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Writing Relevant Word Problems: Seeking to Increase Student Mathematical Achievement

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ABSTRACT

In this action research study of eighth grade mathematics, I investigated my students' use of writing and solving word problems. I collected data to determine if writing and solving word problems would have a positive effect on students' abilities to understand and solve word problems. These word problems are grade-level appropriate and are very similar to the problems on the eighth grade online assessment of state standards. Pre- and post-test data, weekly word problems that focus on specific mathematics topics, beginning and end surveys about word problem perceptions, and a teacher journal reveal that student engagement in this weekly practice of writing and solving word problems did influence the students' overall abilities for, achievement in and attitudes toward solving word problems. Except for some students' perceptions, the influence was largely positive. This suggests that word problems can be a constructive feature in eighth mathematics instruction.

INTRODUCTION

The topic of this inquiry is word problems. More specifically, I chose to explore the consequences of having students write and solve their own word problems to see if this helped them increase their word problem achievement level. As with most school districts, word problems are a struggle for our students and I wanted to explore ways to increase their success in my district.

I have taught my present school for four years. It is a K-12, Class C school district in central Nebraska. There are approximately fifty certified staff and twenty-five classified staff as well as 550 students. I am responsible for teaching seventh and eighth grade mathematics as well as eighth grade reading. The seventh grade mathematics class is a general grade-level mathematics class with an introduction to algebraic concepts and eighth grade mathematics is basically a pre-algebra class. The school district does not offer our students the option of fast-tracking their mathematics classes. The demographics of my students include about 30% diversity and about 40% free and reduced status. The academic needs of my students vary greatly. Our school does not have a pull-out program for high-ability students and those students who qualify for special education are in my classroom. Therefore, the academic and social behaviors exhibited in my classroom are all across the spectrum.

In our school district, our entire staff is involved in the School Improvement Plan (SIP) process. Our current five-year goal as a K-12 district is to increase mathematical achievement in the area of word problems. More specifically, our focus has turned to the types of word problems students would encounter on their homework assignments, criterion-referenced tests, or norm-referenced tests. In our efforts to improve these scores, every teacher seven through twelve is supposed to give a word problem at the beginning of every class period each Wednesday. Each

teacher is to focus on students understanding and labeling the problem. Every teacher has her or his own way of implementing this in the classroom. My students have word problems that are built into their daily homework assignment. So, for instance, on Wednesdays I give students an additional word problem at the beginning of class. I give them a few minutes to work, walk around and look at their solutions, and then go over it in class. I do not grade the problems, but do have students hand them in. Generally speaking, I find that my students do not "show their work" and consistently "forget" to indicate clearly their answers to the problems. I estimate that three-quarters of my students get the right answer. I do try to make these fun and interesting mathematics problems since they are solving mathematics problems regarding specific concepts for me in their homework. One source I use, 225 Fantastic Facts Word Problems (2001) uses real-life data. For example one question asks, "How high an insect can fly?" Then a clue is given that will lead them to the answer: "The Empire State Building is 1,450 feet high and insects have flown up to 2,500 times higher than the Empire State Building." Most of my students look forward to these problems because they give trivial, yet meaningful information!

As our district continued to tailor the school improvement goal, the focus changed from computation and solving the problems to emphasizing the reading and understanding word problems. Most of the teachers in the district agreed that students could successfully solve the word problem once they understood what the problem was actually asking them. This led me to choose a topic of my action research. What would happen if I have students write their own word problems? During their weekly Wednesday problem, I decided to take a 'backwards' approach to word problems and give the students an answer and have them write a word problem to go with it. I thought this would be interesting since we are focusing more on the reading and understanding of a problem instead of the computational part of the problem. I guided them to

write a certain kind of problem whether it was a simple subtraction problem or a more complex two-step problem.

Additionally, I chose this project was because I see my students struggling with comprehension of reading mathematics problems. Many students give up before they even start. They seem to find it intimidating to read their mathematics because reading is also a struggle for several of our students. Therefore, having to combine their math and reading skills, when both are threatening, raises their anxiety considerably. In my ideal world (that I would love to live in) students would come to my classroom with the ability to read AND understand problems written at their grade level so they could focus on the mathematics of the problem. They would be able to show the process of how they solved their problem and label it correctly without being asked or reminded to complete these tasks. My hopes were once students incorporated their own writing into mathematics, reading their mathematics problems would not seem to be such a daunting task.

PROBLEM STATEMENT

I am choosing this topic not only because of the school improvement goal, but because I want to find strategies that will make reading and solving word problems less intimidating for all students. As a teacher in a small school, I teach both mathematics and reading, which has proven to be an interesting combination. I get to see students in two separate lights. Some who excel at mathematics really struggle with reading and vice versa. I especially see this with our Hispanic students who really struggle with the language, but find numbers much easier to understand. In addition, even students who do not struggle with the numbers in mathematics seem to be much less confident in their abilities when they are faced with reading their mathematics. If I can find

ways to make word problems more manageable, mathematics will be a less intimidating subject for ALL students.

My problem of practice relates to nearly all of the National Council of Teachers of Mathematics (NCTM) principles (Appendix A), but it relates most directly to equity and learning. According to NCTM, equity is defined as having high expectations and strong support for all students (NCTM, 2000). By improving all students' comfort with word problems, I am helping them have more of an even ground and bridging the gap so that all understand the problem. NCTM's definition for learning is students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge. By creating a situation where students are actively engaged in writing and solving their own word problems, students are using what they know while gaining the new knowledge of learning how word problems are written.

Of the NCTM Mathematical Standards, two are most closely related to my action research: *Communication* (p. 267) and *Connections* (p. 273). Communication is about using mathematical language and thinking to communicate ideas to others. By writing their own problems, within given guidelines, students can communicate their understanding of the concept to me rather than simply solving a problem that has already been written. Using this practice will help them build better mathematical communication skills, therefore increasing their mathematical understanding.

NCTM defines Connections as the connecting of mathematical ideas, such as the relationship between algebraic equations linear graphs, to bring them into a coherent internal whole while connecting with ideas outside the mathematics classroom. In my asking students to

write their own word problems, I am urging them to use their writing skills and connect them to what they already know about mathematics.

My action research provided an opportunity for me to understand the challenges and complexities of students communicating and connecting their mathematical ideas. By learning more about these challenges and complexities I am able to teach word problem solving strategies to my students in ways that will enable them to be more successful.

LITERATURE REVIEW

Students always seem to struggle with word problems. Some researchers argue it is the reading and understanding of the problem that creates the difficulty, not the mathematics. Others argue it is a combination of the two. I had students write their own word problems within a given context and researched the impact it had on students' confidence and ability to solve word problems. While reading related research articles, I identified the following themes in the research on word problems: the value of word problems, how word problems are problematic for students, the value of writing in the mathematics classroom, strategies for writing in the mathematics classroom, and implementing word problem writing.

The Value of Word Problems

Word problems arise in every mathematics curriculum and are part of norm-referenced and criterion referenced tests. Some texts integrate them as part of every lesson while others isolate them into their own lessons. All the research I found led to the same conclusion: word problems are an integral part to all mathematics classes. Martinez (2001) has explored high school algebra classes and found arguments for word-problem based mathematics courses. Word problems encourage students to think mathematically and develop reasoning rather than relying on formulas. Word problems also engage students' imagination and involve them more in

mathematics because they have to think about the processes they are using to arrive at a reasonable answer. He affirms that meaningful word problems are more effective than traditional exercises at engaging students in comprehensive and active learning. He claims this strategy encourages students to think mathematically and develop reasoning skills instead of just memorizing the steps.

Amit and Klass-Tsirulnikov (2005) focus similarly on the world of algebra and the word problems students' encounters in algebraic situations. From their perspective, word problems are very important because without them, students have no way to relate real-life situations to the mathematics learned in the classroom. Both reiterate the idea that students are unable to link real-life and classroom mathematics. Amit and Klass-Tsirulnikov presented a three-stage method to help bridge the gap between real-life and mathematics. Step one is to create a meaningful problem setting. Step two is to create a logical structure by non-algebraic means. Step three is to accommodate algebraic techniques. Using this method, the authors encourage students to take ownership of their problems by exploring, developing, and building an approach of their own.

Even though most researchers referred to the importance of word problems in mathematics classrooms at every grade level, the above mentioned articles highlight two very important ideas; student engagement and applying concepts to the real world. Both of these relate to the NCTM standards of Communication and Connections. In comparison, the above researchers all had algebra classrooms where they were stressing the importance of meaningful word problems and how real-life connections help students develop mathematical reasoning skills. In contrast, Amit and Klass-Tsirulnikov (2005) provided a three-step method they use for students to follow when solving word problems whereas Martinez (2001) was making observations through his daily teaching.

How Word Problems are Problematic for Students

For some students, the mere words “problem solving” and “word problems” give them a sick feeling in their stomachs. I have yet to find a student who is eager to solve a word problem. There are several reasons and explanations as to why students struggle with word problems. The researchers below all had their own ideas about why word problems are such a struggle in classrooms around the world. Selke, Behr, and Voelker (1991) studied word problems as a basis for their doctoral dissertation. The researchers used seventh grade mathematics students in an upper class suburban junior high school. At the beginning of the project, there were two instructional units; one with the new method of data tables and the other using more traditional procedures. An intermediate test was given that had 12 specific problems that were similar to ones students solved in their units. Lastly, a posttest of 18 questions was given that followed the same guidelines and procedures as the units and intermediate test. Looking specifically at multiplication and division word problems, the researchers found that students had problems with these two operations with real-life word problems because these students were taught on the premise that multiplying always makes a number bigger and division smaller. When students had a word problem with multipliers and divisors less than one, students questioned their ability to correctly solve word problems. These researchers utilized an instructional strategy to help students ‘think’ about the mathematics behind the algorithm when applied to a real-life situation. I believe the concept of multiplication making the answer larger and division smaller is one very specific reason some students have problems choosing the correct operation when tackling word problems.

Mills and Stevens (1998) conducted an action research project on writing and problems solving skills with sixth and seventh grade students. Using a combination of a survey, a teacher

interview, a pretest, and a posttest, they found that there was a lack of academic achievement in both problem-solving and writing. Their research focused on sixth and seventh grade classes and finding techniques to interest students in solving word problems. They saw the difficulties with word problems being the inability to grasp key information and find relevance to the problem. Based on their findings, even high-achieving students struggled with word problems. I believe focusing on the important information in a word problem is a major concern for solving word problems.

In addition, Dr. van Garderen (2004) named very specific reasons why students struggle. She researched the use of reciprocal teaching, a method for reading comprehension, in the mathematics classroom to teach word problems. She zeroed in on the factors of irrelevant information, mathematical terminology, vocabulary level, syntactic complexity for making word problems difficult to understand. All of these factors contribute to students who struggle with understanding word problems. She found that reciprocal teaching was a non-threatening approach that allowed students to work cooperatively to support one another in their learning which further facilitated the performance of students.

Nosegbe-Okoka (2004) focused on helping students make sense of word problems. She taught students at the elementary and middle school level to find a sense-making approach to word problems. According to her, the problem is with the instructional practices teachers use to teach word problems. The focus of school mathematics should be helping students make connections between mathematics and real-life situations. I see this as the biggest reason students avoid word problems – they see no relevance and most word problems really do not have true-to-life meaning for students. In using this method of allowing students to work cooperatively and reflect on the reasonableness of their answers, Nosegbe found that students had a greater

conceptual understanding because they were actually able to make sense of the problem within the given context.

From the research I have found, the reasons students struggle vary across the years from elementary through middle school, but I think all the above named reasons have their place in the world of mathematics. In distinguishing similarities and differences among these researchers, Selke, Behr, and Voelker (1991), used a very specific model for multiplication and division, while the others used a broader spectrum of word problems. Selke, Behr, and Voelker, and Mills and Stevens (1998) both used tests as part of their data collection while van Garderen (2004) and Nosebge-Okoa (2004) were making overall comments they have experienced. Whether it is the actual reading of the problem or the mathematics, the above mentioned researchers highlight the key ideas behind the bad name students give word problems.

The Value of Writing in the Mathematics Classroom

The research I have found all leads to the same main point – writing is very important in the classroom. Over the years, researchers have tended to agree on the reasons why writing is so important. Miller (1992) examined the benefits to teachers who used impromptu writing prompts in their high school algebra classes. Three teachers in Louisiana volunteered to participate in investigating the benefits of writing in a secondary mathematics classroom. Miller was trying to answer two questions: “What can teachers learn about their students’ understanding of mathematics from reading their responses to in-class writing prompts and are instructional practices influenced as a result of reading students’ responses to in-class reading prompts?” (p. 330) Documented materials included students’ responses to timed, in-class impromptu writing prompts, teachers’ writings, and field notes from conversations between Miller and the three teachers. Miller found that students sometimes said they understood and could manipulate the

problem to find the answer but could not explain why or how in writing. There were also differences in perceptions of teaching concepts that the teacher would not have known if not for the journal writing. Secondly, the journals did influence the teaching. Some teachers found they had to be more explicit in their mathematical language. The journals not only showed where students were lacking skills from previous classes, but also where the teachers could improve in their own teaching. I know how it important it is to understand the mathematical background and feelings of the students I teach and obviously writing is one way to learn exactly what student do and do not know.

Winograd and Higgins (1994) project on writing, reading and talking mathematics focused on actually having students write word problems and share them with their peers. They found that student-centered problem-writing as a regular practice will develop students' natural instinct to wonder and ask why. At the conclusion of their study they determined that even the most inexperienced writer will be enthusiastic and thoughtful in writing their word problems because they have their peers who listen to, solve, and question their student-authored problems. From this standpoint, it would be exciting to have everyone participating and exciting about learning. From my experience as an educator, I know that sometimes students learn more from their peers than their teachers. What a great opportunity for peer teaching.

Pugalee (2001) studied whether writing about mathematics problem solving showed evidence of a meta-cognitive framework in a ninth grade algebra classroom. He chose six problems and provided a framework for students to write all their thoughts as they solved the problem. He reiterated a very powerful statement made by the National Council of Teachers of Mathematics. "Writing in mathematics can also help students consolidate their thinking because it requires them to reflect on their work and clarify their thoughts about the ideas" (p. 237).

Knowing exactly what students are thinking is very important. It is essentially a window into their mind; something teachers do not get by asking students to compute a problem.

Ishii (2002) worked with four middle school mathematics teachers who participated in a professional development opportunity and had chosen to implement writing in their mathematics classes. These teachers used journal writing and step-by-step explanation writing. Their research found two great benefits from using writing assignments; more student-to-student and student-to-teacher discourse and an increase of student motivation. Who would not want these two important pieces of learning as a built in part of their curriculum?

Burns (2004), founder of *Math Solutions*, also confirms the importance of writing in the mathematics classroom. Writing helps make sense of mathematics by requiring students to organize, clarify, and reflect on their ideas. It also provides a way for students to explore, extend, and cement their ideas about mathematical concepts. She also makes a very important point that I did not see in any of my other research articles – it is important to focus on ***what*** students write, not ***how*** they write it.

Rothstein and Rothstein (2007) researched the combination of writing and mathematics. They viewed the importance of writing from an educator's perspective and pinpointed four benefits teachers gain by having their students write. First, teachers gain insight into their students' mathematical thinking. Second, they can diagnose students' misconceptions. Third, they can assess students' study habits and attitudes. Last, they can evaluate their own teaching. The first and last reasons are the two I find the most significant because I can use my students' writing and their understanding to help me think about and guide my teaching.

All of the above authors made very poignant positions on their thoughts about writing in the classroom. Winograd and Higgins (1994), and Burns (2004) did not conduct an actual

research project but were making generalizations from their experiences with students. Miller (1992) and Pugalee (2001) focused on high school students while Ishii (2002) researched four different middle school mathematics classrooms. Burns and Miller (1992) also had the teachers keep journals and recognized these journals played a key role in the development of future instructional plans and lessons. Miller, Pugalee, and Ishii had students write their thoughts as students were solving word problems and Winograd and Higgins actually had students writing their own word problems.

Strategies for Writing in the Mathematics Classroom

In several of the articles, researchers have found ways to use writing in the classroom. These strategies vary from being very concept-specific to being very general. Below, I will discuss several ways to incorporate writing into the mathematics classroom. In this case, I do not know that the chronological order plays a part because researchers used writing methods that were conducive to their research questions. Sellke, Behr, and Voelker (1991) used proportions and real-life examples (linking problems) as part of their writing project. They then used explicit step-by-step writing to go along with each step the student took in solving their real-life problem. The students scored better on the twelve-problem multiplicative test given at the end of the research than at the beginning of the research. Even with this post-test data, the researchers questioned whether or not their practice of linking problems and explicit writing was just memorization of a method to arrive at an answer.

Mills and Stevens (1998) had their students write word problems based on their interests and hobbies, then share them with their classmates. They found this intervention had positive effects on student attitudes about short-answer mathematical writing. Rothstein and Rothstein (2007) took a broader view and shared several strategies for incorporating writing such as using

it to build mathematical vocabulary, fluency and organization. These strategies sound very language arts oriented, but students can use mathematical writing to define, explain, compare, contrast, etc. a mathematical concept.

As mentioned, van Garderen (2004) used a method called reciprocal teaching, which is a reading comprehension instructional strategy. There are four components; clarifying, questioning, summarizing, and planning. In small groups students read a mathematics problem and the leader asks if anything needs clarified. Secondly, the leader then questions students to find the key parts of the problem, then summarizes the problem. Lastly, the group devises a plan to solve the problem. All of these steps are written down, hence the writing is incorporated. In van Garderen's article, she did not comment on her findings, rather just presented this as a method. My concern is that students are working in groups and I am not sure *every* student is gaining the skills to effective communicate the steps. Some may be merely writing what their peers tell them to.

Miller (1992) used impromptu journal writing in her research, had a very thought-provoking strategy that I would like to incorporate into my classroom. Students were given five minutes to read the prompt and write a response. Students were either asked to express their understanding of a concept or express their feelings about how class was going. The teachers found the journal writings to be time consuming to look at but the journal writing was worthwhile. The teachers learned about their teaching and their students' understanding, and therefore were able to make educated instructional changes. They also noticed students' attitudes improved. Students viewed the writings as a means through which their teachers could help them understand mathematics. Currently, I do not have writing journals in my classroom, but I would

love to find a way to incorporate writing that would make it meaningful in my day to day teaching.

Implementing Writing Word Problems into the Classroom

Winograd (1992) also conducted research on having fifth grade student write their own mathematics problems. In having students write word problems he found that students made the problems much harder than they would have encountered in a textbook or from their teachers. The three categories he identified were new mathematical concepts, new mathematical procedures, and complex problem solving skills. Even though the problems were harder students found these peer-generated problems much more interesting and challenging and preferred them to the textbook problems. For my use, I gave students parameters in writing their problems, and hopefully when they shared their problems with their peers, my students enjoyed the challenge and now have more of an interest solving these problems.

Winograd (1993) also wrote an article on his research on writing word problems for *Research in the Teaching of English*. For this project, 25 fifth grade mathematics students wrote, solved, and shared mathematics story problems three or four days a week for five months. The classroom teacher used a mathematician's chair for students to share these concepts and problem solving strategies. In this article he also provides background on problem-writing. Mathematics education is text-centered and he wanted to develop a model to make mathematics more student-centered. Having students write problems was one way to do this. Second, problem-posing forced students to make mathematics a creative, generative activity. Therefore, his research focus was to find out whether or not problem-writing improved students' attitudes and beliefs about mathematics. His findings portrayed these students as thoughtful and interesting mathematics word problem writers. Students implicitly developed three strategies for writing word problems

along the way: the use of a focal culminating question, use of free association writing, and use of techniques to increase the difficulty of problems. Optimistically, when my students write their own word problems, I wanted to have similar findings: excited, interested, and challenged students.

Winograd (1997) also shared ways of having students share their student-authored story problems. One method was the mathematician's circle where one student shares their problem and takes a formal role in sharing and explaining their problem. Other more general ideas to utilize writing problems in the mathematics classroom are using open ended problems, introducing unfamiliar concepts and writing imaginative mathematical stories.

Stephens (2003) is interested in the development of students' algebraic reasoning and experimented with her own high school algebra students. Her students had extensive practice with writing equations to go with word problems but did not have experience going the other way. She interviewed several students before and after this study and could categorize their writing in six ways; correct response, operational error, direct translation error, changed unknown, solved equation only, and set up context only. She found that the students, even at a college level, struggled with key words, symbols and developing a context with an equation. Writing these word problems encouraged students to reflect on the meanings of the symbolic representations. When setting up my data collection instruments, I took into consideration her categories of incorrect responses to frame my analysis of incorrect responses. I found it very interesting that even college students struggled with writing word problems and making sense of an equation.

Barlow and Cates (2006) had hundreds of elementary students write their own word problems over the course of a school year. Following are some lessons learned that I took into

consideration while conducting my own research. First, give clear directions. For my purpose, I gave students parameters such as an operation to use and whether or not to make the problem a have more than one step. Second, provide specific units. When I gave my students the answer, I provided choices for my students such as 15 cars or 15 video games. Third, anticipate difficulties. To my knowledge, my students rarely encounter writing their own problems. This action research started out to be very messy with everyone learning along the way. The last lesson learned, and probably the most important is preparing to be amazed. I expected my students to be very hesitant at first, but was interested in their creative ideas.

These researchers all used the concept of writing word problems in their classrooms. Different data collection strategies were used for elementary and high school students. At the high school level, Stephens (2003) had students write word problems to go with specific algebraic equations with teacher-student interviews before and after writing the word problems. Winograd (1997) had students write their own problems then share and solve them in a mathematician's circle. Barlow and Cates (2006) did not indicate their specific data collection technique, but provided tips to educators who are about to delve into student-authored word problems.

Conclusion

My action research project is different from all of the above mentioned research projects. Although I researched the practices and perceptions of approximately 40 eighth grade middle school students as some of the authors did, there is not one researcher that followed the exact same data collection procedures of my project. Even though several of the researchers used pretests and posttests, none of them were using writing word problems as a basis for their research.

My students wrote word problems based on an equation and/or answer I give them. At the beginning of the project, I gave students a word problem pretest. Throughout the project, I interviewed students about their thoughts of word problems and the practice of having them write their own. At the same time, I kept a journal of my thoughts and perceptions as well as noting noteworthy student discourse or actions. At the end of my project I gave a posttest that is similar to the pretest, as a way of measuring the anticipated improvement.

My study revolved around students writing their own word problems. I wanted to know whether this practice would increase students' understanding and achievement on word problems. In light of the literature I have reviewed there is not any research I have found that explicitly examines the actual writing of word problems within given guidelines like those I utilized and the impact it makes on students. I found several articles stating how important writing can be in the classroom. I also found non-research articles written by educators who had students write problems and see some benefits from it, but none were written based solely on research. Like Winograd (1993), I had my students write word problems, but as he stated "More in-depth, qualitative case studies are needed, studies that carefully document students mathematical behavior and learning over a long period of time in socially interactive, problem-writing classrooms" (p. 391).

THE PURPOSE OF RESEARCHING WORD PROBLEMS

This study focused on students writing and solving their own word problems, and whether and how this influences students' mathematical achievement. I collected data during the spring semester of 2008 in my eighth grade mathematics classroom. My study attempted to answer the following research questions:

- What does my teaching look like when I ask students to write and solve their own word problems?
- What happens to students' abilities to understand and solve word problems after they practice writing word problems?

METHODS

In the literature review articles I read, I found many similarities to my action research but none fit exactly with the research I was about to conduct in my classroom. In a sense, I borrowed methodological ideas that many of them had and put them into my project. My methods included surveys, pretest, posttest, and weekly word problem worksheets.

This action research took place during the spring semester of 2008, from February through the beginning of May. I collected data in several ways that I thought would best show the anticipated growth of my students. The first source of data came from a student survey (Appendix B) that I gave all of my students in eighth grade mathematics. The questions I asked were related to their perceptions about word problems. At the end of the project, I gave a very similar survey (Appendix C) to all of my eighth grade mathematics students to see if any of their perceptions had changed throughout the course of my research.

I gave students a pretest (Appendix D) that my school district uses as a school improvement benchmark for word problems. I made this set of 15 questions very similar to the actual word problem assessment we give for state assessments. Consequently, it made sense to use the actual online assessment as my posttest (Appendix E[1]). The fifteen questions on both of these tests consist of very basic knowledge word problems to problems that have multiple steps.

[1] Actual assessment has been removed from this online version of this paper since the assessment is still being used by this school district.

The most vital part of my data collection came from the weekly word problems. Almost every week I made students a worksheet titled, “The Answer Is . . . What is the Question” (Appendix F). On these worksheets, I gave students very specific directions such as, “Use multiplication and addition and arrive at the answer 24 hamburgers.” Students then had space to brainstorm their ideas, write their word problem, and then check their answer to make sure they met my specifications. Throughout the course of my research students completed eight of these. In some instances, I gave students both the answer and the operation to use. In others, I gave only the answer or the operation. For instance, for one I said, “Use subtraction and choose your own answer.” For another, I asked “Choose the operation(s) and arrive at the answer 12 candy bars.” In response to student interest, I also gave them the opportunity to write and solve a problem of their own and then share with a peer.

The final set of word problems (Appendix G) consisted of the four different kinds of problems posed to students during the course of the research project. On the first problem I gave them the answer and the operation; the second an answer but no operation; and the third no answer, but specified the operation. On the fourth I did not give them an answer or operation. I also asked them talk about which of these four problems was the hardest and easiest to write.

I kept a teacher journal (Appendix H) to make notes of observations and conversations with word problems. This was a place to keep track of the ‘ah-hah’ moments for my students as well as myself. In the journal, I noted particular problems or strengths of my weekly word problem. I also kept a researcher journal where I could talk about the tensions I was experience between me being the teacher and researcher.

I started my collection of data with the student survey during the first week of February, 2008. I asked students to be honest on the surveys and told them their answers were in no way

going to affect their grade or my perceptions toward them. It was not until the end of my research project that I looked at surveys because I did not want their answers to influence my research. After this, I gave them their first "The Answer Is . . . What Is the Question?" worksheet and explained to them we were going to take a different approach to the Word Problem Wednesday assignment that we teach as part of our School Improvement Goal. Instead of them solving a problem, I wanted them to write and solve a problem with the given answer to see if this helped them become better word problem solvers. The first week, February 4th, 2008, I had a lot of students who were not sure of my expectations and I reassured them that as long as they tried their best, they were meeting my expectations. I also reminded them that we were learning a new strategy and didn't expect their answers to be perfect. I chose not to grade these in any way.

From February 4th to April 7th, I followed much of the same practice. Before handing out any new problems, I would discuss some aspect of writing a word problem such as revising for readability, double checking that they got the same answer that I gave them, etc. At times I gave students class time to complete the assignment, but toward the end of my project, I would allow them a couple of days to turn it in to me due to time.

At the beginning of April, I gave students a word problem attitude survey to complete that was very similar to the attitude survey given at the beginning of the project. I asked students to be very thorough in their writing and reminded them that their answers would in no way reflect upon them. I asked them questions such as, "How do you feel when you see word problems on an assignment?" and "Do you think writing your own problems has helped you be better at solving word problems?"

I gave students the post-test on April 18th even though my project was not complete. The document I used for the post-test is a STAR (Standards That Are Reported) assessment and my

district required me to report it by the 18th. This assessment is a fifteen question online assessment that corresponds with the state standards. According to the standard 8.2.2 , by the end of eighth grade students will be able to students will identify the appropriate operation and do the correct calculations when solving word problems. Question difficulty ranges from simple word problems to complex multi-step problems. Finally, during the week of April 28, I completed my research by giving students the final problem set of four problems which I described earlier.

The overall timeline of my project took place from January 28th through April 28th. In this time, students completed their pretest and posttest, pre-survey and post-survey, and eight weekly word problems. More specific dates can be found on the Data Collection Timeline (Appendix M).

Initially I focused only on whether students correctly wrote and solved each problem and whether or not they used the correct labels when they were writing their problems. I was using a rubric to assess all these aspects, but soon realized for the purpose of my action research, the label was not important. Then I turned my focus to whether or not students could write and solve their own word problems with the information I had given them. This seemed to be much more manageable and a better fit for my action research.

Since my pretest and posttest were so similar, I looked at each question individually to see if there was improvement as well as looking at each student's performance before and after the research project. The only difference was that the pretest was not multiple choices; students had to provide the answer. The posttest was multiple-choice due to the format of our district's assessments. To compensate for this, I made students show their work on each problem on both the pretest and posttest.

I had to figure out ways to disaggregate my data. I finally decided to separate out both by ability level and gender. I did this to show that students from all abilities and both genders were benefiting from writing and solving their own word problems. This also helped me to more clearly see differences from the beginning to the end of my research.

While disaggregating data, I used charts to help me organize my data. The first chart I used was the pretest/posttest chart (Appendix I). This helped me look at each individual question and each individual student. To analyze each week's problem, I used a rubric (Appendix J) to see if they used the correct numerical values and operations. I also looked to see how well the problem was written. In addition, I used a weekly chart (Appendix K) that had each student listed and used the same categories as the rubric so I could compare overall class performance from week to week. The last chart I used to analyze my data was the Survey Chart (Appendix L). In this chart, I looked at each student's responses before and after the research project so I could keep track of any preference changes. In this chart, I also made note of specific comments that I thought would be useful to my research.

MY RESARCH FINDINGS

My Teaching and Writing and Solving Word Problems

My first research question dealt with my teaching. I wanted to know what my teaching looked like when I asked students to write and solve their own word problems. Using solely examples from my journals, I found that my teaching evolved from the beginning to the end of my project. At the beginning I was very unsure of where this new practice was headed, but as the students and I grew more accustomed to this new strategy of writing word problems, I was much more confident in how I was presenting the material to my students.

Throughout the project my teaching of writing and solving word problems could be viewed as an indirect style. By this, I mean I was not standing in front of the class telling them exactly what to do. Instead, at the beginning of class, I handed out one of the worksheets and read through it with them. I then asked the students to reiterate to me what answer they needed to arrive at and what operations they were to use. After this, I would let students work and individual students would encourage them to ask for more direction or clarification. This was a new way of working with word problems for both the students and me; several students conscientiously wanted to make sure they were on the right track. In my first week's journal dated February 4th, I noted, "Their motivation is great, but several are really hesitant to hand in their papers. They want my reassurance that they are writing their problem correctly." As students asked fewer questions and worked through the process on their own, I knew they were growing more comfortable with writing word problems. In my February 18th journal I noted, "I did not assist any student in writing and solving their word problem." That does not mean I was refusing to help them, they simply did not ask for any help. Since I have had these students for two years and they are very comfortable asking me questions, I took this as a way of knowing students were growing more confident in their writing and solving word problems within a given context.

In following weeks, I would read aloud a couple of problems from the previous week that I thought were especially well. Then my teaching took much the same path as before. I would walk around while they wrote and solved their own word problems. By Week 4, February 25th, of my project, students were asking to be 'set free' and create their own word problems. So, the following week, I granted their wish and let them come up with their own word problem. The

worksheet followed the same format, but they had to fill in the answer and operations they used. I wrote in my journal on March 3rd:

> Some students with varying abilities struggled with the freedom of writing and solving their own word problems, but some wrote and solved VERY complex word problems for their mathematical and writing abilities. In fact, one student who rarely hands in assignments on time and has been failing my class for the majority of the year wrote and solved the following problem, 'A pair of shoes cost $50 and lunch at Subway costs $12. If the shoes are 75% off and your mom paid for half of your lunch, how much did YOU spend all together?' I was astonished she could successfully solve this problem.

Toward the middle of my project, March 10th, the students were getting restless and the newness and excitement of writing and solving word problems were decreasing! I noted on March 10th, that 100% of the students were handing in their worksheet even though I was not grading them, but I needed to come up with a new twist to reengage their motivation. At this time, my research buddy and even some students suggested that I have students write a word problem, then have another student solve it. I tried this the following week. Students had to write a word problem then give it to a peer to solve. The peer also had to make one positive comment about the problem and one suggestion to make it a better word problem. As an example of a positive comment one student wrote, "I loved your creative word problem, it made me laugh." A suggestion given by a student was, "I'm not very smart, but I thought this problem was way too easy. It needs to be harder." It was just the right idea to spur their interest once again. On March 24th I noted:

> It was awesome to watch the student interactions. I let students choose their own partner and I had one pair with opposite-end-of-the-spectrum abilities. The low-ability student

> was able to successfully solve the high-ability student's problem. He was very proud of himself. In another group, I had two students working together to solve one of their problems. The 'teacher' of the group struggles with math, but was able to explain the problem she had written step by step and they were able to successfully solve the problem. Additionally, no student asked me for help; they completely relied on one another.

With the last weekly problem I gave to the students, April 7th, I took a word problem from the assessment and changed the numbers: When the product of 3 and 4 is subtracted from the sum of 5 and 6, what is the difference? This problem always gives students problems because of the wording. As a class we discussed and solved this word problem in class, then I asked them to write one of their own and solve it. Once they had solved the problem, I had them exchange with a neighbor to see if he/she got the same answer. If not, they needed to come to an agreement as to what the correct answer should be. Once more, the conversations and interactions wowed me. As I walked around my classroom listening, I observed and wrote in my journal the following conversation between two students. These two students were reading each other's problems and Alison[2] notice a mistake in Tyler's writing. She said, "Tyler, you have a little mistake in your problem, but I think I know what you meant to say. I will help you fix it." All Tyler had done was make a simple computational mistake, but he had all the writing correct. During this week, I drew another conclusion that really made me stop and think about my students. I wrote:

> Once again, I am so proud of my eighth graders. I have had these students for two years and I wish they could see how much they have grown mathematically. The interactions

[2] All names are pseudonyms.

were ‘priceless’. Instead of hearing, ‘yours is wrong’ or ‘that is a stupid problem’ like you would expect to hear from eighth graders, they took the time to help their peers to make sure everyone was on the right track. How powerful for all involved!

At the conclusion of my data collection, I gave them a post-test which is also an online assessment. I merely walked around the room anxiously awaiting their scores!

My second research question centered around my students’ abilities to understand and solve word problems when they practiced writing word problems. I knew that to write a solvable and coherent word problem, students would have to organize their thoughts and then write them in a way that made sense mathematically. I wondered if this process would help them see how a word problem was written and whether or not they would key in on specific wording that would help them solve a word problem in the future. My hopes were that in writing these word problems, my students would also see that word problems really are not that scary to solve.

From my data collection, I can discern two distinct things. First, generally speaking, my students were better word problem solvers at the end of the project than at the beginning which leads to me to conclude that writing word problems did make a difference. Second, writing and solving word problems helped my lower-ability students build more confidence in their writing and solving word problem skills since as the project went along, those particular students wrote more complex and thoughtful problems.

Becoming better word problem solvers

Over the course of almost three months my students became better word problem solvers. I have several forms of evidence that helped me draw this conclusion: pretest/posttest results, pre/post-survey results, and student comments.

At the beginning of the project, I gave students a pretest with fifteen word problems on it (Appendix D) Students were asked to show their work. Calculators were not permitted on this pretest. Once all students completed the pretest, I tabulated the results. I strictly looked for the correct answers and ignored the label since during the online posttest, labels would be given to them.

The posttest, described earlier, also served as their online assessment for 8.2.2 (Appendix E) which is multiple choice. I printed a paper copy for each student and they had to show their work, then circle their answer. As with the pretest, calculators were not permitted. Once students completed the paper/pencil test, I had them enter their answers online. The questions on both tests were very similar. Below are two examples:

Pretest	**Post-test**
Joe had six dollars and 24 cents. Then his mom gave him some money. Now he has 9 dollars and 16 cents. How much money did his mom give him?	Bob had five dollars and forty-two cents. Then his mom gave him some money. Now he has nine dollars and sixty-five cents. How much money did his mom give him?
The first number 854. The second number is 597. The third number was twice the sum of the first two. What was the third number?	The first number was 743. The second number was 486. The third number was twice the sum of the first two. What was the third number?

For the most part the only thing that changed was the numbers on each problem. Below is a chart comparing the percentage of correct solutions of my thirty-three eighth grade students.

Question	Pretest	Posttest	Percent Change
1	82%	100%	+ 18%
2	55%	65%	+10%
3	61%	91%	+ 30%
4	24%	88%	+64%
5	24%	50%	+26%
6	91%	68%	- 23%
7	56%	65%	+ 9%
8	94%	85%	- 9%
9	30%	94%	+ 64%
10	39%	59%	+ 20%
11	67%	79%	+ 12%
12	39%	68%	+ 29%
13	12%	76%	+ 64%
14	27%	44%	+ 17%
15	79%	59%	- 20%
Mean	52%	72.73%	
Median	55%	68%	
Mode	24%, 39%	65%	
Range	67%	56%	
St. Dev.	26.5384	16.0144	

Table 1

Table 1 shows that there was an increase of percentage of correct answers on all questions except for three. Overall, the mean scores went up 21%. The standard deviation is high because I used percentages, which gives a wide range, especially when one student accounts for 3%.

Another way to compare the data is student by student. Below is a chart that has the test scores from both the pretest and posttest. There were a total of fifteen questions so their score is the number correct out of fifteen.

Student	Pretest	Posttest
3A	8	10
3B	7	9
3C	6	8
3D	8	6
3E	8	13
3F	4	8
3G	8	12
3H	11	13
3I	7	9
3J	9	13
3K	11	11
3L	1	4
3M	8	12
3N	13	15
3O	9	14
3Q	10	10
3R	8	5
5A	9	15
5B	2	7
5C	7	9
5D	12	12
5F	6	9
5G	7	13
5H	10	15
5I	6	11
5J	5	11
5K	8	10
5L	9	8
5M	6	10
5N	11	13
5O	6	8
5P	5	13
5Q	13	14
Mean	7.82	10.61
Median	8	11
Mode	8	13
Range	12	11
Std. Dev.	2.7778	2.9041

Table 2

Table 2 data shows that every student improved or stayed the same except for three students, who account for 9% of the class. Improvement was more significant for some students than for others. The students who showed the most improvement tend to be the students who put forth the most effort.

To better show student improvement and to what extent the scores changed from the pretest to the posttest, the bar graph below focuses on each student's growth or decline.

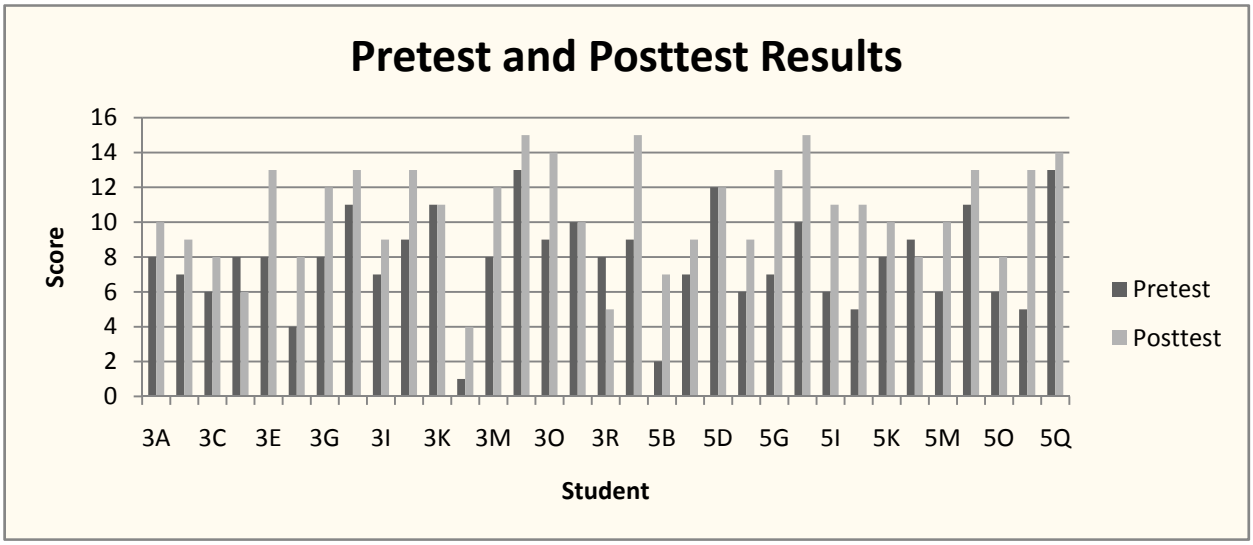

Table 3

I also disaggregated my data based on gender. I compared the pre-test questions with the corresponding posttest question to see if improvement was made based on gender. Below is the data table as well as a chart with the results.

Question	Pre-Female	Post-Female	Pre-Male	Post-Male
1	16	19	11	14
2	9	14	9	7
3	10	17	10	13
4	5	17	3	12
5	6	9	2	7
6	16	11	14	11
7	10	13	9	8
8	18	16	13	12
9	4	17	6	14
10	5	13	8	8
11	13	17	9	9
12	9	14	4	8
13	2	15	2	10
14	2	7	6	8
15	17	10	9	9
Average	9.466666667	13.93333	7.666667	10

Table 4

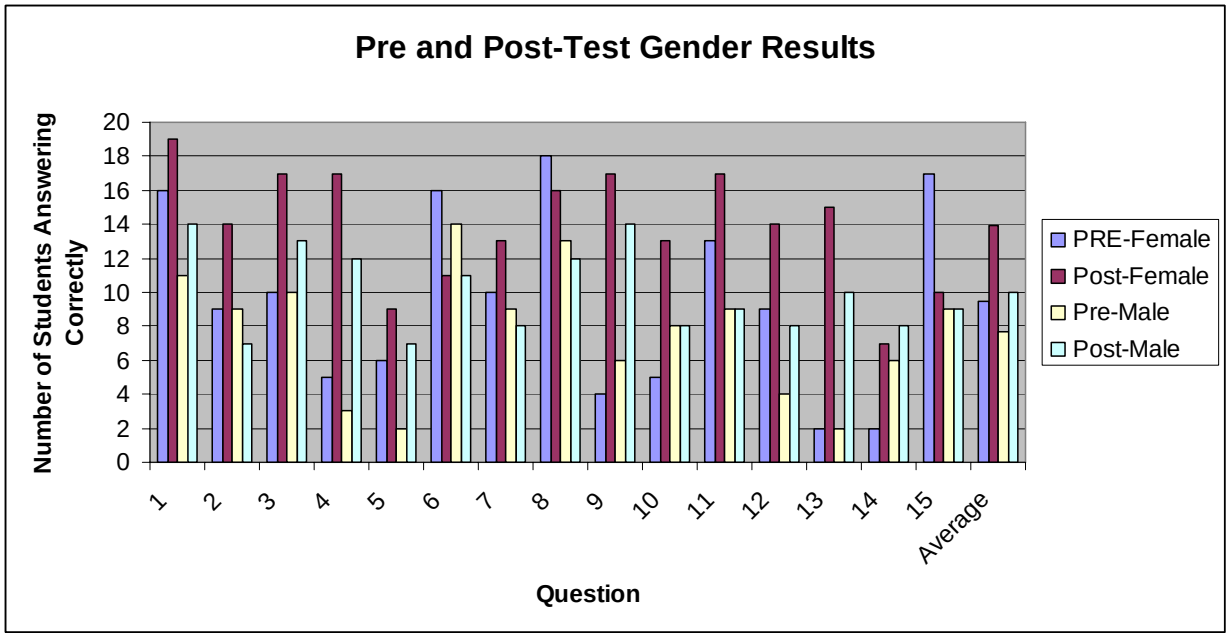

Table 5

From these visual representations it can be concluded that improvement was made by both genders. On average, the number of females who answered correctly on the pretest was about nine students and on the posttest the number rose to almost fourteen. That is a 55.5% increase. Likewise, on average the number of males who answered correctly on the pretest was about eight students and on the posttest the number rose to ten. That shows a 25% increase. Even when disaggregating the data, there is visible improvement.

The surveys I gave students also showed that feelings about writing and solving mathematics problems changed throughout the course of the project. I focused on two questions from the survey: “How do you feel when you see word problems on an assignment and why?” and “Do you think writing your own word problems will help you (has helped you) be better at solving word problems and why?” I coded students’ responses as either positive or negative for both the pre-survey and post-survey. Below is a chart with this information:

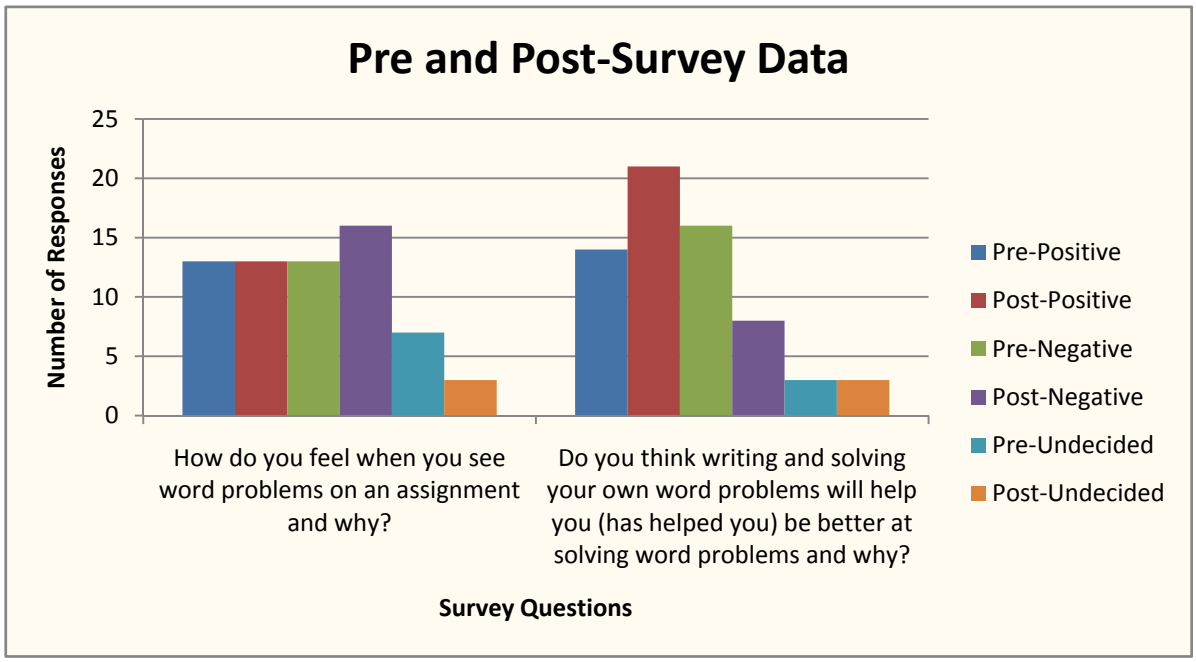

Table 6

Below are the tallied results that are depicted in the graph.

Question	Pre-Positive	Post-Positive	Pre-Negative	Post-Negative	Pre-Undecided	Post-Undecided
How do you feel when you see word problems on an assignment and why?	13	13	13	16	7	3
Do you think writing and solving your own word problems will help you (has helped you) be better at solving word problems and why?	14	21	16	8	3	3

Table 7

Even though the negative responses went up in the post-test for the first question, the number of positive responses stayed the same and the undecideds went down. Individual responses cannot be seen on this chart, but four students perceptions changed for the good, four student's perception changed negatively. Eleven students had negative responses for both surveys while nine stayed positive throughout. All in all, this question did not show much, but in the end four students perceptions were improved.

The second question, “Do you think writing your own word problems will help you (has helped you) be better at solving word problems and why?” shows more useful data. The positive responses went up dramatically while the negative responses decreased. The number of undecidededs stayed the same. Individually, eleven students who did not think this practice would help them at the beginning changed their mind and decided it did. On the pre-survey fourteen students thought writing word problems would be helpful and on the post-survey 21 thought they were better.

Student comments are similarly revealing. On the survey question, “Do you think writing your own word problems will help you (has helped you) be better at solving word problems and why?” students had to write down why they answered with a yes or no. Below is a list of insightful comments that reassured me that writing and solving word problems really did help some of my students.

- Yes, it shows you how a problem is broken down.
- Yes, it helps me understand the problems.
- Yes, I get to see the ‘structure’ going up.
- Yes, now I get them more.
- Yes, I know better how they work.
- Yes, because now I know how to set them up.
- Yes, because it better helps me understand them.

Of those students who responded no, the most frequent comments were similar to, “My problems I write are too easy.” and “I am not just good at word problems.”

My final form of evidence is the weekly problems (Appendix F) I gave students. Below is a table showing the weekly problems and the number of students with correct solutions each week.

Week	Number of Students With Correct Solutions	Percentage of Correct Solutions
1	24	73%
2	16	48%
3	18	55%
4	25	76%
5	24	73%
6	24	73%
7	24	73%
8	17	52%

Table 8

The average percent correct for the first ½ of the project was 63%, while the average percent correct for the second ½ of the project was 68%. This is only a 5% increase, but keep in mind the project only lasted about 10 weeks.

I also gave a final problem set, as explained earlier, (Appendix G) that included four problems. Each problem was a bit different. The table of data tells the problem and how many students out of 32 answered it correctly along with the percentage.

Problem	Number of Students Answering Correctly	Percentage of Students Answering Correctly
The answer is: 12 candy bars Operation to use: Division	23	72%
The answer is: 4 bananas Operation to use: It must have two steps; you choose the operations.	17	53%
The answer is: (you choose) Operations to use: Addition and Multiplication	20	63%
The answer is: you choose! Operation to use: you choose!	22	69%
Average	20.5	64.5%

Table 9

The average score of the final problem set is still higher than the first half of my project which shows some improvement in the 10 week period of time.

Low Ability Students and Word Problems

By having students write and solve word problems, all my students are writing and solving more complex grade level appropriate word problems, including those who have been labeled “low ability”. Both the comments written by students and the pretest and posttest data show improvement.

I see this in students’ work. One student, Adam has gone from writing and solving basic one-step problems to writing and solving multi-step problems. For example, Adam’s first word problem had to have the answer of $14.41. This was his problem:

I went to shop for a pair of pants and the cost was $28.82. I had $14.41. How much more do I need to buy these pants?

He was able to correctly solve the word problem. A couple of weeks later he had to write a word problem where I did not give them a specific answer or operation they had to use. This was his word problem:

If you go to the store and buy a bag of chips and a Gatorade and the Gatorade is $1.19 and the bag of chips is $3.15 and you pay with $5.00, how much money will you get back?

I realize the wording is not perfect (I have made some spelling changes too!), but the problem is much more complex because he had to write and solve a problem with two steps and operations. He was also able to correctly solve the word problem.

Another student, Marcy is a strong writer, but demonstrably dislikes mathematics. She writes the problems well, but the mathematics is really hard for her. For example, one week students had to write a two-step word problem with an answer of 24 hamburgers. Marcy’s word problem was great, but she really had no idea how to solve it:

Tori, Sarah, Emily, and I paid $37.44 all together at McDonalds. If the price of one hamburger was $1.20 and the sales tax was 3%, how many hamburgers did we buy?

She had lots of mathematical ideas written down. She knew that 24 hamburgers were going to cost $28.80, but she could not figure out how to do 3% of $28.80. Since I was looking at these papers several days after the fact, I did not take the opportunity to show Marcy how to compute 3%, but I would have loved to show her how complex she had made her problem! Toward the end of the project, students had to write a word problem that was less specific. They could write any sort of word problem they chose. This time she had several steps to her word problem and was able to show me each step and the final answer as well as all the operations she used to solve it. This was her word problem:

A pair of shoes cost $50.00 and lunch at Subway costs $12.00. If the shoes were 75% off and your mom paid for half of your lunch, how much did YOU spend all together?

My journal entries reflect my observations that my lower-ability students were writing and solving more complex word problems. Some students' dependency on me lessened as the project went on. I noticed that students, especially lower ability students, were very dependent upon me at the beginning of my project. During the week of February 11th, I noted that my challenge was about helping these lower ability students be successful without changing the outcome of my research project. In Memo 2, I wrote that this same group of students started out by writing and solving very basic word problems and have come a long ways and wanted to account for that in the rubric I was using to assess their writing and solving of word problems. Throughout the course of my research, I have always had students, mostly lower ability, who

come to me to help them write a word problem. In the February 18th journal and again in the March 24th journal, I documented that no one asked me for assistance, yet all my lower-ability students correctly wrote and solved the problem.

I conducted student surveys at the beginning and the end of data collection. I compared results that I have from my survey I gave at the beginning of my research project to the survey questions I asked my students toward the end of the project. Three students offer representative example of meaningful comments that stuck out to me. Adam is a student who really struggles with mathematics and finds any type of mathematics problems to be very frustrating. Tyler is a verified special education student. Dana is a student who I would consider average to above-average.

Question	***Adam***	***Tyler***	***Dana***
Survey Question from before the project started: Do you think writing your own word problems will help you be better at solving word problems and why?	No, because I will not know how to do it.	No because you have to figure out how to word the problem AND you have to know how you solve it.	No, because I might write an easy problem.
Surveys done from March 6th to the end of the project. Do you think writing your own word problems has helped you be better at solving word problems and why?	A little since I already know the answer.	Yes, they are easy.	Now I do because it is not as easy as it sounds.
What is your favorite part about writing your own word problems?	"Reading it because you wrote it and you know what it says."		

Table 10

It is interesting that my low functioning student's attitude really changed from the beginning of the project. At the end he says that it has helped him a little and his favorite part is actually knowing what the problem says. I also find it interesting that my special education students thought writing word problems would not help him, but when I asked the same question again, he thought it had helped and that it was easy. I included Dana's comment to show that even the average students saw some benefit to writing word problems. These comments really said a lot to me. I'd found a strategy, that at least for this particular class, had made a difference to students of all abilities. Adam, who struggles with almost everything you give him, found a way to make an assignment 'a little easier'. He was able to take some ownership of a problem he'd written and see that he could be successful. The same could be said for Tyler. Even though his mathematical abilities have grown with leaps and bounds over the past two years, a task that at first seemed daunting because he not only had to write a problem he had to solve it too, found it to be 'easy'! I was concerned at first with my above-average students slacking off and writing very simplistic word problems, and with Dana's comments I could see that she agreed with me. But once she was able to write these word problems, she was able to see that it wasn't as easy as it looked and along the way she wrote some very perplexing and challenging word problems.

CONCLUSIONS AND IMPLICATIONS

The adventure of my action research project was very eye-opening for me. I was surprised by my students' honesty and high motivation throughout the entire project. As a teacher, I learned from my surveys and interviews that word problems were a struggle for even the students who like mathematics and have the self-confidence to tackle any problem. By trying something new, I helped more students gain their self-confidence and be more successful in solving word problems. Even students with lower mathematical abilities, as well as students who

strongly dislike math, showed improvement in just the few weeks I implemented this practice. For this reason, I want to continue to investigate strategies and practices that will 'ease the pain' of word problems for all students.

I also found out that trying a new way, a 'backwards way', of approaching word problems was helpful for the majority of my students. Not very often is writing part of the mathematics curriculum. In the upcoming school year, I am going to continue to implement the writing and solving of word problems of various difficulty levels into my mathematics curriculum and document students' progress. I am anxious to see if this method is as successful for my incoming students as it was for this particular group of students. I also want to incorporate more writing into my curriculum to see if this improves student demeanor toward mathematics.

In addition, and maybe most importantly, this project was a great reminder to me how powerful it can be to let students be creative, guide their own learning, and mentor one another. Mathematics is not always about a right answer, but rather a way to communicate ideas.

I will enjoy sharing my findings with other educators. One way I could do this is share my master's presentation with all staff at the beginning of the year during our staff in-service days. Another way would be to present my findings as part of an ESU workshop on word problems. At these presentations, I would focus on how I collected my data and what my findings were. I would stress the impact that writing and solving word problems had on my students as well as how important it is to try something new because you never know how powerful taking a different approach may be.

References

Amit, M. & Klass-Tsirulnikov, B. (2005). Paving a way to algebraic word problems using a nonalgebraic route. *Mathematics Teaching in the Middle School, 10,* 271-276.

Barlow, A. T., & Cates, J. M. (2007). The answer is 20 cookies. What is the question?. *Teaching Children Mathematics, 13,* 252-255.

Burns, M. (2004). Writing in math. *Educational Leadership, 52,* 30-33.

Charlesworth, E. (2001). 225 Fantastic Facts Word Problems. 6.

Ishii, D. K. (2002). Emergent issues in middle school mathematics action research: A meta-analysis of writing as a pedagogical strategy. Unpublished manuscript for Annual Meeting of the Mid-Western Educational Research Association, Columbus, Ohio.

Martinez, J. G. R. (2001).Thinking and writing mathematically: "Achilles and the tortoise" as an Algebraic Word Problem. *Mathematics Teacher, 94,* 248-252.

Miller, L. D. (1992). Teacher benefits from using impromptu writing prompts in algebra classes. *Journal for Research in Mathematics Education, 23,* 329-340.

Mills, M. & Stevens, P. (1998). Improving writing and problem solving skills of middle schools students. Unpublished manuscript for Master's Action Research Project, Saint Xavier University.

National Council of Teachers of Mathematics. (2000). Principles and standards for school mathematics. Reston, VA: Author.

Nosegbe-Okoka, C. (2004). A sense-making approach to word problems. *Mathematics Teaching in the Middle School, 10,* 41-45.

Pugalee, D. (2001). Writing, mathematics, and metacognition: Looking for connections through students' work in mathematical problem solving. *School Science and Mathematics, 101,* 236-245.

Rothstein, A., & Rothstein, E. (2007). Writing and mathematics: An exponential combination. *Principal Leadership, 7,* 21-25.

Sellke, D. H., Behr, M. J., & Voelker, A. M. (1991). Using data tables to represent and solve multiplicative story problems. *Journal for Research in Mathematics Education, 22,* 30-38.

Stephens, A. (2003). Another look at word problems. *Mathematics Teacher, 96,* 63-66.

van Garderen, D. (2004). Reciprocal teaching as a comprehension strategy for understanding mathematical word problems. *Reading and Writing Quarterly, 20,* 225-229.

Winograd, K., & Higgins, K. (1994). Writing, reading, and talking mathematics: One interdisciplinary possibility. *The Reading Teacher, 48,* 310-318.

Winograd, K. (1992). What fifth graders learn when they write their own math problems. *Educational Leadership, 49,* 64-67.

Winograd, K. (1993). Selected writing behaviors of fifth graders as they composed original mathematics story problems. *Research in the Teaching of English, 27,* 369-394.

Winograd, K. (1997). Ways of sharing student-authored story problems. *Teaching Children Mathematics, 4,* 40-47.

Appendix A

NCTM Principles for School Mathematics

- ***Equity.*** Excellence in mathematics education requires equity—high expectations and strong support for all students.
- ***Curriculum.*** A curriculum is more than a collection of activities: it must be coherent, focused on important mathematics, and well articulated across the grades.
- ***Teaching.*** Effective mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well.
- ***Learning.*** Students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge.
- ***Assessment.*** Assessment should support the learning of important mathematics and furnish useful information to both teachers and students.
- ***Technology.*** Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning.

NCTM Standards for School Mathematics

- Number and Operations
- Algebra
- Geometry
- Measurement
- Data Analysis and Probability
- Problem Solving
- Reasoning and Proof
- Communication
- Connections
- Representation

Appendix B

Student Survey Questions: (Before the project.)

1. How do you feel when you see word problems on an assignment?

2. What is the hardest part of solving a word problem? Why do you think that is?

3. What is the easiest part of solving a word problem? Why do you think that is?

4. What strategies do you use when you solve word problems?

5. Do you think that writing your own word problems will help you be better at solving word problems and why?

6. What key words can you use for different operations?
   Addition:

   Subtraction:

   Multiplication:

   Division:

7. Why do you think I tell students that labels are important to the answer when you are solving a word problem?

8. As I think about planning my mathematics class for next year, what advice would you give me about having students write their own word problems?

Appendix C

Student Interview Questions: (After the Project)

Please write honest and complete comments. Your answers do not affect your grade. These will only be used for my research project. Thanks for your help!!

1. How do you feel when you see word problems on an assignment and why?

2. What is the hardest part of solving a word problem? Why do you think that is?

3. What is the easiest part of solving a word problem? Why do you think that is?

4. What strategies do you use when you solve word problems?

5. Do you think that writing your own word problems has helped you be better at solving word problems and why?

6. What has been the easiest part about writing your own word problems? Why?

7. What has been the hardest part about writing your own word problems? Why?

8. What is your favorite part about writing word problems? Why?

9. What is your least favorite part about writing your own word problems? Why?

10. When you write word problems, you have to use key words that help someone decide what to do to solve the problem. What key words can you use for different operations?

    Addition:

    Subtraction:

    Multiplication:

    Division:

11. Why do you think I tell students that labels are important to the answer when you are solving a word problem?

12. As I think about planning my mathematics class for next year, what advice would you give me about having students write their own word problems?

Appendix D

Name: _____ 8.2.2 Benchmark Quiz

Please show your work!!! NO CALCULATORS!!!
This is test data to be used by our school district!! Try your hardest!!

1. Joe had six dollars and 24 cents. Then his mom gave him some money. Now he has 9 dollars and 16 cents. How much money did his mom give him?

2. Kelly wants to bring the least amount of money to buy a $46 present for her dad. If she only has $5 bills, how much money will she have to bring to pay for it and the 8% sales tax?

3. Cari wants to tip the waiter 10% of the cost of the meal. If the meal costs $22.50, about how much should be left for a tip?

4. The first box contained 6,186 red marbles and 9,234 green marbles. The second box had **twice** as many red marbles and **3 times** as many green marbles. How many total marbles were in **both boxes**?

5. Matt scored 37,253 points in the first video game. He scored 8 times as many points in the second game. How many points did he score **in all?**

6. Tony has a piece of string that is 56 inches long. What is the greatest number of 14 inch pieces that can be made?

7. The first number 854. The second number is 597. The third number was twice the sum of the first two. What was the third number?

8. What is the difference between 80 and 20?

9. A squirrel could store 59 nuts in each hiding place. If there are 879 nuts to hide, how many hiding places did the squirrel need?

10. The quotient of 30 and 14 is what?

11. Cathy charges $20 to mow and $7.50 to trim lawns. The total amount is represented by the expression $20x + 7.50x$, where x is the number of lawns mowed and trimmed. If Cathy mows and trims 8 lawns in one week, how much will be earned?

12. Fifty-two students can ride on each bus. There are 2375 students going on a trip. How many buses are needed to take all the students?

13. When the product of 3 and 4 is subtracted from the sum of 5 and 6, what is the difference?

14. Find the sum of 5 consecutive whole numbers, if the first whole number is 5.

15. The student council voted to sponsor a hat day to raise $400 to have a bench installed near the school entrance. Each student who pays $2.50 will be allowed to wear a hat all day at school. How many students need to wear a hat to raise $400? Show me what you would do to find the answer. **I don't want the answer, just set it up!!**

Appendix E

Test Printout for **Math 8.2.2**

By the end of eighth grade, students will identify the appropriate operation and do the correct calculations when solving word problems.

This material was removed in order to make this action research report public on the internet, since this state assessment is still in use.

Appendix F

**** Every week's worksheet followed this format.

Name: _____ Week of February 4th

The Answer Is . . . What is the Question?

This word problem assignment looks a little different from what you are used to solving. Instead of giving you the problem, I am giving you the answer and YOU have to write the problem. Notice that written below the answer, I have told you to write this problem using addition and subtraction. Be creative and HAVE FUN!!

1. The answer is $14.41. What is the question?
   Operation to use: Addition or Subtraction

Here is some room to brainstorm your ideas first:

Final Word Problem:

_____

_____

_____

_____

_____

_____

Check to see that you're right: (Work out your problem.)

Appendix G

FINAL PROBLEM SET!!!!! **Name: _____**

We made it – this is the last time I will ask you to write and solve your own word problems!! I really appreciate all the hard work you have put into my project. When you come back next fall, you'll be able to see the final product of all our hard work ☺

For this last problem set, I am going to have you WRITE and SOLVE four word problems. After this, I want you to rate the difficulty of the problem. Use the rating scale below. It is important that you do each step. I started with an example to show you what I expect.

Difficulty Level Scale: 1 – Easy Problem 2 – Average Problem 3 – Challenging Problem

Example Problem: Difficulty Level: 2

The Answer Is: 210 ounces
Operation to Use: two-step – multiplication and addition

Write It:
When Gavin was a baby he drank five bottles a day. If he drank 6 ounces each time, how many ounces did he drink in a week?

Solve It:
In one day Gavin drank 30 ounces and there are 7 days in a week, so Gavin drank 210 ounces a week.

Problem One: Difficulty Level:

The Answer Is: 12 candy bars
Operation to Use: division

Write It:

Solve It:

Problem Two: Difficulty Level:

The Answer Is: 4 bananas
Operations to Use: It must have two steps, so you can choose the two operations.

Write It:

Solve It:

Problem Three:
Difficulty Level:

The Answer Is: _____
Operations to Use: It must have two steps, but I want you to use addition and multiplication.

Write It:

Solve It:

Problem Four: Difficulty Level:

For this problem, I want you to provide an answer, the operation(s). Then write your problem and solve it to make sure you have the correct answer written in.

The Answer Is: _____

Operations to Use: _____

Write It:

Solve It:

Last, but not least, please answer these final questions that will help me with my paper.

1. When I gave you the answers to the word problems and had you write and solve them, sometimes I gave you the answer and operation and other times I did not provide the answer or operation and let you choose. Rate the following with 1 being the easiest and 4 being the hardest.

   _____ Mrs. Stark told me the answer and the operation to use.

   _____ Mrs. Stark told me the answer, but not the operation.

   _____ Mrs. Stark didn't tell me the answer, but told me what operation to use.

   _____ Mrs. Stark didn't tell me the answer or operation – I had to come up with my own answer and operations.

2. In a sentence or two tell me why your choice was the easiest.

3. In a sentence or two tell me why your choice was the hardest.

Appendix H

Week of _____

Teaching Reflection Questions

1. What did my teaching look like in my classroom this week?
2. What am I keeping the same? Why?
3. What am I changing as a result of my research questions? Why?
4. What does the change in my classroom look like?
5. What went well with my teaching this week?
6. What challenges did I face in my teaching this week?
7. What is going well with writing word problems this week in my teaching?
8. What do I need to think further about in my teaching, related to my action research project?

Appendix I

Pre-test/Post-test Survey Results

PRE-TEST				POST-TEST		
Student Name	**Student ID**	**Correct Solution**	**Correct Label**	**Correct Solution**	**Correct Label**	**Comments**
	3A					
	3B					
	3C					
	3D					
	3E					
	3F					
	3G					
	3H					
	3I					
	3J					
	3K					
	3L					
	3M					
	3N					
	3O					
	3P					
	3Q					
	3R					

Appendix J

Student Name: _____ Code: _____ Week of _____

Written Word Problem Rubric:

Category	**Limited – 1 pt** *Huh – I'm Lost!*	**Basic – 2 pt** *I'm on my way!*	**Proficient – 3 pt** *Awesome – I've got it!*
Numerical Values	Incorrect numerical values.	Some correct numerical values.	All correct numerical values.
Operations/Key Words	Incorrect operations/key words used.	Some correct operations/key words used.	All correct operations/key words used.
Label	Incorrect label.		Correct label.
Writing	Writing of word problem does not make sense.	Writing is in illogical sequence or difficult to understand.	Writing is arranged in a logical manner and is solvable.

Appendix K

Student ID	**Correct Solution**	**Incorrect Solution**				
		Wrong Operation	*No Label*	*Writing*	*Wrong Numbers Used*	*Extra Category if Needed*
3A						
3B						
3C						
3D						
3E						
3F						
3G						
3H						
3I						
3J						
3K						
3L						
3M						
3N						
3O						
3P						
3Q						
3R						
5A						
5B						
5C						
5D						
5E						
5F						
5G						
5H						
5I						
5J						
5K						
5L						
5M						
5N						
5O						
5P						
5Q						

Appendix L

Question 1: How do you feel when you see word problems on an assignment and why?

- 4 students perceptions changed for the good

Student	Pretest Feelings	Posttest Feelings	Perception Changed
3A	Nervous	Scared	0
3B	Get stuck	Looks tough	0
3C	Might be hard	I can do them, but they're hard	+
3D	Oh great, I don't like them	Oh great	0
3E	Scared	Scared, they're gonna be hard	0
3F	good	Good, I know how to do them	+
3G	Use my brain alot	Easy, because I understand most of them	+
3H	I like them	Fine, I'm good at working them out	0
3I	Feels good, challenges me	OK, I get word problems	0
3J	More work for me	They look hard, but when I try they're not so hard	+
3K	nervous	Afraid that I'll get a bad grade	0
3L	Nervous, they're pretty hard	Bad, I'm not that smart	0
3M	Don't like them; leave them to last	I don't like to do all the steps	0
3N	No difference, they're easy	Just depends	0
3O	Assignment is challenging		
3P	Assignment is easier	Good they're easy	0
3Q	5 or 6 is OK, 10 I get tired of it	Tired, they take longer	0
3R	OK if I work through them carefully	Leave them til the end	0
5A	Good I like to do them	Get worried	-
5B	Not that much different	OK	0
5C	Excited, they're easy	Excited, make math fun	0

5D	Good as long as I can solve it	Freak myself out	0
5E	If I take my time, I can do it right the first time	If I try I can figure them out	0
5F	If it's easy excited, if not, not so much	Might be hard to understand	0
5G	Don't want to do it	Don't want to do it	0
5H	Seems hard, but once its explained its easy	Feel like it will be hard	0
5I	Depends on what formulas I have to use	If I don't understand it, I'm confused	0
5J	bored	Anxious	0
5K	Feel really calm	Cool	0
5L	comfortable	Relaxed	0
5M	Feel pretty good	Good	0
5N	Don't care for them	It will be hard	0
5O	Scared, sometimes I don't understand them	scared	0
5P			

Question 2: Do you think writing your own word problems will help you (has helped you) be better at solving word problems and why?

- At the beginning 11 students who said no, changed their minds to yes at the end of the project.
- There were 14 students who thought writing word problems would help them at the beginning. At the end of the project, 21 thought they were better.

Student	Pretest	Posttest	Perception Changed
3A	Yes	Yes	
3B	No	?	
3C	?	No	
3D	Yes	Yes	
3E	No	No	
3F	No	No	
3G	No	No	
3H	No	Yes	**
3I	?	Yes	**
3J	Yes	Yes	
3K	No	Yes*	**
3L	No	Yes	**
3M	Yes	Yes*	
3N	No	Yes*	**
3O	Yes		
3P	Yes	Yes*	
3Q	No	Yes	**

3R	No	Yes	**
5A	Yes	Yes	
5B	No	Yes	**
5C	Yes	Yes*	
5D	Yes	No	
5E	No	Yes*	**
5F	No	?	
5G	Yes	No	
5H	No	No	
5I	Yes	Yes*	
5J	Yes	No	
5K	Yes	Yes	
5L	No	Yes	**
5M	No	Yes	**
5N	Yes	Yes	
5O	?	?	

* denotes notable comment
** denotes a positive change in perception

Appendix M

Data Collection Timeline

Date:	**Action Taken:**
Week of January 28th	Parental/Student Consent Forms
Week of February 4th	Pretest
	Student Surveys
	The Answer Is . . . What is the Question #1
Week of February 11th	The Answer Is . . . What is the Question #2
Week of February 18th	The Answer Is . . . What is the Question #3
Week of February 25th	The Answer Is . . . What is the Question #4
Week of March 3rd	The Answer Is . . . What is the Question #5
Week of March 10th	The Answer Is . . . What is the Question #6
Week of March 24th	The Answer Is . . . What is the Question #7
Week of April 7th	Began the Final Student Surveys
	The Answer Is . . . What is the Question #8
Week of April 14th	Posttest
Week of April 28th	Final Problem Set