Decoding, Deciphering, and Applying Skills:

Increasing understanding on Mathematical word problems

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Abstract

Students often struggle with math word problems for a variety of reasons. They have difficulty with vocabulary used, the amount of information given and how to decipher what to do with that information, or how to make the connections from the words to the mathematical skill. For this research, data was from the feedback of two secondary students who used three different types of graphic organizers to work with three different word problems taken from New York State Integrated Algebra Regents exams. The students were given the opportunity to create their own graphic organizer including the sections that they liked and found helpful. It was shown that graphic organizers help the students organize information, but they need to be designed to benefit the individual's needs.

Introduction

If you ask a mathematics teacher what the most frequently asked question from students is, you will most likely get the answer of, "When will I ever use this?" In my experience as a teacher of math, a subject for which many students have a strong dislike, I have noticed that there are certain mathematical concepts and skills that give children more difficulty than others. Working with word problems is one of those topics that math students hate; the first sight of a word problem sends students "running for the hills."

Literacy and mathematical skills need to be taught in combination to help students improve their math abilities and their comprehension and reading skills. Getting students to understand mathematics can be a difficult task; trying to get students to understand mathematical word problems is another difficulty. Although students may not realize it, there is a connection between literacy and mathematics. If students are unable to comprehend what they are reading, no matter what subject it is, then they will not be able answer questions successfully.

All students have the potential of being successful in math, but for many, because of their mathematical abilities, reading skills, and comprehension skills, they struggle with reading the text and the word problems. Some students may be able to read a word problem without struggling, but do not know what to do with the information given to them. Students also struggle with the idea of "organizing" the information given to them and determining what is necessary or unnecessary information.

Students need to have skills and strategies to help them decipher the extra, unnecessary information and the important, necessary information that will help them arrive at the correct answer. When shown the difference between these two pieces of information, students will be able to sift through the problem and pull out what they need in order to make mathematical

decisions on how the problem should be solved. Even something as simple as crossing out the actual words in a word problem to show that they are unnecessary information has the potential of helping a student focus on the task at hand.

In order for students to gain a better understanding of word problems, they need to have some sort of strategies to help guide them on the right path for solving a problem. Providing strategies will give the students focus and help them organize their thoughts and ideas. Strategies will help students decipher what is important information, decode the mathematical vocabulary, and apply the mathematical skills that they know. The object is to find ways that allow students to approach a word problem and try it. What will get students to the point of giving themselves a chance to be successful in a word problem and not go "running for the hills" when they see one?

Theoretical Framework

Zaleta and Ruebel (2008) state in their article titled Exploring Mathematical Concepts in Literature, that "[w]e live in a mathematical world." They also state that, "[w]e live in a world in which reading is essential" (p 36). With mathematical skills and reading skills, opportunities are more accessible, job and job prospects are more abundant and rewarding, and lives are more fulfilled (Zaleta & Ruebel, 2008). "Using mathematics … has the potential to improve reading comprehension" (p 37). The only way reading comprehension will be improved upon is by students taking data and turning it into useful knowledge that can be applied to other subjects and their real lives (p 37). One would think that enmeshing math and literacy together on a consistent basis could only increase critical thinking and problem solving.

Gee (2001) writes that literacy is a combination of non-formal teaching where hands-on exposure is allowed and formal teaching where material is broken down for better understanding.

Larson and Marsh (2005) claim that literacy is something that is obtained through social interaction. They state that acquiring literacy should not be viewed as a set of rigid steps that you must follow one after another, but instead it is the skills that are taken in through other texts and activities that a culture and the surrounding environment induce on a person that develop literacy.

Similar to literacy, mathematical literacy is the ability to "reason, analyze, formulate, and solve problems in a real-world setting" (Martin, 2007, p 29). Lutzer (2005) says that it is the ability to "communicate and understand ideas written in the language of mathematics" (p 6). The only way a student will fully understand a mathematical concept is through exposure to it by formal teaching and shown how to work through a problem. A student must use reasoning to analyze and formulate his or her idea into a cohesive thought through non-formal teaching when they practice on their own. Then, by being able to correctly explain how to do the problem in their own words, either verbally to another person or by writing it down, a student will initiate the comprehension process. With repetitive use of these guidelines, a student can demonstrate his or her mastery of a concept or material.

Critical literacy is a crucial part of deciphering and interpreting mathematical word problems. Students need to be able to understand the vocabulary used in a word problem in order to pick out the important information that can be used to correctly answer a question. Teachers, therefore, guide students to become critical thinkers, able to analyze the question that is being asked. Once a student is able to "analyze and evaluate texts" in order to "meaningfully question their origin and purpose" (McLaughlin, 2008, p 95) students are well on their way in mastering word problems.

Not only are students being shown how to complete a word problem, but in the same respect, they are learning the skills of how to understand and interpret future word problems. By incorporating literacy with mathematics, "It not only equips students with the skills to pull mathematical rabbits out of hats, but also challenges students to understand how those rabbits got into the hats in the first place." (Miller & Koesling, 2009, p 66). Martin (2007) states that the key behind word problems is teaching students to "mathematize" which includes:

> 1. Starting with a problem whose roots are situated in reality
> 2. Organizing the information and data according to mathematical concepts
> 3. Transforming a real-world, concrete application to an abstract problem whose roots are situated in mathematics
> 4. Solving the mathematical problem
> 5. Reflecting back from the mathematical solution to the real-world situation to determine whether the answer makes sense.
>
> (p 29)

By showing students how to decipher mathematical word problems, the intent is that they will see the connection between math, reading, comprehension, and the English classroom. The skills that a student learns in English carry through all the other subjects. Math being one of those subjects, students need to realize that they are always reading and always need to be thinking about what they read. The world is full of numbers and letters whether we realize it or not; students need to know how to decipher, decode, and apply the skills that they have both in and outside of the classroom.

Research Question

Students need to use their literacy skills in order to master the understanding of word problems in mathematics. Observing that students are greatly challenged with mathematical word problems and how to sort information to answer the problems, what are strategies that would improve secondary students' ability to decode, decipher, and apply skills in order to increase their understanding of mathematical word problems?

Literature Review

Through observation, one can tell that students get anxiety from mathematics period; whether they are working on a word problem or not. Although a big portion of this anxiety could be attributed to a child's low reading abilities. If they are unable to read and comprehend, even a portion of the word problem, then they are at a disadvantage at the start. It seems as though a combination of reading ability and mathematical ability could be the real reason why students do not understand word problems. Without the reading ability and some sort of mathematical knowledge, a student is not going to even try to read and understand a word problem. With the confidence in their reading abilities and the conceptual understanding of a mathematical background, a student would be able to tackle almost any word problem.

New York State developed standards that outline what students should be able to perform by certain grade levels. The New York State Education Department states that the learning standards are the "core of what all people should know, understand and be able to do as a result of their schooling." (New York State Education Department, 2009) Standard 3 under the New York State Learning Standards for Mathematics, Science, and Technology is the "Mathematics" standard. This standard's overall focus is to get students, no matter what the grade level, in the position where they, "understand mathematics and become mathematically confident by communicating and reasoning mathematically, by applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, data analysis, probability, and trigonometry." (New York State Education Department, 2007) In order for students to "understand mathematics", they need to understand what they are reading. Once they master that they will be on their way to "become mathematically confident".

A child's anxiety towards mathematics and word problems all stem from "not knowing what the problem says, not understanding what the problem means, and not recognizing how to do the problem" (Ponce & Garrison, 2004, p 256). If a child was able to understand and recognize all of these concepts than, understandably, he or she should have no anxiety and no difficulty with correctly answering a word problem. Moyer (2001) states, "Children's inability to solve word problems results from their inability to read or to compute effectively simply are not true." (p 52) She states that the issue is more with the child not knowing the way to best go about working on the word problem, they "simply do not understand the mathematics well enough conceptually to make the connection with the problem-solving situation" (p 52). Guerrero (2010) would agree with Moyer (2001) on this issue and add that part of the reason for students having difficulty would be caused by the fact that, "algebra is the point at which math stops making sense and stops having any connection with the real world." (p 397).

Could students be having difficulty with understanding a mathematical word problem because of the order of the words used? Even though it seems that word problems are comprised of a series of words put together in a sentence, some may say that it is the words that are used and how they are ordered has a determining factor of the success of the student. "Features of a test that make interfering content more accessible, such as foregrounding in a math story problem, not only impair performance, but also alter what predicts success." (Mattarella-Micke & Beilock, 2010, p 110) Foregrounding is used by making nonessential information in a word problem seem like it is an important part of the story (Mattarella-Micke & Beilock, 2010, p 106). Even the change of one word could alter how the student performs on a certain problem. If an object is "associated" with a character in a word problem (by picking something up or carrying it somewhere), this information is recognized and memorized easily, it is read faster, and it has an

enormous effect on the readers' thought process in developing a solution. (Mattarella-Micke & Beilock, 2010, p 106)

Mattarella-Micke & Beilock (2010), write about the results from two experiments that tackled the idea of how a word problem is worded and how it impacts the student in their performance on the word problem. Both experiments used University of Chicago students that averaged to be around 21 years of age. The first experiment had a total of 38 students (27 females and 11 males) and the second experiment had a total of 21 participants (12 females and 9 males) that did not take part in the first experiment. There was a total of 72 problems tested in the first experiment where half of the questions dealt with multiplication and the other half was division. Experiment 2 had 144 word problems all together with a breakdown of half being multiplication and the other being division.

As a result, both experiments portrayed a huge difference between high interference and low interference when there was association with the protagonist of the word problem. The high interference questions caused the most word problem questions to be answered incorrectly. High interference was when there was a correlation between the numbers that needed to be multiplied and the answer if you were to add the numbers together. When there was low interference, there was less questions answered wrong. The low interference was when the extra information that was given had no connection to the numbers that needed to be multiplied.

Strategies to Help with Word Problems

Some students may not have any difficulty with reading a mathematical word problem, but may have difficulty with understanding the information given. Students need guidance in figuring out keywords that may give them clues as to how to solve a word problem. They also need guidance as to what information is helpful and essential to solving a problem and what

information may be extra and not needed in order to answer a question. Some may say that graphic organizers are what will help students the best in answering word problems or others may say guess and check may be the strategy to use.

By having an order of steps in solving a word problem limits the thoughts of a student, "Such an approach limits the conceptual process of problem solving to a procedural method." (Zollman, 2009a, p 223) Zollman (2009a) defines a graphic organizer as "a visual representation of content classification, concept development, and relationship comparisons." (p 224) Graphic organizers have the ability to, "have overlapping effects in connecting, communicating, justifying, and solving mathematical problems." (Zollman, 2009a, p 228) From a teacher's point of view, "graphic organizers offer quick, efficient diagnoses of individual students' problem-solving abilities, skills, strengths, and weaknesses in a comfortable, familiar, problem-solving instructional setting." (Zollman, 2009a, p 228)

Zollman (2009a) advocates for the "four-corners-and-a-diamond" graphic organizer. He used this particular graphic organizer in a study he conducted with 240 third, fourth, and fifth grade students. In the study, the graphic organizer was broken up into four corners and a diamond in the middle of them. Each section of the graphic organizer had a question or leading statement as to what type of information should be filled out in the particular sections. The diamond in the middle had the question: What do you need to know?, and the four corners had (going from the upper left and moving in a clockwise direction): What do you already know?, Brainstorm possible ways to solve this problem., Which response items should you include?, and Try your ways here. (p 224) (Appendix A) This "pictorial orientation allows students to record their ideas in whatever order they occur." (Zollman, 2009b, p 6)

Zollman (2009) cites one of the advantages to this graphic organizer shares is that it can work with any student at any mathematical level of understanding. Not only does it help students organize the information given to them in a word problem, but it also guides them as to how they should be thinking in terms of solving the problem, what should they be focusing their energy in figuring out, and what information is really needed in answering this problem. As a result of using the graphic organizer, Zollman (2009) reported that there was a 42 percent increase in achievement in the 240 students that participated in the study. Collectively, the group of students studied started at a 22 percent success rate on open-response mathematical word problems and grew to 62 percent success rate. To match the increase in achievement rates, teachers reported that students were attempting to work on word problems more where before they were not even trying them. (Zollman, 2009, p 226-227) Through the use of the graphic organizer, "Teachers saw that students who normally would not attempt open-response problems now had partial written solutions." and they, "…changed their instruction to include more writing in mathematical problem solving." (Zollman, 2009, p 227)

Another strategy to help students with word problems is the "guess and check" method. Sowder et al. (1998) state that guess and check is a tool that allows students to, "first identify relevant quantities and their relationships, rather than focusing on numbers and numerical relationships" (p 133). Guerrero (2010) agrees with Ponce and Garrison (2004) by stating what they say about what leads students to frustration in regards to word problems: "not knowing what the problem says, not understanding what the problem means, and not recognizing how to do the problem". Guess and check is structured, "in which students guess a value for the unknown component of a word problem, then check whether their guessed value satisfies the conditions of the problem" (Guerrero, 2010, p 394). Guerrero (2010) defines the steps of guess and check as:

1. Identify the information given, and clarify the unknown component.
2. Begin a table by guessing a value for the unknown.
3. Use the guessed value for the unknown to determine subsequent column(s) and value(s) that are associated with numerical relations within the word problem.
4. Check that your final answer correctly reflects the words of the problem. If not, use the results from the previous guess to make a better next guess.

(p 394)

Guess and check is used for more of a thought process strategy where eventually, "…reading and making sense of word problems and the conceptual understanding needed to break a word problem down into workable and understandable numerical relations will become habits." (Guerrero, 2010, p 397)

Method

Context

The research will be conducted by using two subjects. One subject is from an urban school located in Rochester, New York and the other subject is from a suburban school located in Rochester, New York. Both students are in high school grade levels.

The urban school is made up of grades 7 through 12. Based on the '08-'09 New York State School Report Card, there are around 1,049 students with 62% of the student body consisting of African American students and 16% of the students consisting of white Caucasian students. As a school, the NYS Report Card states that 80% (118 students) of the 148 students that took the Comprehensive English Regents Exam scored a passing grade of 65 or better. On the Integrated Algebra Regents Exam, there were 180 students in total that took the exam and 42% (76 students) scored a passing grade of 65 or better.

The suburban school consists of grades 6 through 12. The '08-'09 New York State School Report Card reports that the school consists of 790 students where 91% of the students

are white Caucasian and 3% of the students are African American. Out of the 111 students that took the Comprehensive English Regents Exam, as reported in the NYS Report Card, 98 % (109 students) scored a passing grade of 65 or better. Of the 141 students that took the Integrated Algebra Regents Exam, 92% (130 students) scored a passing grade of 65 or better.

Participants

In this study, I will be working with two female students. Heather (a pseudonym) is a 16 year old female in the 9th grade and Sarah (a pseudonym) is an 18 year old female who is in the 12th grade. Both students have taken the Integrated Algebra and the Comprehensive English regents exams and have passed.

Heather is an intelligent young lady who takes pride in her learning and education. Her parents are divorced and they are both remarried. Her family is quite extensive and is composed of two blood-related sisters and numerous step and half brothers and sisters. Heather is biracial due to her mother being Caucasian and her father being African American. She enjoys reading books, watching television, and spending time with her friends.

Her favorite subjects in school are science and mathematics. Her goal is to become a doctor or a forensic scientist. She understands that there are steps that need to be taken in order to get where she wants to be. If it is a doctor that she ultimately wants to be, she plans on going to school for nursing, getting a job, and then pursuing the field of medicine in order to become a doctor. Heather is always looking for a challenge. Her enthusiasm for education is always visible and she is driven to succeed to her full potential.

Sarah is a well dedicated student to her education that takes part in advanced placement classes as a senior for the school year that the research was conducted. She is a white Caucasian female who comes from a large family. Her parents are her biological parents who have been

married for over twenty years. Sarah has three older sisters and an older brother. She is the only child left in the house with her older siblings being at least seven years older than her.

Sarah enjoys listening to music, watching movies, reading books, and going shopping. She has been accepted to attend the SUNY College of Environmental Science and Forestry, which is affiliated with the University of Syracuse, when she graduates from high school. She aspires to work with animals in connection with a zoo or animal organization. She enjoys listening to music, watching movies, reading books, and going shopping.

Researcher Stance

During this research, I took the stance of the teacher and facilitator. I am certified in Mathematics for grades 5 through 12 and am currently working on my master's degree in literacy where I will be certified birth through grade 12. As a mathematics teacher, I have been teaching math for a total of four years. My first year teaching was in Southern Maryland where I taught Algebra II, Geometry, and Integrated Algebra. My second year of teaching, I was a substitute in four different area school districts around Rochester, New York. For the last two years, I have been teaching at Charlotte High School. My first year at Charlotte, I taught 7^{th} grade math and Advanced Integrated Algebra. This year I teach 7^{th} grade math, Integrate Algebra, and Intermediate Algebra. Because of the classes that I teach, I see students from grades 7, 9, 10, 11, and 12 throughout the entire day.

Through this study, I was determined to figure out a way that will help students with mathematical word problems. As a teacher, I have observed students struggle and shut down when it comes to interacting with word problems. They do not know what to do with the information given to them and they do not comprehend it. In order to find a strategy that will work for students, I need to know how students view different strategies.

Method

Heather and I worked one-on-one in a classroom at an urban high school for two sessions. The first session lasted for two hours and the second session lasted for one hour. This is a classroom that she is familiar with; she has math class in the same room. I worked with Heather to see if there was any change in her abilities of solving mathematical word problems. Along with Heather increasing her solving abilities, I also observed the strategies that seemed to improve her abilities. Her feedback will help to assess what she thought helped her solve the word problems.

Sarah and I worked together one-on-one at her house. We worked in the dining room where we had room to work and where it was quiet to discuss with each other. I spent two sessions working with Sarah where each session lasted for an hour and a half. With working with Sarah, I was able to discuss and observe her solving abilities. In using the graphic organizers, I wanted to watch how Sarah used them and how effective they were for her.

I compiled three different versions of graphic organizers that displayed ways of organizing information differently and ask to identify information in different forms. Heather worked on solving New York State Regents exam word problems with a graphic organizer. For each of the questions, Heather worked with a different graphic organizer. We discussed the positive and negative things about each organizer. At the end of working with all three of the different graphic organizers, Heather had the opportunity to create her own graphic organizer combining all of the elements that she liked from the individual graphic organizers.

Consent and Protecting the Rights

In order to keep the confidentiality of the student, Heather's and Sarah's real name will be replaced with a pseudonym and no other information will be provided that could be used to

identify the student. Due to Heather being a minor in High School, I received assent directly from the student and permission from the students' mother. While Sarah was not considered to be a minor due to her age, assent from her was received along with permission from her mother.

Data Collection

My collection of data is not number and statistical based; it is based on qualitative data. I interviewed students and had them work on three different graphic organizers while working with Integrated Regents Exam word problem questions from parts 2, 3, and 4. Each exam word problem was accompanied by a different graphic organizer. For each student, the same graphic organizer was paired with the same word problem question. Once the students completed the problem, we discussed them. The students were given the opportunity to voice their opinion as to what they thought about the graphic organizers and to also share what they thought other students might think of the graphic organizers.

The three different word problem solving strategies that I used were the Diamond Graphic Organizer, the SOLVE strategy, and the Guided Problem Solving layout. The students worked on question 35 from Test 1 from the New York State Integrated Algebra practice Regents exams with the Diamond Graphic Organizer, question 37 from the June 2008 NYS Integrated Algebra Exam was used in conjunction with the Guided Problem Solving layout, and there was a word problem pre determined to be used with the SOLVE strategy.

I met with the students on a one-to-one basis in a tutoring type setting. I explained to each student that the purpose of this study was to understand what strategies were the best for students in working with word problems. I also explained to the students that they would be working with three different types of word problems and three different types of word problem solving strategies. They were told that their opinions mattered and that I would be giving them

an opportunity to share their ideas once they have used the strategy. After each of the different strategies were used, the students were asked to share their thoughts about the method that they just finished using; what did they like or not like about it. I recorded the likes and dislikes about each strategy as they shared. We also discussed what they might change about each of the strategies such as the look of the strategy or the wording of the strategy.

Once all three of the strategies, graphic organizers, were used and discussed about their positives and negatives, I asked the students to create their own solving strategy by using the ideas that they liked from the strategies that they previously used. The students were able to bring in their own ideas about the three graphic organizers. After they had some time to create their own strategy, the students shared what they created and why they created it the way they did.

Credibility

By working with the students in a one-on-one setting, I was able to make constant observations as they were working with the graphic organizers and the word problems. Being able to observe them allowed for better understanding of what the students were talking about when the discussed the pros and cons of the graphic organizer. Through observation and discussion, the research was able to reflect a better credibility with the findings. Mills (2011) defines credibility as, "the researcher's ability to take into account the complexities that present themselves in a study and to deal with patterns that are not easily explained." (p 104)

Transferability

Since the two students are exceptional math students, they were able to focus more on using the graphic organizer than figuring out the actual word problem. The students were able to

give stronger opinions about the pros and cons of the individual graphic organizers since they focused in on how they needed to use them.

Having the students create their own graphic organizers was another artifact that can be taken directly into the classroom. Other students may benefit from the modified versions of the graphic organizers or may have a way to modify them even more. All of this information can be transferred into other math classes and also can be altered to fit into an English classroom. Transferability is, "the researcher's belief that everything is context-bound." and letting, "the consumer of the research" to "identify with the setting." (Mills, 2011, p 104)

Dependability

By using three different graphic organizers with three different word problem questions, the students were forced to use the graphic organizers instead of using the same information with all three graphic organizers. The students were required to follow the individual graphic organizers with each word problem in order to realize the benefits and the distractions that came with using them.

The research showed dependability in the fact that more than one graphic organizer was used in figuring out a good strategy that would help students decode, decipher, and apply their skills and knowledge. Mills (2011) quoted dependability as, "the stability of the data." (p104)

Confirmability

In comparing the work and feedback from the two students, the research was able to identify similarities and differences in their opinion and their work abilities. In being objective and staying neutral, confirmability has been displayed by keeping, "the neutrality or objectivity of the data that has been collected." (Mills, 2011, p 105)

Findings and Discussion

Heather and Sarah both thought graphic organizers were a helpful tool when it came to solving a mathematical word problem. They both thought that the graphic organizer helped in organizing and laying out the information so that it was easier to see all the important pieces.

Diamond Graphic Organizer

The diamond graphic organizer (Appendix A) was the first one that was presented to the students. Even though the students could fill in the boxes and diamond in any particular order, both students started in the top left hand box labeled "What do you already know?" I predicted that this was where the students would start as that is how we are taught to read, from the top left across until reaching the bottom right. The students might have started in the middle diamond labeled, "What do you need to find?" because when reading a mathematical word problem, typically the diamond area is the last thing that one reads. I thought that Heather and Sara might have filled this in first as it was one of the last things that they read from the word problem so it was fresh in their minds.

Both students proceeded to fill in the first "already know" box with the dollar amounts found in the word problem. Then from there, they filled in the "brainstorm" box and the diamond simultaneously by going back and forth to the two sections. Once those were filled in they moved on to the "Try it here" box and once they found their answer they filled it in the "explanations" box. As Heather worked in the "try it here" box, if there was another piece in showing the work for the problem, she went back to the "brainstorm" section to add in the process.

Heather had an advantage using the graphic organizer because of her prior exposure to it; she had used the organizer in her own math class for a couple of days before she worked with me

on it. Sarah had never seen this format of a graphic organizer, but was familiar with working with graphic organizers in her classes so she was not new to the idea and how it worked.

Feedback

In comparing the information shared in the interview chart (Appendix L), there were some ideas that both girls had in common. Heather and Sarah agreed that the "Already Know" section was good to have and was helpful. They both had the idea of the section helping in the organization of the information taken from the actual word problem and that it saved having to review the word problem over and over again, as all of the important information should be all in the section. Another similarity was that both Heather and Sarah expressed a need for more room in the "Try it here" work section. They thought that at least one of the other sections could be reduced in size in order to give more room for the workspace area. By looking at Heather's (Appendix H) and Sarah's (Appendix D) Diamond graphic organizers, it is clear the "explanations" section is one that could be reduced in size.

The girls seemed to have a difference in opinion on the "Brainstorm" section. Heather liked the section because it allowed her to get all of her ideas and thoughts on paper so that she could see them. Instead of keeping the ideas in her head and trying to remember everything, Heather liked that fact that there was an area for her to write it all down and to see a visual form of it. Sarah on the other hand did not like the "Brainstorm" section; she thought it was a repetition of the middle diamond shaped section. To her the idea of stating, "What do you need to find?" is the same thing as brainstorming ways in which to solve the problem. For Sarah, she was determining what she needed to find and how to go about doing it at the same time in the same section.

Guided Problem Solving Graphic Organizer

The guided problem solving graphic organizer (Appendix B) was the second graphic organizer given to the students to work with on a second word problem. This organizer had more of a specific order to it than the diamond graphic organizer; instead of being laid out on a piece of paper, the sections were consecutive. The students started off with the "Understand" section. By following the graphic organizer, the students were expected to begin by rewriting the word problem in the space provided. I had instructed the students not to worry about rewriting the actual problem since I was giving them their own copy.

Both students answered both specified questions that were in the "Understand" section. They also both shared very similar answers in the same way. The question asked the students to find the length and width of the walkway; they wrote that they already knew the area and the length. The area was shown in numerical form and the length was represented in word form on both papers. Heather and Sarah both identified that they would need to find the length and the width numerically in order to answer the particular word problem.

When it came to the "Plan" section, Heather took the guiding questions more literally than Sarah did. Heather was very specific in what she would use in order to solve the problem by listing the actual operations like addition, subtraction, and division. Sarah read the guiding questions and generalized her answer by writing a form of explanation as to what she would do to answer the problem. Sarah also generalized her strategy by identifying that she would use exponents and need to solve for x (the variable).

When it came to the "Solve" section, both students had a good idea of what they were going to do. Even though Heather used the formula of perimeter instead of area, she still showed all her work and calculations. Sarah used the correct area formula and correctly factored the equation in order to get right length and width values. When Heather got to the last section,

"Look Back", she checked her work in order to make sure her math was correct and she showed the work for the check as well. Sarah used her answers and checked them, in a different way than Heather; instead of her plugging her answers into the equation that she used to solve the problem, she went back to the actual word problem and checked to make sure her values made sense with what the problem was asking.

If Heather had gone back to the actual problem in order to check her work, she might have caught her mistake of doing the perimeter instead of the area. Sarah's technique of going to the word problem itself and not to the work that she performed assured her success. Heather's work is an example of how an organizer can help guide a student through the steps that they should be get into the habit of doing, but also exemplifies that a graphic organizer cannot guarantee that a student will get the answer one hundred percent correct if he/she uses it.

Feedback

By comparing the interview responses (Appendix L) of both students, they liked the fact that there was the "Look Back" section with the Guided Problem Solving graphic organizer and they liked the organizer for a very similar reason; they both basically said that it was good to at least have it stated so that students are reminded of doing it, whether they checked it in their heads or did an actual check on the paper. On their own graphic organizers, both students worked out a proof system based on their answer (Appendices E and I). Both girls agreed that instead of calling it "Look Back" it should be renamed as simply "Check."

Heather did not like the question in the E section that asked, "Is the answer reasonable?" She thought that the question was too similar to the other guiding question, "Does this make sense?" Heather liked the "Does this make sense?" question better and understood that it was trying to get the student to reflect and check their own work. On the other hand, Sarah found "Is

the answer reasonable?" to be a good guiding reflection question. It made her go back and check her work and answer to make sure that it made sense with what she was working with.

SOLVE Graphic Organizer

Each of the girls was given the third word problem to accompany the third graphic organizer (Appendix C); we reviewed each letter of the word SOLVE, what each stood for, and what the two girls needed to do in order to complete the organizer. Both students completed the S portion by underlining the question. Sarah boxed in the important information on the actual word problem whereas Heather did not; she just identified the question by underlining. Heather and Sarah both crossed out the same words that were extra and unimportant information to solving the problem. Both students identified the three important pieces of information needed to answer the problem.

To complete the L portion of the strategy, Heather identified the operations as needing to use subtraction and division. When stating the plan, she expressed that she would need to "make an equation" where she would then use the order of operations method, PEMDAS, for solving the problem; PEMDAS is an acronym for the mathematical order of operations of parenthesis, exponents, multiplication, division, addition, subtraction, Sarah identified that she would need to use multiplication and addition in order to solve the problem. In her explanation of the plan, Sarah wrote out the equation that she would use in words and symbols. Both students acknowledged that that they needed to develop an equation in order to properly solve this problem, but had different takes on what the equation needed to look like.

For the V portion of the organizer, the students needed to show their process and work the particular problem that was given to them out. Heather created an equation and solved for

the unknown variable, but did not have the correct equation set-up. Sarah did not show an equation, but had the individual steps needed in order to arrive at the correct answer.

For the last step, the E, Heather mentally answered the guiding questions in her head. In her mind the answer that she came up with made sense, was reasonable, and she thought it was accurate. She shared this information with me when we went through and discussed for likes and dislikes about the graphic organizer. Sarah answered the guiding questions on the paper. Both students ended the problem by having their final answer in a complete sentence.

Even though Heather's answer was incorrect it was close to the correct answer and it was a reasonable one. A graphic organizer can provide a means but is not a guarantee to getting the answer completely correct. If I were to correct this problem as a Regents exam question, Heather would probably get at least a point on this question for all the correct work that was shown.

Feedback

In reviewing the participants' comments (Appendix L) about the SOLVE graphic organizer, they shared similar thoughts and ideas. They agreed that it was a good thing to identify the important information by some sort of highlighting, whether it was by boxing it in or using an actual highlighter. The girls also agreed that this organizer did not provide enough work space in each of the sections and it had way too many words to read. This organizer added even more reading to the already existing reading that they had to do in the actual word problem. They brought up the point that if a student has trouble or refuses to read a three to four line word problem, then he/she may not want to read even more on how to go about solving the problem. Additionally, the students thought that the strategy organizer was too long all together and the format was not something that students would remember.

Due to different ways of thinking and working out problems, Heather (Appendix J) liked the fact that she was instructed to write out the plans for solving the problem. She liked it because, once again, it took "Everything in my head and put it down on paper." Sarah (Appendix F) would rather set up the problem and solve for the answer. She did not like the fact that she had to write down her plans in words without using any numbers before she could do the actual work.

Sarah disliked this graphic organizer out of all of them. She thought that the guided questions were too specific and did not allow her to add her own thoughts and ideas. Sarah saw this particular graphic organizer as being too structured, too long, and too "outliney." She thought that this was not one that should be used for working on a math problem.

Overall Outcomes

By reviewing how Heather and Sarah commented with positives and negatives and observing them while working with the graphic organizers, it seemed as though the best graphic organizer was the Diamond graphic organizer. This organizer had the least amount of words to read on the layout and the words themselves seemed to be straight forward enough to where the students did not need any further explanation other than what was written on the paper. It seemed to allow the students the freedom to write as much information in the sections as they wanted to. The other graphic organizers had leading questions to the individual sections and the girls seemed to like them, but they thought that the Diamond organizer did not need any guiding questions.

The second favorite graphic organizer was the Guided Problem Solving organizer. Even though it was laid out over two pages, there was still more room for the students to think for themselves and to still have guiding questions. The guiding questions seemed to help them in

some sections, but annoy them in other sections. Other than the "Understand" section of the graphic organizer, the students thought that it was necessary for only one guiding question. The students also shared that they liked that they could "Look Back" at their work, but reflected on the fact that it should have been more of a thought process than something they actually had to show work for.

The least favorite graphic organizer was the SOLVE – Word Problem Strategy. Both girls shared that it was too wordy and guided them too much to the point that they were not really focused on the word problem itself. They were more focused on trying to understand the guiding question and what they needed to put in order to answer it. Along with being overwhelmed with the extra reading portion of the graphic organizer, they also did not like that there was not enough room to show any work in each of the sections.

Implications

The two participants demonstrated their mathematical abilities along with their understanding in working with graphic organizers. Heather had an advantage in working with the diamond graphic organizer as she had practice with the organizer in her math class a couple of times with practice Regents exam questions; however Heather had no previous interaction with the other two graphic organizers. Sarah had not used any of the graphic organizers before and only had previous knowledge of using graphic organizers in general based on her own academic use of them in her classes at school.

During the time that was allotted to interact with the students, Heather and Sarah both shared that no matter what kind of graphic organizer they were working with, whether they hated it or liked it, it forced them to slow down and to really work on the problem at hand. This was one of the underlying goals of the study; often students race through exams, homework, and

classwork without slowing down and taking time to really read the questions. Through observing Heather and Sarah while they worked, I noted that in the beginning of the tutoring sessions they did not give themselves time to comprehend what was being asked of them through the word problem.

In the future, this study should be conducted with a larger group of participants. By working with two students, I was only able to get ideas and findings from a small population of students. Having a limited amount of time was a factor in how many students I was able to work with as well. Due to the limitation of time with working with Heather and Sarah, I was limited to the amount of information that I could collect. Would the findings and conclusions of the study be the same if there were more participants or if both genders were studied? When a larger pool of students and both genders are used, there would be more concrete evidence to support or negate a claim.

Another limitation to the study was the mathematical knowledge and background of the participants. Both females were good students in school and, more specifically, good in math, and they volunteered their own time in order to meet and work on mathematical word problems outside of the school day. If students who had low mathematical abilities had participated in the study, their responses might have changed the results as to how graphic organizers helped them or hindered them in being able to answer word problems. Their feedback would have been help in creating a graphic organizer that might benefit a larger range of students.

With a larger number of participants representing a variety of mathematical abilities, participants would have represented a range of reading abilities as well. Both Heather and Sarah were reading at their grade level or above, and are not struggling readers. Having students who struggle with reading and comprehension would have enhanced the graphic organizer abilities.

The research may have been able to determine if graphic organizers really help students who are at low reading and comprehension levels. In having participants from a variety of reading levels in the study, the findings would have had the potential to indicate if a particular graphic organizer can help the lower reading level students or if there needs to be another strategy used to improve their deciphering and decoding. Once the students are able to decipher and decode they would be able to start applying those skills to mathematical word problems.

There is still valuable information to be taken from this study; the study can act as a catalyst in the search for a strategy that will help students improve their mathematical word problem abilities. With the students having a good understanding of math, Heather and Sarah were able to share how they best understood math; they were able to view the graphic organizers from a students' perspective and to report on what they thought and how their classmates might perceive the different organizers. Their input and feedback will help me to modify and develop a graphic organizer that will interest other students and would be beneficial to them in their deciphering of word problems.

Knowing what Heather and Sarah liked and disliked about the different graphic organizers will help me develop one that would incorporate more of their positive reactions. In a classroom setting I would present a word problem with a copy of the Diamond graphic organizer. The students would have the opportunity to discuss how to use the organizer and would be able to actually use themselves with a word problem. After using it and talking about the outcome, I would allow the students to create their own graphic organizer using pieces from the Diamond graphic organizer that they liked and also adding in pieces that they wish was on there. This will give the students an opportunity to create something unique and helpful to them and only to them.

Conclusion

I focused this research study on the question, "What is a strategy that would help students decode, decipher, and apply their skills to mathematical word problems?" I had found through observation within my own math classes that students were not understanding word problems and some were to the point where they refused to even try them. In researching this question, I not only found information about certain strategies, but I was also able to get student perspectives from the two with whom I worked. They gave me feedback about what they found to be difficult about word problems and some ways that would help them tackle the problems.

By having the two students work on word problems along with three different graphic organizers, the students determined what they liked and what they did not like about each of them. Once the students had some information about what helped them, they were better able to create an organizer that would suit their own personal needs. The two students included similar sections on their graphic organizers, but each had a completely different layout. This was proof that each student had individual needs in helping her work through a problem, but clearly the graphic organizers helped guide the students in solving the word problems.

All students are different and learn in different ways. They need their own personal ways in understanding and solving problems. Allowing students to create their own strategy is the key to get them to begin decoding, deciphering, and applying. Graphic organizers can be changed, revised, revamped, and formatted to help students tackle word problems. With that in mind, I pose the question, "What might other graphic organizers include that will help students to decode, decipher, and apply their skills?

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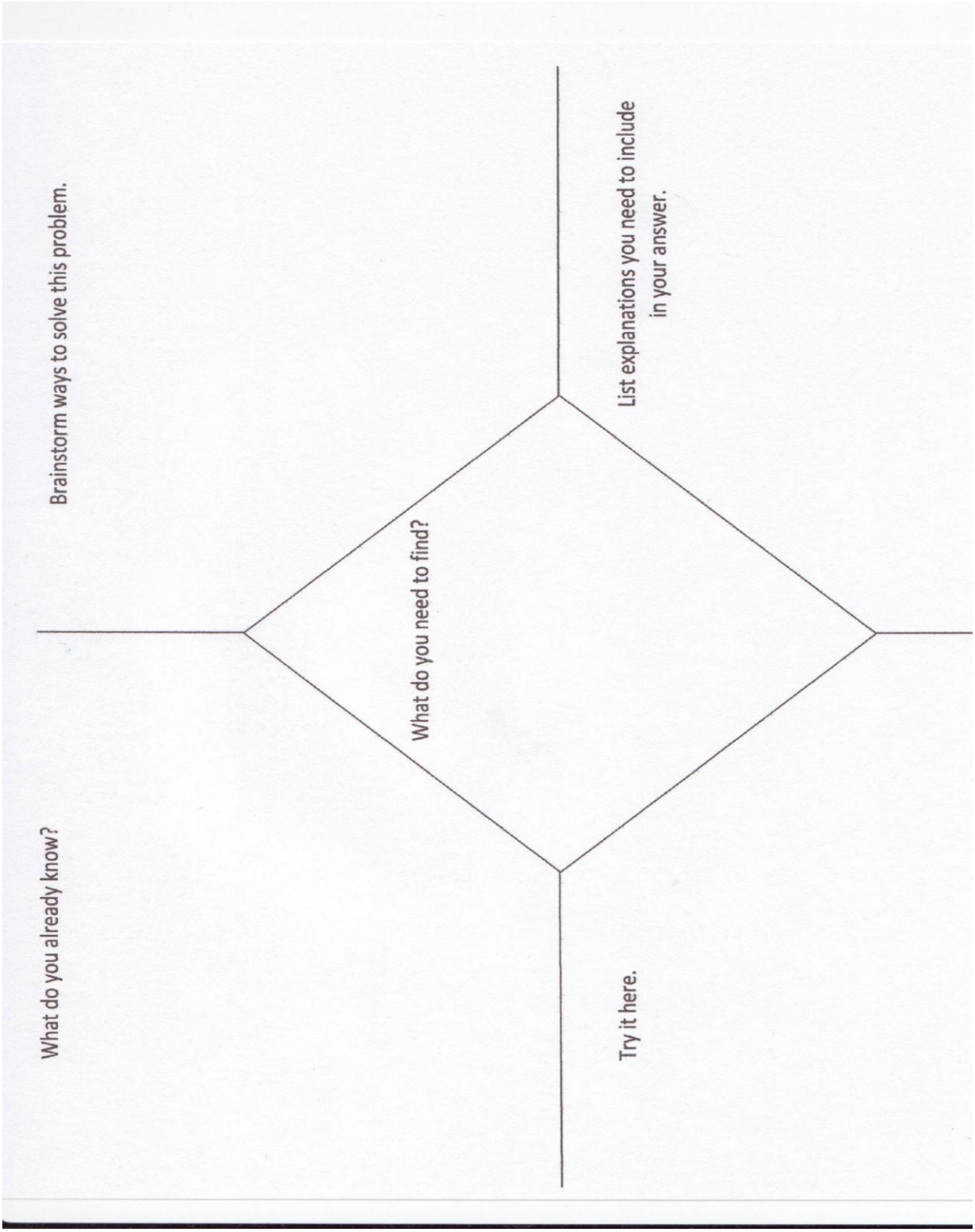
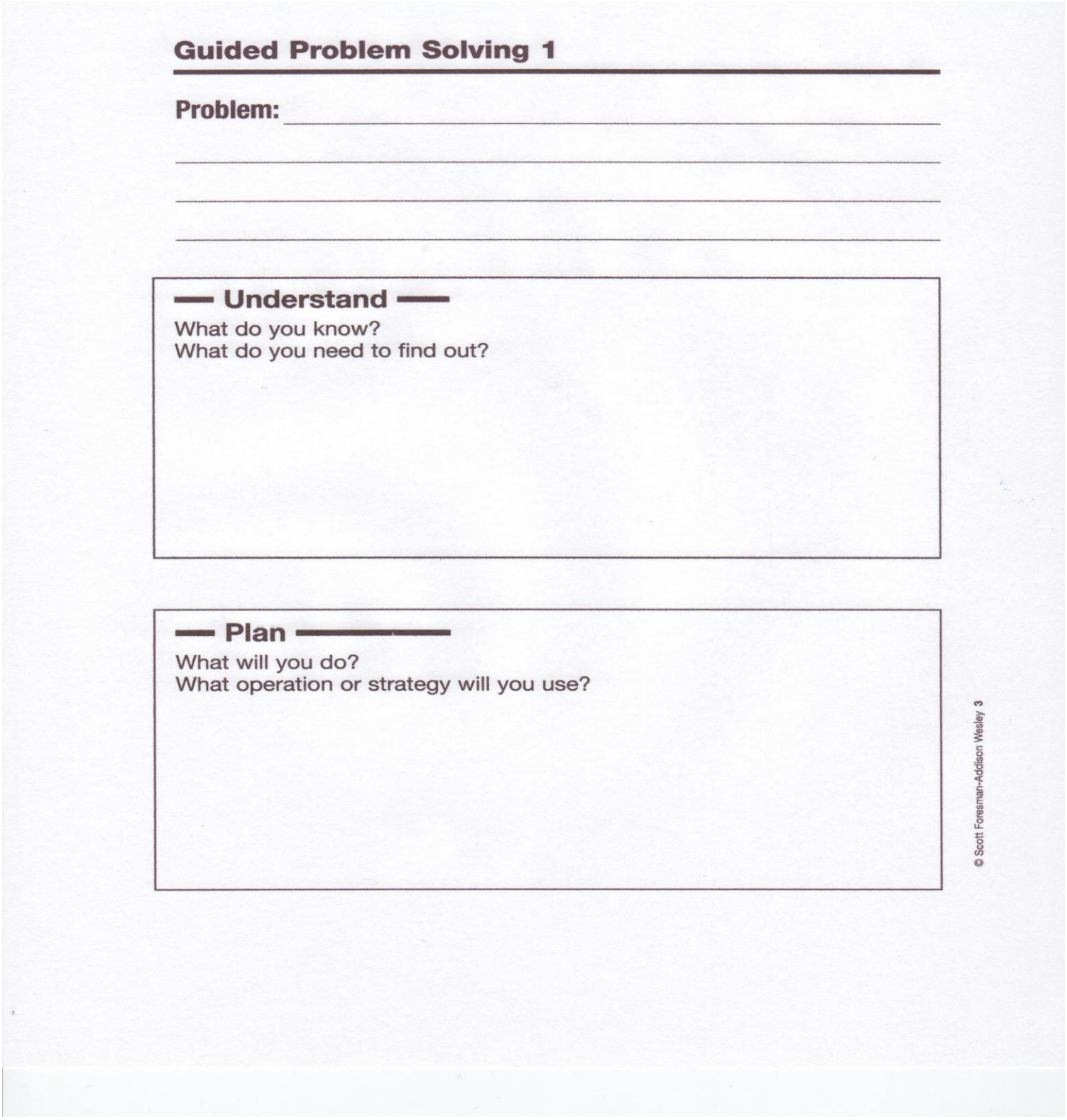
Appendix A

Diamond Graphic Organizer



Appendix B

Guided Problem Solving Graphic Organizer (front side)



Guided Problem Solving 1

Problem: _____

_____

_____

_____

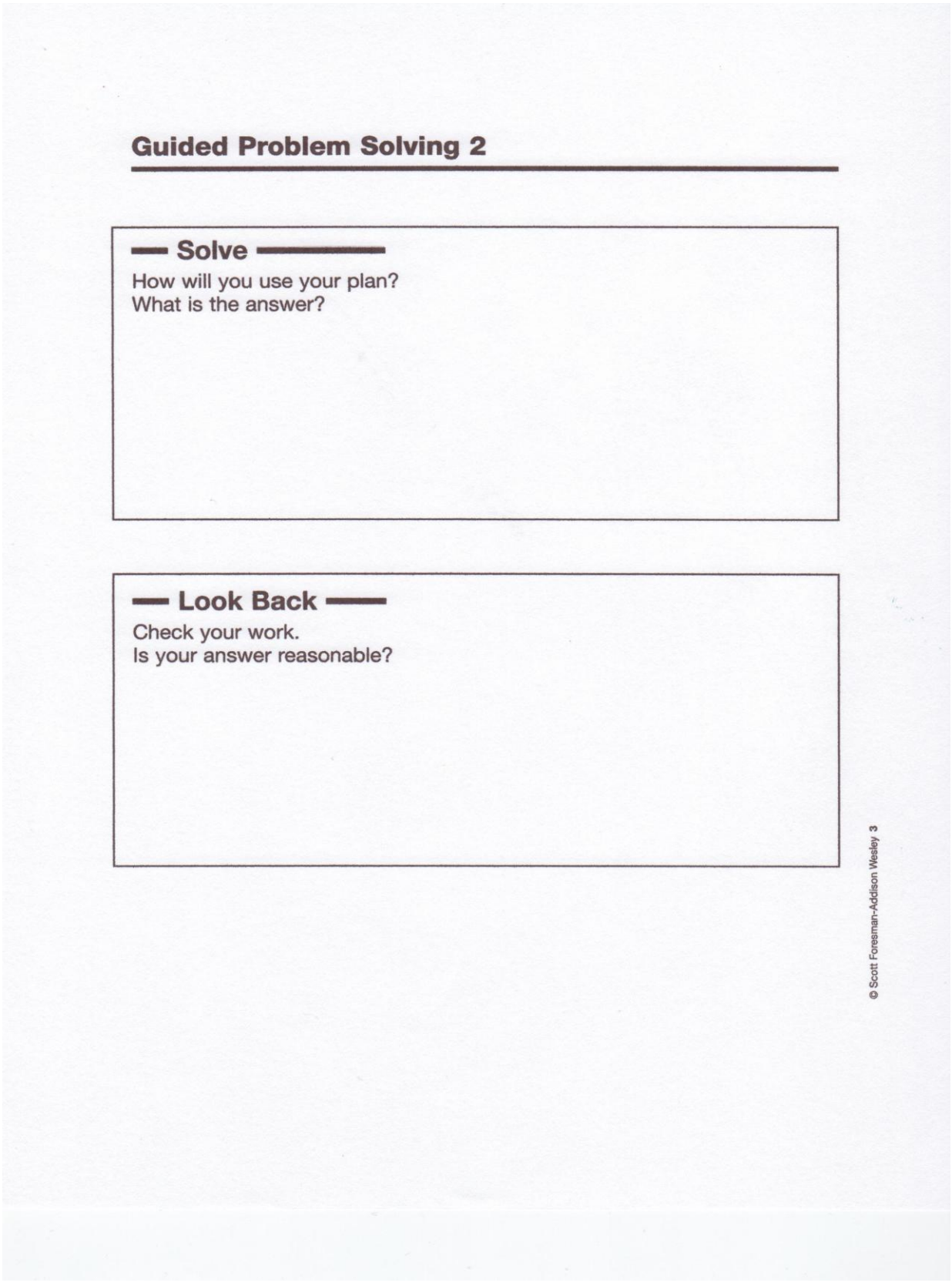
— Understand —

What do you know?
What do you need to find out?

— Plan ———

What will you do?
What operation or strategy will you use?

Guided Problem Solving Graphic Organizer (back side)



Guided Problem Solving 2

Solve

How will you use your plan?
What is the answer?

Look Back

Check your work.
Is your answer reasonable?

Appendix C

SOLVE Graphic Organizer

Example #1:

David wanted to ride a taxi from his house to the mall. The taxi driver said there was a $2.00 fee plus $.75 per mile. David knee the mall was 11 miles from his house. How much would David's taxi ride cost?

Study the problem:

-Highlight or underline the question:

Organize the facts:

-Draw a line through the unnecessary facts
-List necessary facts:

Line up a plan:

-Choose operations:
-State the plan in words (no numbers):

Verify you plan:

-Estimate: t
-Find the answer:

Examine the results

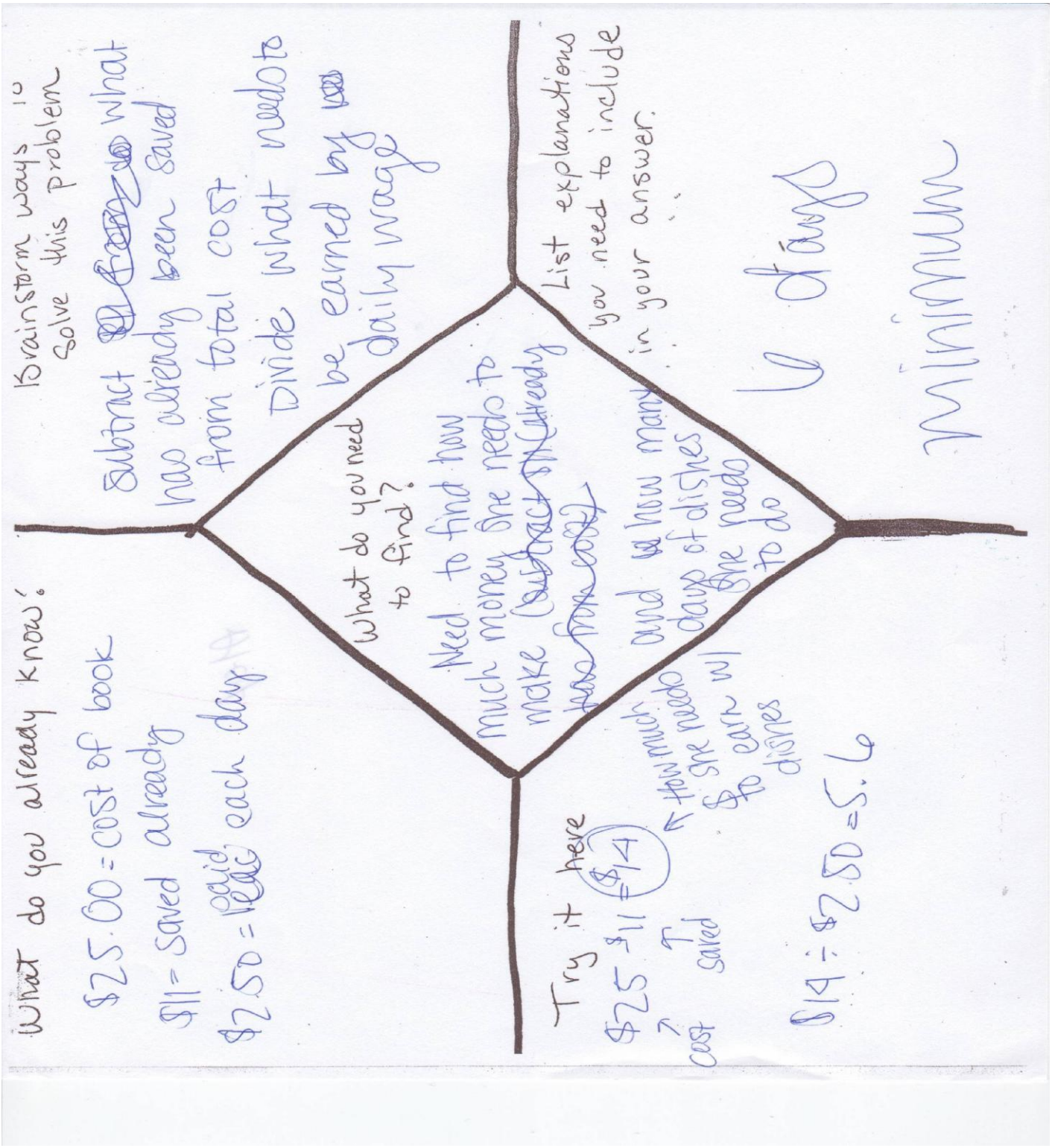
- Does $_____ make sense?
- Is $_____ reasonable?
- Is $_____ accurate? (Double check the math)

- Write answer in complete sentence:

Student Worksheet

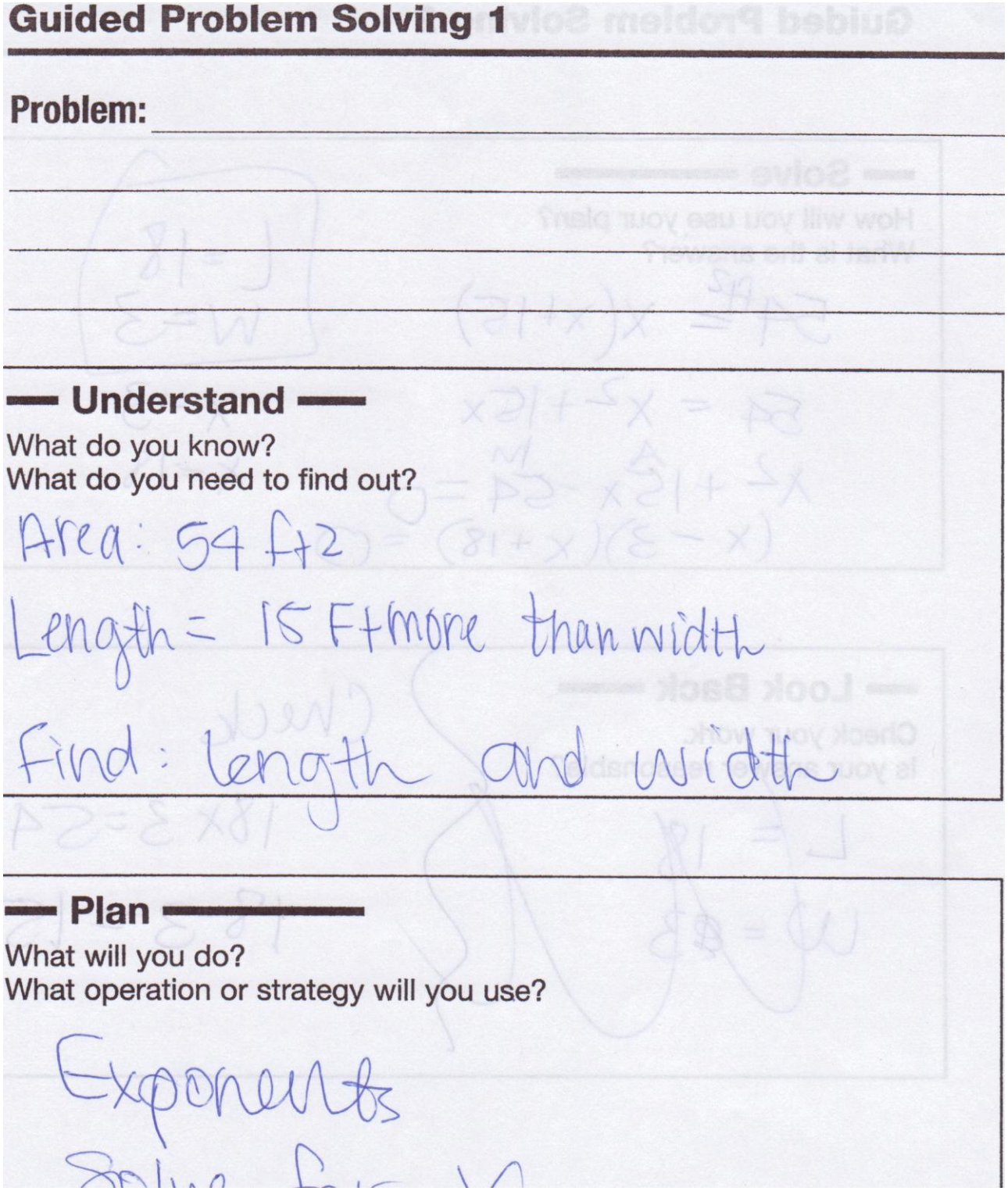
Appendix D

Sarah's Diamond Graphic Organizer



Appendix E

Sarah's Guided Problem Solving Graphic Organizer (front side)



Guided Problem Solving 1

Problem: _____

Understand

What do you know?
What do you need to find out?

Area: 54 ft2

Length = 15 Ft more than width

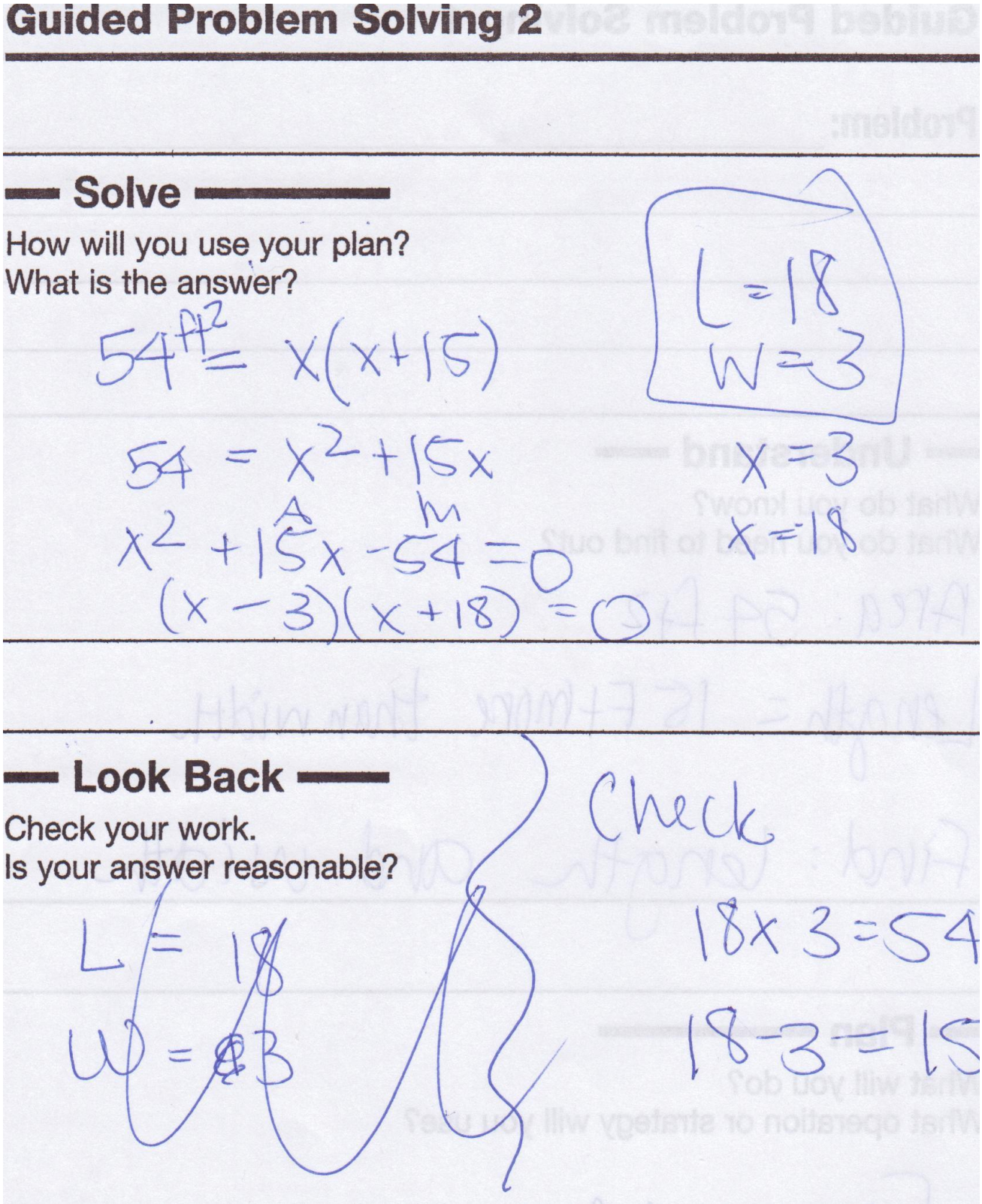
Find: length and width

Plan

What will you do?
What operation or strategy will you use?

Exponents

Sarah's Guided Problem Solving Graphic Organizer (back side)



Guided Problem Solving 2

Solve

How will you use your plan?
What is the answer?

$54 ft^2 = x(x+15)$

$54 = x^2 + 15x$

$x^2 + 15x - 54 = 0$ (A, M)

$(x-3)(x+18) = 0$

$L = 18$
$W = 3$

$x = 3$
$x = -18$

Look Back

Check your work.
Is your answer reasonable?

$L = 18$
$W = 3$

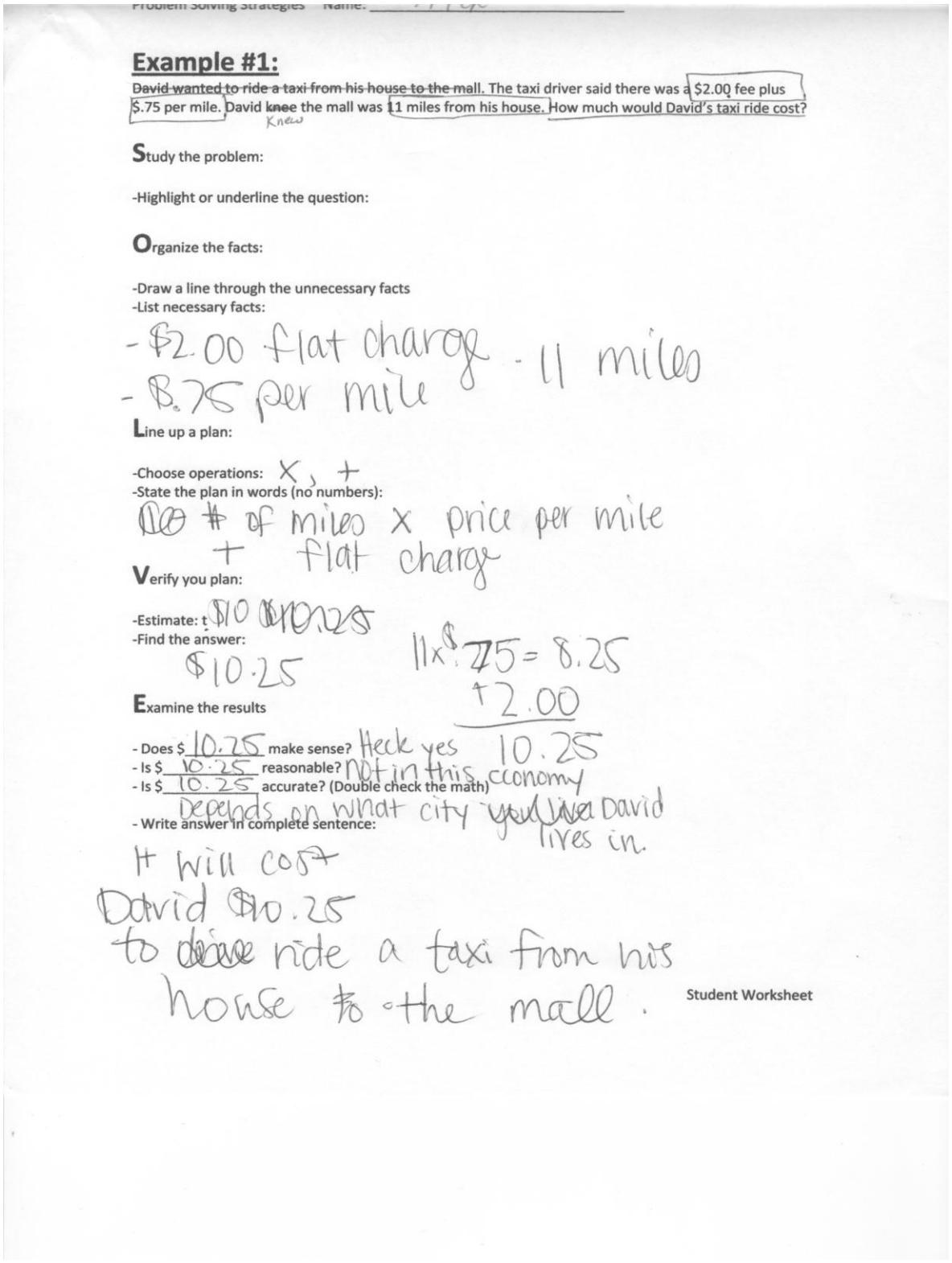
Check

$18 \times 3 = 54$

$18 - 3 = 15$

Appendix F

Sarah's SOLVE Graphic Organizer



Problem Solving Strategies Name: _____

Example #1:

~~David wanted to ride a taxi from his house to the mall.~~ The taxi driver said there was a $2.00 fee plus $.75 per mile. David ~~knee~~ Knew the mall was 11 miles from his house. How much would David's taxi ride cost?

Study the problem:

-Highlight or underline the question:

Organize the facts:

-Draw a line through the unnecessary facts
-List necessary facts:

- $2.00 flat charge - 11 miles
- $.75 per mile

Line up a plan:

-Choose operations: x, +
-State the plan in words (no numbers):

# of miles x price per mile + flat charge

Verify you plan:

-Estimate: $10 ~~$10.25~~
-Find the answer:

$10.25

11 x $.75 = 8.25
+ 2.00
10.25

Examine the results

- Does $ 10.25 make sense? Heck yes
- Is $ 10.25 reasonable? not in this economy
- Is $ 10.25 accurate? (Double check the math)

Depends on what city you live David lives in.

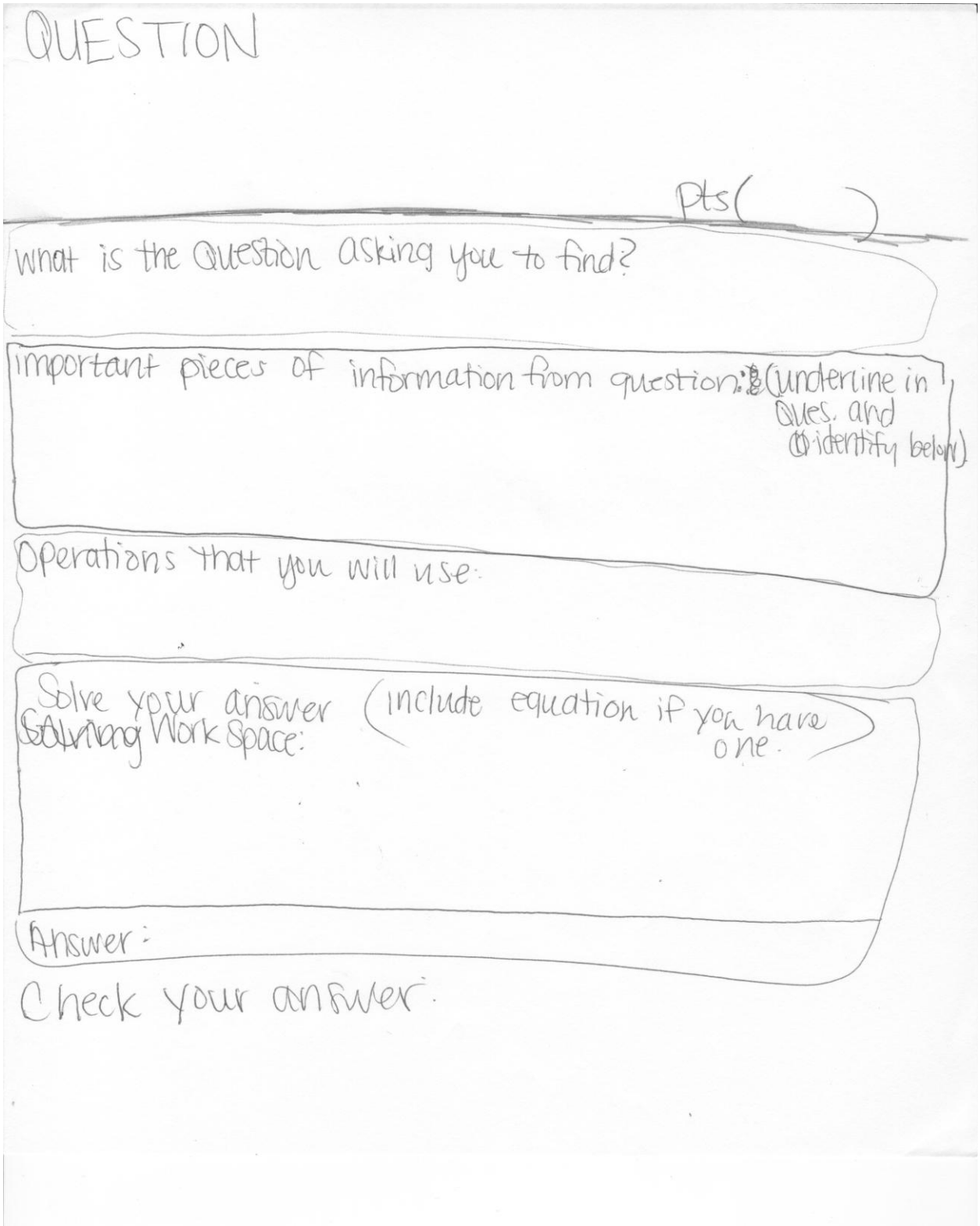
- Write answer in complete sentence:

It will cost David $10.25 to ~~drive~~ ride a taxi from his house to the mall.

Student Worksheet

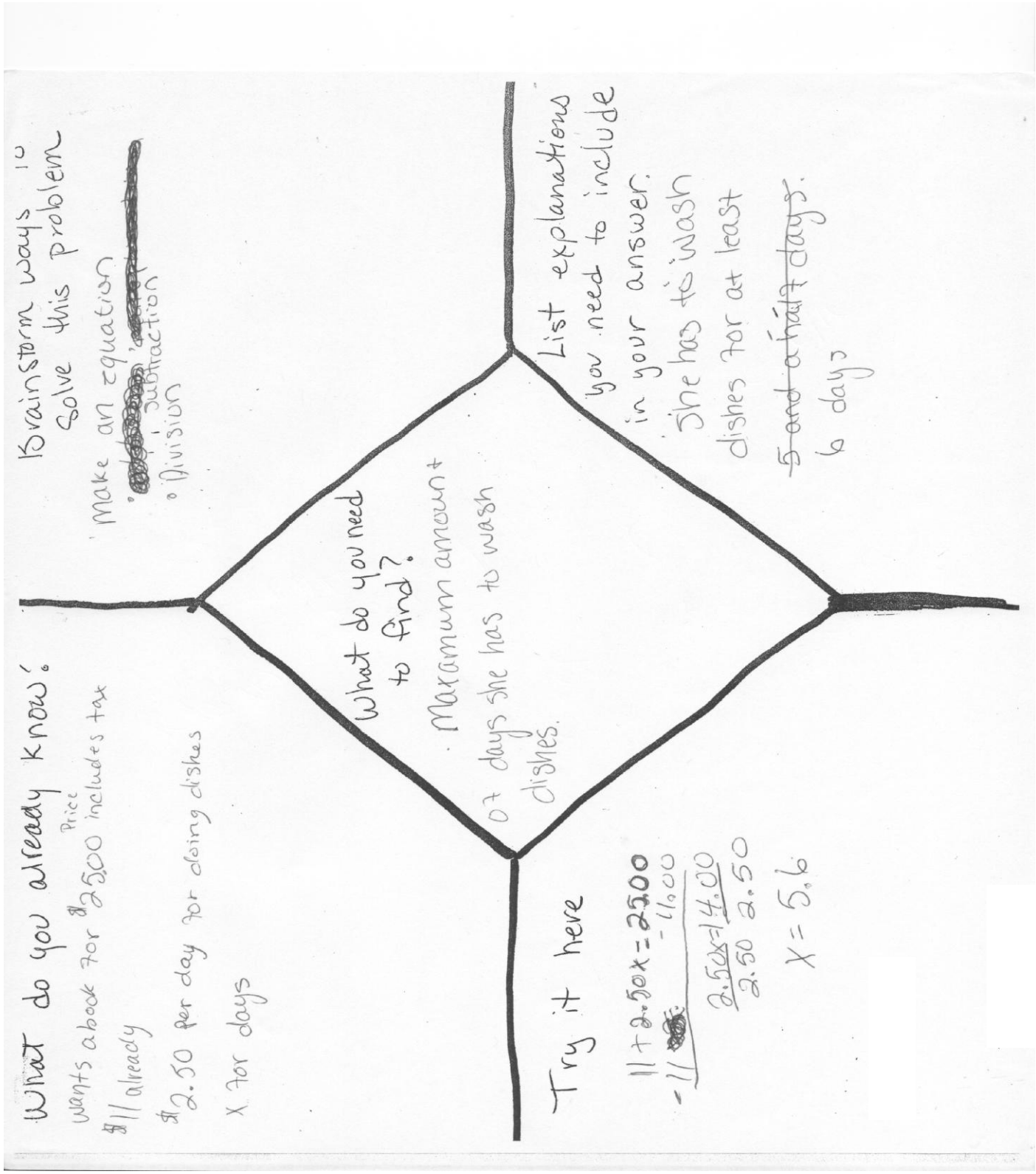
Appendix G

Sarah's Self-created Graphic Organizer



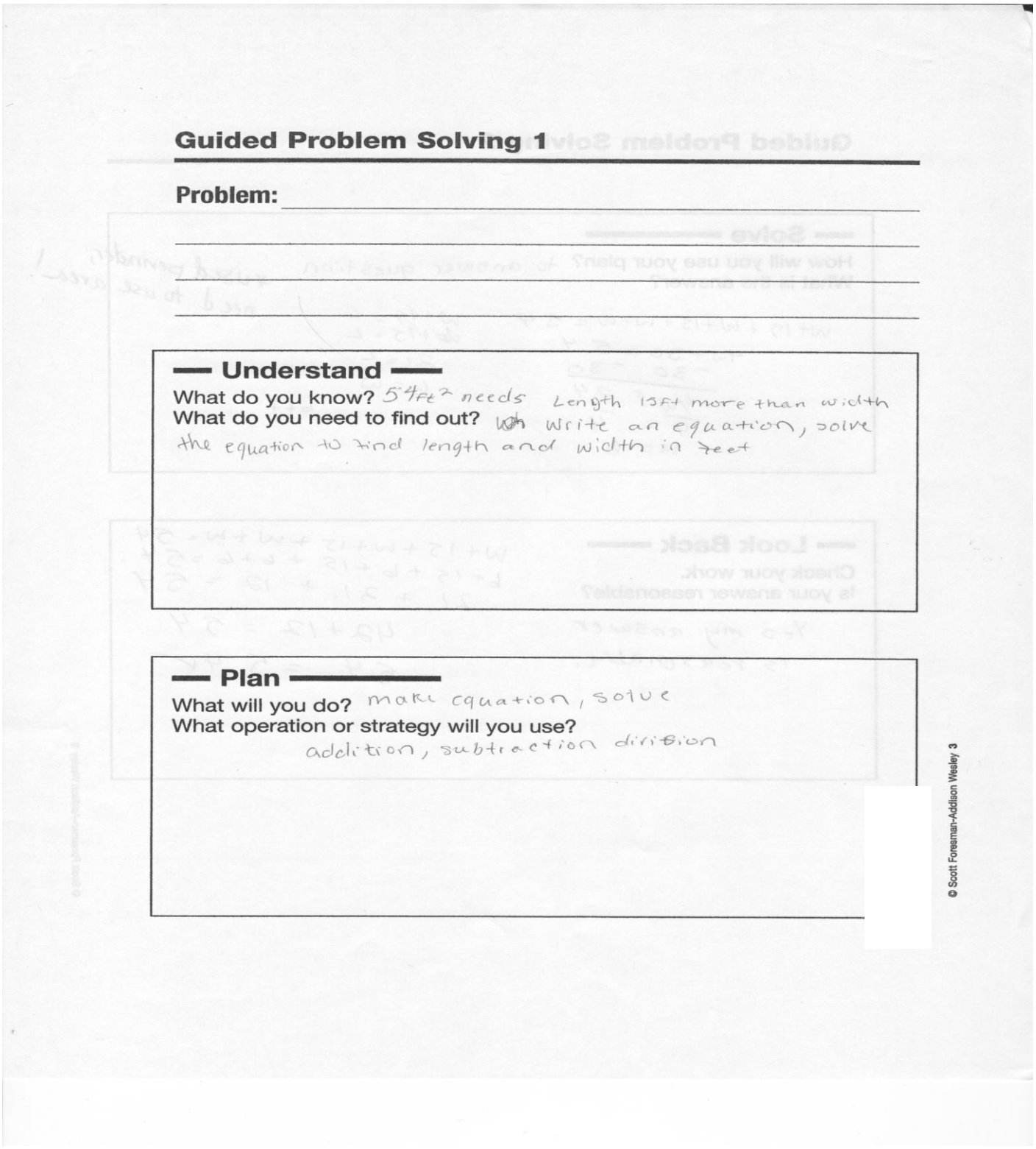
Appendix H

Heather's Diamond Graphic Organizer



Appendix I

Heather's Guided Problem Solving Graphic Organizer (front side)



Guided Problem Solving 1

Problem: _____

Understand

What do you know? 54 Ft² needs Length 13Ft more than width
What do you need to find out? Write an equation, solve the equation to find length and width in feet

Plan

What will you do? make equation, solve
What operation or strategy will you use? addition, subtraction division

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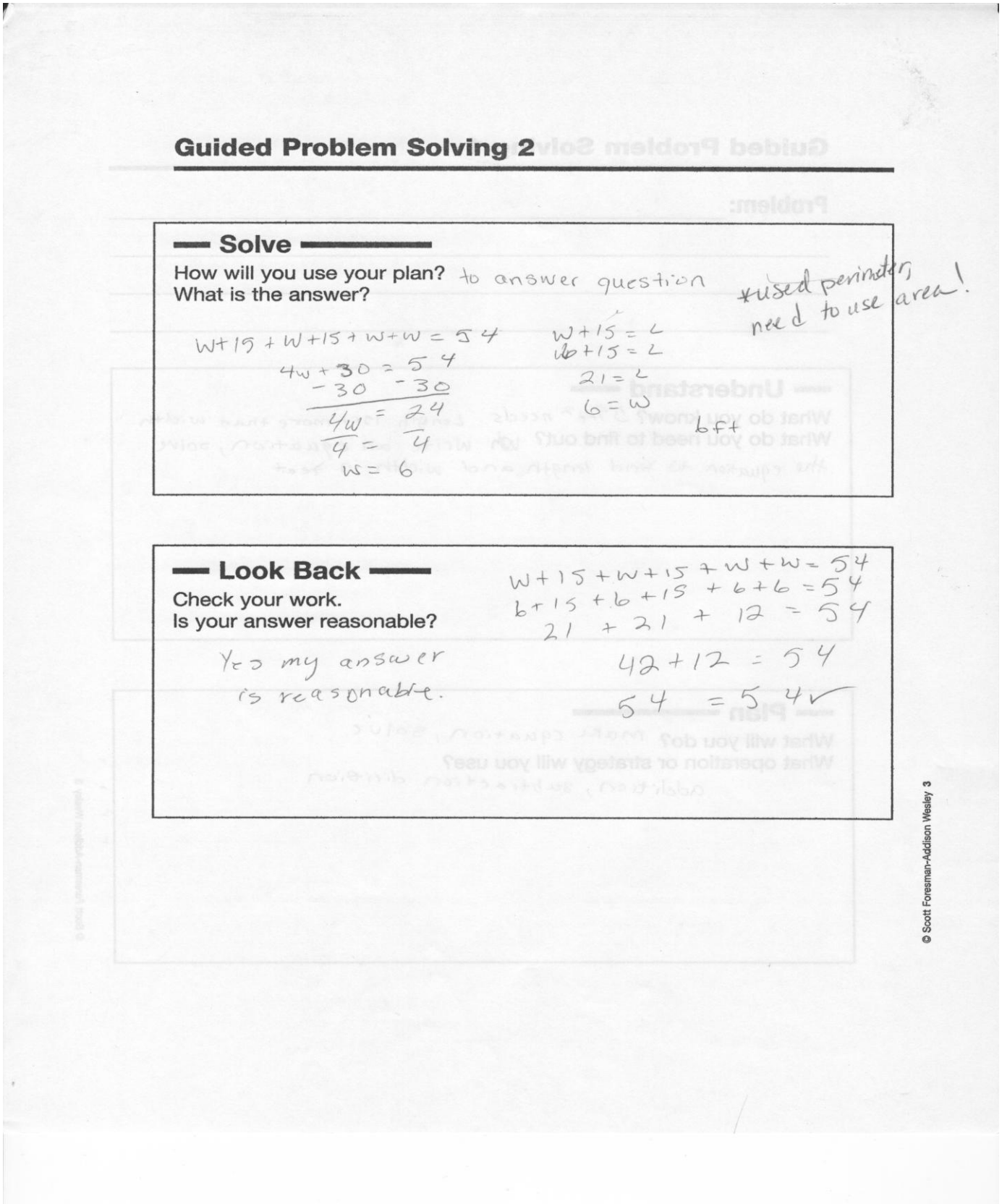
Heather's Guided Problem Solving Graphic Organizer (back side)



Guided Problem Solving 2

Solve

How will you use your plan? to answer question
What is the answer?

*used perimeter, need to use area!

$w+15+w+15+w+w=54$

$4w+30=54$

$-30 \quad -30$

$\frac{4w}{4}=\frac{24}{4}$

$w=6$

$w+15=L$

$6+15=L$

$21=L$

$6=w$

6 ft

Look Back

Check your work.
Is your answer reasonable?

Yes my answer is reasonable.

$w+15+w+15+w+w=54$

$6+15+6+15+6+6=54$

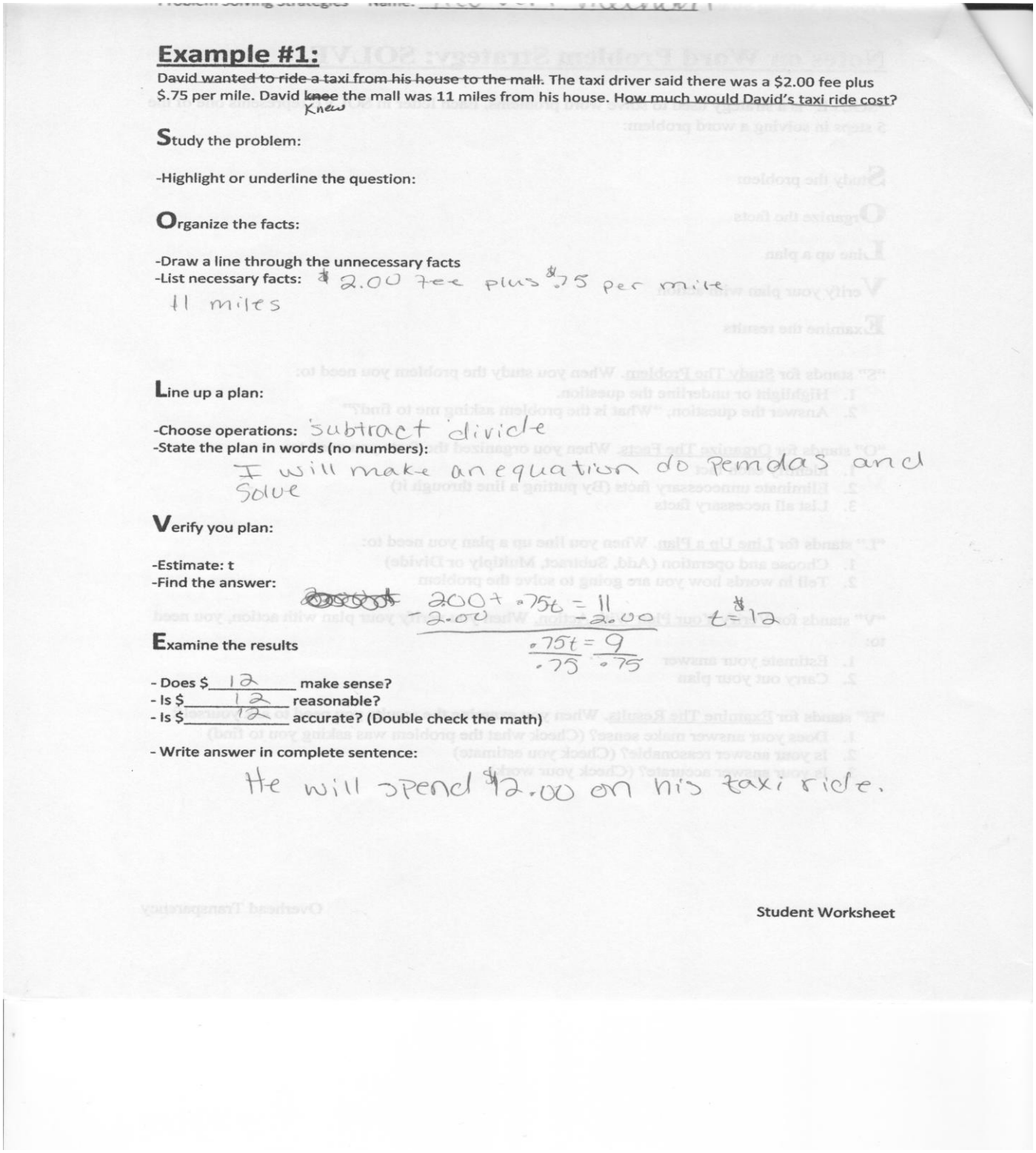
$21+21+12=54$

$42+12=54$

$54=54$ ✓

Appendix J

Heather's SOLVE Graphic Organizer



Example #1:

~~David wanted to ride a taxi from his house to the mall.~~ The taxi driver said there was a $2.00 fee plus $.75 per mile. David ~~knee~~ Knew the mall was 11 miles from his house. How much would David's taxi ride cost?

Study the problem:

-Highlight or underline the question:

Organize the facts:

-Draw a line through the unnecessary facts
-List necessary facts: $2.00 fee plus $.75 per mile
11 miles

Line up a plan:

-Choose operations: subtract divide
-State the plan in words (no numbers):
I will make an equation do pemdas and solve

Verify you plan:

-Estimate: t
-Find the answer:

$$\begin{array}{r} .75t + 2.00 = 11 \\ -2.00 \quad -2.00 \\ \hline \frac{.75t}{.75} = \frac{9}{.75} \end{array} \qquad t = \$12$$

Examine the results

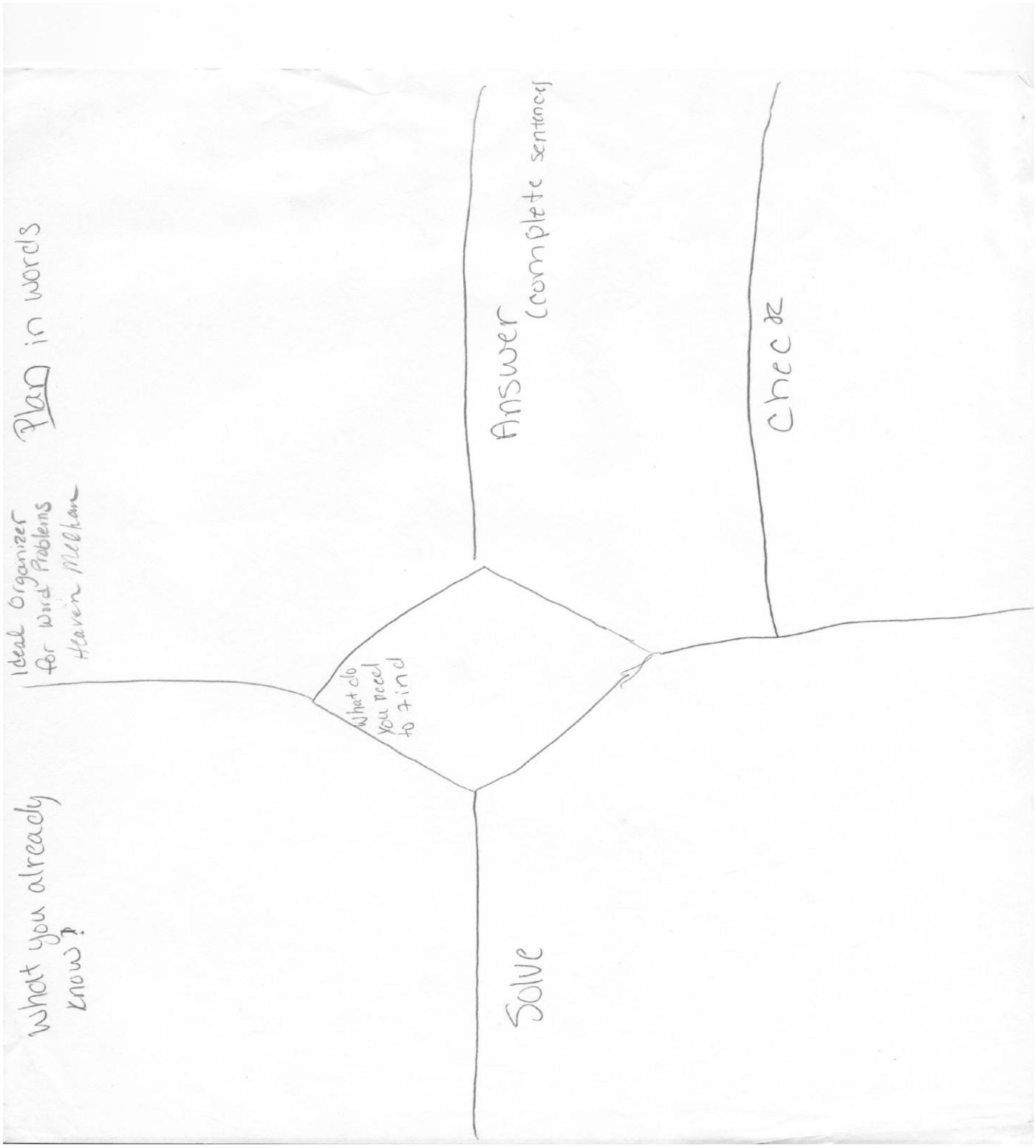
- Does $ 12 make sense?
- Is $ 12 reasonable?
- Is $ 12 accurate? (Double check the math)
- Write answer in complete sentence:

He will spend $12.00 on his taxi ride.

Student Worksheet

Appendix K

Heather's Self-created Graphic Organizer



Appendix L

Interview Chart

Heather 16 years old Born: April 7, 1994 Ethnicity: African American/Caucasian Favorite Subject: Math and Science Hobbies: reading books, watching t.v., spending time with friends Future Plans: wants to become a nurse and then go for being a doctor or wants to be a forensic scientist	Sarah 18 years old Born: December 7, 1991 Ethnicity: Caucasian Favorite Subject: History and Biology Hobbies: listening to music, watching movies, reading books, and shopping Future Plans: going to ESF at Syracuse University to pursue Environmental Science. She hopes to become a Veterinarian
Diamond Graphic Organizer	**Diamond Graphic Organizer**
Positive: • Helpful • Simplifies the word problem • The already know section helps organize information to help guide how to solve word problem • Brainstorm section helps to write thoughts down instead of keeping them all in your head	Positive: • Already Know section was good section to have; it saved time so didn't have to go back and reread question for needed information • Organizer as whole forced you to think out the question instead of going with the first instinct • Makes you slow down and think beyond the first answer that pops into your head • Good thing to have work space
Negative: • Need more room for the try it section in order to have enough work space • Explanation section should guide more in a way of getting students to write a sentence for their final answer to the word problem	Negative: • Brainstorm and Diamond section redundant b/c brainstorm wrote what needed to do which was in the diamond • Brainstorm not needed at all b/c of redundancy can do both brainstorm and diamond in one • The brainstorm section was confusing b/c she found herself using too many words instead of paraphrasing • Already Know section should have different title should be "Crucial information given within the question" • No "Try it here" – call it "Work Space" • Should have area to indicate point

	value of each question • Better to have blocks and have a sequence as to what to fill in and in what order o Don't like bouncing around to the different sections o Thought order should be: Already Know section-Diamond section-Brainstorm-Try it here-Explain section
SOLVE – Word Problem Strategy	**SOLVE – Word Problem Strategy**
Positive: • Likes the highlighting idea to make you look for important information • Good idea in listing the necessary facts and information • Liked in the L section that you had to state your plan in words – "takes everything in my head and puts it down on paper"	Positive: • Had the idea of a check going • Had a good identifying of the important facts • Asked "What is the problem asking you to find?" • Likes to write on problem itself instead of writing it out separately
Negative: • Examine part – has too many questions • The crossing out of not needed information is too time consuming and creates more of a mess to the question • There are too many guiding questions, too many extra words to read above the words in the question itself • The guiding questions make it too long and lengthy • Not enough working/writing space in the sections • Too wordy with the explain and expectations • Would think a lot of students would not like it or use it due to it being too long	Negative: • HATED this strategy the worst over all • Too many words • Too long as to what each letter stood for • Too much in order to understand what each letter stood for and figure out the word problem itself • No boxes to keep work together – likes boxes to stay organized • Not enough work space • Redundant in O section-identify each fact and list all necessary facts (asking same thing) • Would rather show work in math than write in words • Extra time and work was wasted in order to estimate answer and then find the real answer • Reasonable answer question should just say to check work • Too many steps o follow in

	understanding what SOLVE means • Font is too small • Too many subtitles • Too "outliney" – doesn't work for math • In the E section – the blanks were confusing as to what goes in them • Question itself should have been bigger to make it easier to read
Guided Problem Solving	**Guided Problem Solving**
Positive: • The plan section is similar to the brainstorm section in the Diamond Organizer • Liked guiding questions • Like that there's a spot to check answer instead of assuming that it is being done	Positive: • Had some form of sequence/flow to follow • Questions in boxes were more straight forward and easier to understand • Heading were useful in giving idea of what will do in each box • Forced you to check your work and answer b/c she normally wouldn't do it • "is your answer reasonable" is a helpful reflection question based on the students' work • If Look Back not there she wouldn't have done it
Negative: • It was only necessary to have one guiding question in each box except for in the Understand Box • Don't need "how will you use your plan" • Add another box between Solve and Look Back called "Final Answer" or "Final Answer in Sentence" • Don't like in the E section – "is the answer reasonable?" • Instead of Look Back it should be called "Check"	Negative: • Don't like the fact that it is back and front – want it all on one side • Solving and answer box should be separate boxes/spaces • "What you need" and "What do you need to find out" should be separate steps/separate boxes • Change Look Back to Check
What is the biggest problem with word problems? What makes them so difficult?	**What is the biggest problem with word problems? What makes them so difficult?**
• The length of the word problems, they can be very lengthy at times • She thinks that the length is what keeps	• A lot of information to sort through • Need to know what to filter: what's important vs. not important

students from wanting to read them and attempting them all together • Not knowing the mathematical terms and vocabulary used in the questions is an issue • Good idea to keep a personal math dictionary to refer back to when they come across a word they do not know for future references	• Having to do multiple steps • Language used could be confusing • Names used that are difficult for students to read and they are unfamiliar with may keep students hung up on it and be distracting

Appendix M

Question that paired with the Diamond graphic organizer

Natalie wanted to buy a book that costs $25.00. (The price includes the tax.) She has $11 saved already and is going to earn the rest of the money by washing the dishes at home every day. She gets paid $2.50 per day for doing the dishes. What is the minimum number of days she has to wash the dishes before she has enough money to buy the book?

Question that paired with the Guided Problem Solving graphic organizer

A contractor needs 54 square feet of brick to construct a rectangular walkway. The length of the walkway is 15 feet more than the width. Write an equation that could be used to determine the dimensions of the walkway. Solve this equation to find the length and width, in feet, of the walkway.

Question that paired with the SOLVE graphic organizer

David wanted to ride a taxi from his house to the mall. The taxi driver said there was a $2.00 fee plus $.75 per mile. David knew the mall was 11 miles from his house. How much would David's taxi ride cost?