to problem solve, whether that the be using diagrams, finding patterns, or applying special case algorithms to solve word-problems. The standards in the mathematics classroom should always, “emphasize practices such as helping young students learn to think algebraically, emphasize problem solving as early as kindergarten, and develop deep and meaningful understanding of mathematics by helping students talk and write about the significance of their math learning” (Saul, 2006, p. 1). When it comes to problem solving in the mathematics classroom, teachers need to remember that both the curriculum and the instruction need to engage the students in real-life problems, so that students are able to validate the reasonability in their answers, as well as practice their abilities to think and act when they find themselves faced with a problem that is more difficult and is not familiar to them. Ultimately, the 21st century calls upon students to posses and use 21st century skills, which includes problem solving, critical thinking, creativity, collaboration and communication (Wismath, & Orr. 2015).

Now, having examined why students experience problems with solving word-based math problems, the question that still remains is how can educators help students to better their problem solving abilities? How can educators develop and implement appropriate strategies to help their students become more successful when it comes to solving word-based math problems? There are many best practices that a teacher can use in the classroom to help develop and foster life-long problem solving skills. Simple ideas such as vocabulary walls, math talk, writing to learn by journaling, math centers, number lines, hands-on manipulatives, and anchor charts are all valuable tools when helping students to become better problem solvers (Fogelberg, Skalinder, Satz, Hiller, Bernstein & Vitantonio, 2008). Research has spoken to the fact that general habits such as persistence, flexible thinking, and metacognition are needed and must be taught in multiple subjects in order to ensure student success when problem solving (Sheperd, Sakashita, 2009).

Promoting Problem Solving With Graphic Organizers

Students need the chance to utilize different strategies when problem solving. It is only as a result of being exposed to problem solving on a regular basis that students are able to identify strategies that work best for their own learning styles. As Van de Walle (2004) stated, "the process of solving problems is completely interwoven with the learning; children are learning mathematics by doing mathematics" (p.37).

Regular exposure to word problems allows students the chance to make sense of the language of mathematics. Daily classroom activities that Adams (2003), Barton and Heidema (2002) and Martin (2007) suggest include the use of a word wall. Martin further explains that the problems students solve should be related to their real life experiences.

Another recommended strategy suggested by Braselton and Decker (1994) and Clarke (1991) is the implementation of visual organizers. A graphic organizer, define by Clarke, consists of “graphic frames that have been used most prominently to organize student processing of text, in both reading and writing” (p. 526). Barton and Heidema (2002) reiterate the use of graphic organizers when problem solving, arguing that teachers can use graphic organizers to help students to see underlying concepts, as well as how the concepts in a given problem are related to one another.

A strategy encouraged by De Corete et Al (1985), Davis-Dorsey, Ross, & Morisson (1991) is to have students read the problem and then take the time to reword the problem into their own words. It is only when students can put the question into their own words that they are then able to properly understand what the problem is asking of them. Further, this research stated that is also helpful to use “context personalization,” which is the task of substituting the names of different subjects in a word problem with the names of people that the solver was familiar with, substituting fraction vales for whole numbers, making it easier to comprehend the structure of the problem and the representation of the problem to make sense of the problem.

Mathematician George Polya’s book *How to Solve It*, first published back in 1957 and still in print in a 2014 edition, presents four phases that make up the best practice framework for helping student’s problem solve. The four steps are described as “understanding the problem, devising a plan to solve the problem, implementing the plan, and reflecting on the problem.” These phases help students with the problem solving process. These steps help to guide the student in their thinking process as they work through the problem. In addition, this model for problem solving emphasizes the use of comprehension monitoring techniques that help to improve the mathematical problem solving performance of students. Using these steps as a model or as a graphic organizer for students would require the teacher to given specific modeling, guided practice, as well as independent practice to assist students in using the graphic organizer.

In an action research study conducted by Braselton and Decker (1994) the use of a graphic organizer, which required students to restate the question, decide what information was necessary and important to solve, plan the steps to solve, carrying out the computation, and finally reflect on the reasonability in the answer, demonstrated that over time, the graphic organizer helped students to create a relationship between the information in a given problem and develop ways to organize the information to support their ability to solve the given problem. The outcome of Braselton and Decker's study found that providing students with a systematic approach to problem solving helped the students to find an entry point to solving the problem, as well as helped students to slow down when solving. Students were no longer rushing into it, they had increased their ability to be independent problem solvers and the graphic organizers supported their ability to do more computational and procedural mathematical operations.

Problem solving requires the student to go through several cognitive processes and requires the student to exemplify many metacognitive strategies such as visualization, estimation, self-questioning. Problem representation is key to being successful when solving, therefore best practices related to the process are key when trying to help students work with word problems. Teaching students through the process of problem solving process is key to any type of instruction geared toward their success (Rosenzweig, Krawec, & Montague, 2011).

When implementing any type of problem solving strategy in the classroom, the teacher must decide on the type of process they want students to go through (Henton, J., Marotz-Baden, R., & Kieran, D. 1979). Teachers can organize their process in a step-wise procedural method and see which methods work best with students when solving a word problem (Henton, J., Marotz-Baden, R., & Kieran, D.). The role of the teacher during problem solving is to act as facilitator and to help students connect the problem solving process to their own learning styles (Henton, J., Marotz-Baden, R., & Kieran, D.). The student, when engaged in solving a word problem, must analyze and interpret the problem using their cognitive framework (Henton, J., Marotz-Baden, R., & Kieran, D.).

Metacognition

Research has placed a great deal of emphasis on the importance of students being able to be aware of their own cognitive process while reading, which is referred to as metacognition (Alexander & Jetton, 2000; Mokhtari &

Reichard, 2002). Metacognition is regarded as "the knowledge of the reader's cognition about reading and the self-control mechanisms they exercise when monitoring and regulating text comprehension" (Mokhtari & Reichard, pp. 249). In order to enhance learning, students must become more aware of their own thinking when problem solving and teachers can help students to do this by informing students about effective problem-solving strategies, as well as discussing cognitive and motivational characteristics of thinking (Mokhtari & Reichard; Paris & Winograd 1990). The ability to plan, monitor, and evaluate performance are all characteristics of a person who is highly cognitive in their thinking (Joseph, 2006).

In order for students to be successful when problem solving, they must assess their learning strategies and students must be self-regulated when they plan and assess their own performance. Therefore, there needs to be constant monitoring and reinforcement to know what is a productive and non-productive learning strategy (Joseph, 2006). Research conducted by Alan Schoenfeld (1992) confirms that the issue many students face when problem solving is not merely the fact that they do not have the mastery or ability to problem solve nor do they lack the knowledge to be successful, rather students likely are not using the appropriate methods to solve the problem. For example, Schoenfeld (1992) presented his students with a trigonometry problem and some students used partial fractions to solve and others used trigonometry substitutions, both of which worked, but the majority of the students used the substitution method, which was the much more difficult way to solve and resulted in those students losing time on other portions of their assessment. The students in his research study were unable to monitor their thinking and they also did not take the time to plan out the strategies that may have saved them more time and ultimately help them to avoid unnecessary work associated with the method they chose.

With efficient use of self-monitoring and self-regulation, students can spend less time solving problems because they would be using strategies that are the most appropriate and time efficient (Schoenfeld). Once this type of thinking is reinforced with students, then the students are able to recognize their own weaknesses and work through their areas of difficulties without succumbing to frustration and recognizing that they can overcome the challenge that is in front of them when solving.

Finally, many students believe that mathematics in school is always procedural, therefore they are unable to make the connection between their learning and real life. Schoenfeld (1992) exemplifies this by use of example in his writing when he discusses how a secondary mathematics exam was given out to 45,000 students nationwide and students were asked, “An army bus holds 36 soldiers. If 1128 soldiers are being bused to their training site, how many buses are needed?” (p.196). Almost 70% of students set the problem up correctly, but those 70% of students said the number of buses they needed were 31 remainder

12. It was clear from this example, that the students were unable to solve this problem successfully because they were unable to self-monitor and self-regulate their thinking to make sense of the final answer. It was clear from the student who answered the question that they had made no connection between their own procedural knowledge and their knowledge of the real world. These students did not go back to check their work or to ask themselves if their answer made sense and it was clear their answer had little to do with the real world; as we all know you cannot have a remainder or a fraction of a bus. (Schoenfeld, 1992).

To summarize, if students are asked to solve word-based math problems, then teachers must provide students with instruction on how to activate their metacognitive thinking, how to plan their solving strategies, how to self-monitor and self-regulate their thinking through the solving process and to reflect on the validity of their answers when completing the problem at hand. Students cannot be expected to know how to carry out these skills, students must be taught what the skills are and how to use them (Schoenfeld).

Self-Talk and the Power of Inner Speech

Best practices that help to foster metacognition, self-monitoring and self-regulation require the teacher to activate inner speech in student's thinking. Inner speech is no different than what research has called "writing-to-learn," an approach in which students see a problem and then write the process of how they arrived at their final answer (Zakin, 2007; Steele, 2005; Bean, 2001). This type of learning approach activates metacognitive thinking, self-monitoring and self-regulation because it provides an opportunity for the students to reflect on what they know and what they understand, as well as a way to see how they learn (Zakin, 2007).

Writing to learn is not the only practice that fosters metacognitive thinking in our students. A simple practice referred to as "self-talk" or a "think-aloud" will serve the same purpose. Self-talk, "enables students to direct and monitor their cognitive processing, and derive a deeper understanding and appreciation of their own thinking processes" (Zakin, p. 1). Self-talk can be modeled by the teacher and allows for a more active constructive activity to metacognitive understanding, ultimately helping students to control and enhance their ability to think about their own learning process. Self-talk can help students to track their thinking and this can be accomplished through journaling, talking with peers, justifying their reasoning in group work or with other groups (Zakin).

A self-talk approach to teaching will always begin with the teacher modeling it and will eventually move to the students as a whole group and then students working in small groups and can be then used in partner work or at the individual level. According to Zakin self-talk has three different steps, the first consists of inner speech thinking which are questions that the learners asks of themselves, then moves to inner speech facilitating comments, which are comments the learner makes to work through the problem, and finally moves to the evaluation of inner speech, which is the time when learners think of learning in terms of whether or not they've completed the task at hand. These steps can all by modeled by the teacher and if used appropriately and with fidelity, can help to enhance a student's ability to be more metacognitive in their learning, self-monitor and self-regulate their learning process.

Reading, Understanding and Organizing

Braselton and Decker (2004) state that "mathematics is the most difficult content area material to read because there are more concepts per word, per sentence, and per paragraph than in any other subject" and that "the mixture of words, numerals, letters, symbols, and graphics require the reader to shift from one type of vocabulary to another" (p.276). In addition, Seifi, Haghverdi, Azizmohamadi (2012) concluded that teachers noticed that almost half of their students struggled with representing the problem, as well as understanding the problem because of their ability to read and understand the math text before being able to apply their math skills. This line of thinking was also present in work by Bautista (2009) and Eric (2005), who both also agreed that the word choice and ability for students to understand the context of math word problem made up for a large percentage of the reason why students struggled to solve the problem.

Therefore, the teacher has to be aware that there may not only be mathematical challenges, but there actually have more reading and comprehension challenges. Students solving word problems may have more difficulty decoding the words in the problems and comprehending the sentence, as well as not understanding specific vocabulary, all while lacking the confidence and ability to concentrate when reading (Ballew and Cunningham, 1982; Shuard and Rothery, 1984). Students may have a difficult time creating an image of the word problem, as well as validating their answers because they have not been shown how to consider real-life factors and constraints when giving an answer to a word problem, which ends in many students providing answers that may be nearly impossible in the context of the problem being given (Verschaffel, De Corte and Lasure, 1994; Cooper and Dunne, 2000; Seifi, Haghverdi, Azizmohamadi, 2012).

An action research study conducted by Sara Gooding (2009) at the University of Cambridge finds that it is an imperative practice for teachers to encourage students to overcome difficulties with word problems by encouraging them to read work problems more thoroughly (p. 35). Gooding understood that many students had poor performance with mathematical word problems and formulated five categories that children have difficulties with while tackling word problems. Gooding identified reading and understanding the language, recognizing and imagining the context, forming a number sentence to represent the mathematics, carrying out the mathematical calculation, and interpreting the answer as the five major areas of struggle. Gooding wanted to increase teachers' awareness of the difficulties students experience when solving word problems. At the end of Gooding's study, she reminds teachers that best practices geared toward problem solving in mathematics should focus on making sure that students are practicing with word problems on a regular basis to help them work with both wording and structure, while also practicing using different calculations. Also, Gooding's work encourages teacher to instill practices in their classroom that focus on having students write down their work, to avoid confusion when solving and when explaining their reasoning's, and to always encourage students to check if their answer makes sense in the context of the problem.

Appropriate Level of Challenge

While metacognitive strategies can help students toward problem completion, certain cognitive processes and skills have to be present. Therefore, unless the problem presents some level of difficulty, the student solving cannot active metacognitive strategies. "Students who have achieved mastery will not need to activate metacognitive strategies to solve math word problems unless the problems are challenge and will produce fewer metacognitive verbalizations than students who have not yet mastered the problem solving processes and skills" (Rosenzweig, Krawec, & Montague, 2011, p. 6). It is important to make sure that the word problems are at an appropriate level of difficulty for the students who are engaging with them in order to ensure that the students are becoming better problem solvers, rather than merely engaging in problem solving. Therefore, teaching students how the process of problem solving works, how to engage with it, while providing them with an appropriate level of challenge are all key components to ensuring that students become better at solving math word problems.

In a recent study, students in an eighth grade metropolitan school district were exposed to a cognitive-metacognitive intervention known as "Solve It!" This intervention was instructed in a general education classroom and students were trained on "how to use thinking out loud methods through modeling, such as self-questioning, checking back, and monitoring progress as well as affective statements related to the problem" (Rosenzweig, Krawec, &Montague, 2011, p. 512). The "Solve It" strategy mirrored the thinking process for problem solving because it includes a "Say, Ask, Check" procedure as a part of the cognitive-metacognitive routine to explicitly teach students how to tell how to tell themselves what to do, ask themselves questions, and check themselves as they solve problems. Having the students verbalize their processes in this study allowed the researcher to see what students were thinking versus seeing students say what they do.

Social Interactions

One best practice associated with teaching metacognitive thinking is through social interactions in the process of learning (Lerman, 1996). Small group interactions when problem solving gives a student the "natural setting to supply explanations and elaborate one's reasoning" (Kramarski, Mevarech, & Arami, 2002, pg. 228). In addition, social interactions through the use of small groups when learning, encourages interpersonal monitoring and reflection (Artzt & Armour-Thomas, 1992). Lastly, small group interactions give students the time to discuss and consider other valid solutions to a problem when solving (Ben-Ari & Kedem-Friedrich, 2000).

A study conducted by two action researchers Cozza and Oreshinka (2013) looked at group of students in Russia, Spain, Hungary, and the United States. Cozza and Oreshinka (2013) sought to investigate the cognitive and metacognitive processes of mathematics problem-solving discourse, as well as explore the patterns of social interactions during small group work. In each of the locations of the study, Cozza and Oreshinka (2013) worked with two to four small groups and conducted problem-solving sessions, involving total of 5-12 students participating at each of the locations. The results indicated that when working in a small group, many students first action was to understand the problem. The study also found that the more challenging the task, the more reflective and metacognitive the students were. After the understanding of the task, the next behavior that occurred revolved around implementation, when the students engaged in actions to solve the problem while reflecting on what they had already done so far. Students were making progress with the task. The third behavior revolved around verification "when the students compared their solutions with the answer keys to if their thinking aligned correctly when arriving at the final solution” (Cozza, & Oreshinka; p. 281). In sum, the students in these studies were experiencing the same process of problem solving. The students were all experiencing the understanding of the problem, the implementation and verification stages. The study found that students are constantly switching between exploration of what the question is asking of them and implementation of the strategy. Students are exploring, testing, and implementing new ideas and starting the process again each time they are asked to work together to solve. This study showed this approach to problem solving unfolded when students had the opportunity to collaborate with one another and when were more successful when each solution built upon the ideas and actions of group members (Cozza, Oreshinka, 2013). This study highlights how necessary it is to, “develop and plan learning tasks that require independent problem solving in small groups, as well as informing teachers of when it is appropriate to step back and when it is appropriate to intervene in small group problem solving” (Cozza, & Oreshinka, p. 283).

Independent vs. Interdependent Work

Collaborative work has been defined as any type of work that require students to work together in which students explore a solution to a problem, in some cases prepare a project, and can also refer to a variety of strategies used in the classroom in which students are working and interacting with each other (Wismath, & Orr, 2015). Providing the opportunity for collaborative work has been shown to be the best way to foster the skills of problem solving within students. If assigning collaborative work to students, one must keep in mind that this type of work has specific features such as: “tasks assigned are clear and straightforward to do; students must depend on one another to complete the task; the instructor acts as a guide or mediator, but without giving constant assistance; and students are responsible for working together and accomplishing a collective goal” (Wismath, Orr, p.1).

Also, collaborative work has been shown to not only foster problem solving abilities, but it also provides students with a safe atmosphere in which the students feel comfortable taking risks, feel more engaged as learners and feel as though they are teachers themselves, helping others learn (Wismath, & Orr, 2015). In cases when students are working together, students are socially constructing knowledge, rather than hearing information from a teacher. It is during this authentic learning experience that students are retaining information and transferring the information to their long-term memories.

In Wismath and Orr’s case study, they examined the role of student collaboration in the development of problem solving skills at the college level. The students involved in Wismath and Orr’s study met 39 times over a thirteen-week period. The class engaged mostly in collaborative work, as lecture was minimal. In this class, the students and teachers were learning together and learning from one another by sharing their solutions, rather than following a specific directive on how to solve a specific problem based on prior teacher modeling.

Wismath and Orr's findings discovered a pattern on how their students approached problems. Wismath and Orr state, "Students generally appeared to begin work on a new problem individually, taking time to read and absorb the puzzle and often to attempt the application of an initial strategy to solve the puzzle. If this did not lead to success, many students appeared to then switch to a mode of attack in which they consulted with others around them, comparing different understandings and approaches. Once this led to new ideas for how to address a problem there seemed generally to be a return to individual independent work, to check out details and push forward to a solution" (Wismath, & Orr, 2015, p. 4). Following a solution, the students would then return to another person in the class and go over their solutions, by comparing them in terms of how they arrived at their solutions.

Ultimately, when solving any type of problem, it is important to remember that different components of individual versus group work have a time and place. When solving problems, the beginning of the process may be the individual students carefully reading what it is they are working on, thinking through the problem and devising a plan on their own. Then, after they have read and understood, possibly even attempted to solve the problem, students will join together to bounce ideas off of one another and switch between strategies. It may be after this discussion that the students again move back to working independently to solve and finally coming back together to compare final solutions through reflection and discussion with one another. There is a mixed approach to problem solving, but the flexibility of the teacher is key to this teaching strategy. A teacher must be willing to allow freedom in how the students work, individually or collaboratively, because group work cannot be forced. Group work must be seen as an important part of the path that leads them to a solution, but that is it not the job of the group to get the answer, rather it's the group's job to describe and utilize different solving strategies.

Student Reflection

When asking students to engage in metacognitive thinking, it is important to explain to them how to do this. In addition, it is equally important to give students an opportunity to put their metacognitive thinking into practice, so that students can develop a true sense of what metacognitive thinking looks and sounds like. Described by Flavell (1979), a metacognitive mind is thinking about thinking. What this means, is that the student involved in problem solving has to have knowledge of the topic, knowledge about the strategies for learning and problem solving, and the student needs to know the strengths and weaknesses of the learning strategies in terms of their own abilities (Wismath, & Orr, 2015).

In order to ensure students are thinking metacognitively, students need to recognize their own planning, as well as their own decisions as they make their way through a problem. One-way to get students to understand how important metacognitive thinking is or to the extent to which they each use it when problem solving, reflection in the form writing or verbal expression is important. It is during self-reflection that they are able to look at where they started, the process they went through, as well as a time to validate their solutions (Wismath, & Orr). By allowing time for reflection what happens is that those working together develop more metacognitive awareness in terms of the advantages of working independently and the benefits of working with others during the problem-solving process.

Perseverance and Productive Failure

A common finding is that students tend to give up within a few minutes if they are unable to solve a complex problem. We often hear that U.S. math students deal with less challenging mathematics than students in other countries (Seeley, 2009). On average, according to Stevenson and Stigler (1989) students in the U.S. tends to believe that their ability to do mathematics relies more on talent than actual effort. Most mathematics teachers report that their students are not willing to try hard problems that they cannot immediately see how to solve. (Seeley). Stigler and Heibert (1999) reported that in U.S. classrooms, students are exposed too much lower level of mathematics content than students in other countries. In addition, they noted that students in U.S. classrooms did not have as many opportunities to develop new mathematical learning, rather they were being told to how to solve problems. More often times, teachers are telling students how to solve a problem before they have a chance to approach it on their own, there is little to no struggle for them when it comes to solving. It is important to teach our students that mathematics is in fact hard and that the struggle to find the answer, to figure out the pieces needed to solve a problem, is a necessary part of the problem solving process.

Two reasons that students will persevere through tasks are because they find it interesting and because they believe they are capable of working through it. Unfortunately, students in our classrooms today do not have the confidence or skills to persevere with challenging mathematical word problems. Dweck (2006) speaks to the connection between student persistence and a "growth" mindset, which describes a learners' willingness to try because they believe that a difficult challenge can be mastered.

In order to develop perseverance, students need multiple opportunities to be exposed to cases when they can show perseverance and persistence at a given task. Ball (2008) suggested that nightly homework include a task called "looking ahead." This type of problem involve ideas that students have not worked on in class, but provides an opportunity for students to try to make sense of what is being asked and make an effort to at least try to start solving the problem. The problem can involve material that students will learn, but the small preview gives the students the opportunity to learn to not shut down just because they have not learned it yet, but to stretch their thinking and attempt something unknown to them.

Another way to develop perseverance is to advocate constructive struggling in the classroom, not pointless frustration (Seeley, 2009). Constructive struggling can only occur when students are given an opportunity to engage in a challenging problem. This type of challenging problem should be demanding, in most cases time consuming, and provide more learning value than several shorter but more obvious problems. These types of problems need to be provided by the teacher and in unison with guiding questions that provides guidance but do not tell students everything they need or need to do to solve a problem. These types of problems can range in type, which means they can consist of problems that require straightforward application of recently learned skills to more complex problems that require the students to use critical thinking and connect more than one skill or idea at a given time. When this type of learning atmosphere is created, "the students begin to develop an appreciation for the "constructive struggle" and they learn that perseverance, in-depth analysis, and critical thinking are valued in mathematics as much as quick recall, direct skill application, and instant intuition" (Seely, p. 2).

Conclusion: It's All About the Process

When problem solving is place at the core of our instruction, we as teachers are able to separate learning from knowing (Berthoff, 1971). When teaching problem solving, the teacher must structure learning in a way that places students in situations to face a new question, define the questions they face, and to evaluate their solutions. When this type of instruction is implemented in the classroom, emphasis shifts from memorization of content to process (Henton, J., Marotz-Baden, R., & Kieran, D. 1979). It is only through the use of metacognitive thinking strategies, which are activated by challenging, yet appropriate problems, that students can become better problem solvers. In addition, it is the responsibility of the teacher to model and show students how to self-talk and monitor their strategies and thinking while engaging in the problem solving process. Problem solving is a structured task, as well as a skill. When given the opportunity to self-monitor and self-regulate their thinking, students will become more focused on identifying what the problem is asking of them, honing in on questions they have about the problem and self-reflecting on their chosen strategies and ways they could improve their process after comparing their work with others. Finally, when students are given the opportunity to work with others they are inherently reflecting on their thinking process, hearing the thinking processes of others and building on other students' ideas (Fogelberg, Skalinder, Satz, Hiller, Bernstein, & Vitantonio, 2008). When students are given the opportunity to hear the thoughts of their peers, they are given another opportunity to revisit their ideas, while strengthening their understandings. There are many ways to discuss how to help our students become better problem solvers, but prior to working on their reading skills and prior to focusing in on key terms, we as educators must help students to understand what it means to be metacognitive in the learning process and use the best practices mentioned to help our students become self-reflective and aware of the ways they learn best. The problem solving process in mathematics can only begin when students understand what it means to be metacognitive and demonstrate what it means to be metacognitive.

RESEARCH AND METHODLOGY

Problem solving is one of the most important skills that students must possess in the 21st century. Teaching students to develop the ability to solve real life problems, as well as apply their knowledge and understandings to multiple concepts at one time is crucial. The intent of this action research project was to help motivate students to become better at problem solving and to persevere through problems that are not immediately or easily understood. The implementation of best practices that were used while carrying out this action research project included a guided question organizer that prompted students to paraphrase the question in front of them, as well as identify important and relevant information, visually represent the problem, and provide a justification for their solving steps and final answer. To facilitate the use of this guided organizer, warm-up word problems were provided to students on a daily basis in order to create a daily problem-solving environment for students. This study was conducted over nine weeks and included content related to the seventh grade math standards, as well as encompassed standards taught in both fifth and sixth grade.

Setting

The setting of this action research project was at a middle school in Hellertown Pennsylvania. There are approximately 750 students in grades five through eight that attend the middle school. The population that attends the district is 56% proficient in mathematics and 72% proficient in reading.

When students were engaged in the problem solving process they used their iPads to solve the problems by answering the guided questions, discussed the word problem with their peers and finally submitted their completed problems online to the application known as Schoology. Schoology is an online course management system that allows teachers to create and manage academic courses for their students. It provides teachers with a way of managing lessons, engaging students, sharing content, and connecting with other educators. Students use this system to submit their work for the teacher to review.

When solving word problems, my students spent the first few minutes reading the problem independently, paraphrasing the problem in front of them, picking out important information and generating a way to solve the problem themselves. After this, students joined with others around them and worked in collaboration to review their individual thinking and collaborate on ways to solve with another before arriving and agreeing upon one single answer.

Participants

There were seventeen participants who were all in the seventh grade and were approximately twelve to thirteen years old. There were twelve girls and five boys within the classroom. The classroom was heterogeneously group with regard to academic ability and there was a wide range of both reading and math fluency levels amongst the participating students. There were no students in the classroom with an IEP, although there was one student with a 504 plan who did not attend school often enough to gather data from.

Procedures

Prior to any type of problem solving occurring, I administered a math survey to my students relating to student's confidence level with regard to problem solving as well as surveying their strategies for problem solving (Appendix B., section i). Students had completed the survey about problem solving and I began to ask them questions as an entire group, prompting an informal interview. I asked students what they believe to be the scariest part of problem solving, what it meant to "check their work", and how they begin to solve word problems. Students expressed that they believed word problems were difficult for them because problems were often long, confusing, very wordy, and required several different operations before arriving at the final solution. Students expressed that they usually panicked when seeing a word problem because they knew they would have to do more than a single step. Students also expressed that they did not have feel confident when problem solving because the words within the problem often confused them and they were afraid of arriving at the wrong answer, ultimately leading them to have to start over.

Approximately fifteen to twenty minutes were dedicated each period to working through a math word problem. This included five to ten minutes' students working individually to complete word problems and then another five to ten minutes was spent having students collaborate, compare, and justify their thinking.

Week One

- Obtain principal consent (Appendix A., section i). Pass out student (Appendix A., section iii) and parent consent form (Appendix A., section ii) to each individual student explains the action research study.
- Math survey (Appendix B., section i) relating to student's confidence level with regard to problem solving as well as surveying their strategies for problem solving.

Week Two and Week Three

- Provide students with a daily warm-up and work with students to demonstrate how to use the graphic organizer (Appendix C., section i and section ii) for problem solving.
- Demonstrate strategies of visual representation and justification of a solution to a problem.
- Work with students to explain what collaboration sounds like when working with peers and how it looks.

Week Three and Week Four

- Continue to provide students with warm-up word problems, but focus word problems on having students draw pictures to represent their thinking.
- Release responsibility to students when it comes to working through a word problem and using the graphic organizer.
- Ask students to provide justification in writing for the steps they followed and the reasons why their answer is correct.

Week Five and Week Six

- Continue to provide students with warm-up word problems, but focus word problems on having students create a chart or make organized list.
- Monitor student motivation and feelings toward problem solving.
- Monitor and interview students on their thoughts with regard to working with others and comparing answers to the warm-up word problems.
- Provide students with the mid-action research survey (Appendix B., section ii) to gather their thoughts and feelings on how they have developed with regard to solving math word problems.

Week Seven

- Continue to provide students with warm-up word problems that provide an option with regard to drawing a picture, creating a chart, or making an organized list.
- Monitor student motivation and feelings toward problem solving.
- Monitor and interview students on their thoughts with regard to working with others and comparing answers to the warm-up word problems.

Week Eight

- Continue to provide students with warm-up word problems that require multiple steps and topics that they have been exposed to but not completely taught. Have students work through these problems together and collaborate on their thinking.

Week Nine

- Administer end of action research survey to students (Appendix B., section iii).

Data Gathering Methods

Surveys

After receiving the forms back from my students, I began the first step towards answering my research question. I administered a pre-survey (Appendix B., section ii.) to students to get a sense of their attitudes toward math, problem solving and provided them with two open ended questions about how they deal with word problems and to identify their strategies for solving math based word problems (Hendricks, 2009). While administering this survey, I had not required students to place their names on the survey, as I wanted them to provide their most honest thoughts without the possibility of being judged too early on in the school year. I read the questions aloud to students, reading each question twice. This helped my struggling readers to maintain focus and helped students to understand the questions they were reading and to hear them read aloud. After students finished and looked over their surveys, I collected them and used the surveys to identify which students were not confident in their ability to use problem solving strategies, as well as students who needed improvement with regard to their attitudes toward math. In addition to this survey, I administered a mid-study survey to students (Appendix B., section ii) and following the conclusion of my research, I administered a similar survey (Appendix B., section iii) to students for a third time and I looked to see if there were any improvements in terms of their ability to name problem solving strategies, as well as if there were any gains in their attitude and confidence with regard to solving math word problems (Hendricks, 2009).

Student Artifacts

Students received daily warm-ups and kept track of the problems they solved throughout this action research project by placing all of the word problems in a folder on their iPads. Following my own modeling of a specific strategy in class, by way of demonstrating how to use the graphic organizer, students were given a series of word problems that required them to use the learned strategy. This gave them the time to develop their skills and properly put both the organizer and strategy to use.

Throughout the research study, I collected the daily warm-up problems from students and looked at the student's abilities to successfully use the organizer of questions, as well as apply different strategies to successfully solve the problems presented to them (Hendricks, 2009). When looking at student work, I used a rubric to code student responses (Appendix D). I used Polya's (1985) problem solving stages to develop this rubric. Students received one point for their ability to restate what the question was asking, one point if they could identify the known information from the problem, one point if they were able to identify appropriate operations and key words, one point if they devised a plan for solving and were able to explain how they solved the problem. This also served as a measure of on-going formative assessment. During the time that students were working with others and using the problem solving strategies, I walked around the room and kept a field log of their comments to one another and recorded significant interactions that spoke to their feelings of confidence when solving word problems, as well as their ability to talk through the organizer with others and finally the application of different problem solving strategies (Hendricks, 2009).

Participation Observations

From the beginning to the end of my action research project, I carried out a triangulation of data collection tools, such as observations, analysis of student artifacts and reflection on all surveys given to students. The observations gathered during my action research project were based on the interactions amongst my students when solving math word problems both in a group and when solving in isolation. The organizers that students collaborated on and completed when problem solving showed how students were able to use the organizer as a way of understanding and solve a given word problem. The surveys presented many different insights into what the students were feeling in terms of what they learned about problem solving, how they felt about their ability to problem solve, how they felt about their ability to begin a problem and carry out different problem solving strategies.

Field Log

In order to keep track of the important details of my action research project, I created a field log journal that I wrote in on a daily basis. This field log journal described the process of my action research project from the beginning to the end. Within my field log journal, I recorded my observations of student work, student discourse, as well as direct student quotes, comments, and feelings. In addition, I recorded my own thoughts, feelings, and any questions that I had throughout the action research process.

My field log journal was important to my data collection because it helped me to see what was taking place as a result of implementing my action research project. From my field log journal, I was able to hone in on different patterns and draw many different conclusions throughout the duration of my project. My field log served as an important component in my own reflection on how my project was developing over time. It allowed me to see what was working, what needed to be changed, and how my students were responding to the organizers and how they were feeling when solving word problems.

The triangulated data from student pre-surveys, post-surveys, student artifacts, interviews, and my own field log journal, as a way to understand my study and to determine if the problem solving strategies helped students become more confident in solving word based math problems.

Trustworthiness Statement

Throughout my study, I worked to ensure that the findings and results of my study are valid and trustworthy. I used the triangulated data, participant feedback, and low-inference descriptors. I collected data over a nine-week period; keeping track of the participant's problem solving abilities, discourse with other students and their submitted problem solving work. I consistently spoke with my students to obtain their feedback about the changes they were seeing their own problem solving process. The use of multiple data sources, such as pre-and post-surveys, student interviews, student artifacts, and my field log notes allowed me to triangulate my data and draw different conclusions and interpretations with regard to my action research project.

Prior to beginning my study, I completed the appropriate paperwork that was required by Moravian College's Human Subjects Internal Review Board. After receiving their approval and revising the document to meet the expectations, I sent a letter of consent to my principal to obtain her approval to carry out my research (Appendix A., section i). After providing my principal with the letter and obtaining her signature, I was able to send letters home with my students for their parents to sign (Appendix B., section ii and section iii), acknowledging the study and the purpose behind it. The letter stated my position of study at Moravian College, as well as the purpose behind my study. I let both the students and their parents know how I would be collecting data throughout the process, in the form of surveys, pre-and post-tests, interviews with students, and journaling. The consent forms stressed how I would take all measures to ensure that anonymity of students and their names by providing them with pseudonyms. In addition, I opened the doors of communication for parents and students by providing them with my principal's school phone number and email, as well as my own school phone number and email. All of the slips were returned within two days of handing them out. In addition, I explained the project to my students, and they filled out a consent form (Appendix B., section iii).

When all of the signatures were obtained from all parties including principal consent, student consent, and the parents/legal guardian's consent, I was then able to begin my action research project and interpret the data from different perspectives. When carrying out my study, I consistently monitored student progress by looking at their graphic organizers and using a rubric to score how well they were doing in terms of following out the given steps. In addition, I was able to consistently observe students and their actions and document important observations in my double-entry field log journal (Hendricks, 2012). The double-entry field log journal that I kept began on the first day of my action research project and was added to on a daily basis until my action research project came to an end. The duration of my action research project was a way to ensure that my results were as accurate and reflective in terms of student growth with regard to motivation and solving math word problems as possible. My students were always curious about how they were doing and with how my research project was going; therefore I shared my observations and thoughts with my students on a weekly basis. This was a way to ensure that I properly understood how students were reacting to my action research project and that the information I was documenting in my double-entry field log journal was in fact accurate and valid of what they were feeling.

Another way to ensure the reliability in my research study was the use of data triangulation (Hendricks, 2012). In which case, I was able to hone in on student artifacts such as their completed graphic organizers, the observational data recorded in my double-entry field log journal, and the information I gathered from the pre-survey, mid-survey, and post-survey with regard to how students were feeling about their ability to problem solve and successfully use the graphic organizer. Finally, it was through careful reflection on my own double-entry field log journal that I was able to see what changes needed to be made in my action research project to better meet the needs of my students in terms of their ability to persevere through word problems and use the graphic organizer successfully to solve any given word problem.

My Story

Why Problem Solving?

This was now going to be my second year teaching seventh grade. In the beginning of the year I usually find myself feeling extremely optimistic and excited about the endless possibilities when it comes to the teaching and learning of my students, but this year was different. That excitement was still there, but not as much as I had wished, as we had just received word from our school principal that the 7th grade math PSSA scores were well below that of any other grade level in mathematics within the district. I kept trying to wrap my head around what I did and did not do enough of in the previous school year that my students did not perform well or demonstrate proficiency on the PSSA mathematics section. I compared my students' scores with that of the rest of students in the state of Pennsylvania and saw that they scored just at the state average of seventh grade students who took the assessment. At this point, I knew that this was not just a problem for me, but a problem facing most teachers instructing 7th grade across the state.

I knew that this year, I would have to re-vamp and re-structure the way I would deliver content and provide my students with the opportunity to become better problem solvers. I based this on the fact that the PSSA released items were highly concentrated in the area of reading and solving word problems than it was carrying out simple computations. Therefore, I knew that instruction on how to carry out simple computation and the memorization of formulas were still necessary, but that the bulk of my instruction had to be invested in ways to place the content into real-word problems for my students to solve, as well as provide opportunities for my students to take control of their learning and persevere through problems that were not immediately obvious or easy to solve.

This year was bit different for me, as I had actually missed the first two days of school. I had come down with a terrible case of hand-food-mouth disease and this resulted in having to miss the entire three-day in-service that occurred the days before school started and then the first two days of school. It was hard for me to sit home those two days and not feel anxious about not having the opportunity to begin the year with my students from day one. After feeling better, I returned to school on Thursday of the first week and I was so excited to meet my students.

We began the day by introducing ourselves; talking about the things they loved about math and of course the parts of math that they did not like. Students voiced opinions such as, “I do not like math because there is always a lot of homework,” and statements such as, “I do not like math because it has a lot of word problems and I do not like reading, reading should not be a part of math.” It was more than obvious to me that I had a classroom of students with split opinions on how they felt about and viewed math.

After the first day wound down, I went home and began to revisit the "data" on my students using a school platform known as Performance Tracker. This is a database of scores that include local and state assessments. This database provides a snapshot view of how my students do in terms of major assessments such as the PSSA and also predicts success on future state and local assessments. I saw that fifteen of the students in my period three Core 7 math students were basic on the 2015-2016 PSSA in math and that one student was below basic, while only one student was proficient. In addition, there were four students in this class that received double language arts class in their schedules in place of foreign language, because they had not met the requirements for the Reading/Language Arts portion of the PSSA. From this statistics alone, I knew that many of my students would be turned off about having to read any type of lengthy word problem and that I had my work cut out for me.

I began my second day with my students by having them rearrange their desks into a circle formation. I had them sit on their desks, feet dangling on the edge and we all were facing each other. I wanted them to feel comfortable and I wanted to get to the center of how they felt about math. All of the students were staring at each other, giggling and asking me if this was some type of test. I wanted to get their unbiased opinion about math and the different questions I wanted to pose to them before explaining my thesis topic to them.

I began our circle discussion by explaining to them that anything they've ever felt about math class was going to change, or at least I hoped it would. The first question I asked was, "What is math?" The room went silent and no one volunteered an answer, partly because I think students did not want to say the wrong thing or thought that if they expressed their true feelings that I would not like them. To break the silence, I said, "Wow, you are a talkative bunch! Okay, let me tell you about my thoughts on math." They all stared at each other, most likely thinking that I would begin a long rant on my love for math. "Growing up, I went to a Catholic school and I had always struggled with math, in-fact I had a double math class two times a week with a different teacher who would pull me out of the classroom and provide small group instruction for myself and two other students. I had never scored above the 50^{th} percentile on any state assessment I had taken and I was never confident in math. I had always wanted to become a teacher, but I knew that I would teach history or another subject, but never math." The students began to look at me, most likely thinking to themselves, "yeah right." Although it was true, math had always been a struggle for me and becoming a math teacher was never something I imagined I would be doing. I said, "math is hard, it is confusing, and it is sometimes long and boring. Sometimes I can't use every part of math I learned in real life, but there are some parts of math that I use all the time. I never imagined I would teach math and there will be times when I teach something and you will be confused or you will not get it and I am not perfect, so you will have to help me learn how to better do something so that you can become better math students."

I decided not to return to the question I had posed to student asking them to define what math was, but shifted my question to "do you think you're a math person?" One student finally broke the ice and said, "I am a math person some times when I know what I am doing, but if I don't then I'm not a math person." Followed by another student who said, "I'm never a math person and I've always been bad at math." Another student said, "I am really good at math, I am really good at memorizing and that is what math is all about." I began to see student responses playing off one another, either by stating the same opinions in a different way or just responding that they did not feel they were good or bad at math.

I then began to talk to students about the specific part of math that I knew my action research project would focus on and that was the problem solving aspect. I asked students, "What is a math word problem and how do you feel about them?" One student said, "math word problems are so confusing, there are so many words and you have to add and then multiply before you get the final answer. There are so many different steps." Another student responded, "Math word problems take a long time and I do not like doing them." I waited for more students to jump on board to my question and re-asked it to students again, trying to elicit more responses. One student said, "When I start a problem, I get really excited and just start solving it, but then the teacher always tells me to slow down and re-read it, I don't get why I have to read it again if I know what to do." This was interesting, I had began to wonder if this student always arrived at a successful answer when jumping immediately to computing operations with the numbers before fully reading the entire question that his teacher had to remind him to slow down and read more carefully. Another student responded by stating, "I do not mind word problems if I am allowed to work with my friends because they help me get it." This was a valuable piece of feedback, as collaboration amongst students was an important component in the action research project that I was going to be carrying out with students. I asked the student to explain further what he meant by his phrase, "help me get it." The student responded by saying, "you know they tell me what to do and what I was doing wrong and then I get it right." It seemed to me from his feedback that student collaboration was a situation that helped guide and re-structure the student's thinking to arrive at the right answer.

I had students come down from sitting on their desks and I handed out the student and parent consent form (Appendix A., section ii and section iii). I began to explain to the students the details of my action research project that I would be carrying out over the next few weeks and the important role each of them would play in helping me to become a better teacher. After explaining the thesis project that I would be writing and how important their work would be to my own learning as their teacher and their learning as my students, they seemed quite confused about the entire explanation. They kept asking me questions such as, “so you’re going to write about me in your paper?” which was almost immediately followed by, “what if I don’t want to be a part of your paper?” I had to further explain to them that with their approval and their parent’s permission, that their work would be included in my action research project. I let my students know that they would all be completing the same work even if they did not want to participate in the study.

I waited until the end of week when I had finally collected all of the student and parental consent forms to begin my first piece of data collection. Once all of the consent forms were accounted for, I handed each of the students in my classroom pre-survey (Appendix B., section i) to get a sense of their feelings and attitudes towards math, as well as problem solving strategies.

Students responded to the survey questions by responding always, usually, sometimes, rarely, or never. In addition, there were two open-ended questions at the beginning of the survey.

When the school day ended, I took their surveys home and began to study and interpret the data to determine how my students felt about math and problem solving. When reviewing student responses to the first survey question, which questioned how they felt with regard to their level of confidence when problem solving math, almost nine students, more than half expressed that they lacked confidence when solving word problems because of the difficulty in separating necessary and unnecessary information within the context of the problem.

When looking at the second open-ended question, which asked students to discuss specific strategies for problem solving, the vast majority of the students stated they did not know any strategies and four of the students repeated the same strategies of "highlighting key words." Interestingly, one student stated that "PEMDAS" was a strategy for solving, which demonstrated to me the lack of understanding when it came to how students see "strategy" with regard to problem solving. "PEMDAS" is not a strategy for solving, this stands for "parenthesis, exponents, multiplication, division, addition and subtraction," which is a skills required to simplify numerical expressions with multiple operations.

To summarize, it was clear to me in the first two questions from the survey, that more than half of the students surveyed expressed not feeling confident in their ability to solve math word problems nor could they provide strategies outside of underlining key words, taking their time, or re-reading the question in front of them.

With regard to he other questions in the survey, when asked questions related to their ability to apply different strategies to word problems, eight of the students circled that they "usually" try different strategies and five of the students that they "usually" know strategies to solve math problems, which was contradictory to many of the students inability to answer the second open-ended question. It was nice to see that ten out of the seventeen students felt "accomplished" when succeeding at solving math word problems and that twelve of them felt that it was rarely or never a waste of time to re-read a math word problem.

This survey demonstrated to me that although my students may not be confident in their ability to problem solve or be able to hone in on different strategies, but that they were willing to persevere through hard problems and enjoyed feeling successful when solving problems correctly, which would be a key component in keeping my students motivated throughout my action research project.

Earning Our PsD's

On the third day of school, which was the Tuesday of the following week, I decided to draw a parallel between problem solving in the math classroom and the job of a doctor. This idea came from a book I read, entitled "Teaching, Thinking, and Problem Solving in Math: Strategies, Problems, and Activities" by Char Forsten (1996). Forsten states in her book when solving a word-based math word problem, the solver must think like a doctor and properly diagnose the problem in front of them. Further, that it would be silly for a doctor to see a patient with a headache and provide a treatment for their foot!

Similarly, for many students solving word problems, "the solving involves multiple skills that require students to be good readers and to be proficient at thinking critically, computing and using a process to solve problems (p. 12)." The point I tried to convey to students in that moment is that they too must be careful when solving word problems and that they may not always get the problem correct, as many doctors diagnose symptoms incorrectly the first time around, but that they must pay careful attention and use what they know to begin solving the right way. I finished my explanation by telling students that they were going to earn their own "Ps.D." which stood for Doctor of Problem Solving, another idea that I incorporated from Forsten's book.

This was the exact hook that I needed to ensure my students thought about solving math problems differently than they had before. I said that in order for them to become doctors, they first had to go through the rounds of being an "intern." During this intern phase, they would work on diagnosing a word problem, as a doctor would a patient. They would carefully study the vocabulary in the problem and the numerical values in the problem, as they both represented the "symptoms" that would help guide them to a proper diagnosis. When finishing solving a word problem, just as a doctor would schedule his "check-up" appointment to see how his patient was doing, the students should check that their diagnosis worked and that their final answer made sense.

The students became much more excited about the idea of being a doctor; one student said, "I always wanted to be a doctor," and another student said, "I would be so mad if the doctor gave me medicine for my foot if my head hurt!" I think this saying hit home for many of them and each time we began a word problem going forward, students began to joke and ask if they needed “gloves” to begin their “surgery.” Problem solving in the classroom, even in its early stages in my classroom, was looked at differently once I told my students about that parallel story and their new role in earning their own “PsD.”

Two Heads Are Better Than One.

We had already established the classroom routine of how our daily classroom activities would run. Students would enter the classroom and write down their homework, which was posted on the homework calendar board and then read and complete the warm-up activity on the warm-up board. After our discussion about becoming doctors of problem solving, we were ready to dive in. Today, I would give them their first warm-up, which we referred to our as “patient of the day.”

Our first topic of the year that had to be covered was order of operations. This is a topic and concept that students had exposure to in both fifth and sixth grade and I knew that this type of question would get their brains working. I wrote the question on the board, “How many different ways can you represent today?” Today’s date was September 12^{th}.

Students came into the room, wrote down their homework and then began to read the question on the board. They immediately all looked at each other confused. They were trying to figure out if this was a “real” question. Many of them wrote “Sept. 12” (thinking that the question asked them to include the month in their answer, not just the day) abbreviating the word September as “Sept.” was a different way to represent the date; others wrote “09/12/16” thinking that that I was asking them to change the word September to its respective number. I waited to see if there were any other answers that students wrote down, but there was not much outside of those two solutions. I then asked the students to get together with others and come up with other ways to represent the date.

Together, the students began to brainstorm ideas for representing the date. I did not want to give them any examples; I wanted to see what they could do on their own. I knew if I provided one example, then that would lead to a domino effect of answers, but this is not what I wanted to happen. I let them discuss in small groups the different ways to answer the question. One group of students began drawing tally marks to represent the 12th. This was the first creative idea I had seen. Students began to become extremely antsy and defeated. They immediately started raising their hands and asking for help, unaware of what they should write down or how they should represent the day. This was very telling; it was clear to me that students lacked perseverance when faced with a challenge.

I finally had to step in and I turned to the board, picked up a dry erase maker, and wrote “September 11+1, 2016.” Instantly, students felt inspired and shouted out. They kept saying, “I didn’t know that’s what you wanted us to do!” “I knew that!” and “Miss G, C’mon how were we supposed to know to do that?” I turned to them, shook my head, giggled at them, and said, “You can do anything you want, as long as it makes sense.” It was pure madness how quickly students began writing different ways to get to “12” for today’s date. Most of them picked up quickly that they could use not only one operation, as many of them were picking multiple operations. Students were creating different numerical expressions that provided a sum, product, difference or quotient of 12. They were checking each other’s problems and making sure their list of ways to get to 12 worked. Students became excited when working through problems that their group members created. I walked around the room and I heard students discussing with one another, explaining why the problem did or did not result in an answer of 12. Many of the reasons included, “you cannot add before you multiply, remember ‘Please excuse my Dear Aunt Sally?’” They were helping fix simple computation errors that occurred when solving and working together to come up with as many ways to get an answer of 12 that worked.

Before the period ended, I took five minutes to de-brief with students on what the point of the lesson was. I explained to them that this question from today’s class was to show that they should always be creative and willing to step out of their comfort zones to solve problems. Further, that it was okay to try something and be wrong and to then adjust what they had originally been thinking. I advised them that the best part about problem solving is that there are multiple ways to arrive at a solution, that we do not always have to take the same path. When working together, the students could share with one another about the different paths they took. The best part of sharing was that if a student decided they liked the path another student in their group took; they were more than welcome to adjust their thinking and use it to solve. That was the art of problem solving.

Let's Slow Down

A specific quote from a student named Mary resonated with me very quickly when beginning this action research project. When discussing the subject of problem solving, Mary stated, "When I start a problem, I get really excited and just start solving it, but then the teacher always tells me to slow down and re-read it, I don't get why I have to read it again if I know what to do." I looked at Mary after she stated this and asked her why she thought the teacher had told her to re-read it. Mary responded by saying, "I am not sure, but it was always so annoying." I asked other students if this had been their experience with problem solving and many of the students' hands went up. I began to question whether or not this student actually understood the steps she was taking to arrive at the correct answer and how accurate this student was as providing the correct answer. I began to question and think of different ways that I could get this student to slow down, all while keeping her excited about solving math word problems.

I wanted this student and all of my students to slow down when engaging in problem solving, I wanted my students to try multiple strategies and discover that it is not about always arriving at an answer, rather it was more important for them to be justified in their thinking and their steps. Computation errors would always exist, but their thinking and explanation for how they solve and why they solved a problem a specific way was most important to my research.

In order to do this, I provided my students with non-routine problems that were not only related to the content we were studying, but problems that included content they've seen before, as well as problems that would prompt them to draw a picture, make an organized list, use logical thinking, as well opportunities to work backwards or guess and check.

When reviewing the word problems, I would ask students for the different ways the problem could have been solved. I would take the time in the beginning to display the different ways each person chose to solve the problem and demonstrate that there would always be alternative ways to go about a given problem. This gave each student a new perspective on the problem they solved, as well as provide my students with alternative strategies for solving. It was my hope, that by slowing down their problem solving, providing them with a structured way of thinking when solving, and demonstrating different ways to think about and solve both routine and non-routine word problems, that students would hold on to the strategies presented to them by their peers and myself and ultimately apply those strategies to word problems they solve in the future.

Do We Have To Use The Organizer?

The following week, I showed students the graphic organizer we would be using to solve word problems (Appendix C., section i). The organizer asked students to dissect the vocabulary and consider what the question was asking of them, prior to jumping right to solving the problem after their initial read of the question. I knew that many students would utter some type of complaint as to why they would need to answer all of the questions before solving and ask that one question that we, as teachers, absolutely dread, "Why do we have to do this? How will I use this in real-life?" which is exactly what happened when I provided them with their first word problem and questioning prompts. My response to their question, "If you went to the doctor, would you appreciate if the doctor looked at you, prescribed you a medicine and never asked you what was wrong? What if the doctor never asked you what was bothering you or about the different symptoms you were experiencing? How would you get a proper and accurate diagnosis?" The students did not have any response to my question and many of them began to giggle and they slowly came around the idea that they would be bothered if that happened to them at the doctor's office. I reminded them again of their "PsD" and how important it was to always ask themselves a series of questions before deciding how best to "diagnose" or in our case, approach and solve the word problem.

I Do, You Do, And We Do.

Before I could model the organizer or present a word problem to students, I knew I had to build the framework for student confidence by demonstrating to students how much knowledge they had and how much they had learned up to this point in math. Therefore, I prompted my students to think of all of the topics they had ever learned in math and we began to make a list of the topics on the board. The rationale behind this activity was that in the survey I gave to students, many of them stated that when they felt confident solving word problems were the times in which they felt the material was familiar to them or that they had worked with a similar problem in the past. I felt it was important to show students how honing in on previously learned information could help them be more successful when solving word problems. In addition, as an attempt to boost their confidence and motivation, this activity was going to show my students that they knew more than they thought and if they were able to place the problem they were solving into a topic they've seen before, they could be more successful in their strategy for solving.

As a response to my question about the topics that students have learned in math, students said things such as, "addition, subtraction, multiplication, division, decimals, percent, proportion's, measurement, time, money, greater than, less than, median, mode, mean, variables, algebra, etc." The list was quite extensive and I was impressed by the enthusiasm that students showed when providing answers to my question. After this was done, we took the list that students made and broke it up into five major categories: number operations, algebra, ratios and proportions, geometry, and data/statistics. As a whole group, we went through and placed each topic into its appropriate category. This took an entire period to do; therefore, we had to continue our problem the following day. I had kept the organizer on the board for the following day.

When we returned to the organizer on the board the following day, I began to discuss with students the importance of reading a word problem and first trying to considering whether or not parts of the problem looked or seemed familiar to anything they've learned before. I informed students that when solving any type of word problem, it would be helpful to place the problem they were solving into one of the topics on the board, versus automatically trying to rely on words that signal specific operations. Relying only on key words and associated operations would be important, but would not always help them to solve the problem correctly. I reminded them that when solving word problems it would be important for them to try to understand the question being asked of them, versus only looking for key words and numbers in a given word problem.

Therefore, with this in mind, we decided and agreed that prior to solving any problem presented to us, we would always begin by trying to re-phrase the question in our own words, summarize what was happening in the problem, and then place the problem in front of us into one of the categories we developed on the board over the course of the last two days. Then, we would identify the key words and associate the word with a mathematical operation. I provided each of my students with an operations "cheat" sheet (Figure 1) to help them when solving word problems. Each time we would work on our daily warm-ups, students would take out this reference sheet and it would also be displayed on the backboard of the classroom.

Addition +	**Subtraction -**
combined	minus
increased	less than
total of	less
sum	fewer than
added to	difference
together	decreased
plus	take away
	more than
Multiplication x	**Division ÷**
multiplied	divided by
product of	into
times	per
of	quotient of
	percent (divided by 100)
	out of
	ratio of

Figure 4.1: Operations Key Word Cheat Sheet

Before beginning to solve our first problem, it was important for us to not only discuss the topics that the problem may be touching on, the vocabulary, but we had to discuss the ways in which to approach the problem.

I had referenced the students' surveys (Appendix B., section i) and knew that many of them considered reading the problem more than once a helpful strategy, so we began there. I had stressed to my students that it was important to read the problems slowly and several times, stressing that they should not stop re-reading the problem until they came to comprehend it and could explain it in their own words. Therefore, going forward in my action research project, I knew I would have to teach students the different ways to break down the problems, which the organizer (Appendix C., section ii) would help address.

The Struggle is REAL!

I had to help my students, who only felt confident in situations when they knew what to do, find the mindset to persevere when solving hard problems and to consider other strategies for solving. I found it important at this time to share a few different articles with my students.

The first article I shared with them was an article titled, "Growth Mindset: How to Normalize Mistake Making and Struggle in Class" by Katrina Schwartz. This article addressed the math mindset and discourse for solving in the classroom. We read this article out loud in class and we watched the video that went along with the video. After watching the video, I had students come together in groups to summarize the important points the article made.

When students finished reading and discussing the article, I had began to pose a few questions to the entire group. I asked, "Is it okay to struggle in math?"

Instantly, students began to raise and their hands and respond. One student stated, “I always struggle, the struggle is real.” I knew this student was trying to make light of the article and promote laughter amongst his classmates. I asked this student, “How do you overcome the struggle?” This student did not have a response.

I had to continue building the discussion, so I pointed to the quote in the article that stated, “Everyone is going to feel stuck, everyone is going to feel challenged by problems.” I asked students to comment on what they thought about that quote. Students responded by stating, “I like to solve hard problems and when I get them right I feel really good about myself.” Another student stated, “I hate when teachers think I am being lazy when I have nothing written down, it doesn’t mean I am not working, I am just still thinking about it.” This was quite interesting to me, as I sometimes I am guilty of assuming students are not on task when they produce little amounts of work when having been given a long enough time to tackle a problem. I began to re-think the way that I gauge student productivity in relation to problem solving in my classroom.

The take-away from this article was that my students and I came to an agreement on how we would approach and solve word problems in the classroom. We took the time as an entire class to come up with our own goals and rules for problem solving in the classroom. As a whole group, we named the following rules:

- When problem solving, it is okay to feel "stuck."
- When problem solving, it is necessary to read the problem more than once.
- When problem solving, it is more important to justifying our thinking than it is to get the correct answer.
- When problem solving, we should provide evidence for our solving and strategy versus providing an answer.
- When problem solving, we will ask other students around us to explain their thinking and help ourselves further our understandings and those of others.
- When problem solving, it is okay to disagree with our classmates, but that is our job to understand and question the thinking of others and ourselves.
- When solving a problem, the struggle is real! We must embrace the struggle.

It was most important for my study to focus the first two weeks on outlining the rules for problem solving and to help my students understand their mindset when solving problems. Research has shown that there is a connection between the attitudes and beliefs students hold about themselves and their academic performance. Therefore, it was important for me to create an environment with my students where they could feel comfortable to be incorrect, where they could feel themselves learning and growing as a result of preserving in the face of hard math word problems.

Giving Students The Time

The largest struggle that I had when beginning this action research project was giving myself the time to step away from the "curriculum" and provide my students with the appropriate amount of time to solve word problems, reason through their strategies and work, as well time to explain their thinking to their peers. I am always worried when I see some groups getting ahead and others falling behind, which usually puts me in a position to end an activity or rush it along, which is not benefiting all of the learners in my classroom.

Therefore, having now normalized the struggle with my students, the next step was to give them the time to work through the problems, this is when I hoped the true learning would occur. When we began this study, I asked students what they thought about problem solving in math and one of my students, McKenna, stated, "problem solving is trash, it's so hard." It was my goal to alter not only this student's mindset, but also the mindset of all of my students. We were now ready to re-start and begin the journey in becoming better problem solvers.

The First Time Is Not Always A Charm

Having laid the groundwork thus far, it was now time to begin solving the very first word problem as a group. This was my time to model the procedure for solving and to get my students on board with how the organizer would help them to solve down when solving and really think about the problem in front of them.

I had to first show students what I expected as far as the answers to their questions. If not properly modeled, then my students would never be able to demonstrate the appropriate way to think about a word problem. It was now time to introduce students to the guided questions and organizer (Figure 2) that they would be using when solving a math based word problem.

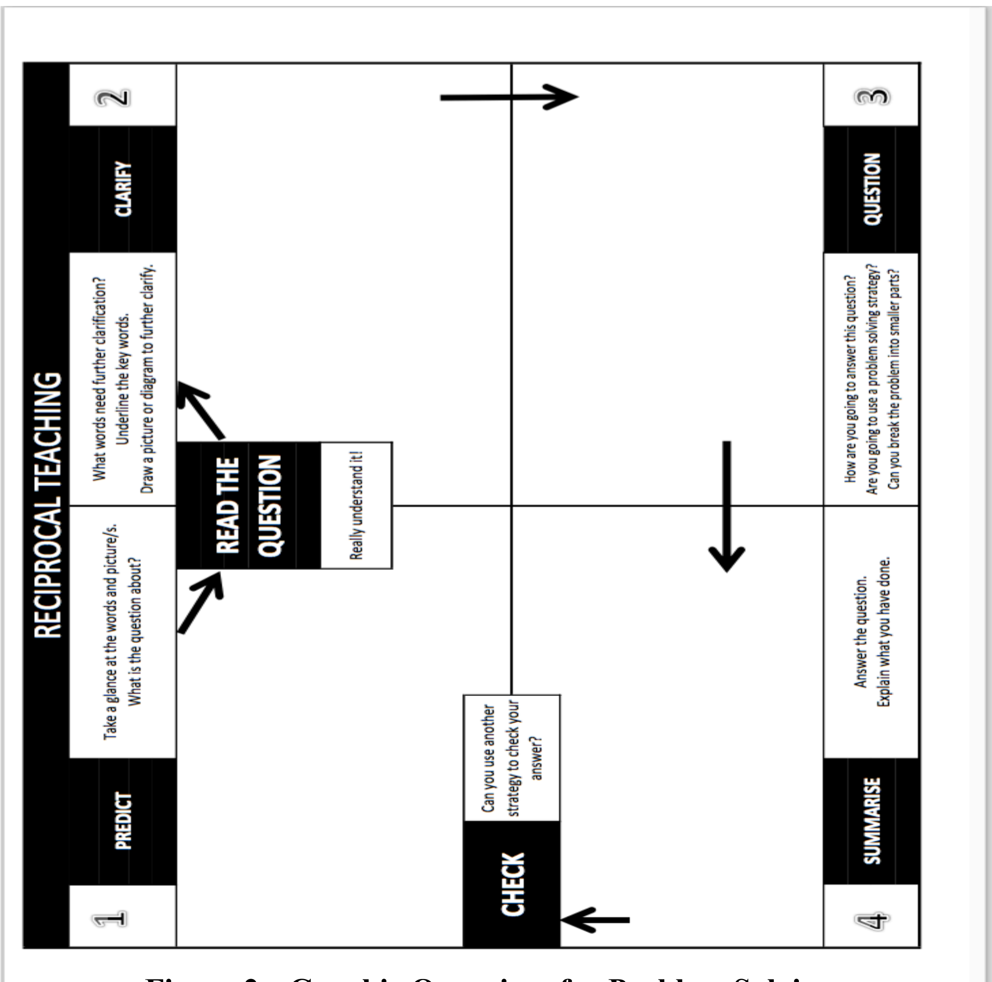


Figure 2: Graphic Organizer for Problem Solving

Before beginning an actual problem with students, we first began by looking at the organizer (Figure 2) and reading over the different boxes and the expectation and purpose for each box. The first box, “predict” aligned directly with the activity students and I have completed on the board just a few days prior. It would require students to look over the problem and decide if the problem in front of them had any similarity to the problem or piece of content they had covered previously. This would serve to activate any prior knowledge students had with regard to the problem in front of them. They would justify their predictions with key words in the problem and rely on their operations cheat sheet (Figure 1) if necessary.

In the second box, “clarify,” students would then write down any areas of uncertainty, whether it be certain words or vocabulary used in the problem that they were unfamiliar with. They would also then take the time to underline key words in the problem that they knew or had questions about. It would be during this time they I would encourage students to begin to draw a picture or diagram of what they believe the question is asking or a picture of how they understand the problem, which could clear up some of their questions.

After this box was completed, students would then move to the “question” box. This is the time during the problem solving process when the students would begin to break down the problem, relying on the information they know and taking it one step at a time. They would have to rely on their metacognitive thinking skills and take their time trying to figure out different ways to solve the problem. This would be the point in time when students would either ask questions of themselves or their peers. This box would lead to discourse amongst the students and actively engage them in the problem solving process. During this time, students would discuss their reasoning's behind what they believe the question is asking them to do and hear the thoughts of their peers. They would rely on their problem solving strategies, such as drawing a picture, making an organized list, working backwards, or simply guessing and checking to solve.

Finally, students would move to the "summarize" box of the organizer (Figure 2) and explain the steps they took to solve and provide a sentence that answers the problem they solved. At this point, students would then check to see if there is a way to check the validity of their answers, exploring other ways to solve the problem. It was during this final stage that students would evaluate the success of their plan for solving the problem.

Once the graphic organizer was explained, I then began to model our first word problem, relying heavily on "think-aloud" strategy to explain and model so that my students could understand how to work through the organizer and formulate questions, which would lead to conversation amongst their peers and lead the way toward a strategy for solving and solution to the problem. I would model the graphic organizer a few different times, so that students could become more used to it and my hope was to step back and allow my students to take the lead with the organizer. The organizer was there to provide structure to the problem solving process. The organizer served as a way to spark conversation amongst students and encourage them to talk about the math and how they solved the problem. Opening students up to the idea that there are multiple ways to approach a problem was the key to this action research study. Students often feel defeated when they do not know where to start on a problem or if they feel they are doing it wrong just because they are doing it differently than those other students around them, which is not the case. It was my hope that having explained the organizer to my students that once they were able to use it successfully that they would feel more confident in their abilities to solve complex word problems and explain their solutions. Empowering my students and helping them to feel more confident when solving math word problems was my ultimate goal.

We were now ready to begin our first word problem together (Figure 3) and I would model, using a think-aloud when modeling how to solve using the organizer.

> "Bob and Dave are digging tunnels. Bob was 10 feet below the surface. He dug 18 feet down then dug to the side and started digging up and rose 5 feet. Then dug down again 12 feet more than rested. Dave dug his tunnel down 22 feet, dug to the side and started digging up five feet. Then he dug down another 18 feet. Then he rested. Who rested at a greater depth, Bob or Dave?"

Figure 3: First Word Problem

I asked for a volunteer to read the question. Mary raised her hand and began to read the question aloud. She had read through the question very fast and I noticed that Jerry was still uploading the document onto his iPad when Mary was almost through the third sentence. Having recognized that not everyone was ready, I had Mary re-read the question, asking her to read a bit slower. This time, she read it a bit louder and much slower. I thanked her for reading it and then turned my attention to the group of students, who were sitting in groups of four students each.

I then asked students, “What do you think this problem is about?” McKenna, a student in Mary’s group, raised her hand and said, “Well, I am not sure if this is right but…two people are digging underground and we need to know who went the deepest.” I shook my head confirming her thinking and then asked if anyone else had a different thought. I could see students drawing pictures on their papers, diving right into the solving portion and already jumping ahead of me. I asked students to put their “fingers down,” as we were working on the iPad and not using actual pencil and paper. I had them turn their attention to the board, where the categories of topics we discussed previously were still written. I said to students, “What topic do you think this falls under?” Forrest raised his hand and said, “adding and subtracting, because both Bob and Dave are going up and down so their distance is changing.” I again nodded at Forrest and commended him on his thinking. I asked students to pay attention to their peers and write these ideas on their organizers. I modeled this by writing it on my own organizer projected up on the overhead. Dakota had raised his hand and stated, “This is a problem about integers, the positive and negative numbers.” I smiled back and Dakota and asked him why he had suggested that. Dakota responded by stating, “Well Dave and

Bob are below ground and we did a lot of problems last year with a fisherman and how he was catching fish underwater and whenever it is below the ground or below the water then it is negative." I asked students if they could relate to what Dakota had said and they began to talk out loud and echoed the same idea, they all remembered the "fisherman" problems from sixth grade. I responded to the students understanding of the context of this word problem and reminded them of the excellent job they were doing trying to understand the problem and place it into their own words.

We were then ready to move on to the clarifying box and at this point I had become completely focused on the students and their responses to my guiding questions, that I was not focusing on their ability to completely fill out the organizer as we worked through it. I then asked students, "Are there any words or symbols or even terms that you are not sure of? What information do we still need to solve problem?" McKenna, the same student who had offered an explanation as to what the problem was asking, again raised her hand and said "Well, I am not sure if this is right but…we have to know where they both started before we can figure out where they both ended up." My hope for McKenna, as this action research project progressed was that she would become she was more confident in her answers, and rely less on preluding her responses to my questions with a statement of her uncertainty. Andy, another student in the class raised his hand and said, "I don't understand, how can Bob dig to the side? How could Dave be digging underground and not be crushed by the dirt?" A few other students must have been thinking the same thing, because two students, Jay and Cody both voiced the same question, trying to turn this problem into something more comical and less mathematical. Without having raised another question to Andy, Jay's and Cody's thinking, Mary raised her hand and I called on her. Mary said, "Well, if Dave and Bob are digging to the side, it just means they are not getting any deeper or any closer to the surface, they remain at the same distance. They probably have protective gear on anyway, that's how all the people dress who work in tunnels." Mary did an excellent job at bringing the group back to the math aspect of the problem.

At this point, as a whole group we had completed the prediction aspect of the organizer, we had even gone as far as connecting this problem to the fisherman problems student had completed the year prior, and we had clarified what the problem was asking by re-stating the problem in our own words and we had identified the parts of the problem that the students were unsure of. I had to take a step back at this point and remind students that up until this point, despite the questions we have asked and the discussion we have had, that we had not solved the problem yet, which was important.

I had pointed out to students that making sense of the problem and taking the time to break the problem down, pulling out the information would be the most important part next to solving. At this point, we were now ready to move into the third box of the organizer and began strategizing and solving the problem. This is when the problem solving strategies would play a role in our organizer. Many of them knew that this would be a problem they could draw a picture for, as they remember drawing many pictures for the fisherman problem. I had asked them to work their groups and begin solving the problem. I began walking around and listened to their interactions. At this point, I knew I had not modeled the entirety of the organizer, but I had modeled the most important part prior to solving. I was confident that students would be able to work through the third box of the organizer, as it was the “solving” portion of the problem. Unfortunately, our class period was coming to an end and we had to stop discussions and wait until the next day to finish the organizer.

As students entered the room the next day, I had them take out their organizers and the word problem and pick up where they had left off. I began to walk around the room and watch, as well as listen in on the different groups. I noticed right away that students, despite my modeling of the organizer on the board and our discussions in class skipped the first and second box. Dakota’s organizer (Figure 4) showed that he did not complete the first two boxes; despite sharing out how this problem was about integers and understanding what the problem was asking. The only part of the organizer Dakota had addressed was box number three, the question box, which he demonstrated under the organizer by drawing a picture to solve the problem.

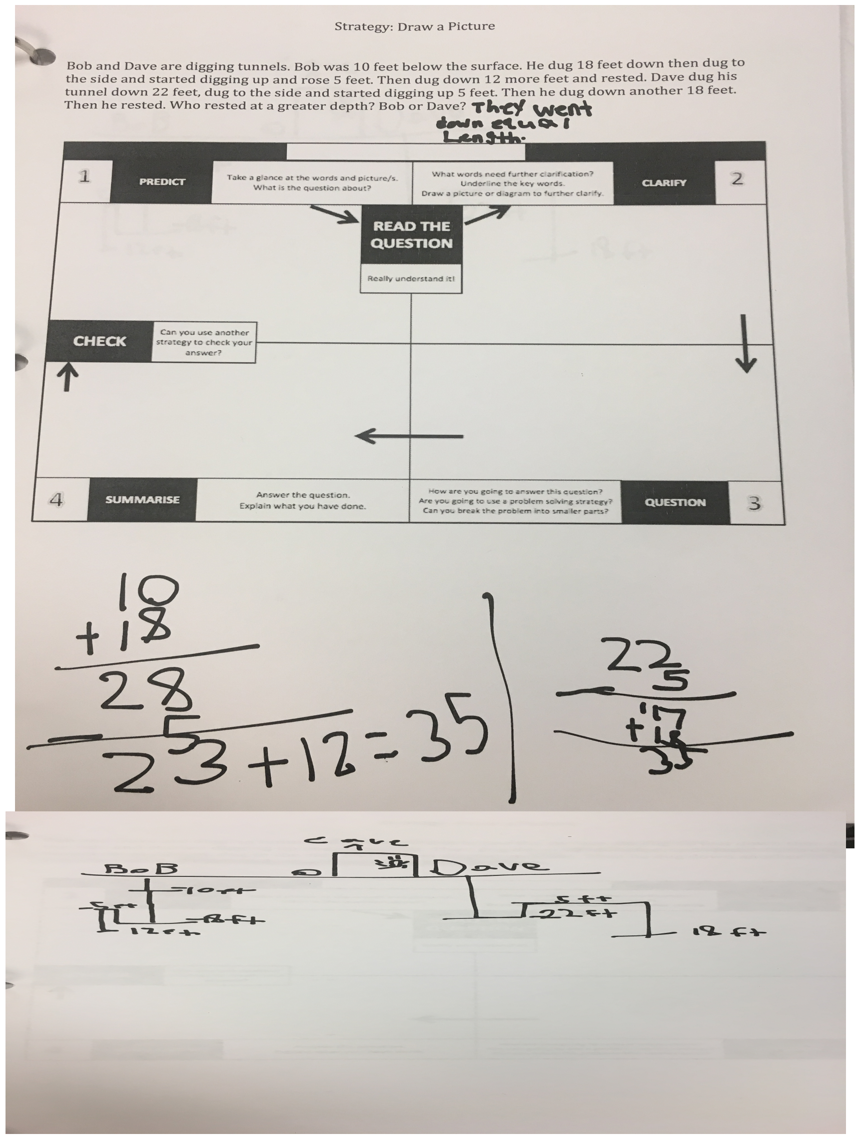


Figure 4: Dakota's Graphic Organizer for the First Word Problem

I asked Dakota why he had skipped the boxes and he stated, "I will go back to those boxes, I am just solving the problem first." I found this quite puzzling, as I had felt the first two boxes were imperative to the problem solving process, as well as frustrating because of the amount of time we had spent the previous day discussing and modeling the filling out of the organizer as a whole class. I wanted to see if Dakota was the only student to have completely missed my modeling and what I had thought were very clear instructions on completing the organizer.

I walked around the room and began to look at other students and their organizers. In the next group, I took notice that one student, Alyssa, highlighted and underlined key words in the word problem on her organizer (Figure 5) as we had done together the previous day when we discussed what we understood and did not understand in box two of the organizer. Yet, despite her following along with underlining as modeled previously, her organizer was still blank in the first two boxes!

Despite her incomplete organizer, the promising part of Alyssa's organizer was that compared to Dakota's picture drawing strategy (Figure 4) for solving, Alyssa demonstrated that to solve the problem, she made an organized mathematical expression to show how she solved for Bob's total distance under ground. How had students, such as Jerry and Alyssa, two students who engaged in the lesson, completely miss filling out the organizer? They both assured me that they would go back to fill it out, but that defeated the organizer's purpose. I needed my students to see the importance in filling out the organizer.

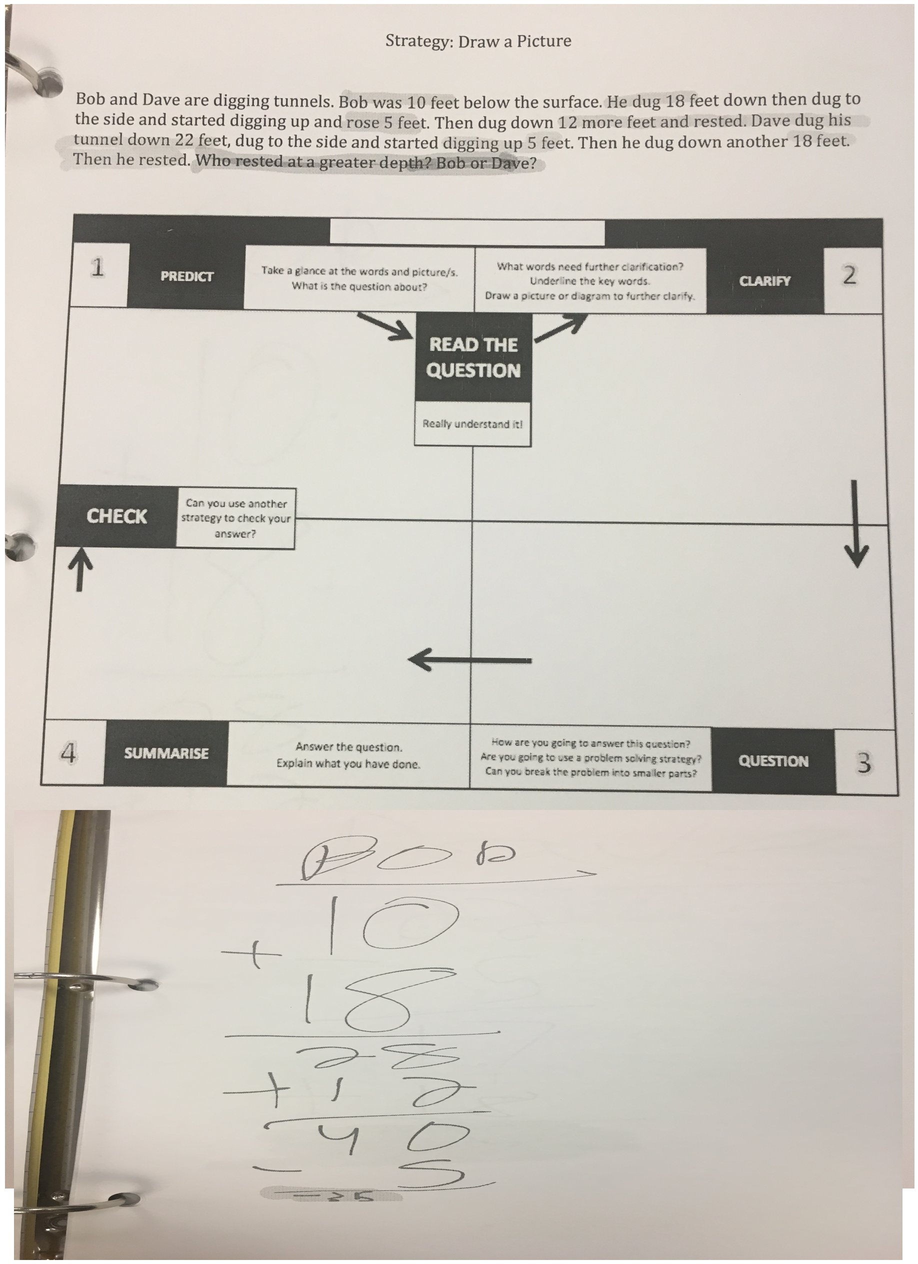


Figure 5: Alyssa's Graphic Organizer for the First Word Problem

All hope was not lost, as I made my way over to another group and noticed that Mary had done an excellent job following along and filling in her organizer (Figure 6).

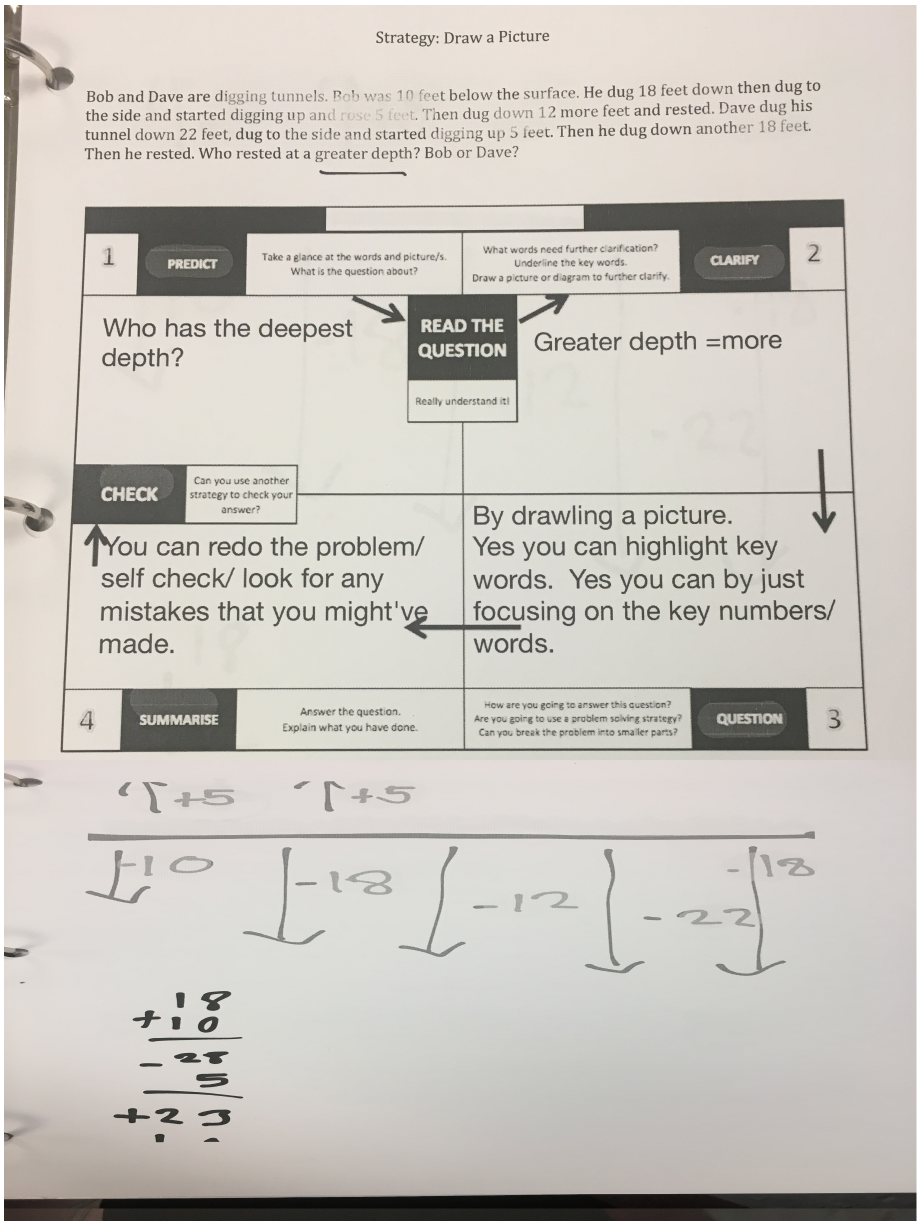


Figure 6: Mary's Graphic Organizer for the First Word Problem

I gave students twenty minutes to work with their groups to solve the problem. I then asked students to compare their ways of thinking and to figure out if any of their group members had done something different than them to arrive at answer. I gave them 5 minutes to discuss this. I then had each group share out their ways of solving. Students began to recognize that they could have drawn a picture or written a numerical expression to solve the problem.

When the period was about to end, I had them submit their problem to the assignment in Schoology where I could go in and read over their organizers. When I had chance to go back and look at their work and reflect on it, I noticed that the students who said they would go back to complete the organizer never did. I had students who did not know how to explain how they solved and arrived at their answer and simply drew an arrow that pointed to their work. When using the rubric score student work, many of the students received only one to two points, because they had not followed through with all of the steps. Slightly panicking at the failure of the organizer, I had come to draw some of my own conclusions that made me re-think the ways in which the organizer promoted the learning of students when solving word problems.

It was clear that the way the organizer was set up left students in a position to pick and chose what they wanted to answer and fill out and what they did not want to complete. I began to question if this was the organizer I needed and if it was beneficial to my students and their learning? I began to question the way I wanted to students to think and solve word problems. Did I care if they filled out every box, but arrived at the correct answer? How could I organize the strategies for solving in a way that was purposeful and meaningful for students, versus forcing them to complete boxes in a particular order?

It was also clear after reviewing my students' work and their organizers that they did not know how to check if their answers made sense, as a few students wrote, "you can redo the problem" as a way to check their answer. I thought to myself, "What is the value in re-doing the problem if you believe your answer to be correct?" This was the problem I would need to address immediately. This was a small bump in the road, but I had to find a way to make the organizer meaningful and present it in a way that students found value in using it when engaging in the problem solving process. I asked students the following day what had happened, I stated, "How come some of the organizers were not completed?" Students vocally expressed that they did not like how the boxes were "so tiny" and that they did not like the "set-up" of the organizer. Understanding where they were coming from, I decided to restructure the organizer (Appendix C., section ii).

New Day, New Organizer

At the beginning of the following week, I had to let my students know that their concerns about the initial organizer were heard and that I had tried something new in terms of setting up the organizer (Appendix C., section ii). We worked on the following problem (Figure 7) together and worked through the organizer.

> "Debbie had $5\frac{1}{2}$ yards of ribbon. She cut it into pieces that were $1\frac{1}{2}$ yards long. How many inches long is the left over piece?"

Figure 7: Second Word Problem

As usual, I asked for a volunteer to read the question aloud. Julia volunteered. I had her read the problem twice and then I read the question to students, providing inflection in my voice where key words were mentioned in the problem. I then asked students, "What is this problem asking us to do? Can anyone put it into their own words?" Dakota, raised his hand instantly and said, "They want to know how much is left over, so subtract." I looked at Dakota and I said, "What makes you jump right to the idea that we would subtract?" Dakota responded, "Well it says left over, that always means subtract." I asked the rest of the class if they agreed with Dakota and to raise their hands if they agreed. I noticed the way that the students began to look around the room for confirmation as to whether or not they should raise their hand. All of the hands in the room went up. With my own blank organizer on the board, we all agreed that the question was asking how long the left over piece was in inches. Students began to write this down with me, all of the students were writing, which was a good sign. I walked around the room with my iPad to make sure that they were all filling out the specific question we were answering on the organizer (Figure 8).

Debbie had $5\frac{1}{2}$ yards of ribbon. She cut it into pieces that were $1\frac{1}{2}$ yard long. How many inches long is the left over piece?

- **What is the question asking?**

  How many inches long is the left over piece.

- **What information is given to you in the problem?**

  Debbie had 5 1/2 yards of ribbon. Cut them into pieces that were 1 1/2 yard long.

- **What operations (+, −, x, ÷) will this problem require and why? (key words)**

  I think it's division because you have to divide 5 1/2 and 1 1/2 together. Then you have to multiply the answer you get after dividing and multiply it by 1 1/2. Lastly you have to subtract it from the whole ribbon(5 1/2).

- **Is there anything you still have to figure out before solving for the final answer?**

  You have to figure out what the answer is after dividing the two numbers you have to divide so you can go farther.

- **Solve the problem.**

  $5\frac{1}{2} \div 1\frac{1}{2}$

  $\frac{11}{2} \div \frac{3}{2}$

  $\frac{11}{\cancel{2}} \times \frac{\cancel{2}}{3} = \frac{11}{3} = 3\frac{2}{3}$

  $\frac{3}{1} \times \frac{3}{2} = \frac{9}{2} = 4\frac{1}{2}$

  $5\frac{1}{2} - 4\frac{1}{2}$

  1 yard

  36 inches

- **How can you justify your answer? Explain how you got your answer and why.**

  First I took 5 1/2 and divided it by 1 1/2. Then I took 3 and multiplied it by 1 1/2. Lastly I took 4 1/2 and subtracted it by 5 1/2 and got 1 yard which is 36 inches.

Figure 8: Second Word Problem With Completed Graphic Organizer

We then moved to the next question on the organizer (Figure 8). The next question read, “what information is given to you in the problem?” I read this aloud to students. Again, Dakota’s hand went up. Although I appreciated his enthusiasm, I did want to mix up the responses and hear from students who were not willing to volunteer answers. I turned to Andy and said, “Andy, tell me something in the problem that you know for sure.” Andy, hesitating for a second, responded, “Well, Debbie started with five and a half yards of ribbon.” I responded by nodding my hand and affirming his response by saying, “Good, thank you!” I then asked, “Do we know anything else?” Mary raised her hand, as well as Dakota; I could see Dakota was growing frustrated I did not call him for the last question. I called on Mary, who stated, “She took the ribbon and cut it up into different pieces that were one and a half yards long.” Again, I smiled back at Mary and asked the class if they agreed with Mary’s statement, I saw a consistent head nod from the students at their desks. I could see them actively filling in the questions on their organizers and I continued to fill out the one I was displaying on the board.

Just as I was finishing my organizer, McKenna’s hand went up. I could tell she was eager to share something, which I could see as she waved her hand in the air back and forth and repeated the words, “Miss G, Miss G!” I called on McKenna and asked her if there was something we missed and McKenna stated, “Miss G, they want to know how many inches were left over, not how many feet, so we can't just subtract like Dakota said." I smiled at McKenna and said, "Did everyone hear McKenna, and do you agree with her?" I could see students turning their attention back to the words in the problem. The students slowly realized that they were so quick in their thinking of using subtraction because of the word "left over" that they missed important information such as the difference between the units given the problem. Andy could be heard in the background saying, "Oh yeah!" I could feel the student's brains working and see their thought process changing as McKenna offered up that very important piece of information.

We continued to fill out the organizer (Figure 8) and I asked the next question, "What operations will this problem require and why?" Forrest had his hand in the air and I called on him. Forrest said, "Well, we do have to use subtraction like Dakota said, but since the ribbon is in yards and we want to figure out how many inches are left over, after we subtract we have to change yards to inches so we have to use multiplication too." I asked the class if they agreed with Forrest and once again, I saw the nodding motion of my students' heads as they sat at their desks.

The next piece of the organizer (Figure 8) asked if there was anything we still had to figure out before solving for a final answer. Halle, a rather quiet student, raised her hand and said, "We need to find out how many bracelets she could make to figure out how much was left over, so shouldn't we divide?" I thought Halle's question was great! She had the class re-thinking the operation choices that we had discussed in the previous question. Dakota raise his hand and I called on him. Dakota said, “Well you could do five and a half minus one and a half and keep doing it until the fraction is less than one and a half and count the number of times you subtracted, that is the number of bracelets, which is the same thing as dividing.” I looked at the class and asked them if they agreed. Again, the head nod. I wanted to highlight at this time how important it is when solving any problem, to share our ideas, because just as Dakota had suggested using subtraction, Halle was also correct in her thinking when using division. Both strategies for solving would help us reach our final answer.

Moving down the organizer (Figure 8) the next question asked us to solve the problem. It was at this point that I took the opportunity to illustrate the use of drawing a picture. I reminded students that the easiest way to understand a problem and what is happening in the problem is to try visualizing it and drawing a picture. I explained that this was the perfect example for drawing a picture. I began to draw a picture on the board, but I had told students they did not need to draw a picture if they did not want to, that they could use simple computation, whether it be repeated subtraction or division to show how they calculated their answers.

Once done with this step, we came to the conclusion that Debbie was able to make 3 complete bracelets and that she would have one yard left over. After writing this down in the “solve the problem” section on the organizer (Figure 8) we all recognized that we were still not done. The student's quickly volunteered information related to converting between yards, feet, and inches. We concluded that there were three feet in one yard, therefore there were twelve inches in one foot, so if we had one yard left, that meant we had three feet of ribbon left, and we multiplied three by twelve converting feet to inches. We arrived at the final answer of thirty-six inches of ribbon were left over. It was at this point that I used my think aloud strategy to "justify" and explain how an answer was arrived at on the organizer (Figure 4.8). Students followed along and complete the organizer successfully. I had them submit their problem to our Schoology system and I reviewed their work later against my rubric. I saw that 100% of the students completed the organizer in its entirety. I was thrilled! I knew that by the end of the week students were going to be able to be successful in using the organizer.

It was important for them to see that the organizer of questions was not a way to make them do more work, but a way to slow down their problem solving process, focusing in on the information they knew and the information they still had figure out, as well as the operations. The graphic organizer of questions was meant to increase my students understanding, as well as help them break down the information in the problem into smaller, manageable pieces. By doing so, my students can think about all of the components that make up the problem and work with one another to solve. The organizer would help guide their thinking about their own thinking when engaged in the problem solving process. It was my hope that this type of routine problem solving would dissipate the “fear” students had when being exposed to word problems. Moving forward, I had hoped that students would look at the reasonableness of their answers to recognize when their answers did not make sense.

Problems Here, Problems There, Problems Everywhere!

On a daily basis, for the following seven weeks of my action research study, I made solving word problems a common event inside my classroom. By making problem solving a common occurrence in my classroom and implementing the organizer, I noticed that each one of my students had a starting point when presented with a problem. I saw a decrease in the amount of students who would immediately give up after one read through of a given problem. Instead, I saw my students writing down what they knew from the problem, highlighting important information, relying on their background knowledge and trying to strategize with their peers about how to solve the problem, as well as seek help from another student or myself during the problem solving process. The problems that I exposed students to were not problems they would immediately be able to solve based on instruction in class, rather they consisted of problems that students had to think about, strategize about and then compare their thinking with those of students around them.

It now had become time to expose students to the first problem they would solve on their own, without my help or guidance (Figure 9).

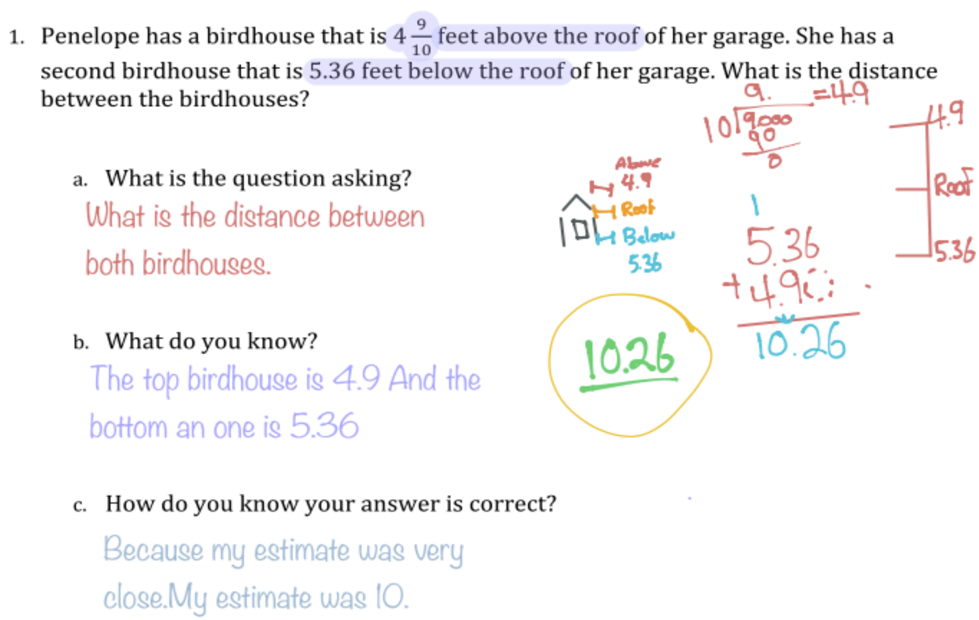
"Penelope has a birdhouse that is $4\frac{9}{10}$ feet above the roof of her garage. She has a second birdhouse that is 5.36 feet below the roof of her garage. What is the distance between the birdhouse?"

Figure 9: Word Problem without Teacher Guidance

After posting this question as a document in student's Schoology, I read the problem out loud to students twice. Then, I asked students to individually read the problem and answer the first three questions of their organizer by themselves. Once they had done this, I then asked them to join with their group members to discuss their approaches.

I walked around to monitor how students were doing and listening to their collaboration. Almost immediately, after reading through the problem, I saw hands go up in the air. All of my students were asking the same questions, "What do we do with a decimal and a fraction?" I looked at them and asked them to look around and then said, "Are you sitting alone?" The students looked at me funny, knowing they were not sitting alone. I said, "Are you working in groups or you working individually?" One student, Jerry, stated, "We are working in groups." I said, "Yes, that's what I thought! So, let's rely on the help of those around you to help you get through this problem." I reminded them of our famous rule, "Ask three before me." This rule meant that students should always ask at least three other students when they are unsure before approaching the teacher. Once I stated this to students, they were forced to become less reliant on me and more reliant on those students around them. The students in my class were not thrilled with my response and as expected they became easily frustrated when they did not know how to instantly solve a problem. This was the issue, students were used to applying algorithms and formulas in the sequence they learned them, so that when students were exposed to a problem outside their realm of recent understanding, they would instantly give up. I needed to continue to instill in them that there was not always one correct way to solve a problem. That problem solving was a process of defining the problem, strategizing, being wrong and trying again, persevering in instances when problems were hard.

Students resumed working in their groups. It was evident that they had understood what the question was asking, as I noticed many of them were able to answer the first question, "What is the question asking? (Figure10).


1. Penelope has a birdhouse that is $4\frac{9}{10}$ feet above the roof of her garage. She has a second birdhouse that is 5.36 feet below the roof of her garage. What is the distance between the birdhouses?

a. What is the question asking?

What is the distance between both birdhouses.

b. What do you know?

The top birdhouse is 4.9 And the bottom an one is 5.36

c. How do you know your answer is correct?

Because my estimate was very close.My estimate was 10.

Figure 10: Example of Completed Organizer without Teacher Guidance

As I continued to look at this group's organizer, I had noticed that they group highlighted important information in the word problem, as well as remembered our class discussion about the benefits of drawing a picture to understand the problem (Figure 10). One student in the group, McKenna said, "Guys, I don't think that answer is right, because there is no way the two bird houses are one foot apart, the one birdhouse is up here and the other is down here." Dakota said, "This is easy, if one is about four feet, which is actually closer to five feet with the fraction and the other is 5.36 feet away, then really the two birdhouses are on top of each other, it is less than 1." McKenna, as a response to Dakota's comment said, "I don't know if that is right, looks at my picture, the birdhouse is above the roof and the second birdhouse is below the roof." The students in her group began drawing a picture like she had drawn (Figure 10).

Dakota, once seeing the picture McKenna drew, stated, "Oh, I didn't realize the other house was under the roof, that makes sense." Despite Dakota's incorrect thinking, he was not afraid to re-vise his thinking once he had seen McKenna's explanation. I commended Dakota for his ability to use his number sense to estimate the answer, despite his incorrect answer. The students in that group had differed in their approach, but their ability to work with another toward a solution was amazing! Some of them had not drawn a picture and did not understand right away that one of the birdhouses was not directly under the other one, rather that the roof represented "0" and the other birdhouse was much further away. At this point, walking around the room, I noticed many of the groups thinking were aligned with how Dakota first saw the problem. I did not want to step in and explain why the answers that student groups were agreeing on was incorrect. In response to this, I had McKenna, the student in the other group who drew a picture, come up to the board and explain how she went about solving the problem. McKenna connected to the Apple T.V. in my room and displayed her organizer, as well as her drawing. She walked students through the organizer herself and explained her thinking. Immediately after her explanation to the class, students began erasing their answers and fixing the work on their paper.

McKenna was not the type of student who liked to raise her hand, let alone speak out in front of the class. Therefore, today was a huge moment for her, being able to stand in front of the class and explain her thinking. She showed she was confident in her answer and her chosen strategy for solving. This confidence allowed her to be able to speak to her strategy for solving the word problem. I was very proud her of and I had hoped to see her confidence grow, as well as see other students take an initiative to solve problems, as well as explain and justify their solutions to the class. I considered this day in our classroom a positive step in the right direction in terms of preserving through the problem solving process. I saw that student engagement was high, students were feeling more positive about their problem solving abilities, and their confidence was improving. I was hoping to see this continue throughout the study.

A Step in the Right Direction

Each time I provided students with a word problem, I incorporated ways to show them different ways for solving, whether it was drawing a picture, guessing and checking, working backwards, or making an organized list. It was important for my students to being using these strategies consistently in order for them to properly use them; opportunity to put them into practice was key. Each time we worked at a problem, I reiterated to them the importance of strategy and taking their time, versus giving up when they did not know what to do. In addition, the word problems I provided to students always incorporated the names of the students who were in my class. By incorporating their names into the problems, I saw more motivation for students to buy into the problem solving process. They were interested to see how the problem turned out and if the problem compared two people in the class; they were even more interested to see the result of the problem. This, combined with providing my students with questions to guide them cognitively through the problem solving process gave students the motivation and tools they needed to be successful, or at least start on a problem before giving up.

As the weeks progressed, with each problem we approached, students showed frustration, mostly in their words, small complaints here and there about how hard the problem was, but they did not easily give up, they tried, and even when they failed, they revaluated their answers, corrected their errors, and tried something new. Over time, they became quicker with picking out information in non-routine problems and actively engaged in the process of solving and explaining their thinking.

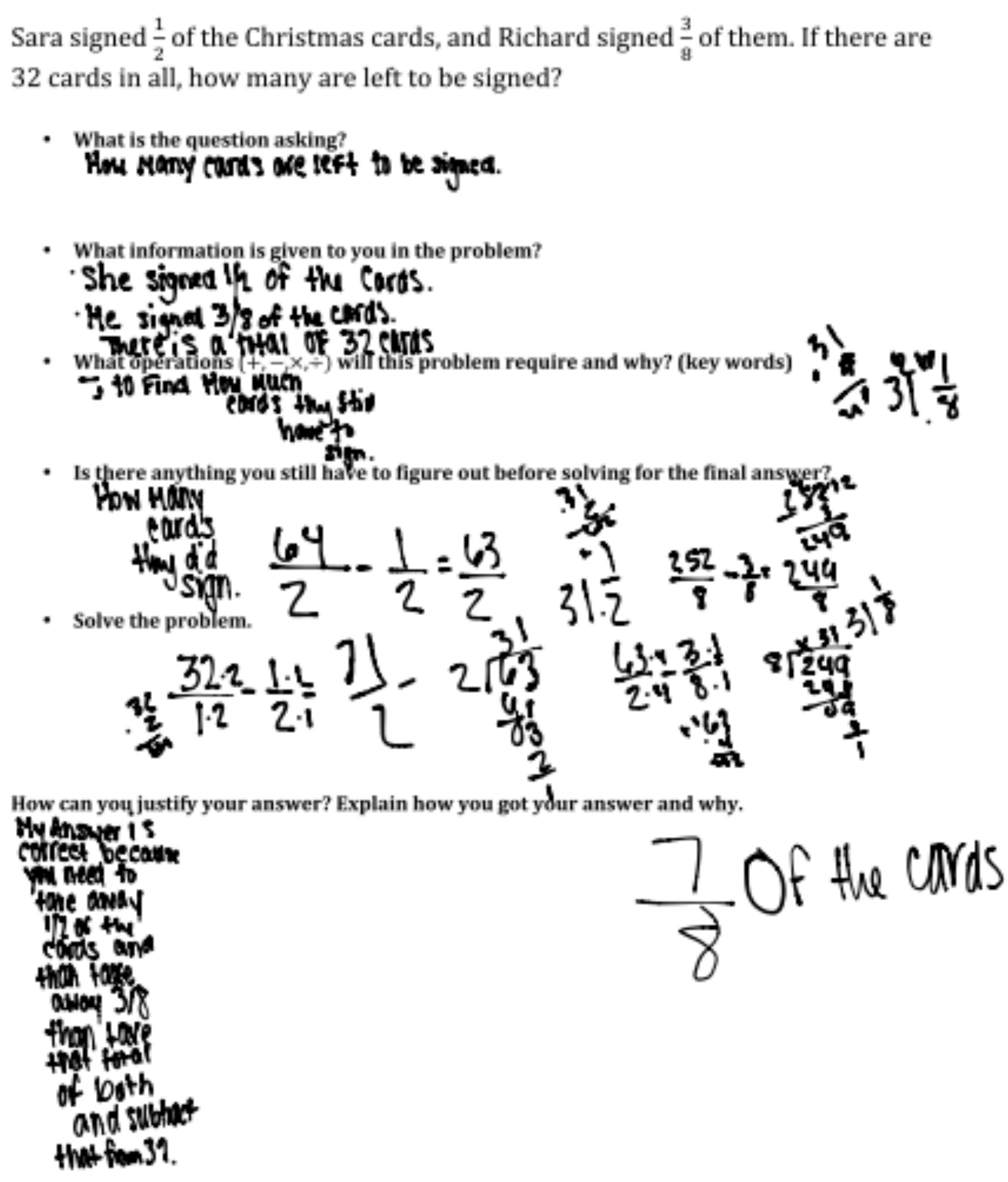
Non-Routine Problem Solving.

Over the next few weeks, each problem provided to students reflected growth in terms of my student's abilities to complete the organizer of questions, which is reflected in the rubric (Appendix C., section ii) I used to score each of the students organizers. I could see and measure which of my students were becoming stronger in explaining their reasons behind their chosen operations, as well as their justifications for their chosen strategies. My students were also becoming vocal in asking other students how each of their answers made sense (Figure 11)

> "*Sara signed ½ of the Christmas cards, and Richard signed 3/8 of them. If there were 32 cards in all, how many cards are left to be signed?*

Figure 11: Problem Solving Example #3

Students responded with answers such as "7/8 cards" and "26 cards (Figure 12)" One student, Mary, turned to two students in his group, Andy and Cody and while pointing to her organizer (Figure 13) asked, "How could it be 26 cards when there were only 32 cards to begin with and we know that Sara signed half of them, that means at least 13 cards were signed and 32 minus those 13 is greater than 26. How can you have 7/8 of a card to sign?"


Sara signed $\frac{1}{2}$ of the Christmas cards, and Richard signed $\frac{3}{8}$ of them. If there are 32 cards in all, how many are left to be signed?

- What is the question asking?

  How many cards are left to be signed.

- What information is given to you in the problem?

  · She signed 1/2 of the cards.
  · He signed 3/8 of the cards.
  There is a total of 32 cards

- What operations (+, −, ×, ÷) will this problem require and why? (key words)

  − to find how much cards they still have to sign.

- Is there anything you still have to figure out before solving for the final answer?

  How many cards they did sign.

- Solve the problem.

How can you justify your answer? Explain how you got your answer and why.

My Answer is correct because you need to take away 1/2 of the cards and than take away 3/8 than take that total of both and subtract that from 32.

7/8 Of the cards

Figure 12: Example of Incorrect Solution to Word Problem #3

Sara signed $\frac{1}{2}$ of the Christmas cards, and Richard signed $\frac{3}{8}$ of them. If there are 32 cards in all, how many are left to be signed?

- **What is the question asking?**

How many Cards are left to sign

- **What information is given to you in the problem?**

Sara = Signed ½ the cards
Richard = Signed 3/8 the cards

- **What operations (+, −, ×, ÷) will this problem require and why? (key words)**

- **Is there anything you still have to figure out before solving for the final answer?**

- **Solve the problem.**

$\frac{32}{1} \cdot \frac{1}{2} = \frac{16}{1} \cdot \frac{3}{8} = \frac{6}{1}$

$32 - 6 = 26$ cards left

How can you justify your answer? Explain how you got your answer and why.

Justify	Explanation
$\frac{32}{1} \cdot \frac{1}{2} = \frac{16}{1} \cdot \frac{3}{8} = 6$ (half) 26 Key word(s): Of & left.	First, I know that Sara signed half the cards which means that half of 32 is 16 , so Sara signed 16 cards. Then, of the 16 cards Richard signed 3/8 which left us with Richard signing 6 cards. Lastly

Figure 13: Mary's Graphic Organizer for Word Problem #3

Mary had a point and it was clear she thought about the answers that her peers gave when solving. She was not condescending in her approach to questioning their answers either. She was talking reasonably with them. Both Andy and Cody laughed as they realized how much sense Mary's reasoning sounded. Andy responded, "You're right, unless I cut a card up in pieces…I cannot have 7/8's of a card." It was clear that despite their justification and work, they had not taken the time to check the sensibility of their answers (Figure 12).

Rising to the Challenge

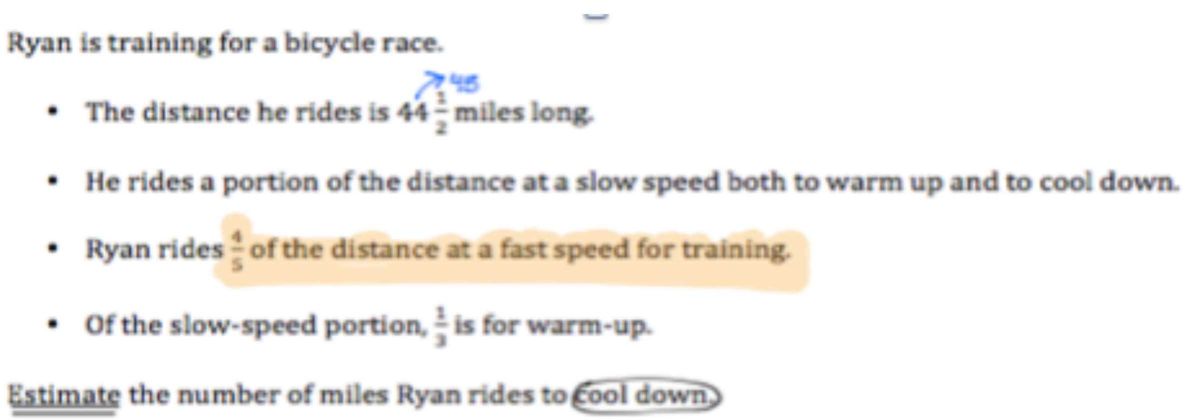
One of the defining problem solving moments in our classroom occurred when I provided students with a word problem with multiple operations. This word problem, although it included rational number operations, a topic we were currently studying, challenged students to understand the key words in the problem and apply multiple computations. I allowed students to use a calculator, as I felt their strategies for solving were more important than the computation that came along with performing the operations. I listened as students solved the following problem (Figure 14)

> *"Ryan is training for a bicycle race. The distance he rides is 44 ½ miles long. He rides a portion of the distance at a slow speed both to warm up and to cool down. Ryan rides $\frac{4}{5}$ of the distance at a fast speed for training. Of the slow-speed portion, $\frac{1}{3}$ is for warm-up. Estimate the number of miles Ryan needs to cool down."*

Figure 14: Problem Solving Example #4 Multiple Operations

I walked around and listened to the students talk about the problem. They were clearly overwhelmed by the amount of information given to them in the problem, but they did not seem resistant to beginning the problem or vocalizing how difficult it was, let alone giving up right away.

I watched and listened to Mary speak to her group, “Guys, we can estimate the 44 ½ miles to 45, that makes it easier to think about.” I saw her entire group cross out the miles and replace it was with 45 (Figure 15).


Ryan is training for a bicycle race.

- The distance he rides is $44\frac{1}{2}$ miles long. 45
- He rides a portion of the distance at a slow speed both to warm up and to cool down.
- Ryan rides $\frac{4}{5}$ of the distance at a fast speed for training.
- Of the slow-speed portion, $\frac{1}{3}$ is for warm-up.

Estimate the number of miles Ryan rides to cool down.

Figure 15: Mary’s Graphic Organizer for Example #4

I then saw the group members highlight the numbers in the problem and discuss problem (Figure 15). McKenna read the questions in the organizer out loud, she stated, “The question is asking us how many of the miles were cool down miles.” Then, students in her group began writing down what she had said, all in agreement. Dakota took over and without having to read the next question since he was had grown used to the organizer, said, “Well, we know that he rode about 45 miles and 4/5 of those 45 miles were fast miles, but then 1/3 of the miles were slow." His group listened and actively wrote down the "known" information. Forrest, the other group member said, "I see the word "of" and that means multiply." Halle said, "Oh yeah, Miss G, of means multiply, right?" Halle, although she had agreed with Forrest, wanted confirmation from me as to whether or not her group understood the word problem correctly. I turned to her and said, "Halle, it depends, why could it mean multiply in this problem?" Mary looked up and me and said, "Well, he is doing pieces of these miles in his total amount of miles, so it's a part of the entire amount of miles." I said, "Exactly, the word "of" in this case means a part of the whole, which would require you to multiply." The group began to circle or write down the multiplication sign for the next question, followed by the use of the word "of" as their justification for the operation (Figure 16).

McKenna finally came out from her silence and said, "We still have to figure out how many miles were slow miles before we find out how many of those miles were cool down miles. We should draw a picture." McKenna had shed light on the piece of information the group still needed to figure out, filling in the next piece of the organizer. She also demonstrated once again that drawing a picture could be helpful to better understand the problem. She drew the picture in front of the entire group and explained how she was labeling it. Mary followed along and drew a similar picture (Figure 17).

Ryan is training for a bicycle race.

- The distance he rides is $44\frac{1}{2}$ 45 miles long.
- He rides a portion of the distance at a slow speed both to warm up and to cool down.
- Ryan rides $\frac{4}{5}$ of the distance at a fast speed for training.
- Of the slow-speed portion, $\frac{1}{3}$ is for warm-up.

Estimate the number of miles Ryan rides to cool down.

- **What is the question asking?**

  Ryan's cool down miles

- **What information is given to you in the problem?**

  -Rides 45miles
  -4/5 of the 45miles is fast
  -1/3 of the slow miles is the cool down

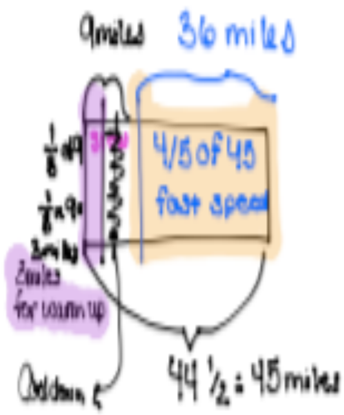
- **What operations (+, −, ×, ÷) will this problem require and why? (key words)**

  X: "of"

- **Is there anything you still have to figure out before solving for the final answer?** -fast miles?
  -Slow miles?
  -Cool down miles?
  -Warm-up miles?

Figure 16: Mary's Graphic Organizer for Example #4 Part 2

- **Solve the problem.**



- **How can you justify your answer? Explain how you got your answer and why.**

The way that I got my answer is first you would make 44 1/2 45 because you are dealing with whole numbers. The the slow amount of numbers is 9 miles then the fast speed amount is 36 miles then you would subtract the 36 from the 9 and get 27. Then you would take the slow amount of miles and do 1/3 times 9 and get 3 miles and do 9-3 and get 6 miles for the cool down amount of miles.

Figure 17: Mary's Graphic Organizer for Example #4 Part 3

The group members around her watched, not trying to copy her drawing but focusing on her drawing and explanation. By this time, they were able to solve the problem together, all using McKenna's drawing. I watched them intently, amazed by the collaborative effort and their excitement. McKenna raised her hand and called me over. She said, "Miss G, is the answer 6 miles?" I looked at her, smiled, and said, "Awesome job!" She looked at her group and said, "Lit!" Her group members repeated her phrase and began saying "Lit, that was lit!" I wasn't sure what this meant, so I turned to her and her group and said, "Lit? What does that mean?" They all laughed and smiled and McKenna said, "Miss G, c'mon you don't know?" They seemed embarrassed by the fact that they used that phrase in front of me. Another student said, "Miss G, it means that something is lit, it is cool!" I came to find out that "lit" was the new phrase students were using to describe a situation that was awesome, which was quite a change from when McKenna previously described problem solving as something that belonged in the trash. Problem solving in the classroom had gone from trash to "lit" in a 10 week time period.

When it came time to justify their answer to the problem, as well as explain how they arrived at their answer, I saw each of them individually take to their own organizer and begin the explaining process. They were all on the same page.

When it came time to share out, I had McKenna display her organizer on the Apple TV the airplay to show everyone. She was feeling more and more confident; I wanted to continue to build on that. Her group stood beside her and chimed in to help explain the steps to solving. They were all proud of themselves, having persevered through a very difficult problem. They did a wonderful job explaining their thinking and justifying their answer.

I continued to provide problems to students over the course of this action research project. I watched students persist when problem solving. I watched my students stick with a problem, deal with the parts of the problem that were unclear to them and work through the problem with their peers. I continued to ask students how they were feeling about their ability to problem solve throughout the study. The students were expressing they felt more confident over time. I faced less and less resistance when solving word problems as students were exposed to problems on a daily basis. Students were less vocal about not knowing where to start and not knowing what to do and more engaged in answering the questions to the organizer. They had a place to start and a group of students to collaborate and work through the problems with. We addressed a problem a day and problem solving became a normal activity in our classroom and still is to this day.

DATA ANALYSIS

A variety of data sources were collected for this study. Each data point served a purpose, and was meant to demonstrate the focus group's feelings, capabilities, and growth in regards to persevering through non-routine word problems in a 7th grade math class. When the data sources were collected and reviewed, I was able to gain a clear understanding of the impact of my organizer on my students' abilities to start solving word problems that were unclear to them and then collaboratively solve them as well as the impact on their attitudes toward problem solving.

Surveys

When I first started my action research, I administered a pre-survey (Appendix B., section i) to students to gauge their feelings on problem solving and their knowledge of strategies for solving word problems. It was evident in the first survey that many of my students, 9 out of 17, did not believe in their abilities to solve word problem, as they circled the "rarely" response to "if I am given a word problem quite different from examples in the book, I can figure it out myself." Therefore, when faced with non-routine problems in the beginning of this action research project, it was not surprising that many of my students complained about the difficulty of the problem, followed by expressing how they did not know what to do. Many of the students wanted to give up much more quickly, which contradicted their responses to the survey. Another interesting finding in the first survey was that when asked to respond to the statement, "When I have finished working a problem, I check my calculation for errors" 7 of the students stated that they "always" and "usually" check their calculations and asked to respond to, "When I get the answer to a problem, I look back at the problem to see if my answer made sense" 13 of the 17 students responded with an "always" or "usually" response. Contradictory to this, in the beginning and even through the middle of this action research project, I found that many students were unable to successfully fill out the portion of the organizers that asked them to explain how they checked or made sense of their answer. In fact, when I provided a word problem with the Christmas cards, student responses such as "7/8 cards" and "26 cards" clearly had not been checked or reviewed in terms of sensibility. It was evident that despite saying that they checked their calculations, many of them did not know how or did not actually do this. In terms of student's attitudes about problem solving, the pre-survey showed that more than half of my students did not feel confident in their ability to solve math word problems, but that students were interested in becoming skilled at new strategies for solving problems in math, and all of the students responded with either "always" or "usually" with regard to feeling accomplished when they solved a math word problem correctly.

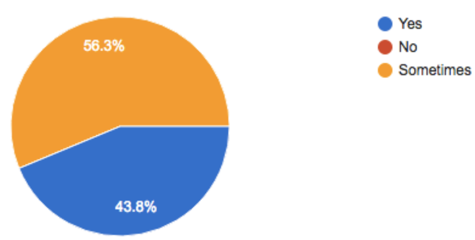
Halfway through the study, once students had been exposed to the organizer of questions and the problem solving process, I had administered the mid-survey (Appendix B., section ii) to students. This survey was given to students in October. I decided to change the responses to some of the survey questions to get more definitive responses from students. The survey response questions included yes, no, or sometimes response options.

The mid-study survey was the most telling of the progress that was taking place in action research project. All of my seventeen students responded "yes" to the question of "when solving math word problems, I know that it is not easy, but I am growing more confident in my ability to read and worth through problems," demonstrating that all of my students understood that solving math word problems was not an easy task, but were growing more confident in their ability to work through the problems. In addition, all of my seventeen students responded "yes" to question #7 and #8. Students were feeling more comfortable with word problems because they were a part of students' daily routine inside the classroom and they were feeling more confident in their ability to become better at solving word problems. It was clear through the mid-study survey that all students were on board in feeling that daily exposure to word problems made it less scary for them to solve problems and that they were growing more confident in their ability to work through word problems.

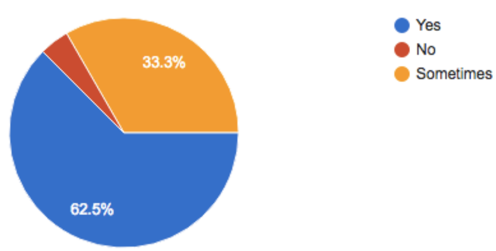
Finally, in December, I administered my post-survey (Appendix B., section iii) to students. I modified the questions a bit, but still kept the same "yes," "no," and "sometimes" response. The only exception was the last question in which students had to explain their response for choosing yes, no, or maybe. The best way to represent this data is by the use of circle graphs (Figure 18), because in the beginning of this action research project, over half of my students felt less than confident in their abilities to solve math word problems. Now, having read and completed over forty word problems since the beginning of this project, students' responses are reflective of the great change this action research project provided to them as a result of problem solving on a daily basis with the use of a graphic organizer. Now, over half of my students showed that they were in fact feeling more confident, did not give up quite as easily, used their peers to help guide them, relied on the on the graphic organizer to guide them through the problem solving process.

Throughout the surveys (Appendix B), I was able to determine whether or not my students felt an improvement with regard to their attitude toward problem solving, how they felt the organizer of questions helped them to be successful when solving, and how collaboration with their peers supported their problem solving abilities. Over 85% of my 17 students felt that that help of their group members, along with my support helped them to be more successful when solving the warm-up word problem. In addition, 75% of my 17 students responded that they felt it was helpful to work with others especially when solving a problem that was not familiar to them, which was a significant changed compared to the first survey when over 50% of them felt they were not confident in solving problems that were unfamiliar to them. Finally, 15 of the 17 students, 88% of students responded to the final question with a yes, demonstrating that by the end of this action research project, they felt both the collaboration of their peers and the question organizer helped them to be successful when solving word problems. One of the students specifically stated how the organizer helped her to begin the problem and work through the steps for solving (Figure 18).

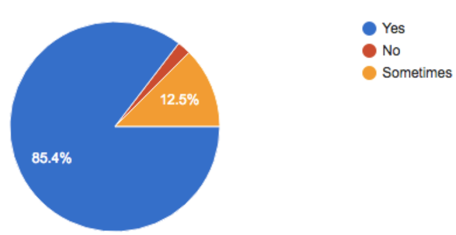
1) When I am confused or stuck on a math problem, I try different strategies to solve and I try not to give up.



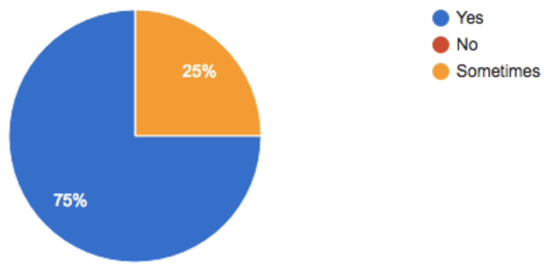
2) The word problems I was asked to solve on a daily basis challenged me to think.



3) If I did not understand the warm-up problem the members in my group, along with my teacher, would help guide me.



4) The math word problems sometimes were about topics in math that I knew about and at times they were sometimes about topics I had barely learned about, but with the help of my peers, I was able to successfully solve the problems.



5) Do you believe you're better at problem solving as a result of the daily word problem warm-ups that included the question organizer, as well as being able to work through the word problem with your peers?

Yes because I have learned that if one way doesn't work there are other strategies. By learning multiple ways I have learned that you can solve a problem in more than one way and that if something is wrong I try my other strategies.
Yes, because the daily warm ups to think about what you are doing.
Yes I am because if I get one wrong my friends and teacher would guide me
Yes, we do them every day at the start of class so I think I got better at problem solving
Yes because each time I figured out how to do something and if I got it wrong I would know why and know how to not make that mistake again.
I am better at problem solving because we have tried many different ways to help me understand it.
Yes because they get me started on how to do the problems and the steps you use to get through them
Yes. Within doing this I learned how to do certain math problems I didn't know how do solve before
No, because word problems over complicate the problem that is to be solved.
Maybe because some are really hard and some of them are easy
Yes because it help me think
Yes, because they sometimes have word problems I have never encountered, so it helps when my teacher guides me through it.
I am better at problem solving because we have tried many different ways to help me understand it.
Yes, because it is a nice practice to see different ways to solve problems.

Yes the warm has higher order thinking questions that have me think
Yes because They are becoming easier every time that I do them.
Yes because it challenged me to think and try harder.

Figure 18: Post-Survey Results with Circle Graphs

Field Log

Over the course of the study, I kept a double-entry journal in order to keep track of my own thoughts, beliefs, reflections, and questions about ways in which the question organizer was altering learning in my classroom with regard to my students success when solving math word problems. On a daily basis, I would park myself in a seat in the middle of the room and I would open my laptop to my field log and begin to type out the words and dialogue of my students as they discussed the word problems and engaged with the graphic organizer. I would move around the room from group to group to do this. I was able to capture misconceptions, justifications, students questioning the strategies of other students, and after the students presented their answers, I would go back to the field log when class ended and add any important reactions that occurred since putting my laptop away. By keeping a daily field log, I was able to come to important conclusions about my students learning with regard to the question organizer. I kept track of my goals for student learning and reflected on the goals for my project on a daily basis.

In addition to the field log writing I compiled during my study, other pieces of reflection that were key to my understanding of how my study was developing and where it was going was the writing up of my mid-study methodological memo. This memo was a piece of writing that I was asked to complete during my action research course in October. It was a writing piece that required me to look at the data I had collected halfway through my action research project and construct a preliminary analysis on the amount of data I had collected. It helped me to narrow in on important insights I had gained up to that point and to decide on my future plan of action with regard to how my students were responding to my study. This memo tremendously helped my research study, as I was able to see the patterns in my students' progress with the question organizer. It also helped to summarize the data I had gathered and helped me to make meaning of its relevance to my study.

As I looked back on my field log and mid-study methodological memo I came to understand important patterns in my study and drew many important conclusions. First, I noticed that students demonstrated that they were more intentional in their ability to chose and justify which operations to use give a specific word problem as a result of working with the graphic organizer. Students went from simply writing the sign of an operation to explaining the reason behind their chosen operation, whether it was by explaining how the problem related to one they solved previously or by providing a key word that signaled the use of a specific operation. In addition, students demonstrated more follow through when it came to completing the guiding questions and solving of the problems. No longer were students just filling in parts of the organizer, they were in fact engaged with every question. They had learned the questions after repetitively using the organizer that working through the word problem and graphic organizer at the same time became more of a fluid process.

Over the course of the project, I found that students were able to move quickly through the questions and spent more time thinking about strategies versus only focusing on what they "didn't know.” Students gained and expressed feeling more confident in their problem solving skills; most importantly they could explain why they felt more confident, versus in the beginning when they wrote things such as "I am confident because I read the problem more than once and can explain what it is asking in my own words” rather than a response in their pre-survey (Appendix B., section i) that stated, “I am confident at problem solving because I know math." Their reasoning had shifted to phrases such as, “I feel more confident because I became better at picking out key words, relating the problem to something I've solved before,” and “I'm now better with drawing pictures to represent what the problem is talking about,” as well as, “even if I am not sure of what to do, I know I can try what I think will work and then work with my friends to see if I was right and fix it if I'm wrong."

Another important conclusion I made from my field log was that students showed more patience with problems and did not simply give up when they did not understand the problem after reading it one time. In the mid-study survey (Appendix B., section ii) that I administered, I noticed that students' dislike for word problems decreased, while many of them cited that they had a more positive attitude when working with word problems. Overall, student's justifications and explanations for their chosen operations and reasons behind their strategy improved with regard to thoroughness in explanation. Students were able to explain their reasons for solving over the time of this research study and were able to do in a more understandable and concise way.

One of the most amazing reflections I had during my study was that students were becoming more successful at being able to solve problems that required them to carry out skills they had never learned. This was possible because I introduced small topics that they knew and provided them with the time to investigate and grow that knowledge. I continually built off of it throughout the week with the problem solving. With my help and scaffolding, my students soon realized that they were able to reach far beyond what they had ever accomplished previously.

To illustrate this, on a Monday, I gave one warm-up word problem that required students to find the circumference of a circular garden; I provided them the 7th grade PSSA formula sheet in this word problem. I also realized that many of my students had no clue what the parts of a circle were, so with my help, I provided them with a 2 minute picture representation of what circumference was, diameter, radius, pi, and how to use the circumference formula. We solved the problem together and then moved on to the content scheduled for that day in class.

On Tuesday, I had them solve a word problem that asked them to find the distance a person would travel when sitting on a Ferris wheel for one rotation. Again, same concept as the warm-up word problem given to students the day prior, but worded differently. No explanation was given, but a formula sheet was provided. Students were able to successfully demonstrate that the distance around the Ferris wheel mirror the term “circumference” and using the diameters of the Ferris wheel students were able to find the distance of one rotation.

By Wednesday, I had given my students the circumference of a garden and asked them how far someone would have to walk to get from one side of the garden to center, asking them to find the diameter of the garden. This time, using the same formula, they had to manipulate it find the radius, which was good, because we just had finished solving one-step equations. They need small instruction but it was basically a smooth problem solving process. They were more familiar with the terms and formula.

By Thursday, students were given the circumference of a patio and asked to find the distance across, enforcing Wednesday's warm-up, but careful reading was reading was required, as the word circumference was not used, rather it was used as "distance around."

Finally, on Friday, with no help from me, they had to find out if two circles with a certain diameter could be cut from a piece of paper, bringing in the need to find area of the paper and the circles, multiple operations. Also the introduction of the area formula for circle. This went extremely well, as students were interested in learning more about circles and solving for the final answer. They were motivated because this was a newer topic to them and they wanted to find the correct answer.

It was evident that my students had gained more knowledge about a topic completely unfamiliar to them with the help of my scaffolding, the organizer of questions and the support of their peers. My students were amazed by their own abilities to solve circle problems by the end of that week. Therefore, because of the gradual introduction of circles to students, using content students had little knowledge of, students made incredible discoveries. Again, these were not topics covered in class. The field log of these findings were imperative to my study and helping me to understand the patterns and learning with regard to solving math word problems and the motivation amongst my students.

Analysis of Student Artifacts through a Rubric

From the beginning to the end of my study, I collected all word problems that students solved by having them submit their work on our school platform called Schoology. I was able to see how students changed from the beginning in terms of their ability to follow the question organizer to the end. Students were given a word problem daily, which means they used the organizer of questions and worked with their peers to collaboratively discuss their strategies for solving and then solve the problem. I evaluated each warm-up word problem that students turned in by following a scoring rubric (Appendix D). I created a rubric (Appendix D) and scored the warm-ups on a 5-point scale. Students received one point for being able to re-state the problem in their own words and re-write it accurately according to what the question was asking. Students received one point if they could provide which operation or operations to use and provide a supporting sentence behind their choice. Students received one point for recording the given information in the problem, another point for showing their work in solving the problem and finally another point for justifying their answer and explaining the steps they went through to solve. In the beginning of my study, after handing out the new, revised graphic organizer (Appendix C., section ii), I showed the students how I would be scoring their organizers by providing them with a copy of the rubric (Appendix D). 60% of my students did not receive over a score of a 2 on the rubric. By the mid-study survey, 74% of my students were scoring a 3-4 on the rubric. By December, the end of my study, 82% of my students scored anywhere between a 4-5 on the rubric.

Analysis of Data through Coding and Bins

In order to code my data, I read through my typed field log and annotated the margins of each page using a color-coded system to mark specific words and phrases related to a specific action. I was looking for actions that supported themes in my study such as, student process, student perceptions, collaboration, justification, confidence, and student strategies.

Once I had coded all of my data, I began to read through my codes and group them into bins (see Figure 19). Ultimately, six categories came to the forefront of my study. Each of the bins represented the related data over the course of the study. The bins showed different effects of using the question organizer and engaging in collaboration with peers when problem solving. The bins and codes have been expressed in a graphic organizer to represent the themes represent within my action research study.

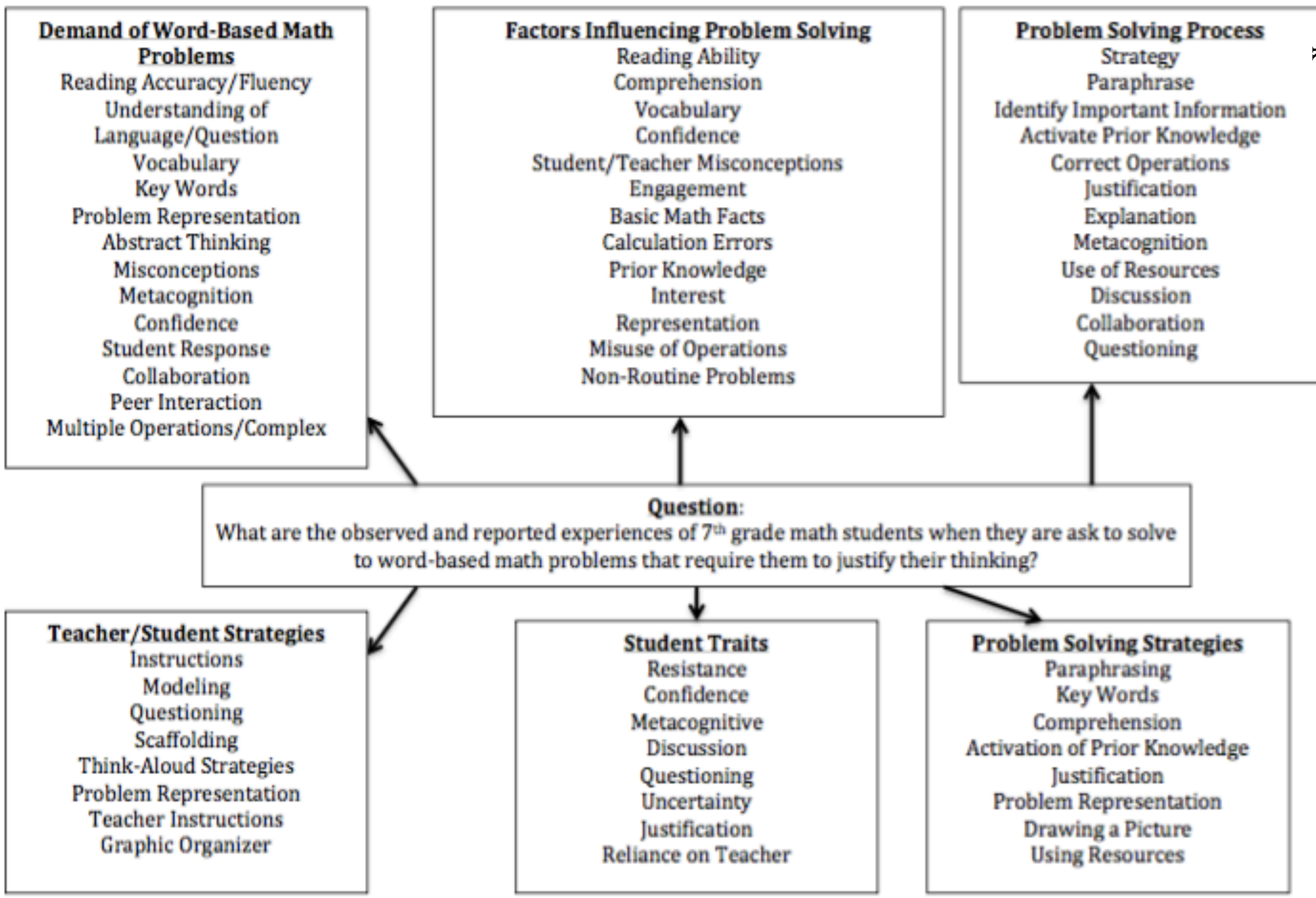


Figure 19: Codes and Bins

RESEARCH FINDINGS

The purpose of my research study was to help my students slow down when solving math based word problems, as well as to feel more confident in their ability to solve word problems using the graphic organizer. In addition to slowing down their problem solving process, it was also my goal to ensure that my students would be able to actively engage with others when solving and justifying their solutions. This study was designed because each year, I continually see my students rush through the reading of a math-based word problem and jump right into problem solving. More times than not, the students incorrectly understood what the question was asking of them and usually solved them in a way that best fit their own thinking versus the thinking required from the problem in front of them. The following theme statements represent the findings of my action research project, which were present in my students' surveys, their graphic organizers, their dialogue, and my double-entry field log journal.

Problem Solving Strategies

When solving word-based math problems, students must be flexible in their approach. Students need to be encouraged to develop and discover their own problem-solving strategies, including identifying important information, and trying a strategy while working in collaboration with others to justify and to explain their thinking.

Exposing students to daily math word problems was important to the non-routine problem solving process that we want all students in our classrooms to be successful with. Most of the time spent in math classrooms revolves around learning a new skill and applying that skill to solve word problems related to only that one isolated skill. This type of opportunity for teaching students problem solving is not conducive to the outcome of having mathematically proficient students. This leaves students reliant on the teacher direct instruction and less flexible in their thinking.

When providing my students a the graphic organizer of questions, it was clear in the beginning of my action research project that many of them did not see the value in having to answer all of the questions. They would much rather be told what to do and how to solve a problem, versus having to apply too much effort to worth through a more complex problem. They needed encouragement from both myself and those in their group to push through the organizer, as the organizer helped them to see important information given in the problem. Once pulling out and re-phrasing the problem in their own words, students felt more confident in their ability to begin the problem. As students began to work with this organizer on a daily basis, the process of filling in the organizer became a much easier task. Students were able to engage in more meaningful conversations with their peers and make comparisons about important information from the problem and devise ways to solve the problem. The conversations became less about how difficult the problem was and became more focused on discussing strategies and justifying their thinking with one another.

Paul Friere (1970) reminds us in his writing that, “knowledge emerges only through invention and re-invention, through restless, impatient, continuing, hopeful inquiry, human beings pursue in the world, with the world, and with each other (p.72).” In the beginning of my study, when students were struggling with word problems, they were likely to give up rather quickly when they chose the wrong operation or realized that they had solved the problem incorrectly. Most times, my students would not make a second attempt at the problem, but would wait for me to go over the answer or would wait until they heard the answer from another student. I allowed my students more time to work through the problems, meeting the needs of both my fast and slower learners. Providing the time for my students to solve problems gave them the opportunity that they needed to go back to the wording within the problem, and when they did not get it right, they had the chance to continue to re-think about the problem in front of them and devise a new way of solving, while working with their peers.

Student Traits

Students are often frustrated when it comes to solving non-routine word based math problems. Often times, students have not mastered the knowledge of basic facts, which poses a problem to their basic problem solving techniques and strategy.

According to Dewey (1938), “if an experiences arouses curiosity, strengthens initiative, and sets up desires and purposes that are sufficiently intense to carry a person over dead places in the future, continuity works in a very different way…Every experience is a moving force. Its value can be judged only on the ground of what it moves toward and into (p. 38).” Many students do not find interest in all subjects and content they cover throughout their education and this puts them in a place where they feel unmotivated and without a desire to learn. In order for students to find meaning and feel the desire to learn no matter what the content may be, educators must understand each learner as an individual and help to make sure each student makes meaning of their learning in order for them to continue the desire to learn throughout their lives. My action research project has everything to do with Dewey’s quote because many of my students became easily frustrated when they began to deal with word problems. Many students did not understand what questions they are being asked when problem solving and they became easily frustrated when asked to compute using multiple operations and strategies. Most of the time, when they became frustrated, they just want to be done with the problem and move past it. They have little or no desire to express their thoughts or strengthen their skills related to problem solving and this becomes a “dead place” when it comes to their future with regard to any situation that requires them to problem solve.

Demand of Word-Based Math Problems

Solving math word problems is a challenging task for students in all grades, requiring that they know how to read, comprehend what they have read and apply their learned knowledge to problem solve. Students become easily frustrated when solving math word problems, which lead many students to feeling less confident and afraid of solving word-based math problems.

Through my action research, I saw my students gain the confidence they needed to become more curious about ways to solve problems and to become better problem solvers, which aided in their ability to see how learning problem solving strategies can be meaningful to them and help them to overcome any obstacle they come across. My action research project created the opportunity for my students to engage in the mathematical problem solving in the most productive way possible.

Most importantly, Vygotsky (1978) reminds any teacher in the classroom that, "it is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers (p. 86)." Although, I was always pushing my students to monitor their thinking when problem solving, as well as become more confident when solving problems on their own, I recognized that in order for them to gain knowledge when problem solving they needed me and their peers to be a part of the process. When students were problem solving, I interacted with them and provided them with the appropriate assistance that would give them the boost they need to complete the problem they are solving. I provided them with scaffolding questions, asking them to re-phrase the question or pointing to important information in the problem. I provided my students with the opportunity to work with their peers and discuss their methods for solving problems, which helped all of them to gain different perspectives about how to approach and solve the problem. (When I provided students with my knowledge and allowed them to interact with the knowledge their peers possessed, they gained a deeper understanding and were able to reach a zone of development that they would not have been able to reach alone and as a result, each became better at problem solving.)

Teacher Strategies in the Problem Solving Process

When helping students solve word-based math problems, the teacher must model and explain to students how to go about the process, asking students to articulate their problem solving process, as well as providing students with encouragement and positive reinforcement throughout the process.

My thorough reflection on my field log through my entire action research project has shown me that with my guidance and modeling, students can be successful at pulling out important information within a word problem and re-phrasing the question in a way that makes sense and relates to what is asked of them. Further, that by identifying important information within a word problem, students who typically would give up now know where to begin, they finally had a starting point. That small piece of hope allowed my students to not feel completely defeated by the amount of information they faced after their first read through a problem. By allowing my students to work collaboratively with other students, they were able to further pick apart at what the question was asking of them and begin solving. With my assistance and feedback as my students engaged in this process on a daily basis, students gain confidence and did not feel so helpless when faced with a problem unknown and non-routine to them.

Next Steps

I will continue to use this graphic organizer in my classroom on a daily basis, as I have seen that the students find it helpful to use when engaged in the problem solving process. Yet, I find myself questioning whether or not my students will transfer and use this learning tool when solving math word problems in the future, especially when I am not there to provide them with the graphic organizer. I am now in search of a way to ensure that this learning transfers. If I could re-do this project, I would take the time to develop a meaningful acronym to help students remember the steps to this solving process when faced with word problems. I would also want to develop this acronym with my students, that way the students are able to make a connection with the meaning behind the acronym. I am working through figuring out the ways to make this graphic organizer a tool that students can use it effectively when they are not given a hard copy of the organizer. In addition to creating this memory tool, I am also looking into ways to share this organizer with other math teachers. I think it is extremely important to align the ways in which the teachers in my district teach word problems, so that when students are faced with them, all teachers can hone in on the same metacognitive tool to help students solve more successfully.

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APPENDICES

A. Consent Forms

i. Principal Consent Form

April 20, 2016

Dear Principal Bernardo,

I am currently taking courses towards a Master's Degree at Moravian College. The courses I have taken are assisting me to successfully implement effective teaching practices, as well as reflection in my classroom. During the fall of 2016-2017 school year, I am required to carry out a systematic study of my own teaching. My action research project will examine the practice of reciprocal teaching with regard to problem solving strategies in the classroom and its effect on student's ability to comprehend multi-step mathematical word problems, while working collaboratively with their peers. Reciprocal teaching is a valuable strategy in the classroom and can ultimately help students across all subject areas when it comes to their reading comprehension and ability to access the text. Reciprocal teaching will help my students to monitor their own comprehension, as well as the opportunity to learn from their peers.

I will be gathering information for my action research study through the use of student surveys, student pre-test and post-test, sample work from my students and observation. All of the students engaged in this action research project will be given the opportunity to provide feedback to me throughout and following the conclusion of the project. I will only use the information I gather from the students from those who have permission to participate in this study. All of the names of my students will be kept confidential, as well as the names of teacher and other staff members. Any information that may reveal a student's identity will be altered to protect anonymity. No names will be included on work samples or in any reports of my study. All research materials will be kept in a secure location in my home and all data that was collected throughout the study will be destroyed at the conclusion of the study. All students will be participating in reciprocal teaching as a part of the regular curriculum. No student will be singled out as a participant or non-participant at any point in the study.

Throughout this study, I am hoping that I see the students in my classroom become more motivated in their ability to problem solve even when the problem gets tough. I am hoping to re-shape their previously held beliefs that math is “too hard” and provide them with a strategy for access text across subjects, not just in mathematics. It is my goal to see that students recognize the knowledge they possess and the skills they already have to be successful in mathematical problem solving.

I will be conducting my research as soon as I am given permission to do so. The only person who will have access to my data will be my graduate professor and Moravian College. All of the students in class will be given parental consent forms to participate in this study. Participation is option and any student may withdraw from the study at any time without being penalized. All my students will be provided with pseudonyms.

If you should have any questions about my research at any time, please feel free to contact me. My faculty sponsor is Dr. Richard Grove. He can be contacted at Moravian College by phone at (610)-861 –1300 or by email at rwgrove@ptd.net

I want to thank you for your time and consideration in this matter. I also would like to thank you for your support in helping me to aid my students in being more successful in their ability to access text and solve word problems through the use of reciprocal teaching.

Please check the appropriate box below and sign the form:

[ ] I give permission to the researcher to conduct the above named research in my school as described in the proposal.

[ ] I do not give permission to the researcher to conduct the above named research in my school as described in the proposal.

____ ____________

Signature of Principal Date

Thank you,

Amanda Giangiobbe
610-730-8236
Amanda.giangiobbe@svpanthers.org

ii. Parent Consent Form

Dear Parents or Guardians,

I am currently taking courses towards a Master's Degree at Moravian College. The courses I have taken are assisting me to successfully implement effective teaching practices, as well as reflection in my classroom. During the fall of 2016-2017 school year, I am required to carry out a systematic study of my own teaching. My action research project will examine the practice of reciprocal teaching with regard to problem solving strategies in the classroom and its effect on student's ability to comprehend multi-step mathematical word problems, while working collaboratively with their peers. Reciprocal teaching is a valuable strategy in the classroom and can ultimately help students across all subject areas when it comes to their reading comprehension and ability to access the text. Reciprocal teaching will help my students to monitor their own comprehension, as well as the opportunity to learn from their peers.

I will be gathering information for my action research study through the use of student surveys, student pre-test and post-test, sample work from my students and observation. All of the students engaged in this action research project will be given the opportunity to provide feedback to me throughout and following the conclusion of the project. I will only use the information I gather from the students from those who have permission to participate in this study. All of the names of my students will be kept confidential, as well as the names of teacher and other staff members. Any information that may reveal a student's identity will be altered to protect anonymity. No names will be included on work samples or in any reports of my study. All research materials will be kept in a secure location in my home and all data that was collected throughout the study will be destroyed at the conclusion of the study. All students will be participating in reciprocal teaching as a part of the regular curriculum. No student will be singled out as a participant or non-participant at any point in the study.

Throughout this study, I am hoping that I see the students in my classroom become more motivated in their ability to problem solve even when the problem gets tough. I am hoping to re-shape their previously held beliefs that math is "too hard" and provide them with a strategy for access text across subjects, not just in mathematics. It is my goal to see that students recognize the knowledge they possess and the skills they already have to be successful in mathematical problem solving.

I will be conducting my research as soon as I am given permission to do so. The only person who will have access to my data will be my graduate professor and Moravian College. All of the students in class will be given parental consent forms to participate in this study. Participation is option and any student may withdraw from the study at any time without being penalized. All my students will be provided with pseudonyms.

If you should have any questions about my research at any time, please feel free to contact me. My faculty sponsor is Dr. Richard Grove. He can be contacted at Moravian College by phone at (610)-861 –1300 or by email at rwgrove@ptd.net

If you approve of your child being a participant in my teacher research, please sign and return the bottom portion of this letter. Thank you for your help.

Sincerely,

Miss Amanda Giangiobbe
610-730-8236
Amanda.giangiobbe@svpanthers.org

I understand that Miss Amanda Giangiobbe will be observing and collecting data as a part of her search on reciprocal teaching in her classroom, and my child has permission to be a participant in the study.

Child's Name:

____

Parent/Guardian Signature:

____

Date: ____________________________

ii. Student Consent Form

Dear Seventh Grade Student,

I am currently enrolled in the Master Program at Moravian College. This fall I will be conducting an action research project for my thesis (which is a study) in which I am hoping that I see students in my classroom become more motivated in their ability to problem solve even when the problem gets tough using a graphic organizer. I am hoping to re-shape previously held beliefs that math is "too hard" and provide a strategy for access text across subjects, not just in mathematics. It is my goal to see confidence levels rise with regard to solving word-based math problems.

During the study I will collect lots of data (student surveys, notes on student engagement and motivation, interviews and samples of student work) to determine whether the graphic organizer was a success.

I am writing to ask permission to use the data I collect from you during this process. This study will help me to become a better teacher and will take place from September 2016 through November 2016. Participation in this project is voluntary, and you may withdraw yourself from this study at any time without penalty simply by notifying me. Participation in this study will not affect your grade. If you have any questions you may talk with me or Mrs. Bernardo, who has approved this study.

Thank You!

Mrs. Giangiobbe
7th Grade Math Teacher

Please check the appropriate box below and sign the form:

o I give permission for my teacher, Mrs. Giangiobbe, to use my data to be in her study. I understand that I will receive a signed copy of this consent form. I have read this form and understand it.

o I do not give permission for my teacher, Mrs. Giangiobbe , to use my data in her project.

Student's Name Student's Signature ___________________________________

Date ___________

B. Surveys

i. Pre-Survey

Pre-Survey

1. Do you feel confident when solving math word problems? **Explain** your answer.

2. List the problem solving strategies that you know when it comes to solving math word problems.

Circle the word in the following statements that closely describe your approach to and attitudes towards problem solving.

3. If I am given a problem quite different from the examples in the book, I can figure it out myself.

   Always Usually Sometimes Rarely Never

4. Drawing pictures or imagining real physical situations helps me to do mathematics.

   Always Usually Sometimes Rarely Never

5. Reading a problem more than once is a waste of time.

Always Usually Sometimes Rarely Never

6. When I have finished working a problem, I check my calculations for errors.

Always Usually Sometimes Rarely Never

7. I stop thinking about a problem after I get an answer.

Always Usually Sometimes Rarely Never

8. When I get the answer to a problem, I look back at the problem to see if my answer makes sense.

Always Usually Sometimes Rarely Never

9. I try to restate a new math problem in my own words.

Always Usually Sometimes Rarely Never

10. I have trouble getting started on a problem that is new to me.

Always Usually Sometimes Rarely Never

11. I enjoy solving problems that require me to figure out my own individual approach.

Always Usually Sometimes Rarely Never

12. I learn mathematics best when someone shows me exactly how to do the problem and I can practice the technique.

Always Usually Sometimes Rarely Never

13. After reading a problem, I try to remember if I have ever done a similar problem before.

Always Usually Sometimes Rarely Never

14. I can think of at least one way to begin to work on a math problem that I have never seen before.

Always Usually Sometimes Rarely Never

15. I focus in math class.

Always Usually Sometimes Rarely Never

16. I make an effort to respond to mathematics questions the teacher asks.

Always Usually Sometimes Rarely Never

17. If I make mistakes in a math problem, I work until I find the correct solution.

Always Usually Sometimes Rarely Never

18. If I can't do a math problem, I keep trying different strategies.

Always Usually Sometimes Rarely Never

19. If I can't do a math problem, I seek help to solve the problem.

Always Usually Sometimes Rarely Never

20. I get good grades in mathematics.

Always Usually Sometimes Rarely Never

21. I know how to solve math word problems.

Always Usually Sometimes Rarely Never

22. I know strategies that can help me solve math word problems.

Always Usually Sometimes Rarely Never

23. I am confident in my math skills and strategies.

Always Usually Sometimes Rarely Never

24. I am interested to become skilled at new strategies in math.

Always Usually Sometimes Rarely Never

25. Learning math is fun for me.

Always Usually Sometimes Rarely Never

26. I feel accomplished when I solve a math word problem correctly.

Always Usually Sometimes Rarely Never

ii. Mid-Study Survey

Mid-Study Survey

1. **When I have finished working through a word problem, I check my calculations for errors.**

   Yes No Sometimes

2. **After reading a problem, I try to remember if I have ever done a similar problem before.**

   Yes No Sometimes

3. **If I make a mistake when solving a math word problem, I work until I find the correct solution.**

   Yes No Sometimes

4. **When solving math word problems, I know that it is not easy, but I am confident that if I read carefully and continue to work through the problem, that I can solve it.**

   Yes No Sometimes

5. **When I finish a word problem, I can justify my answer my explaining how I completed the problems and the reasons behind the steps I chose.**

   Yes No Sometimes

6. **The word problems that we complete for warm-ups help me to learn new strategies to solve**

   Yes No Sometimes

7. **I get more confident every day in my ability to solve math word problems in math**

   Yes No Sometimes

8. **When I get an answer to a word problem, I look back at the problem to see if my answer makes sense.**

   Yes No Sometimes

9. **When solving word problems, I try to restate the problem in my own words.**

   Yes No Sometimes

10. **Drawing pictures or imagine real physical situations help me do mathematics**

    Yes No Sometimes

iii. Post-Survey

Post-Survey

1. When I am confused or stuck on a math problem, I try different strategies to solve and I try not to give up.

   Yes No Sometimes

2. The word problems I was asked to solve on a daily basis challenged me to think.

   Yes No Sometimes

3. If I did not understand the warm-up problem the members in my group, along with my teacher, would help guide me.

   Yes No Sometimes

4. The math word problems sometimes were about topics in math that I knew about and at times they were sometimes about topics I had barely learned about, but with the help of my peers, I was able to successfully solve the problems.

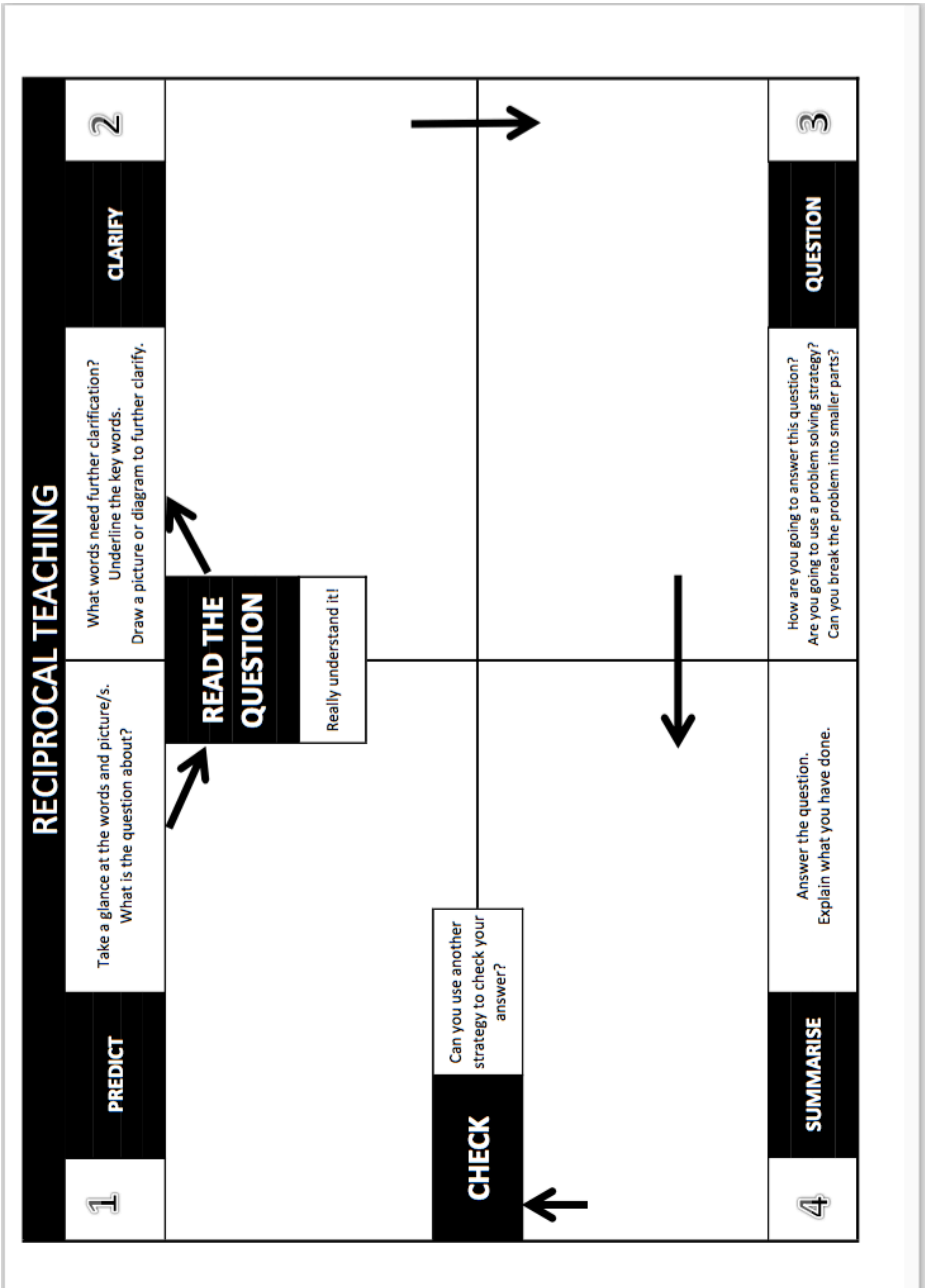
   Yes No Sometimes

5. Do you believe you're better at problem solving as a result of the daily word problem warm-ups that included the question organizer, as well as being able to work through the word problem with your peers?

   Open Ended -

C. Graphic Organizers

i. Original Graphic Organizer



ii. New Graphic Organizer

Graphic Organizer for Problem Solving

1. **What is the problem asking?**

2. **What information is given to you in the problem?**

3. **What operations (+, -, x, ÷) will this problem require and why? (key words).**

4. **Is there anything you still have to figure out before solving for the final answer?**

5. **Solve the problem.**

6. **How can you justify your answer? Explain how you got your answer and why.**

D. Grading Rubric

Graphic Organizer Grading Rubric

Student Name:

Date of Word Problem:

Score from Previous Word Problem Rubric:

Restated the question in own words	**______/ 1**
Identify important information given in the problem	**______/ 1**
Identify appropriate operations and key words	**______/ 1**
Devised a plan for solving	**______/ 1**
Explained how solving was carried out and reasons behind chosen strategy.	**______/ 1**

Total Points ________ / 5