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Does Decoding Increase Word Problem Solving Skills?

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Math in the Middle Institute Partnership
Action Research Project Report

in partial fulfillment of the MAT Degree
Department of Mathematics
University of Nebraska-Lincoln
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Does Decoding Increase Word Problem Solving Skills?

Abstract

In this action research study of my classroom of 7\textsuperscript{th} grade mathematics, I investigated whether the use of decoding would increase the students’ ability to problem solve. I discovered that knowing how to decode a word problem is only one facet of being a successful problem solver. I also discovered that confidence, effective instruction, and practice have an impact on improving problem solving skills. Because of this research, I plan to alter my problem solving guide that will enable it to be used by any classroom teacher. I also plan to keep adding to my math problem solving clue words and share with others. My hope is that I will be able to explain my project to math teachers in my district to make them aware of the importance of knowing the steps to solve a word problem.
INTRODUCTION

I envision my utopian classroom being one in which my middle school students possessed basic mathematical knowledge, problem solving skills, and the confidence to try any mathematical problem presented to them. Presently, my students are lacking the ability to solve problems, which has caused them to lose confidence in themselves and their ability to do math. For the last two years, I have stressed the importance of basic mathematical skills and knowledge, but I have fallen short on this subject. I attribute this shortcoming to receiving minimal instruction on problem solving skills throughout my education. This lack of instruction led to my own lack of self-confidence in solving word problems.

During a normal mathematics class, I began with a 10-15 minute question-and-answer session. The majority of questions during this time pertain to the word problems on the previous day’s assignment. I found that the longer the word problem was, the more questions were asked. Most of the questions relate to deciding how to solve the problem. In addition, during the class periods that focus on Habits of Mind problems, the number of questions asked increases dramatically. Habits of Mind problems are challenge problems, which are extensions of the concept material being studied in the classroom. They are solved by using higher-level thinking skills, which may need multiple strategies and concepts to complete.

My solution to this current dilemma in my class is to have problem solving be the focus of my action research project. This pertains to the National Council of Teachers of Mathematics (NCTM) process standard of problem solving, specifically, choosing a strategy or strategies to solve problems. The focus of my research would determine if decoding or breaking down a problem will enable the student to choose a strategy or strategies to solve any type of mathematical word problem. The general plan of action is to work with word problems on a
daily basis. A set of questions was given to the students that guided them through the problem solving process. As the semester progresses, fewer questions that provide guidance was given. This allowed the students to use knowledge obtained from the prior weeks and have less apprehension toward word problems. This research is important not only in my classroom, but also to other math teachers at other levels. If I can give my students the tools to use in solving problems, it will give them the confidence needed to thrive in all areas of math.

**PROBLEM STATEMENT**

The NCTM Problem Solving process standard was chosen as my point of reference because I want the students to be able to appropriately identify and use various strategies to solve problems. This is one objective listed in the *NCTM Principles and Standards* website under problem solving. This project is also related to the NCTM principles of learning, representation, connections, reasoning and proof, and communication.

According to the learning principle, in order for students to solve problems, they need to have a conceptual and procedural understanding of the problem. In addition, confidence and perseverance are qualities necessary to start and finish when a challenge is given. The students also need to be able to select and apply mathematical representations. This skill was key to my research because the students were to identify operation words (decoding) in word problems and represent them with correct symbols. Students were then not only asked to take those representations and use reasoning to decide upon an appropriate problem solving strategy, but to also give a justifiable statement as to their decision. My last expectation was for students to be able to communicate their findings to other classmates and myself. In showing their thought
process, a connection was made between different mathematical concepts and how they built upon one another.

If proven successful, I believe the use of decoding could increase the students’ ability to solve problems. The students could also gain confidence at the academic and emotional levels while working individually and in groups. Their knowledge of mathematical operation words and problem solving strategies may give them the confidence to not only attempt, but to solve mathematical problems they encounter. This newfound knowledge has the capacity to lead to self-confidence, which is needed in their career as a student and contributing citizen.

**LITERATURE REVIEW**

The topic of my action research project concerns whether or not decoding has any effect on word problem solving, primarily being able to select a strategy from the given information. I chose this topic because mathematics educators have consistently struggled with students and word problem solving instruction. The debate stems over what affects students and their ability to be good problem solvers. Themes found while conducting research which creates a successful problem solving classroom include 1) word problem comprehension, 2) understanding math vocabulary, 3) translating key words to mathematical representations, 4) having prior knowledge, 5) confidence in themselves, and 6) teacher instructional techniques.

Comprehension difficulties in both reading and mathematics have been found to affect students’ problem solving capabilities. These problems relate to their lack of math vocabulary knowledge and translating key words into mathematical representations. Research has also indicated that a student’s prior knowledge and confidence levels, along with a teacher’s instructional technique play major roles in creating a constructive problem solving classroom environment. This changed many people’s view of the importance of computational skills in the
mathematics classroom. A constructive classroom environment determines if students can decipher what appropriate problem solving steps and strategies should be used in finding a solution from the information given in the word problem.

**Reading Levels and Comprehension Skills**

Word problem solving involves more than basic computational skills. Math teachers have to teach students how to interpret vocabulary and comprehend the mathematical language. In essence, the math teacher must also be a reading teacher (Maikos-Diegnan, 2000). In her action research project, Maikos-Diegnan studied 44 fourth-graders on the effects of traditional computation instruction versus computation instruction using story problems. Her purpose was to investigate if difficulty in reading a word problem affects the outcome of problem solving. The study showed no significant difference between the two groups who were each given five word problems over a nine-day period. In my experience, two days is not enough time to completely discuss the mathematical concepts in the word problem and demonstrate multiple approaches to finding a solution.

A study by Knifong and Holtan (1977) also did not show that reading ability levels affect a student's ability to solve word problems. These researchers interviewed students who missed problems on the Metropolitan Achievement Test (MAT) on the word problem portion. They found other factors contributed to difficulties in solving word problems, not reading comprehension.

Roti, Trahey, and Zerafa (2000) performed a study using 5th and 6th grade students on the effects of reading comprehension in word problem solving. Their findings supported that if there was a reading difficulty, the student tended to rush through the word problem without giving any
thought to what the problem was asking. Frustration over the inability to understand the mathematical language caused errors in solving the problem.

Maikos-Diegnan (2000) and the research team of Roti, Trahey, and Zerafa (2000) conducted research for a Master’s Thesis, while Knifong and Holtan (1977) conducted research when poor scores on the word problem section of the MAT prompted investigation. All of the research projects were concerned if comprehension affects success in solving word problems. In comparing the studies, all three were similar in grade levels studied, the number of students studied, methodology, and findings. Each used examples of word problems to determine how comprehension affected groups of 30-50 fourth to sixth grade students. In addition, Knifong and Holtan also used interviews of sixth grade students in explaining their thought process of solving given word problems. All three studies’ findings showed no significant difference in scores or performance from pre-research to post-research. Maikos-Diegnan, however, did find that her students seemed to struggle less when mathematical vocabulary was explained to students. All concluded in saying that although comprehension may be a factor in problem solving, there are also many others that can affect success as well.

**Math Vocabulary and Translation**

In order for students to improve their reading comprehension, an understanding of the mathematical text is to be expected. According to Fuentes (1998), this process can be achieved by giving students a lot of experience in reading word problems and translating their meaning into numbers and symbols and vice versa. Fuentes is a veteran middle school mathematics teacher who is an advocate for the necessity of reading comprehension and vocabulary in the mathematics classroom. He also states that every word in a word problem is necessary for it to be solved. Therefore, having a lot of experience with word problems will enable students to see
terms used in a variety of situations with a different usage. This is a benefit to students because in a mathematical text, certain vocabulary terms will be used differently than in everyday language.

“The mathematical language that we use (symbols, pictures, words, and numbers) is sometimes unique (only used by mathematicians) or is taken from everyday language and turned into something else (i.e. table)” (Kotsopoulos, 2007, p. 302). Mathematical language can cause confusion when it is used in a format that students are not familiar. Kotsopoulos is an assistant professor in the Faculty of Education at Wilfrid Laurier University in Waterloo, Ontario. Her research has primarily pertained to elementary and secondary education, and has recently focused on peer communication, mathematics, and special education, and teachers’ perceptions of student thinking. In her research on the topic of vocabulary, she found that ninth-grade students had difficulties finding the difference between everyday language and mathematical language. An example would be the word “table”. In mathematics, it is a study tool to organize information; in everyday language, it could be a place to sit and eat. This was magnified when the teacher or student in the classroom inappropriately used mathematical language. Therefore, being able to decipher mathematical language will help students be better problem solvers that can transfer words to mathematical representations.

Sometimes students are quick to only look at the numbers and then put operation symbols between them in one-step problems. These students are rushing into finding a calculation (Lee, 2007). Lee is an assistant professor at Oakland University in Rochester. She teaches mathematics methods courses and is interested in developing instructional strategies for conceptual understanding. Hegarty, Mayer, and Monk (1995) performed a study at the college level on the different types of reading errors made by two types of problem solvers—successful and
unsuccessful. They found that unsuccessful problem solvers had more difficulties than successful problem solvers in translating the word problem to mathematical representations because they were more focused on the numbers than on informative words within the problem. Learning how to find these key words in a word problem is a key ingredient to being a successful problem solver and must be modeled within the classroom.

All of the research on this theme states mathematical vocabulary could be an obstacle when problem solving if students do not have a full understanding. They agree that if students do not know the terminology, translating it to mathematical representations is very difficult. The researchers in this area also agree some mathematical context causes confusion when taken from everyday language. Students have difficulty changing their thought process when walking into the math classroom.

The methodology of the research projects by Kotsopoulos (2007) and the team of Hegarty, Mayer, and Monk (1995) both used observations and interviews. Kotsopoulos used observations in a classroom and recorded the number of times terminology was used incorrectly by either the teacher and/or student. She then interviewed students and asked them to explain or demonstrate some math vocabulary terms. Hegarty and her team observed individual students and watched their eye fixations. They recorded the number of times they would look at certain parts of the word problem and how long it would take them to solve the problem. They interviewed the same students, asked them to explain what they remembered about the problems, and recorded their responses. Both researchers were trying to find what else might affect student’s struggle with mathematical text.

Lee (2007) and Fuentes (1998) wrote articles explaining their findings of how mathematical terminology affects students being able to translate word problems into algebraic
terms using numbers and symbols. They reflect on the problem solving process and instructional strategies that may improve student success in the math classroom, such as repetition, teacher modeling, and reflection.

**Instruction of Problem Solving Strategies and Steps**

The modeling process begins with the teacher. Not to put too much pressure on the educators, but their method of instruction will directly affect their students’ learning of how to solve word problems. At a young age, students should be given the foundation of good problem solving steps to follow. A standard four-step method has been altered over the years, but has remained a constant in the problem-solving classroom. The method begins with reading and understanding the problem, then making a plan, followed with working through the plan, and ends with making sure the answer makes sense. The amount of time spent on problem solving instruction, in addition to how instruction is given, will determine the success of the process.

Goldman (1989), an Associate Professor of Education and Psychology at the University of California at Santa Barbara, wrote about three popular methods of instruction that have been proven effective for students of all learning abilities. Direct instruction, self-instruction, and guided learning are all instructional methods that use both a student’s and a teacher’s strengths to create a positive learning environment where students are able to internalize problem-solving strategies. Goldman goes on to say, “Techniques for developing the representation—a process sometimes referred to as *translation*—are perhaps more important than execution of the appropriate arithmetic operations” (p. 48). Calculations are important to solving the problem, but they can only be made after a successful plan is created. In short, the destination, a solution, can only be reached by following the correct process path.
Confidence and Prior Knowledge

The saying that “attitude is 90% of the war” describes what confidence can do for successful students in the mathematics classroom. The element of repetition and practice of working with word problems creates the confidence needed to be a successful problem solver, along with creating a plethora of stored information. “Students’ self-perception may directly influence how they approach a task and the amount of effort they put forth” (Montague & Applegate, 2000, p. 216). Montague is a professor in the Department of Special Education at the University of Miami, while Applegate is an associate professor in the Department of Educational Studies at Western Michigan University. They pursued a study of how 54 middle school students’ with different learning abilities reacted to the difficulty of word problems and its affect on their ability to successfully find a solution. Average students and those with learning disabilities tended to rate problems as being difficult more often then gifted students, but would spend more time trying to find a solution. Gifted students also used more problem solving strategies than the other two groups.

The more knowledge students possess about solving problems, the more their confidence grows in themselves. Fuentes (1988) comments that students need to feel confident when working with problems related to mathematics. Some believe that any word problem will be impossible for them to solve because they do not have the necessary skills to be successful. The more students work with word problems, the less timid they will become.

Fuentes (1988) and the team of Montague & Applegate (2000) know that when students do not enter the classroom fully prepared and confident in their ability, the students’ chance for success decreases. They both state that persistence also stems from confidence. Students who have confidence will spend more time on solving a problem, if it is challenging, or they will use
an effective problem solving strategy, thus completing more problems in a shorter amount of
time.

**Conclusion**

My study investigated the effects decoding word problems had on students’ abilities to
determine what problem solving strategy to use to solve a word problem. The literature I
reviewed reflects the key components to my action research project—reading, comprehension,
translation, instructional methods, problem solving steps and strategies, confidence, and prior
mathematical knowledge.

My action research project primarily uses the same methodology as those I researched,
which is surveying, journaling, interviewing, and observing. I also used grouping, teacher
modeling, intervention, and repetition, which is similar to Maikos-Diegnan (2000), Kotsopoulos
(2007), Roti and et al. (2000), Montague and Applegate (2000), Knifong and Holtan (1977), and
Hegarty and et al. (1995). My research may reiterate what Fuentes (1988) and Maikos-Diegnan
(2000) believe to be important in problem solving, which is reading and vocabulary. My desire
was to have significant evidence, which supported my hypothesis that decoding will enable
students to have more success in the math problem solving classroom. My belief is decoding
brings the elements of comprehension and translation together and along with repetition and
diverse teaching instruction, students will gain the experience and confidence needed to be
successful problem solvers.

**PURPOSE STATEMENT**

The purpose of my project is to determine if decoding a word problem will enable a
student to choose a strategy (-ies) to solve any type of word problem. I examined pieces of
evidence such as student work, a weekly journal, student interviews, and student surveys in seeking to answer the research questions:

- What will happen to students’ ability to use appropriate strategies to solve word problems after receiving instruction in problem solving strategies and decoding?
- What will happen to the frequency and types of questions students ask during class pertaining to solving word problems after receiving instruction in problem solving strategies and decoding?
- What will happen to the level of student confidence in themselves as problem solvers after receiving instruction in problem solving strategies and decoding?
- What does my teaching look like when I try to better teach problem solving to my students?

**METHOD**

My school, during this study, was located in Grand Island, Nebraska. It was a K-8 feeder school and part of the Northwest Public Schools. I taught sixth, seventh, and eighth grade math, and an eighth grade algebra class. My classes had a range of 15 to 23 students. I chose my 7th grade class of 13 regular education students as my subjects of study because they would benefit the most. I collected Quizzes, Problem Sets, and the Final Test from six students who represented three learning ability levels: lower, average, and above-average. Two students from each level were used as a comparison tool when analyzing. However, I used all 13 students when it came to surveys and interviews.

On Monday, February 4, 2008, my action research began with the students taking the Pre-Research Survey (Appendix A), which included questions about confidence, groups, and frequency of questions. On Wednesday of that week, February 7, students were given a Pretest
Problem Solving 12

(Appendix B), which consisted of 10 word problems from most of the problem solving strategies I selected to study. The initial strategy list consisted of 1) guess and check, 2) missing information, 3) identifying extra information, 4) writing and using an equation, 5) working backwards, 6) using tables and drawings, 7) logical reasoning, 8) maps and charts, 9) making an organized list or chart, 10) hidden information, and 11) multi-step problems using formulas. Most students were familiar with some of the strategies if they were in my class the previous year.

As the research progressed, maps and charts, along with logical reasoning, were not covered because of time constraints. Two problem solving strategies were combined—missing information and extra information. I used Thursday and Friday of that same week to discuss the Pretest word problems with the class and beginning the Pre-research interviews (Appendix C). Other parts of the research were discussed during this time, such as the Problem Solving Guide (Appendix D), the Problem Solving Rubric (Appendix E), and the Math Problem Solving Clue Words chart (Appendix F).

A new problem solving strategy was introduced weekly. A Practice Set (Appendix G) and a Problem Set (Appendix H) was given each week. These sets consisted of four word problems using previously introduced strategies and the current strategy. A chart of the strategies and their instruction dates are as follows:

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missing and Extra Information</td>
<td>February 13, 2008</td>
</tr>
<tr>
<td>Writing Equations</td>
<td>February 20, 2008</td>
</tr>
<tr>
<td>Working Backwards</td>
<td>February 27, 2008</td>
</tr>
<tr>
<td>Making Tables and Chart</td>
<td>March 5, 2008</td>
</tr>
<tr>
<td>Hidden Information</td>
<td>March 19, 2008</td>
</tr>
</tbody>
</table>
The Practice Sets were done as a class and used as a reference for the Problem Sets. A Problem Solving Strategy Quiz (Appendix I) consisting of four word problems was given on March 12. The students completed this individually and scores were recorded (same scoring system). Two brief review sessions of the problem solving strategies were held on April 21 and April 22. The Final Test (Appendix J) consisted of 10 problems, similar to the Pretest, and was taken individually on April 23. The word problems on the Problem Sets, Quiz, and Final Test were all graded using one point (five points total) each for 1) decoding, 2) selecting an appropriate problem solving strategy, 3) justifying the problem solving strategy, 4) showing work, and 5) finding the correct answer with a label.

The Problem Sets, Problem Solving Strategy Quiz, and Final Test were corrected and given a grade. The students were able to review their work and ask questions. After a question-and-answer session, the students handed in their work for further analysis. All scores were put into a spreadsheet for data analysis.

The last two components of my data collection were a journal and a question chart. I observed the students when we met on Wednesdays. I kept a personal journal for recording any thoughts I had on my teaching, comments made by the students, and interactions between the students. I particularly looked and listened for comments made by the students during discussion and work habits shown by the students. I would also write down thoughts about my teaching,
which was probably the most beneficial part of journaling. It made me analyze my instructional methods and forced me to look at what improvements could be made.

At the close of the day, I would transfer this information to an official Teacher Journal (see Appendix K for journal prompts). I would take about 30 to 40 minutes to organize my thoughts and observations made throughout the day. In the beginning, I was diligent in writing my Teacher Journal, but as the weeks went by, that diligence faded. My time was taken away with lesson plans, grading papers, analyzing data, creating word problems, etc. At one point in time, I was two weekly journals behind. It became more of a hindrance than a help because it was just another thing I had to complete. I became overwhelmed with the amount of time it took away from my teaching. Because it was done at the end of the day, the papers I corrected during this time had to be taken home. When this occurred, any preparations I made at home for the following day was pushed aside until the next day. This created a sense of frustration about the whole project because I was trying to stay afloat day after day.

During the morning and afternoon sessions, I kept a frequency chart of the types of questions the students asked during class time that pertained to their word problems. The Question Chart (Appendix L) was used to record the frequency of types of questions asked concerning problem solving on a weekly basis. The categories of the types of questions pertained to the follow areas: 1) decoding, 2) choosing a problem solving strategy, 3) justifying a problem solving strategy, 4) setting up the problem, or 5) justifying their answer. At the beginning, I felt I spent more time recording than answering questions because of the high frequency of questions. I had difficulty in categorizing the questions, initially, but as the project progressed, this became easier.
I analyzed the data by looking for any patterns or tendencies in my journals, the spreadsheet containing the scores from the Problem Sets, or my Question Chart. My analysis forced me to look for reoccurring events in the students’ comments, questions, or work in the previously mentioned areas.

All of the 13 students received a folder with fasteners at the beginning of the project. They were given laminated copies of the Problem Solving Guide, the Math Problem Solving Clue Words chart, and the Problem Solving Rubric to put inside the folder. As we went through the problem solving strategies, the students were to put the Practice Sets in the folder as a reference. At the end of the research, the students had made a makeshift book on problem solving.

The Problem Solving Guide was a set of eight steps that guided the students through decoding and solving the word problems. This guide led the students through the problem solving steps for each word problem they encountered. An addition was made to step three to circle the label in the question. This forced the students to look for it and write it down on the Answer line before they started to set up the problem.

A chart of Math Problem Solving Clue Words was generated that helped the students decode English words to mathematical representations. The list consisted of words that represented the four operations, group words, and the equal sign. When the class found another word, the students added it to their list and I added it to the enlarged one on the bulletin board. As the semester progressed, the list became longer as words were added by the students. A rule was made that the class had to “okay” the word before it became officially added to the list.

A Problem Solving Rubric was generated to inform the students of how each Problem Set would be graded. For the first two weeks, the rubric was used, but not properly. I was having
difficulty in grading the Problem Sets because I could not decide on what score they should receive on a 0 to 4 scale for each of the five parts of the rubric. I believe this happened because the rubric was meant for one problem. Because each Problem Set had four problems and five parts-decoding, strategy, justification of strategy, work, and answer with label-I took one point off for each incorrect part.

The final parts of the data collection involved the Post-research Survey (Appendix M) and Post-research Interviews (Appendix N). Both parts contained the same questions given at the beginning of the research. These were given during the week of May 5, 2008.

One thing that remained constant throughout the project was my system of organization. I kept a three-ring binder that held all of the student data I collected, such as the Problem Sets, Problem Solving Strategy Quiz, and Final Test. I also kept hard copies of the Practice Sets, Problem Sets, Quiz, and Test, in addition to the Practice Set transparencies the students and I completed in the morning. I kept this information in a three-ring binder rather than in hanging folders.

**FINDINGS**

Every Wednesday, a new problem solving strategy was introduced. In order for this to occur, I needed to find and/or write eight word problems. I used four word problems in each Practice Set and Problem Set. These word problems needed to be at grade level and pertain to the problem solving strategies already introduced. I tried to use word problems that could be solved by using different problem solving strategies. My word problems came from a variety of sources, but I favored the textbook I was currently using because the students would be more comfortable in using the decoding process on their daily assignments.
I had each math class twice throughout the school day, 45 minutes in the morning and 45 minutes in the afternoon. The only exception was on Wednesdays because of a 2:00 dismissal. This created only 25 minute periods in the afternoon. In the morning, the class worked together with my assistance on a Practice Set of four word problems. I would write on the transparency and the students would “lead” me through each problem. The class would make decisions on clue words, strategies, justifications, set-up, and answer. At first, the word problems only pertained to one particular problem solving strategy, but after the second week, the problems could consist of any previously introduced problem solving strategy. In the afternoon, the students worked in randomly chosen small groups of two or three to complete the Problem Set (Appendix H), which also consisted of four word problems that were scored and recorded.

A typical Wednesday during my research began with the students gathering the necessary materials. My 7th grade class was my homeroom class, so I had them the first period of the day. While I was taking lunch count, the students were preparing for class—colored pencils, a pencil, a calculator, and their problem solving folder.

I would then pass out the Practice Set and put the Practice Set transparency (see Appendix O) on the overhead. Three colored pencils were needed for decoding—red, green, and blue. I used a red, blue, green, and black permanent marker on the transparency. The first step in this process was to use the red pencil for underlining key operation words in the word problem. The second step was to use the blue in circling the necessary information needed for the problem. The last step was to use the green to underline the question and circle a label. An example of a student's work can be seen in Appendix P. Through these steps, the students worked as a group to make decisions on what was circled and underlined. The students acted as
the puppeteer, while I was the puppet. If questions or conflicts arose, I would then take the role of teacher.

The Practice Set would normally be completed during the morning session, but if it was not, then it was in the afternoon session. The afternoon session was used for group work on the Problem Set. I would randomly divide the students into groups of two or three using name cards I had made at the beginning of the year. This was done by turning the cards upside down on a table and choosing groups. The groups would then use the same procedure (Problem Solving Guide steps) to complete the four word problems on the Problem Set. While the students were working on the problems, I would write in my journal. Since there were usually four or five groups, I would sit beside each group for 5 minutes and write down my observations. Also during this time, I would tally any types of questions asked to me or another classmate. If any group had a question while I was observing, they became the priority and I would leave to give guidance. Groups tended to work fairly independently, asking me few questions.

Students usually were not done with the Problem Set during the afternoon session. I usually set aside the next day’s morning session to allow groups to finish. All groups finished their work during this time and then were given regular classroom instruction in the afternoon. I liked to score the Problem Sets when all were finished. This allowed me to see if any differences existed between those who worked together as a group. All Problem Sets were graded because I wanted to give feedback to everyone. This was a normal practice in my classroom and I wanted to be consistent for those who needed that structure. I addressed differences during the next day’s session, in addition to discussing the word problems as a class. I allowed 10-15 minutes for this question-and-answer session before beginning my instruction on the day’s regular lesson.
My first research question was what will happen to students’ ability to use appropriate strategies to solve word problems after receiving instruction in problem solving strategies and decoding? What I found is that students are able to pick out a strategy to use after they have read and decoded the problem, if given a problem solving strategy list.

The first piece of evidence that supports this finding is the Math Problem Solving Clue Words chart. Twenty-five new clue words were added to the list, which included four for addition, nine for subtraction, three for multiplication, two for division, and seven for the equal sign (see Appendix Q). The original list I created for the students, as shown in Appendix F, had sixty-eight words; therefore, there was a 37% increase in the number of clue words. The students discussed continually whether each word was used as a “math” or “English” term in the word problem. The students’ ability to identify clue words improved throughout the research because they were reading the problems more carefully. These discussions about the clue words helped to determine an appropriate problem solving strategy.

During the first two weeks, the practice and problem set questions focused only upon the problem solving strategy discussed in class. However, the practice and problem sets during the last six weeks had a variety of problem solving strategies used in the word problems. The strategies included for each practice or problem set depended upon the number of strategies covered up until that time. In analyzing the last six problem sets where the students had to choose the strategy from the list, six out of six students were able to choose an appropriate problem solving strategy.

The results for the Problem Solving Strategy Quiz and the Final Test were promising. The quiz had four problems, similar to the problem sets. The problem solving strategies the students could have used were 1) missing information, 2) extra information, 3) writing an
equation, 4) working backwards, and 5) tables and drawings. Out of the six students who took the quiz, one student correctly chose all four of the problem solving strategies, three chose three appropriate strategies, and one chose two appropriate strategies, and one chose an appropriate strategy for one word problem. Thus, four out of six, or 67%, of the students chose an appropriate strategy for half of the word problems. This represents significant progress for the students in my class. One of my struggling students was part of the group who chose an appropriate strategy over half of the time.

The Final Test consisted of ten problems where students could have used any of the eight problem solving strategies. It was scored exactly as the Problem Sets and Problem Solving Strategy Quiz. All six students chose an appropriate strategy for six or more of the word problems. One student chose an appropriate strategy for all ten word problems, one chose nine appropriate strategies, one chose eight appropriate strategies, two chose seven appropriate strategies, and one chose six appropriate strategies. Once again, my lower ability student did an excellent job of choosing eight out of the ten strategies.

From observing the students in their groups, one of the lower-level students I am following said, “I would say that it is guess and check because we are going to guess to get an answer.” This occurred during his group’s discussion and work on problem #2 on the Writing Backwards Problem Set. In my daily journal on March 4, 2008, I included the following observations after watching the class work together in their groups. This was the second week that the students were exposed to a practice and problem set where there were five problem strategies for them to choose to solve the word problem.

“Students are starting to look at the problem and setting up the problem. They are thinking of different ways to solve.”
“Erica\textsuperscript{1} and Jane knew that it was working backwards because of the word ‘first’. This has been something we have been working on.”

The evidence given for my first research question pertaining to the student’s ability to choose an appropriate strategy to solve word problem is supported by evidence attained by three data collection instruments-The Math Problem Solving Clue Words chart, the Problem Set and Final Test results, and my teacher journal. First, the Math Problem Solving Clue Words chart showed an increase of 25 new words added during the research. Second, the Problem Set and Final Test results showed progress from the six students I chose to collect and record results. Finally, my teacher journal described examples observed in the classroom during both Practice Set and Problem Set sessions of students demonstrating their approach to selecting an appropriate problem solving strategy.

Students also become better problem solvers from asking questions. I wanted to find out what would happen to the frequency and types of questions students ask during class pertaining to solving word problems after receiving instruction in problem solving strategies and decoding. My assertion is that because of instruction on decoding, the frequency of questions decreased and the types of questions changed from decoding to setting up the problem.

The five types of questions asked by the students were 1) decoding, 2) problem solving strategy, 3) justification of strategy, 4) setting up the problem, and 5) labels. Decoding questions pertained to finding key words, finding needed data, and questions on if words were “English” or “math” words. The second question category related to deciding on an appropriate strategy to solve the problem. If students had questions over giving a reason why they chose a strategy, I put a tally in the third category of justification of strategy. Any questions over how to solve the

\textsuperscript{1} All names are pseudonyms.
problem went in the setting up the problem column. Lastly, if students asked questions on what label was needed, the label category was marked with a tally.

The first piece of evidence that supports this claim is the two frequency charts I kept with the five categories of questions during the Practice set and Problem Set sessions. I would tally each type of question asked during the problem solving sessions and then put actual numbers in the final chart. The charts also contain the Problem Set number and the total number of questions. The number of questions dramatically rose from week #3 to week #4 because I began to include previously instructed strategies into the word problem sets. Otherwise, from week to week, the total number of questions decreased. From beginning to end, the Practice Set questions decreased by 69% and the Problem Set questions decreased by 85%. These charts are as follows:

**Practice Set sessions**

<table>
<thead>
<tr>
<th>Types of Questions Asked</th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4*</th>
<th>#5</th>
<th>#6</th>
<th>#7</th>
<th>#8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decoding (key words, data, question asked)</td>
<td>16</td>
<td>17</td>
<td>11</td>
<td>9</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Problem Solving strategy</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>12</td>
<td>10</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Justification of strategy</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>8</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Setting up the problem</td>
<td>19</td>
<td>15</td>
<td>13</td>
<td>12</td>
<td>8</td>
<td>12</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Labels</td>
<td>2</td>
<td>2</td>
<td>7</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>42</td>
<td>41</td>
<td>38</td>
<td>47</td>
<td>30</td>
<td>30</td>
<td>19</td>
<td>13</td>
</tr>
</tbody>
</table>

*Began using different strategies on the problem set. Week numbers correlate to problem solving strategy

**Problem Set sessions**

<table>
<thead>
<tr>
<th>Types of Questions Asked</th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4*</th>
<th>#5</th>
<th>#6</th>
<th>#7</th>
<th>#8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decoding (key words, data, question asked)</td>
<td>10</td>
<td>12</td>
<td>5</td>
<td>7</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Problem Solving strategy</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>9</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Justification of strategy</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Setting up the problem</td>
<td>11</td>
<td>9</td>
<td>9</td>
<td>10</td>
<td>7</td>
<td>6</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Labels</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>26</td>
<td>28</td>
<td>25</td>
<td>37</td>
<td>22</td>
<td>13</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

*Began using different strategies on the problem set. Week numbers correlate to problem solving strategy
When I wrote Journal 3 on February 21, 2008, I made a comment about the number of questions being asked in the classroom. The observation is as follows:

*The student’s questions directed to me are coming less often because they need to discuss their reasons with others in the class and within their cooperative learning group. They are relying more on each other, but when they cannot decide as a group, they come to me for advice.*

This was only after the third week of instruction, but even at this time, I was working with the students on relying on each other and not me for a question to a word problem. In my journal, written on March 20, 2008, I was still feeling confident in the progress made by the students in asking questions. This observation is as follows:

*The students are focusing more on solving the problem instead of always asking for help. They are talking to each other and picking each other’s brains instead of mine. It is really refreshing to be able just to sit back and let them do the work.*

Another example of what occurred in the classroom, concerning questions, came from my journal, written on April 10, 2008, as I reflected on how the week went.

*They are asking great questions, not only to me, but also to their peers. This is allowing them to direct their learning to concepts and ideas they need to possess.*

In summary, my second research question pertained to the frequency and types of questions asked throughout my researched. I gave evidence supporting my assertion that the frequency of questions decreased as the types of questions asked changed from decoding to setting up the problem. My first and second pieces of evidence were the frequency and tally charts taken during both of the Practice Set and Problem Set sessions. Explanations were given concerning the results. My final piece of evidence was taken from my teacher journals, which provided observations and examples of student questioning.
My third research question was what will happen to the level of student confidence in themselves as problem solvers after receiving instruction in problem solving strategies and decoding. Students had to rely on each other in both the Practice Set and Problem Set sessions. They not only had to trust each other, they had to trust themselves, and with this trust came confidence. My finding for this particular research question is that a student’s level of confidence in problem solving is greater when working in groups rather than individually.

I gave the students an identical survey at the beginning (Pretest) and ending (Posttest) of the research. What I found to be interesting that pertains to confidence is the question that asks if students have more confidence to try problems when they work in a group (question #4). At the beginning of the research, four students responded with a 1 (meaning Strongly Agree), but after the ending of the research, six students responded with a 1. Prior to February (when the research began), the students had many opportunities to work in groups. I taught these students as sixth graders and used cooperative learning extensively throughout the year.

This particular class, however, did not like working in a group setting. They would have preferred to work individually and ask me questions than go to another classmate for help. Therefore, when the mean score at the beginning was closer to a neutral rating at 2.67, it did not surprise me. However, when the ending rating for the same question came closer to the agree rating at 1.58, this surprised me. The following chart shows these results and the results for the remaining questions.

<table>
<thead>
<tr>
<th>Question</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I feel confident in finding key words in a word problem.</td>
<td>Pre-</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2.75</td>
</tr>
<tr>
<td></td>
<td>Post-</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>2.17</td>
</tr>
</tbody>
</table>
All of these questions on the survey pertain to confidence in some manner. As I have stated before, confidence is a key ingredient to solving word problems. In my research, confidence was gained when students worked in groups. Some of the comments made in the interviews at the beginning of the research when asked a question about their attitude towards word problems are as follows:

“Ah, kind of confusing I guess. It’s not that hard in a group because mostly you have more than one person working on it, so it’s easier to figure it out. But when you’re on your own, it’s hard because you don’t know which word to use or which word not to use.”
“...Working in groups helps.”

“Put us in groups while we’re doing it. It’s a lot easier to understand them because you have more than one person working on them and it is more comfortable and not as hard.”

At the end of the research, the students had this to say about solving word problems:

“I feel confident in myself to work on them and finish.”

“I feel like I can just do it.”

“I think it’s easier now because finding the key words helps a lot.”

As a researcher and a teacher, I was able to observe the students both in a class setting and in groups. A good example of confidence levels increasing in the classroom is taken from my journal when I reflected on what occurred in the problem solving sessions. It was written on March 20, 2008 and says

I believe some are becoming more confident in themselves because of the discussions that are occurring within the groups. They are definitely discussing more and making their opinions known. They seem to want to decide upon what strategy to use and what words or data are needed to solve the problem. Some groups are better than others. Some are still holding back, waiting for a little more guidance, but it is much better than it was before.

Another excerpt came from my journal, written on April 10, 2008, when I reflected about what changed I saw in my students’ confidence levels and/or questioning. I responded with this statement:

The higher-level students are beginning to lie back a little and letting other students do more. I believe they realize that is what I want them to do. It is helping all levels of students. The lower and average are able to shine and the higher-level students are able to learn how others are thinking.

In summary, the evidence used to support my third research question on confidence is supported by three pieces of evidence. The first was an identical survey given at the beginning and end of the research. It showed an increase in the number of students selecting Strongly Agree
on the question asking if they (the student) had more confidence working in groups rather than individually. A chart shows the results to all of the survey questions. The second piece of evidence came from student interviews when excerpts were given. My teacher journal was the last piece of evidence, which described my observations and personal reflection.

My final research question asks what does my teaching look like when I try to better teach problem solving to my students. I chose to research decoding and problem solving because I did not have confidence in myself as a problem solver. My hope was that I would gain confidence in instructing problem solving while conducting this action research project and that wish came true.

In my research, I found that my problem solving teaching is dependent upon the students’ needs and questions. In order to increase their confidence, I want them to experience success and feel comfortable in solving word problems. Their progress, or lack of, from week to week determines what and how I teach. For the most part, I let them control the path their learning needs to follow by giving me suggestions either in writing or orally.

In the pre-research interviews, I asked the question, “What could teachers do to help students with problem solving?” Here are some replies from three of my students:

“Take it step by step and go over some hard ones.”

“Maybe more vocabulary words and stuff. It would help break it down. Break down the problem into parts.”

“Put them in groups while we’re doing it. It’s a lot easier to understand them. Because you have more than one person working on them and it is more comfortable and not as hard.”

On February 28, I wrote the following in my personal journal:

“Overall, the students did very well on this Problem Set. I also did something different with this set. I put 2 ‘working backwards’ and 2 other strategies on the 4-problem set. They did surprisingly well. Some solved it first and then decided what
strategy they used. I’ll have to see the different answers the students have. I know that solving first is out of order, but being able to set it up is one of the goals for this research.

I asked the students to write a few sentences after the March 20 problem set introducing the problem solving strategy of hidden information. They were to write about any of their feelings toward problem solving. At the time, I was feeling some frustration. I needed to know if there was something more, I could do or needed to change. Emily, Cheyanne, and Jasmine had these responses:

“I like how when somebody gets confused when we’re working as a class you (directed towards me) help them by making it into a life-like situation.”

“…I think that the underlining and circling is making it better. I hope that it will still get easier. It’s fun to do it with others than by yourself.”

“I think that problem solving is easier by color coding the keywords. In addition, it would probably be easier to have the morning on Wednesdays to do groups, and the other half, two people. I think it’s fine right now, but probably needs to get a little harder. It’s not very challenging right now. It’s also harder to find the key words.”

The responses that I received from the students made me realize that they were actually learning something. Sometimes it was hard to determine what type of learning, or if any, was taking place. This observation, made on March 20, during the Problem Set session was an occurrence that I am not likely to forget.

I did some questioning of my own when the students were working on their problem sets. I wanted to “hear” what they were thinking. The first student that caught my ear was [a student]. He is one of those students who wants to do well, but who really has to work at it. I would consider him one of my average students. He and his partner were working on question 1. I heard him explaining this problem to his partner. Therefore, I asked him to repeat it to me. He told me the steps he took to solving the problem and why he did it. He told me his whole thought process. [A student] brought up a good point about someone looking at his paper and being able to understand how he got his answer. This was great! I had been stressing this point over-and-over, week after week. Finally, somebody actually listened!
The pre-research interviews and teacher journal excerpts provided evidence on what my teaching looked like as the research progressed over the twelve-week period. The interviews gave me guidance as to the wants of the students on what methods would suit their learning. My teacher journals allowed me to reflect upon the week and what I needed to improve on concerning my instruction. In fact, all of my research questions provided guidance on how to make me a more effective teacher. Each week, I would make notes on how to improve some aspect of my teaching related to my research topic of problem solving. A plethora of knowledge was gained on problem solving instruction because I was forced to step out of my comfort zone and acknowledge my weaknesses.

CONCLUSIONS

Teaching problem solving forced me to make changes in my instructional methods to better educate my students. It made me a better educator in the process because I had to step out of my comfort zone and teach something I did not particularly like. I can now relate more to my students’ frustration because I felt frustration many times throughout the research.

I have found through my research that confidence in oneself is an important aspect to becoming a better problem solver. Confidence is gained through feeling success in solving a problem correctly. In my findings, the students felt more confident when working in groups because they began to trust one another. As that trust increased, the students asked more questions to their peers than to me.

I also found that after more instruction and practice was given on problem solving strategies, the students were able to work through the problem solving process—find the key words, transfer them to mathematical representations, choose and justify an appropriate problem solving strategy, and find a solution. At the end of the project, the students were deciding on a
strategy before the decoding process had even begun. This frustrated me at first, but I realized it was a good thing because it meant that they were focusing on the words and those words were giving clues as to how to solve the problem.

My research findings are very similar to the findings of other researchers in the area of problem solving in mathematics, especially Fuentes (1988), Maikos-Diegan (2000), and Goldman (1989). Fuentes (1988) found that confidence is gained when students could read and understand the vocabulary in a mathematical word problem. He believed that they would instantly give up if the vocabulary were too difficult. The more students know about mathematics, the more they will be able to understand mathematical texts. However, they also need to have an organized system of how to store that new information, such as concept maps, Venn diagrams, organizers, etc. This requires teachers to instruct students on numerous problem solving strategies and the vocabulary, which gives clues as to which one to use. I found this statement to be very true because when I gave more examples and explanations of the types of vocabulary each problem strategy would use, the students were looking for those clue words.

Maikos-Diegnan (2000) was a believer in teaching reading in the mathematics classroom. She stated throughout her paper that mathematics teachers must also be reading teachers because they both need to teach strategies to be successful. Math teachers cannot expect students to be able to solve a problem unless they understand the text that makes up the problem. Decoding was essential in the success of my action research project. When the students became more confident in finding the clue words, this became the stepping stone that lead to confidence in finding a strategy to finding a solution to the word problem. The students were then able to find each word problem accessible, which means the students were able to, at least, have the confidence to begin each problem they encountered.
Goldman (1989) spoke of a four-phase model. This was the basis of my Problem Solving Guide. The phases were to 1) read, or become familiar with the problem, 2) find the necessary information, 3) set up the problem with numbers and symbols and solve, and then 4) see if the problem makes sense. I found this model to be very helpful to the students. In following the steps, the students were able to create a solid foundation with their understanding of the text in the problem. Once the students had that understanding, they were on their way to finding a justifiable solution to the problem.

**IMPLICATIONS**

This research project has brought about a definite change in how I teach problem solving. Before, I saw problem solving as something that could be done at the end of a chapter. If I did not have time, I did not have the students do it. In talking to other math teachers in my district, my feelings toward problem solving are shared by many.

The question I am pondering how do I change teachers’ attitudes towards problem solving? Future research is needed about problem solving as it relates to teacher attitudes, not just student attitudes. Students learn from teachers’ behaviors and can sense when we are apprehensive or uncomfortable when teaching a lesson. I know that my students did not particularly care for problem solving because I gave them the impression that it was not fun. Once I began the project, I had to step out of my comfort zone and instruct problem solving skills. I had to learn the material before I could teach it. From the very beginning, the students knew I had to work each problem because I had to be able to give explanations.

From talking to some of my students during class, I have learned that problem solving became more difficult when the pictures became words and the words became “bigger” and
written in sentences. In order to reduce the fear of word problems that many students have, I believe that effective problem solving techniques need to be taught at a young age.

It is my belief that the Problem Solving Guide I made for my 7th grade students could be altered to fit almost any grade level. The best starting place is to lay a solid foundation with math vocabulary. The biggest challenge I have faced throughout my 13 years as a math teacher is teaching students math terminology. Decoding needs to be taught at an early age, when reading skills are being developed. This will enable students to “see” the difference in how English words can also be used as math words. This was one of the obstacles I faced in my research, but it lead to some great classroom discussion. If math vocabulary is mastered, half of the war on effective problem solving instruction is won. This will lead students to believe there is no word problem that is unsolvable. When we give students confidence in the math classroom, I know it will lead them to want to solve bigger and more challenging problems.
REFERENCES


Appendix A

Pre-research survey

**Please give your honest response to each statement.**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I feel confident in finding key words in a word problem.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. I know how to decide on what problem solving strategy to use.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. I ask a lot of questions in trying to solve word problems on my own.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. I have more confidence to try problems when I work in a group.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. I like to do word problems.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. I am able to show my work and explain how I solved a problem.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. I feel confident in math class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

**Please write an honest answer.**

8. What are you best at in solving a problem?

9. What is the worst thing about problem solving?

10. What do you need the most help in solving a problem?
Appendix B

Directions: Read each word problem. Show all work in the space provided. If the problem can be answered, write the answer (with labels) on the line provided. If the problem cannot be answered, write down the information that is needed to solve it.

1. The sum of Jan’s and her mother’s age is 51 years. The difference in their ages is 25. How old are Jan and her mother? _______________

2. During the basketball season, Rhonda scored a total of 170 points. What were her average points per game?
   ________

3. If 934 people in a town of 1450 people watch Sideline News for an hour each day, how many hours of Sideline News will they view in a year? _______________

4. The width of a rectangle is 5 cm less than the length. If the rectangle has a length of 9 cm, what is its area? (A = l w) _______________

5. Mr. and Mrs. Keough dined out last night. When the bill came, Mr. Keough gave the waiter $45 and told him to keep the change as his tip. Mr. Keough had had the crab special for $17.95 and Mrs. Keough had had the flounder for $13.95. Both had had dessert, which cost $3.50 each. How much money had Mr. Keough left to the waiter as a tip? _______________
Appendix B-continued

6. A photograph of the diving team shows Jessie, Erin, Lee, and Raisa. As you look at the photo, they are arranged left to right from shortest to tallest. Jessie is 3 in. shorter than Lee, who is 1 in. taller than Erin. Raisa is 4 in. taller than Jessie. What is their order in the photograph?

_________  __________  __________  __________

7. In a class 13 students enjoy art and 12 enjoy music. Five students enjoy both and two enjoy neither. How many are in the class? __________

8. A pizzeria offers pizzas in three sizes (small, medium, and large), with two types of crust (thick or thin), and with one of four toppings (mushrooms, extra cheese, peppers, or broccoli). From how many different combinations of size, crust, and topping can you choose? __________

9. If a human heart beats 70 times a minute, how many times does it beat in one day? __________

10. Mr. Tanner spent $28.50 for movie tickets for his family. The tickets cost $5.50 for each adult and $3.00 for each child. If three adults went to the movie, how many children went? __________
Appendix C

Does Decoding Increase Word Problem Solving Skills?
By JaLena Clement

Student Interview Questions (Individual pre-research)

Research Question:
3. What will happen to the level of student confidence in themselves as problem solvers after receiving instruction in problem solving strategies and decoding?

Student: 
Class: 
Date: 

Interview Questions:
1. What is your attitude towards decoding a word problem in the math classroom? Why do you think you have that attitude?

2. What do you like best about problem solving? Please explain.

3. What do you like least about problem solving? Please explain.

4. What makes problem solving easy or difficult for you? Please explain.

5. What could teachers do to help students with problem solving?

6. When working a word problem, do you think you can identify the key words and choose a problem solving strategy(-ies)? Can you think of a specific example?
Appendix C-continued

7. Why do you think I tell students that it is important to know the meanings of key words in a word problem (decoding)?


9. How do you determine if you have solved the problem correctly?

10. Are you confident in your math ability? Why or Why not?

11. Are you confident in your problem solving skills? Why or Why not?

12. I would like you to work on this problem, saying aloud whatever it is you are thinking as you work through the problem. I especially want to hear you talk about how you decide what to do to solve the problem.
   • Emma is saving money to buy a bike that costs $72. She wants to buy the bike after saving the same amount of money each week for 6 weeks. How much money does she need to save each week?

13. Is there anything else I should know about you to better understand your problem solving in math?
Appendix D

Problem Solving Guide
By Ja Lena Clement

**Directions: Follow each of the steps to solve each word problem.**

1) With a **red**-colored pencil, underline the key operation and grouping word(s). Put the mathematical symbol above each key word(s).

2) With a **blue**-colored pencil, circle the data needed to solve the word problem. Cross out any data that is not needed.

3) With a **green**-colored pencil, underline the question that is to be answered. If it is not stated, you will have to identify (write) the question to be answered.

4) Identify what problem solving strategy best suits this problem.
   - Guess and Check
   - Missing Information
   - Identifying Extra Information
   - Writing and Using an Equation
   - Working Backwards
   - Using Tables and Drawings
   - Logical Reasoning
   - Maps and Charts
   - Making an Organized List or Chart
   - Hidden Information
   - Multi-Step Problems Using Formulas

5) Prove why this strategy works for the problem. (*I used this strategy because . . .*)

6) Set up the problem using your chosen strategy.

7) Do the computations and double-check your work (and labels) for accuracy. Circle your answer.

8) Refer to the question in STEP 3 and ask yourself “Does my answer make sense?” If not, go back and repeat steps 1-6 until you arrive at an answer that does make sense.
Appendix E

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Decoding words identified</strong></td>
<td>All decoding information is identified (key operation and grouping words, necessary data, and question).</td>
<td>Most decoding information is identified (key operation and grouping words, necessary data, and/or question).</td>
<td>Some decoding information is identified (key operation and grouping words, necessary data, and/or question).</td>
<td>No decoding information is identified (key operation and grouping words, necessary data, and/or question).</td>
<td>No attempt or below grade level work shown.</td>
</tr>
<tr>
<td><strong>Steps #1 - #3</strong></td>
<td>1. Reasonable strategy selected and developed.</td>
<td>1. Reasonable strategy selected and moderately developed.</td>
<td>1. Reasonable strategy selected and minimally developed.</td>
<td>1. There is an attempt to solve the problem.</td>
<td>No attempt or below grade level work shown.</td>
</tr>
<tr>
<td><strong>Strategy chosen and applied</strong></td>
<td>1. Work shown is logical.</td>
<td>1. Work shown has gaps.</td>
<td>1. Work is partially shown.</td>
<td>1. Attempted to solve the problem.</td>
<td>No attempt or below grade level work shown.</td>
</tr>
<tr>
<td><strong>Steps #4 and #6</strong></td>
<td>2. Content knowledge is used correctly.</td>
<td>2. Calculations are mostly correct; may contain minor errors.</td>
<td>2. Major errors may be evident in work.</td>
<td>2. A limited amount of work shown.</td>
<td>No attempt or below grade level work shown.</td>
</tr>
<tr>
<td><strong>Calculations performed</strong></td>
<td>3. Calculations are completely correct and answers properly labeled.</td>
<td>3. Calculations contain major errors.</td>
<td>3. Calculations contain major errors.</td>
<td>3. Calculations are incorrect.</td>
<td>No attempt or below grade level work shown.</td>
</tr>
<tr>
<td><strong>Correct answer</strong></td>
<td>Arrived at correct answer.</td>
<td>Arrived at correct answer that comes from computation errors.</td>
<td>Arrived at a correct answer that comes from conceptual errors.</td>
<td>Incorrect answer.</td>
<td>No attempt or below grade level work shown.</td>
</tr>
<tr>
<td><strong>Step #7</strong></td>
<td>Justifies the strategy, conclusion, and/or answer to the problem.</td>
<td>Justifies the strategy, conclusion, and/or answer, but leaves out details.</td>
<td>Attempts to justify the strategy, conclusion, and/or answer, but the justification is not relevant to the problem.</td>
<td>No justification for the strategy, conclusion, and/or answer.</td>
<td>No attempt or below grade level work shown.</td>
</tr>
<tr>
<td><strong>Justification of strategy, conclusion and/or answer</strong></td>
<td><strong>Steps #5 and #7</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Math Problem Solving Clue Words

<table>
<thead>
<tr>
<th><strong>Addition</strong></th>
<th><strong>Subtraction</strong></th>
<th><strong>Multiplication</strong></th>
<th><strong>Division</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>more than</em></td>
<td><em>less than</em></td>
<td>times</td>
<td>quotient</td>
</tr>
<tr>
<td><em>added to</em></td>
<td><em>subtracted from</em></td>
<td>product</td>
<td>separated into</td>
</tr>
<tr>
<td>plus</td>
<td>less</td>
<td>multiply</td>
<td>divided by</td>
</tr>
<tr>
<td>sum</td>
<td>difference</td>
<td>of</td>
<td>each</td>
</tr>
<tr>
<td>increase</td>
<td>decreased by</td>
<td>twice</td>
<td>average</td>
</tr>
<tr>
<td>add</td>
<td>reduce</td>
<td>tripled</td>
<td>(fraction bar)</td>
</tr>
<tr>
<td>total(s)</td>
<td>reduced by</td>
<td>doubled</td>
<td>per</td>
</tr>
<tr>
<td>in all</td>
<td>lower</td>
<td>several</td>
<td>(ratio)</td>
</tr>
<tr>
<td>combined (with)</td>
<td>take away</td>
<td>in all</td>
<td>each</td>
</tr>
<tr>
<td>all together</td>
<td>diminished by</td>
<td>per</td>
<td>share</td>
</tr>
<tr>
<td>increased by</td>
<td>greater (than)</td>
<td>each</td>
<td>distribute</td>
</tr>
<tr>
<td>more</td>
<td>fewer (than)</td>
<td>total</td>
<td></td>
</tr>
<tr>
<td>net</td>
<td>compare</td>
<td>area</td>
<td></td>
</tr>
<tr>
<td>plus</td>
<td>how much more</td>
<td></td>
<td></td>
</tr>
<tr>
<td>perimeter</td>
<td>exceed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>amounts to</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>together (with)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**OTHERS:**  = (is, was, are, were, amounts to, totals)

**“*” means switch the order**

**GROUP WORDS:** sum, product, difference, quotient
Appendix G

Multi-Step Problems
Practice Set

Use the problem solving guide. Show all work on this page.

1. There are 5 students in Mr. Parker’s art class. He would like to give each of his students 6 sticks to use in a project they are doing. Mr. Parker looked in his drawer and found that he had 2 blue stickers, 3 times as many red stickers as blue stickers, and 4 more green stickers than red ones. Does Mr. Parker have enough stickers for everyone?

   Strategy ____________________________________ Answer ___________________________________

2. Tommy the Turtle crawls 3 in. every 2 sec. Sammy the Snail crawls 5 in. every 3 sec. The two pals have a race to see how long it will take to reach a fence 30 in. away. Who will win the race and by how many seconds will he win?

   Strategy ____________________________________ Answer ___________________________________
Appendix G-continued

3. Jane had a huge appetite at the beach last Saturday. She bought 3 hot dogs, 1 soda, 2 ice cream cones, and 4 candy bars. Figure out how much Jane spent. Here are the clues:

- An ice cream cone costs 20 cents.
- A hot dog costs 3 times as much as an ice cream cone.
- One soda costs the same as 2 hot dogs.
- A candy bar costs half as much as a hot dog.

Strategy ___________________________________ Answer ___________________________________

4. Just before Alex left his house to walk to school, he counted the money he had in his pocket. He had $2.10 in dimes. After walking for 20 minutes, Alex discovered he had a small hole in his pocket. Alex counted his money and estimated that he was losing 1 dime every 4 minutes through the hole. How much money did Alex have after 20 minutes?

Strategy ___________________________________ Answer ___________________________________
Appendix H

Multi-step Problems
Problem Set

Use the problem solving guide. Show all work on this paper.

1. Kerrin is saving to buy a new Magic bike that costs $225. Every time she gets any money, she safely puts it in the bank. Kerrin was given $65 last month for her 12th birthday. She won $75 when she placed first in a writing contest and sold her video games for $40. To get the rest of the money, Kerrin walks Mrs. Oliver’s dog each morning for $5 per week. How many weeks will it take Kerrin to earn the rest of the money?

   Strategy ___________________________ Answer ___________________________

2. Alex ordered a large pizza from Papa’s Pizza. He was so hungry he ate 1/2 of it right away. He cut the other half into 3 equal pieces. Alex gave 2 pieces to his sister and cut the remaining piece into 3 smaller but equal pieces. Alex gave those 3 pieces to his 3 best friends, Amy, Tim, and Ben. What fraction of the pizza did Ben get?

   Strategy ___________________________ Answer ___________________________
Appendix H-continued

3. Rascal, Daisy, and Princess are puppies. The puppies weigh 100 pounds together. Rascal and Daisy weigh the same amount. Daisy and Princess weigh 72 pounds together. Find the weight of each puppy.

Strategy ___________________________  Answer ___________________________

4. Oh, no! It’s 7:50 p.m. The school play will begin in 10 minutes and the 36 balloons needed for the opening scene aren’t ready yet. Nicky is working as quickly as possible, but he can only blow up 3 balloons in 1 minute. Luckily his friend, Evan, came by at 7:54 p.m. and offered to help. Evan can blow up 5 balloons in 1 minute. At what time will they finish the job?

Strategy ___________________________  Answer ___________________________
Problem Solving Strategy Quiz

Use the problem solving guide to answer the following questions. Show all your work. Be sure to justify (prove) why you used a particular strategy. The strategies worked you can use are 1) Guess and Test, 2) Missing Information, 3) Extra Information, 4) Writing an Equation, 5) Working Backwards, and 6) Using Tables and Charts. If not enough information is given, write what is needed as your answer.

1. Jess is twice his brother’s age. The sum of their ages is 21. How old are Jess and his brother?

   Strategy _____________________________  Answer ________________________________

2. Each of the 23 students in a class gave an equal amount of money to the town charity collection. If a total of $161 was collected from the class, how much did each student contribute?

   Strategy _____________________________  Answer ________________________________
Appendix I-continued

3. Franklin was paid for doing yard work. He spent $4.45 of his pay for a sandwich and fruit drink and $2.05 for a magazine. He had $8.55 left. How much was Franklin paid for the yard work?

Strategy _____________________________  Answer ________________________________

4. It takes Bob 32 minutes to deliver the daily papers on his 3 paper routes and 55 minutes to deliver the Sunday papers. How much less time does it take him to deliver the daily papers?

Strategy _____________________________  Answer ________________________________
Appendix J

Final Test

Use the problem solving guide. Show all work on this page. If it is missing information, put the information that is needed on the “Answer” line.

1. You save $3 on Monday. Each day after that you save twice as much as you saved the day before. If this pattern continues, how much would you save on Friday?

   Strategy _______________________________   Answer _____________________________

2. Jack walked from Santa Clara to Palo Alto. It took 1 hour 25 minutes to walk from Santa Clara to Los Altos. Then it took 25 minutes to walk from Los Altos to Palo Alto. He arrived in Palo Alto at 2:45 P.M. At what time did he leave Santa Clara?

   Strategy _______________________________   Answer _____________________________

3. Amy and Judy sold 12 show tickets altogether. Amy sold 2 more tickets than Judy. How many tickets did each girl sell?

   Strategy _______________________________   Answer _____________________________
Appendix J-continued

4. Judy is taking pictures of Jim, Karen and Mike. She asks them, "How many different ways could you three children stand in a line?"

\[ \text{Strategy:} \] _________________________________ \hspace{1cm} \text{Answer:} \] _____________________________

5. Marvin's Taxi Service charges $0.30 for the first mile and $0.05 for each additional mile. If the cab fare was $3.20, how far did the Taxi go?

\[ \text{Strategy:} \] _________________________________ \hspace{1cm} \text{Answer:} \] _____________________________

6. Joe buys a cup of coffee that costs $1.08. He pays with a two dollar bill. If the cashier gives him 8 coins for his change, what could these coins be?

\[ \text{Strategy:} \] _________________________________ \hspace{1cm} \text{Answer:} \] _____________________________
Appendix J-continued

7. Mary looked out of her farmhouse window and saw a group of pigeons and donkeys passing by. She counted all the legs of the pigeons and donkeys and found that the total number of legs add up to 66. How many of each kind of animals (pigeons and donkeys) passed by her window if the total number of animals is 24?

Strategy _____________________________ Answer _____________________________

8. Before the market opens on Monday, a stock is priced at $25. If its price decreases $4 on Monday, increases $6 on Tuesday, and then decreases $2 on Wednesday, what is the final price of the stock on Wednesday?

Strategy _____________________________ Answer _____________________________

9. Frank paid $40 for a pair of shoes, $78 for a jacket, and a pair of socks. After purchasing these articles he had $20.50 left. How much money did Frank have at first?

Strategy _____________________________ Answer _____________________________
Appendix J-continued

10. On Monday, Ginger packed 426 boxes, Tuesday 573, and Wednesday 685. She worked with 3 other people. How many boxes did she pack in 3 days?

Strategy _______________________________  Answer _____________________________
Appendix K

Does Decoding Increase Word Problem Solving Skills?
By JaLena Clement

Teacher Journal Prompt Guidelines for my Research Project:

Research Questions to focus on:
2. What will happen to the frequency and types of questions students ask during class pertaining to solving word problems after receiving instruction in problem solving strategies and decoding?
3. What will happen to the level of student confidence in themselves as problem solvers after receiving instruction in problem solving strategies and decoding?
4. What does my teaching look like when I try to better teach problem solving to my students?

Reflection Questions:
1. How does each of the two incidents I wrote about relate to my research questions (questions and confidence in problem solving)?
2. What changes have I seen in my students’ confidence levels and/or questioning?
3. What changes have I seen in my teaching, related to problem solving?
4. What went really well this week, related to my students and their confidence levels and/or questioning?
5. What surprised me this week, related to my problem of practice (decoding and problem solving strategies)?
6. What did I learn this week that will inform my teaching and/or journaling next week?
Appendix L

<table>
<thead>
<tr>
<th>Types of Questions Asked</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Decoding (key words, data, question asked)</td>
<td></td>
</tr>
<tr>
<td>Problem Solving strategy</td>
<td></td>
</tr>
<tr>
<td>Justification of strategy</td>
<td></td>
</tr>
<tr>
<td>Setting up the problem</td>
<td></td>
</tr>
<tr>
<td>Labels</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>
Appendix M

Post-research survey

Please give your honest response to each statement.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I feel confident in finding key words in a word problem.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. I know how to decide on what problem solving strategy to use.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. I ask a lot of questions in trying to solve word problems on my own.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. I have more confidence to try problems when I work in a group.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. I like to do word problems.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. I am able to show my work and explain how I solved a problem.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. I feel confident in math class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Please write an honest answer.
8. What are you best at in solving a problem?

9. What is the worst thing about problem solving?

10. What do you need the most help in solving a problem?
Appendix N

Does Decoding Increase Word Problem Solving Skills?
By JaLena Clement

Student Interview Questions (Individual post-research)

Research Question:
3. What will happen to the level of student confidence in themselves as problem solvers after receiving instruction in problem solving strategies and decoding?

Student: Class:
Date:

Interview Questions:
1. What is your attitude towards decoding a word problem in the math classroom after studying decoding and working with different problem solving strategies? Why do you think you have that attitude?

2. What do you now like best about problem solving? Please explain.

3. What do you now like least about problem solving? Please explain.

4. What now makes problem solving easy or difficult for you? Please explain.

5. What could teachers do to help students with problem solving?

6. When working a word problem, do you think you can now identify the key words and choose a problem solving strategy(-ies)? Can you think of a specific example?
Appendix N-continued

7. Why do you think I tell students that it is important to know the meanings of key words in a word problem (decoding)?


9. How do you prove to me that you have solved the problem correctly?

10. Are you confident in your math ability? Why or Why not?

11. Are you confident in your problem solving skills? Why or Why not?

12. I would like you to work on this problem, saying aloud whatever it is you are thinking as you work through the problem. I especially want to hear you talk about how you decide what to do to solve the problem.
   • Joan wants to put a fence around her rectangular garden, which has a length of 10 feet and a width of 6 feet. If she starts at a corner, how many fence posts will she need to buy?

13. What advice would you give to another student who is struggling with problem solving or vocabulary?

14. Is there anything else I should know about you to better understand your decoding and problem solving skills in math?
Appendix O

Practice Set Transparency

Use the problem solving guide. Show all work on this page.

1. There are 5 students in Mr. Parker’s art class. He would like to give each of his students 6 sticks to use in a project they are doing. Mr. Parker looked in his drawer and found that he had 2 blue stickers, 3 times as many red stickers as blue stickers, and 4 more green stickers than red ones. Does Mr. Parker have enough stickers for everyone?

   **Strategy:** Multi-Step

   **Answer:** No

   I used this strategy because we need to do more than 1 operation.

   
   
   \[
   \begin{align*}
   5 \times 6 &= 30 \text{ s } & 2 \text{ blue } \\
   10 + 6 + 2 &= 18 \text{ stickers } & 3 \times 2 = 6 \text{ red } \\
   &\text{ Need 30 } & 6 + 4 = 10 \text{ green } \\
   &\text{ Has 18 } & 30 > 18
   \end{align*}
   \]

2. Tommy the Turtle crawls 4 in. every 2 sec. Sammy the Snail crawls 5 in. every 3 sec. The two pals have a race to see how long it will take to reach a fence 30 in. away. Who will win the race and by how many seconds?

   **Strategy:** T+D / Multi-Step

   **Answer:** Sammy by 2 sec.

   I used this strategy(s) because we need to group some information for each animal.

<table>
<thead>
<tr>
<th>in sec</th>
<th>7 in sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>27</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>21</td>
<td>14</td>
</tr>
<tr>
<td>24</td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>in sec</th>
<th>3 in sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>30</td>
<td>18</td>
</tr>
</tbody>
</table>

   \[
   \begin{align*}
   30 & \leq 27 \\
   18 & \leq 12 \\
   T: 20 \text{ sec.} & 20 > 18
   \end{align*}
   \]

   Sammy wins

   \[
   20 - 18 = 2 \text{ sec}
   \]
3. Jane had a huge appetite at the beach last Saturday. She bought 3 hot dogs, 1 soda, 2 ice cream cones, and 4 candy bars. Figure out how much Jane spent. Here are the clues:

- An ice cream cone costs 20 cents.
- A hot dog costs 3 times as much as an ice cream cone.
- One soda costs the same as 2 hot dogs.
- A candy bar costs half as much as a hot dog.

Strategy: Multi-step

I used this strategy because I had to do more than 1 operation.

\[
\begin{align*}
3 \times \$0.20 &= \$0.60 \times 3 = \$1.80 \\
\text{soda } \times \$1.20 \\
\text{candy } \times \$0.30 \times 4 &= \$1.20 \\
\text{Bar } \times \$0.20 \times 2 &= \$0.40 \\
\text{Cone } \times \$0.60 \times 2 &= \$1.20 \\
\end{align*}
\]

\[\$1.80 + \$1.20 + \$1.20 + \$0.40 = \$4.60\]

4. Just before Alex left his house to walk to school, he counted the money he had in his pocket. He had \$2.10 in dimes. After walking for 20 minutes, Alex discovered he had a small hole in his pocket. Alex counted his money and estimated that he was losing 1 dime every 4 minutes through the hole. How much money did Alex have after 20 minutes?

Strategy: T+D

I used this strategy because we needed to group the information.

<table>
<thead>
<tr>
<th>Money</th>
<th>Min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.10</td>
<td>4</td>
</tr>
<tr>
<td>$0.20</td>
<td>8</td>
</tr>
<tr>
<td>$0.30</td>
<td>12</td>
</tr>
<tr>
<td>$0.40</td>
<td>16</td>
</tr>
<tr>
<td>$0.50</td>
<td>20</td>
</tr>
</tbody>
</table>

\[\$2.10 - \$0.50 = \$1.60\]

Check:

\[\$1.60 + \$0.80 = \$2.10\]
Appendix P

Example of student Problem Set work

Name ___________________________ Date 4-9-08

Problem Set

Use the problem solving guide. Show all work on this paper.

1. Kerrin is saving to buy a new Magic bike that costs $225. Every time she gets any money, she safely puts it in the bank. Kerrin was given $65 last month for her 12th birthday. She won $75 when she placed first in a writing contest and sold her video games for $40. To get the rest of the money, Kerrin walks Mrs. Oliver’s dog each morning for $5 per week. How many weeks will it take Kerrin to earn the rest of the money?

Strategy: MS

I used this strategy because there is more than 1 operation. $225-($65 + $75 + $40) $225 - $180 = $45 $45 ÷ 5 = 9

Answer: 9 weeks

2. Alex ordered a large pizza from Papa’s Pizza. He was so hungry he ate 1/2 of it right away. He cut the other half into 3 equal pieces. Alex gave 2 pieces to his sister and cut the remaining piece into 3 smaller but equal pieces. Alex gave those 3 pieces to his 3 best friends, Amy, Tim, and Ben. What fraction of the pizza did Ben get?

Strategy: TAD

I used this strategy because it is a group operation.

Answer: 1/18 of the pizza

Diagram:

- Alex
- 1/2 of the pizza
- Remaining 1/2
  - 3 pieces
    - 2 pieces given to sister
    - 1 piece remaining
      - 3 smaller pieces
        - 1 piece given to Amy
        - 1 piece given to Tim
        - 1 piece given to Ben

- 1/18 of the pizza

Diagram:

- Alex
- 1/2 of the pizza
- Remaining 1/2
  - 3 pieces
    - 2 pieces given to sister
    - 1 piece remaining
      - 3 smaller pieces
        - 1 piece given to Amy
        - 1 piece given to Tim
        - 1 piece given to Ben

- 1/18 of the pizza
3. Rascal, Daisy, and Princess are puppies. The puppies weigh 100 pounds together. Rascal and Daisy weigh the same amount. Daisy and Princess weigh 72 pounds together. Find the weight of each puppy.

**Strategy:** MS

I used this strategy because there is more than 1 operation.

- $100 \div 2 = 50$
- $72 - 50 = 22$

**Answer:**

- Rascal = 50 lb
- Princess = 22 lb

4. Oh, no! It's 7:50 p.m. The school play will begin in 10 minutes and the 36 balloons needed for the opening scene aren't ready yet. Nicky is working as quickly as possible, but he can only blow up 3 balloons in 1 minute. Luckily his friend, Evan, came by at 7:54 p.m. and offered to help. Evan can blow up 5 balloons in 1 minute.

At what time will they finish the job?

**Strategy:** T&D

I used this strategy because it's in an order.

<table>
<thead>
<tr>
<th>Time</th>
<th>Nicky Balloon</th>
<th>Evan Balloon</th>
<th>Total Balloon</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:54</td>
<td>5</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>7:55</td>
<td>0</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>7:56</td>
<td>1</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>7:57</td>
<td>0</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>7:58</td>
<td>2</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>7:59</td>
<td>3</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>8:00</td>
<td>3</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>

Answer:

7:56 p.m.
Appendix Q

Math Problem Solving Clue Word chart in classroom