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Students Writing Original Word Problems

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ABSTRACT

In this action research study of my eighth grade mathematics classroom, I investigated what would happen when I shifted part of my instruction to focus on students writing original word problems. I also investigated whether students could show measureable growth in the quality of word problems they wrote throughout the research project. Additionally, I explored whether my students would develop a more positive attitude toward word problems as a result of writing their own word problems. Through surveys and journal responses, I discovered that the focus of my teaching shifted to a role as a facilitator for my students' writings instead of the role of the instructor. Evaluation by a rubric did not show measurable growth in the quality of word problems written by students. Student surveys, student journals and teacher journals did show a marked improvement in student attitudes toward word problems as a result of the research project. As a result of this research, I plan to continue this practice in my eighth grade classroom in the future.

The topic of my inquiry concerned incorporating writing into my eighth grade classroom, by having students write word problems to meet given criteria. I selected this topic because I had students who could solve an equation when it was given in the standard format but struggled when an equation was embedded in a word problem. Previously, my strategy for helping students with word problem difficulties was to discuss the word problems as they appeared within our lessons and have students do presentations to the class while thinking aloud. The students would talk about what they were thinking at each stage of solving, from the beginning phases of recognizing what the problem was asking through selecting a strategy and implementing that strategy, to the ending phases of solving and then determining if their solution actually answered the question being asked.

I found the think-aloud strategy worked for the short term as students recognized and could implement a strategy on their next attempt; however, they did not seem able to retain the strategy for future problems. I also found students incorrectly applying the think-aloud strategy in a word problem that may seem similar to ones we saw previously; yet students seemed to focus too much on the 'key words.' I tried to anticipate types of word problems that would cause issues for my students and encouraged student-led whole group discussions, which resulted in more exposure of the think-aloud strategy. My attempts to use think-aloud strategies were not as successful as I wanted them to be. Thus, I decided to redirect my energy toward helping students with their own problem-solving skills. I decided to study my teaching more formally through this action research.

The small district where I conducted my action research merged from three separate buildings to a single new P-12 facility during November 2008. The school system educated 339 students, employed 35 teachers, and covered 177.1 square miles. The district serves students

from two small towns with combined populations of 2,000 and the surrounding rural area. The school building was located an equal distance between the two towns. Thirty-six percent of students received free or reduced lunch, 17% received special-education services, and no students were classified as English Language Learners. The mobility rate at that time was 6%. There were six middle school students who received pull-out math services through our special-education instructors. Other students with Individualized Education Plans (IEPs) and 504 plans were served in my classroom with the support of paraeducators, who assisted me during two of my classes.

My teaching assignment during the time of this study, the 2008-09 school year, included one section of sixth grade math, one section of seventh grade math, two sections of eighth grade math, one section of high school general math, and one section of high school pre-algebra. I also mentored one high school student in several academic areas, including mathematics.

This year I also was involved in an unusual teaching situation. One of my eighth grade math sections was a split between pre-algebra and algebra 1. During the 2007-2008 school year, five seventh grade students, who had previously been identified as high-ability learners, excelled beyond the current general math offering provided to all students in the seventh grade. At the end of the school year, the middle school principal, the special-education supervisor and I met to discuss how these students could best be served. We decided to try a new approach, which consisted of having 18 students, including the five high-ability students, all attend a 45-minute class period together. The thought was to have the high-ability students moved into a different area of the room working as an independent learning community with either my support or the support from a paraprofessional. This approach at offering an advanced math class to our eighth grade students has proven to be incredibly difficult to manage and will not be continued in the

future. Next year, we hope to have the high-ability eighth graders take ninth grade algebra 1 courses taught by the high school math teacher, as all grades are now consolidated in the same facility.

PROBLEM STATEMENT

The issue of students writing original word problems is worth discussing, as math teachers often witness students' word-problem anxiety issues. Knowledge about improving word-problem solving skills is important to teachers for their own practice because it is a measure of students' understanding of math and how it is relevant in their world. Knowledge about improving word-problem solving skills is important for the community of teachers at my school because we all interact with the same students and, since we are a small school, we may teach the same students for more than one year. Knowledge about improving word-problem solving skills is important for the larger community of educators to share new knowledge about how students think and process information.

The topic of students writing original word problems relates to the National Council of Teachers of Mathematics (NCTM, 2000) teaching principles because, as a teacher, I need to understand what my students know and need to learn, then challenge and support them to learn mathematics, including strategies for solving word problems. My topic relates to the NCTM learning principle because students must actively build new knowledge, from experience and prior knowledge.

My topic also relates to the NCTM Process Standards in the area of Connections as students need to recognize and use connections among mathematical ideas and understand how mathematical ideas interconnect and build on one another. Further, my topic relates to the Standard of Connections as students need to recognize and apply mathematics in contexts

outside of mathematics. Word problems link the real world application of mathematics to the written word. Finally, my topic relates to the Standard of Representation as students need to use mathematical representations while solving problems.

Students experiencing difficulties while attempting to solve word problems is a common issue in middle school mathematics classrooms. A challenge in researching this issue arises because the root of the issue is difficult to pinpoint. Some researchers have explored the connection between students' abilities to solve word problems and the students' abilities to determine the reasonableness of the answer. Other researchers have pointed to student attitude and anxiety toward word problems as the issue. My research gave me the opportunity to observe my students' attempts to determine the qualities of good word problems and incorporate those qualities into original word problems.

LITERATURE REVIEW

As I began to review literature concerning student's interactions with word problems, I noticed that most of the available research dealt with strategies to solve word problems as opposed to students writing their own original word problems. My topic for action research involved having students write word problems to match a given equation as opposed to the two most common themes in the literature, writing in mathematics and deciphering and solving word problems. The similarities I found in the literature while comparing my approach of teaching word problems to more traditional techniques enabled me to identify and use the common themes while exploring word problems in the classroom. Only Winograd (1993) and Hicks (1994) addressed the same issue as my action research even though their focuses were different from mine. Both Winograd and Hicks looked solely at whether students' attitudes improved and did not address whether students were actually writing quality, or even mathematically correct,

word problems. All of the themes, which revolved around word problems, were similar regardless of which approach was used in looking at word problems. I am going to address the themes of reasoning and word problems. The theme of reasoning was found in most of the literature. The theme of writing word problems was found in the literature that dealt most closely with the topic of students writing original mathematical word problems.

REASONING

Sellke, Behr, and Voelker (1991) studied five intact seventh-grade classes consisting of a total of 107 students. The students were from an upper-middle-class suburban junior high school. Three of the five classes were randomly assigned to the experimental group, and the other two classes became the control group. The authors studied a specific issue students face when solving word problems. Their investigation focused on multipliers and divisors less than one or divisors larger than the dividends. Situations dealing with these factors almost eliminate the strategy of concretely representing the scenario depicted in the word problem. This strategy is generally the first used by many students when they aren't sure how to solve a problem. These factors presented in the study also challenge the understanding of students that multiplication is repeated addition and division is repeated subtraction. Students often become unable to identify the reasonableness of their answer because multiplication is not making the answer bigger and division isn't making the answer smaller. Finally, students also confront the "rule" that they are always to divide the bigger number by the smaller number. The purpose of the study was to provide a way to represent story problems that overrides the inaccurate or incomplete understandings students possess. The authors viewed the word problems not as multiplication and division problems but by what the researchers called linking problems using the properties of multiplying and dividing by one. The conclusion of the investigation was that students in the

experimental group using the linking problems scored significantly higher than the students in the control group.

Alajmi and Reyes (2007) studied 12 teachers in two middle schools in Kuwait and used what they called a Reasonableness Answer Test to determine whether teachers believed students' answers were reasonable. They related what was considered to be a reasonable answer to two main criteria: practicality of the answer and number relationships and the effect of operations. Six of the 12 teachers in the study stated that students should be able to look at the answers and realize they'd made a mistake. Those same teachers also believed answers should be counted completely wrong if they were not correct. The remaining six teachers believed there should be a range of correct answers to allow for students' reasonableness to account for a margin of error. All of the teachers cited knowledge and application of mathematical rules as the key to achieving a reasonable answer.

Silver, Shapiro and Deutsch (1993) studied 195 middle school students from a large urban middle school to investigate how students solved mathematical problems and interpreted their solutions. The authors specifically studied how students solved division with remainder word problems. The word problem given to students required students to divide a given number of riders onto buses and determine how many buses would be needed. The problem was specifically devised so there would be leftover riders and the student would need to determine another bus was needed for the remainder. Seventy percent of the students could correctly execute the procedure to solve division word problems with remainders. The authors found, in part, that students' difficulties could be attributed to their failure to relate their solution to the situation described in the problem. The solver failed to connect the word representation of the text into a mathematical model. One-third of the students gave written responses to their answers

that were deemed appropriate by the researchers. Silver, Shapiro, and Deutsch (1993) concluded, "students' responses provided considerable evidence that computational requirements were not the major barrier to obtaining a correct solution but rather that unsuccessful solutions were more often due to students' failure to engage in interpreting their computational results" (p. 127).

Cai and Silver (1995) further explored the concept previously studied by Silver, Shapiro and Deutsch (1993) and investigated whether Chinese students would encounter the same difficulties as students from the United States when solving division with remainder word problems. Cai and Silver (1995) studied 186 fifth and sixth graders in two different Chinese cities who were judged, by their teachers, to possess average mathematical abilities. The authors explored this topic because they believe it is widely accepted that Chinese students out-perform students from the United States when performing mathematical tasks. The Chinese students were given a similar word problem as was presented by Silver, Shapiro, and Deutsch (1993) that required students to determine the number of buses needed to hold a specific number of bus riders. Silver et al. discovered that more than 90 percent of the students correctly executed the procedure to solve the division word problems with remainder but only 20 percent of the students could provide the reasoning behind their answers. Cai and Silver (1995) concluded the findings of this study support the theory of Chinese students out-performing students from the United States when performing computational problems. In contrast, the Chinese students under-performed students from the United States based on the findings from these two studies.

Lampert (1990) studied a fifth grade mathematics classroom in a public school. Lampert investigated the link between knowing mathematics and learning mathematics in school. Lampert designed and enacted a lesson in which students' final solutions to the mathematical questions were not the factor used to determine whether they knew the mathematics. Instead,

Lampert relied on students' reasoning skills to determine whether they knew the mathematics. Lampert stated, "the most important criterion in picking a problem was that it be the sort of problem that would have the capacity to engage all of the students in the class in making and testing mathematical hypotheses" (p. 39). Students were encouraged to revise, think, explain and answer mathematical questions while continually re-examining their thought process throughout the lesson. The students' reasoning skills were highlighted as they participated within a mathematical community discussing their own and other students' thoughts in approaching the mathematical concept. Students were carefully led on a journey through their mathematical reasoning process as they approached, solved and looked back at the questions they were answering. Lampert stated, "it required courage and modesty to expose one's exploratory thinking to others in the hopes that by engaging in the exchange of ideas in classroom discourse, one might end up with better ideas in the end" (p. 54). Lampert further concluded, "there is convincing evidence that my students learned to do mathematics in a way that is congruent with disciplinary discourse" (p. 58). Lampert's link between knowing mathematics and learning mathematics in school was supported by the investigation where mathematical reasoning skills of the students were highlighted.

Newton and Newton (2007) studied 18 textbooks used by 7- to 11-year-old students in England. They sought to study new teachers and teachers whose main area of expertise was not mathematics. Newton and Newton maintained inexperienced teachers often rely heavily on textbooks to help present topics and help them explain it. They further believed the tendency was to focus on rote applications of procedures, routines and algorithms and not on instilling reasoning skills in students. As a result, Newton and Newton focused on 18 mathematics textbooks and the potential the textbooks may have had to help teachers develop reasoning skills

in students. Newton and Newton (2007) looked at the degree to which the textbook focused on reasoning behind a procedure explained in the textbook. Their findings concluded that many textbooks contained valuable material for teachers even though they did not explain why procedures were used and were unlikely to help teachers when teaching students reasoning skills.

Reasoning took three different forms in the literature I reviewed. First, some authors, including Sellke, Behr and Voelker (1991) and Alamji and Reyes (2007), looked at mathematical reasoning as a final product when determining if an answer was correct. Second, Lampert (1990), Shapiro, Silver and Deutsch (1993) and Cai and Silver (1995) investigated reasoning as a journey where students questioned their own thoughts and the thoughts of others when trying to make sense of a mathematical problem. And third, Newton and Newton (2007) viewed mathematical reasoning as a process that students employed while learning mathematical concepts and developing the sense of "why" they were doing this. Newton and Newton (2007) asserted this knowledge was the link to "why a procedure works, why an answer is correct" (p. 82). Newton and Newton (2007) maintained that knowing and understanding "why" was the connection between transferring math from facts and rules to a body of knowledge or skills.

WRITING WORD PROBLEMS

Winograd (1993) studied eight different fifth grade students as they composed original mathematics story problems. He explored if a student-centered, problem-writing approach to mathematics would positively impact students' learning of mathematics problem solving. He began the research to investigate how elementary students responded when they were invited to write their own mathematics story problems. He examined students' beliefs about math, math story-problem writing behavior, and difficulties with self-generated problems. Students wrote, solved and then shared math story problems three or four days each week during the study.

Winograd (1993) worked with a class of 25 students throughout the five-month study. Winograd's research focused on student's cognitive behavior as they wrote, solved and shared their problems. The students were instructed to write story problems and then see how to solve them. Some of the problems written by the students were incomplete, and others were unable to be solved. Another issue was that students often wrote problems that were so difficult they could not solve their own problems. Winograd (1993) concluded that writers became more enthusiastic in writing their word problems because they had peers to listen to and solve the authors' original problems.

Hicks (1994) related her experience as a GED instructor and adapted writer's workshop strategies for adult students to write original word problems. Her focus was to make math, specifically word problems, more meaningful for adult learners. Her plan was to integrate math, reading and the real world. She began with a focus on process writing with an emphasis on pre-writing, drafting, feedback, revising, and presentation. After the class progressed through the stages of writing, Hicks introduced the idea of creating a book of original math problems using the students' personal experiences. Hicks modeled the process with a recipe and wanting to double the recipe. The discussion then followed regarding adding and multiplying simple fractions and mixed numbers. Terminology such as numerator and common denominator was discussed. The students were assessed using a checklist, checking for clarity, descriptiveness and mathematical accuracy. Hicks summarized her experience as beneficial for her GED students in more ways than just indicated by their math skills and language skills. "The journey through process writing empowered these adult students to integrate mathematics, writing, reading, and speaking into their lives" (p. 27).

Winograd (1993) and Hicks (1994) each addressed my research topic in different ways although neither of them matched it. Winograd's investigation had students writing word problems, but he was more interested in discovering whether they were excited and motivated about doing so. Hicks discussed the integration of mathematics and writing by having the students compose original problems. Her students were able to choose any real-life mathematical situation and write about it. My research focus was giving students equations and having them write word problems to match the equation. Although they both gave insight into the process, Winograd and Hicks did not explore the exact nature of my research project.

LITERATURE REVIEW SUMMARY

My research project involved the impact of having students write original mathematical word problems to match given equations. I explored whether understanding and constructing (the process of writing) a word problem would, in turn, enable students to become better at solving word problems written by others. After reviewing the literature, I found no research that explicitly examines composing original word problems with the same parameters I used in my study. The literature did provide several supporting ideas to consider as I undertook my action research project, such as reasoning, and the overall impact of students writing in a mathematics class. Winograd (1993) stated, "I believe the composition of mathematics story problems is a fertile area for research and one that can effectively link innovations in the teaching of writing with the current interest in applications for writing in the mathematics curriculum" (p. 392). The literature guided my action research. I was interested in investigating students composing original word problems and their changes in attitudes.

PURPOSE STATEMENT

The purpose of my study was to determine the impact of students writing original word problems to improve their ability to solve word problems written by someone else and to improve students' attitudes toward word problems. I examined the research themes of the quality of word problems written by students, the attitudes of students in solving word problems, and changes in my teaching of equations. I sought to answer the following research questions:

- What will happen to my teaching of equations when I shift part of my focus from equations to teaching students how to write story problems to match equations?
- What will happen to the quality of word problems written by students to match a given equation?
- What will happen to students' attitudes toward word problems as they are more aware of the equations embedded in word problems?

METHOD

My eighth grade math classroom was the setting for my study. My research began in February 2009 and concluded in April 2009. The first piece of data I collected was a pre-test based on my school district's word problem assessment that corresponded to Nebraska Mathematics Standard 8.2.2. My school district administered that particular assessment to all eighth grade students later in the spring; thus, I was able to use the district assessment as my post-test. I used the pre- and post-tests to measure growth with regards to solving word problems. Since these assessments are active assessment documents, I was unable to include examples of the questions in this paper. Each question on the assessment measured students' abilities to understand mathematical vocabulary, solve basic and complex word problems, and skills in determining appropriate labels to accompany numerical answers of the word problems.

I used two methods, student journals and student interviews, to collect data regarding students' thoughts throughout the research project. I had my students write journals throughout the data collection period as a way to document students' thoughts about the word problem writing process and judgments about the quality of problems written and presented by peers (Appendix A). I gave the same journal prompt after every presentation period. I used the first journal (Appendix B) and final journal (Appendix C) to prompt students to give more general thoughts about their perceptions of how word problems have been encountered in math class as well as their attitudes toward word problems. Student interviews were conducted in small groups. I interviewed small groups of students during independent work time. The student groups were selected randomly from the entire student population with all student responses documented. At some point, each student in my class was involved in the interview process. At the end of the data collection period, I sorted the student responses into those with signed consent forms and those without signed consent forms. Quotations were only included for students with signed consent forms. Individual student responses were recorded to questions prepared in advance and also follow-up questions that resulted from responses given during the interviews.

The students wrote seven different word problems over the course of the data collection period. Each assigned problem had a different requirement. The first word problem required the students to write an original word problem that utilized multiplication of whole numbers. The second assignment required the multiplication of decimals. The third assignment had students writing a word problem to match a missing number in subtraction equation. The fourth assignment matched a missing number in multiplication. For the fifth and sixth assignments, students used integers when writing word problems. Finally, students wrote word problems using

ratios to compare. Students were given from one to three days to write each word problem after they had received the specific requirements for each. Then students then orally presented their word problems to the rest of the class while I scored each word problem using a rubric (Appendix D).

Throughout the data collection period, I wrote weekly entries in my teacher journal. My entries documented lessons presented to students, comments made by students during the lessons, and my reflections following the lessons. I also used my journal as a way to track my thoughts about what I might want to do depending upon how the data was leading me. I used my journal to record missed opportunities for collecting data as well as frustrations I experienced as my role as researcher and teacher were sometimes in conflict.

In April, I organized the data I had collected into charts making each piece easier to analyze. I charted the pre-test and post-test data while noting individual student performance. I scored the student word problems using a rubric and then recorded my findings. I tracked student journal responses and organized them into a chart. I also recorded students' attitudes using the final written journal. I asked students to rank their attitudes toward word problems before writing their own word problems and after writing their own word problems. The students used a scale ranging from a low of 1 to a high of 5 to record their responses. I organized the data into a chart with changes in attitude documented. I looked for evidence concerning each of my research questions.

FINDINGS

A typical setting for my regular classroom on non-research days consisted of students beginning the class period correcting the previous day's assignment. After students figured their grades and handed in their corrected assignments, we would begin the topic of the day. The

method in which the new topic was presented varied. Some days, I started with examples of previous knowledge and made connections to the new material. Other days, I started with a discussion about a real-life situation that related to the topic. When appropriate, I had the students do some guided reading of their textbooks or an Internet search to explore a new topic. Most days involved some type of guided practice, whether it was in a whole group, in a small group led by me or a paraprofessional, or individual instruction for students. During the research project, the change in my routine came as I used a two-day process for students to compose and present their original word problems.

During the research project, I assigned the new word problem to be written at the end of a regular day. A typical setting for word problem writing in my classroom consisted of two-day process with the students receiving a prompt detailing the requirements for the problem they were to write individually. The presentation day during the research project was only used for presentations. Students read their original word problems aloud while the other members of the class wrote the problem and solved it. Sometimes the prompt was very specific, such as "write a word problem to match the equation: $20.00 – C = $7.13" and other times the prompt gave the student more freedom, such as, *write a multiplication word problem and you must use a decimal number as one of the factors*. At the beginning of the project, many students asked for validation that their word problems were good. I would respond to their question by referring back to the criteria they had developed and ask them the five questions so they could analyze their own word problems. The students would have a minimum of 10 minutes in class to write a draft of their problem, and they also could take the problem home for revisions.

The second day of the process entailed student oral presentations. The students would volunteer to present their original word problems to the rest of the class. I would score the word

problem using my rubric and the rest of the class would take brief notes detailing which parts of the word problem they found interesting. At the end of the presentations, the students would respond in journals. The students would respond to which problem they thought was the best they had heard that day and what about that student's word problem was impressive.

My Teaching of Equations

The first of my three research questions addressed what changes I would see in my teaching after shifting part of my focus from solving linear equations to teaching students how to write word problems to match equations. My classroom evolved to more of a student led atmosphere with my role changing to more of a facilitator. Using examples from my journals, I found that my teaching evolved from the beginning to the end of the project. I discovered that I was taking time in my classroom to really talk to students about word problems and the qualities of good word problems.

At the beginning of my project, I was uncertain as to how my teaching would change. I was open to trying new methods in an attempt to provide instruction to my students that would help them grow as authors of original word problems. In previous years, I used direct instruction to address word problems. I recognized that my students had confidence and execution issues relating to solving word problems. My goal used to be to discuss the word problems and then use a think-aloud strategy by letting some of my stronger students discuss their approaches and strategies to aid those who struggled. Another way I had previously addressed word problem concerns was to model common errors for students and let them identify why that approach would not be effective. In both cases, I was the one leading the classroom with little to no student input. I wrote in my first teacher journal, "I plan to analyze word problems that we've already encountered, but am unsure about how to lead the discussion without telling them what I see

instead of letting them discover what they see" (February 20, 2009). I also noted how the students were reacting to the discussion and wanted to address it.

> The students seemed to respond well to each other, but I could tell that several of them were apprehensive about joining in the discussion because I'm assuming they didn't want to be embarrassed. I really didn't mind that I had students who chose to be listeners rather than talkers because I believe two things: 1) The listeners still learned about the process by listening to the talkers talk. 2) The listeners will become more likely to talk as they become more comfortable with the concept of discussing story problems in this way. (Teacher journal, February 20, 2009)

My decision to let the listeners stay in that role until they were comfortable worked well as many of them did eventually join in the discussions. Previously, I would have attempted to draw the listeners into the conversation myself, so this was a change in my teaching, allowing the discussions to be more student-led.

Further evidence of change in my teaching was documented in my teacher journal dated March 6,

> We, once again, discussed some qualities of good story problems and identified them as possessing the following qualities:
>
> 1) Interesting—not boring or too long
> 2) Asks a specific question
> 3) Gives enough information to understand what to do
> 4) Checks to see if the student really understands the math needed to do the problem

5) Gives a real-life look to how this math might look not in a textbook (Teacher Journal, March 6, 2009)

With this identified criteria in mind, my students began to judge one another's word problems. The criteria would be the basis students used to determine what made a good word problem and what was missing in the problems that were not so good. I even had students who could self-analyze after presenting a problem and realize they had not met all five criteria in their problem. "Three students, after presenting their first problems, instantly recognized that the way they had written the problem did not make sense when it was read aloud." (Teacher Journal, March 6) The first presentations were the most challenging for the students and for me. It was challenging for my students to make sure they had a good problem and not feel embarrassed. It was challenging for me as the teacher to stick with my rubric as the measure of the quality of the word problems, since I realized early on that my rubric was not detailed enough.

> I had an easy time scoring my students on my rubric, which is actually an awful thing. Based on my rubric all but three of my students are at the top. The three that aren't at the top fixed themselves after they read their problem out loud and now know what to do next time. (Teacher Journal March 6).

Student journals reflected students' thoughts. On March 25, Rachelle[1] wrote in her journal, "the hardest part of writing word problems is making sure they make sense." Stephen wrote in his journal, "the hardest part of writing a word problem is writing a good question." Several students responded that the hardest part of writing a word problem is coming up with a good idea. Consider my teacher journal entry from the same date:

[1] All names are pseudonyms.

> I hadn't really every planned on having the criteria as something for the students to follow like a checklist. I thought it would be a general discussion, but when my students started writing the list down, I realized that they saw it as a valuable tool. It was almost as if this was something they had always wanted but never had before (Teacher Journal, March 25).

My teaching of equations changed as a result of facilitating the student-led development of the qualities of good story problems list. My students were relying on the list when identifying what was the hardest part of writing a good word problem. I was relying on the list to help students focus on how they could write a quality problem.

The students' level of creativity increased as the number of days of participation in the action research project increased. The length of the story problems increased as well as the difficulty. The quantity of details and sometimes unnecessary information grew in the problems as the students attempted to impress their classmates and me with their creativity. Consider Mitch's problems from March 20 and April 3:

> Timmy's bank account had negative $15. He deposited $18. How much money does he have in his bank account now? (March 20)

> One day I went to the zoo. I didn't notice I had a hole in my left pocket with $20 in change in it. I reached into my pocket to get some change and realized I only had $7.13 in it. Then I reached further in my pocket and found the hole. Then I turned around and saw a monkey about 10 feet away from me picking up all of my dropped coins and smiling at me. How much money did the monkey have? (April 3)

Mitch's student journal from April 3 indicated he had difficulty "thinking what to write about," an interesting statement given the detailed question he wrote that day. His journal entry

emphasized the point that Mitch was experiencing growth but could not see it for himself yet. My journal entry from April 3, stated, "I wish I had a better rubric. The students' problems are improving so much and the only documentation I have is my belief that they are improving." My journal demonstrates my belief that my students are growing, but shows my frustration that I do not have a way to measure it. Mitch's word problem from April 3 is evidence to me that he is growing as an author, but Mitch's attention to detail in the problem and his way of integrating the information needed to solve the problem show growth that my rubric cannot address.

Another issue raised in my teacher journal addressed the students still clarifying the requirements of writing the word problems,

> After giving the word problem assignment on April 3rd, I asked if there were any questions, Lisa instantly shot her hand into the air and asked if they can make them funny. I reminded them that we had originally discussed the difference between interesting problems and boring problems as part of our criteria for good word problems. (Teacher Journal, April 3)

This journal entry reinforced my assertion that my approach to teaching word problems has changed. When questioned on requirements, I referenced back to the list the students made as the criteria for quality word problems. I understand that I gave my approval of the criteria, but it was the students who went through the process of developing and owning the criteria.

Student interviews revealed that my students also appreciated the being included in the development of the criteria. On March 20th, the conversation I had with my focus group revealed the students' appreciation of one of the changes that had been made in the classroom. Sarah shared, "The list helped me think about word problems in a new way and it described what made

a good word problem." Nicole commented, "I'd really never thought about what made good ones and bad ones. I just thought that some were easy and some were hard." Lisa added,

> "Having the list made it easier to write word problems. When I get ready to write a problem I get out the list to see if I've done everything and when I'm done writing my problem I look at the list again to see if I've done everything on the list. I like it that I got to help make the list so I could remember what was on it and why we said different things on the list were important." (Student Interview, March 20, 2009)

The students' thoughts reinforced the importance of identifying quality criteria to students. My students were able to communicate the benefits of being a part of developing the criteria and then being able to use the criteria when writing word problems.

The final student journal on April 16 included the prompt, *what changes did you see in Mrs. Ostmeyer's teaching since you started the project of writing your own word problems?* Nine of the 18 students surveyed revealed they could not identify any changes in my teaching. The other half of the students identified changes including:

- a different type of homework (2 students)
- we used real-life examples instead of ones from the textbook (1 student)
- we got to write about fun stuff and I learned that not everything in math is hard and complicated (1 student)
- she spent more time talking about word problems and let us talk more about word problems. She used to talk about them before but we didn't. (5 students)

By the end of the research project, half of my students were able to identify changes they saw in the classroom. The final journal entry provided evidence that some students could write specific differences they witnessed in my classroom. My research question dealt with what will

happen to my teaching as I shifted part of my instruction to students writing original word problems. I believe that my students' thoughts can help me identify some of the differences. I believe this is a difficult research question to provide supporting evidence. I have written what I perceive to be changes in my journal, and I have asked my students to do the same individually without asking leading questions.

The shift I identified in my teaching as a direct result of conducting this action research project was the manner in which I discussed word problems with students. I did not use a direct instruction approach during my project, but saw myself more as a facilitator. I let the students tell me what comprised a good word problem. I also used the student journals as a way for my students to communicate to me which of the authors of the story problems were most effective and why they believed a certain way.

Quality of Written Word Problems

The second of my three research questions ultimately became the most difficult research question to address and assess. I developed a rubric to measure what would happen to the quality of word problems written by my students to match given equations. I anticipated that the quality would improve in a measureable way. However, the rubric I developed and used for this study did not provide necessary data to support a claim. My rubric limited the data I gathered by merely focusing on whether the problems matched the equation in the first place, were sensible and reasonable and whether the student followed directions (Appendix F). Many of my students scored the maximum value for each category of my rubric on the first word problem. I noted in my teacher journal dated March 3, "my rubric is a dud!" While I could informally tell the quality of the word problems did increase during the study, I do not have sufficient data to formally make this claim. My rubric did not measuring that type of success. I had hoped to share rubric

information with my students so they could also share their thoughts about measurable improvement in their journals and interviews. Since the rubric was an issue from the start, I did not involve my students in the process.

Even though I did not have a rubric to show evidence of student growth, I do have examples of student work to show growth of their written communication. Consider Trevor. He is a hard-working eighth grade boy who comes in for help or clarification almost daily on his homework assignments. Trevor's response to the first journal question, *Do you think that writing your own word problems will help you be better at solving word problems and why?* was, "I hope it does. I need all of the practice at them I can get." Trevor also indicated in that same journal response that figuring out what the question is asking is the hardest part of word problems. In his final journal response, Trevor indicated, "writing my own word problems has helped me, gratefully with word problems." He further wrote, "Before we started this, word problems were not my favorite and I didn't like to solve them." Trevor's growth as an author of word problems is shown in three examples written over the course of the research project.

Example 1 from the second assigned problem:

Bob bought 5 items for $15.69. The value of his 5 items tripled. What is the new value of his 5 items?

Example 2 from Assigned problem number 3:

Bob went to Wal-Mart and purchased a case of Mountain Dew and Amp Energy Drink. He gave the cashier $20 and received change of $7.13. How much did his drinks cost?

Example 3 from the last assigned problem:

My mom dragged me to Walgreens to purchase some body spray because she said I needed it. Tag body spray was $3.75 for 12 ounces and Axe body spray was $3.25 for 8

ounces. They both smelled good to me so I bought the one that was the better price per ounce. Which one did I buy and how much per ounce did I pay?

Trevor's growth as an author was shown by his increasing detail in his written work over the course of the project.

Jackson's growth as an author is different than the growth of Trevor. Jackson has more confidence in his mathematical skills, and his growth was shown in being able to write problems that were a bit more straightforward and appropriate for an eighth grader to solve. Consider Jackson's examples as he worked to provide clear questions for his listeners and eliminate distracting information:

Example 1 from the first assigned problem:

Twelve monkeys each had one baby. In total, how many monkeys were there?

Example 2:

A bank was robbed by two giraffes with uzis. After the giraffes had cracked the bank's safe with a wet gym sock and taken the entire $20 in it, they went back out the bank's door. Later after the giraffes were taken to jail, police officer Ronald McDonald found the giraffes' loot bag and inside was only $7.13. How much money was lost in the explosion?

Example 3 from the last assigned problem:

Arnold could buy 17 slices of cheesecake from Cheesecake City for $35. Arnold's mom said she could make 10 slices of cheesecake in her kitchen for $23. If Arnold wants to spend the least amount per slice of cheesecake, should he buy it from Cheesecake City or have his mom make it?

Jackson delighted in being able to use words to his advantage to make his first problem more challenging. Over the course of the project, Jackson spent a considerable amount of time ensuring that his questions were clear to the reader. By the end of the research project, Jackson could write questions within his word problems that every listener could identify.

Trevor and Jackson represent the type of growth I witnessed in my eighth grade classroom throughout the research project. Even though both of them met the top requirements of the rubric, which were matches the equation, word problem sensible and reasonable and followed directions, they had room for improvement in their writing and demonstrated that growth in the problems they wrote over the course of the research project.

Students' Attitudes Toward Word Problems

The last of my three research questions addressed students' attitudes toward word problems, as students became more aware of the equations embedded in word problems. Prior to starting my research, my assertion was that students' attitudes toward word problems would become more positive as my research project progressed. My students immediately embraced this project from the beginning, and I began collecting evidence to support my assertion. Their excitement in receiving the prompts as well as their eagerness to present the problems in class grew as the project progressed.

The students' first journal entry provided evidence of students' attitudes at the beginning of the research project. I then recorded students' attitudes at the end of the project using the final journal entry. The first prompt was for the students to complete the following statement: *When I see a word problem on an assignment or a test, I* [blank]. The responses in table 1 revealed students thoughts at the start of the study.

JOURNAL RESPONSES FEBRUARY 17, 2009	
Jackson	Moan and skip it
Rachelle	don't really like doing them so I put them off as long as I can
Crystal	freak out!!
Brent	say Oh Great, it's a word problem
Emma	read it a few times to figure out how to solve it
Lisa	read the problem through and if I don't get it I fight in my head with myself if I should ask Mrs. Ostmeyer for help.
Sarah	I don't want to get to that problem

Table 1: INITIAL JOURNAL OPINIONS TOWARD WORD PROBLEMS

Table 1 reveals thoughts that are consistent with what I expected regarding my students' attitudes. I see students who dread the task of solving word problems. Overall, students' comments, at the beginning of the research project, do not reflect a positive attitude toward word problems.

The final student journal given on April 16, 2009, included the following prompts: *When I see a word problem on a test or an assignment I now think [blank] and this is how my thinking is different from how I looked at word problems before.* Table 2 highlights the same students featured in Table 1 and reveals their attitudes toward word problems at the end of the project.

JOURNAL RESPONSES APRIL 16, 2009	
Jackson	It is more of a routine now than it was before.
Rachelle	I hated them before but now I kind of like them
Crystal	I think o.k. I can do this. Before I freaked out when I saw them.
Brent	Now I think oh this is easy. I used to think oh this is hard
Emma	It is easier now. Before we wrote our own it was hard and I didn't always understand them.
Lisa	Before I thought, "Oh, I can't figure this out" and now I think OH! That's multiplication or any of the others I see.
Sarah	Now, I don't really mind them. Before we started writing our own problems, I didn't really like them because they confused me.

Table 2: FINAL JOURNAL OPINIONS TOWARD WORD PROBLEMS

Responses in Table 2 indicate that students' opinions toward word problems have improved over the course of the research period. I see students' writing in their journals what I am witnessing in

the classroom. My students are more confident at the end of the research project when dealing with word problems.

The final student journal also asked students to rank their attitude toward word problems using a scale of 1-5, with 1 being the lowest (i.e., did not like at all) and 5 being the highest (i.e., loved them). A table located in Appendix C lists the 'before' and 'after' rankings given by the students. The data in Appendix C shows an increase for all students' attitudes based on the five-point scale. Two of the students' attitudes increased from the lowest rank of one to the highest rank of five. Since attitude improvement was an area of my investigation, this one of piece data supporting an improvement was validation of my research question.

My teacher journals also revealed that students' attitudes improved throughout the project:

> I no longer have to ask students to present. They readily volunteer to read them aloud and I suspect some of them are sharing them before class because the classmates start to giggle and the author starts to giggle before they get the entire problem read. It appears as though they are waiting for my reaction. (Teacher Journal, April 3, 2009)

One week later I added:

> Some of the students are starting to earn reputations as really creative story problem authors. The students wanted Michael to wait until last almost like a grand finale! Michael's story problem was: A cow ate $20. He pooped out $7.13. How much money did he still have in his belly? Story problems about poop, steroids and animals sure are a hit! (Teachers Journal, April 10, 2009)

I found evidence in my teacher journals, as well as in the attitude surveys, to say that my students' attitudes toward word problems did improve.

The students' rubric scores for writing word problems showed that all students scored 6 out of 6 on the rubric after the first week. Most students scored highly on the rubric from the very beginning of my study, a theme that was previously addressed. Only three students did not earn the maximum score according the rubric on the first question. Those three students did not earn points for writing a word problem because their problem was not sensible and did not flow. All three of the students finished reading their word problem aloud and instantly recognized that their problem did not make sense. At that point, I encouraged the students to read their problems aloud before reading them to the class. All 18 students were at the upper limits of the rubric following week one.

Improvement in test performance is located in Appendix F, where I analyzed test performance for each corresponding question from the pre-test and the post-test. The table indicates the number of students who correctly answered the question on the pre-test and the number of students who correctly answered the question on the post-test. Many students had higher post-test scores on the 16 items. Four students, B, C, D, and DD, actually missed a question on the post-test which they had answered correctly on the pre-test; however, these students' overall post-test scores were still higher than their pre-test scores. The chart relates to student improvement in relation to word-problem solving. Every test question had a range of 1 to 13 students improving on that question from pre-test to post test. Overall, the chart contains 75 twos. The test responses coded with two indicate that a student did not have a correct answer on the pre-test, but did have the correct answer for the corresponding question on the post-test. Eight of the 16 students, B, D, H, K, M, V, Z, CC, showed an improvement from pre-test to post test of five or greater correct answers. There is only one student, I, who did not show any increases from pre-test to post test. Student I did, however, answer 13 of the 16 questions

correctly on both the pre-test and the post test. I contend that the interventions and activities surrounding word problems in my classroom were a factor in the improvement.

Test questions 13 and 15 had the largest improvement for students from pre-test to post-test. Question 13 probed mathematical vocabulary asking students to find the difference between two numbers. I believe one of the reasons students were more aware of this question on the post-test dealt with our classroom discussions regarding vocabulary in word problems. Question 15 was a multi-step problem that had the structure of the following:

> Abe made X dollars. Ben made three times Abe's amount. Carl made twice the amount that Ben made. What was the total amount of money made by Abe, Ben and Carl?

Even though question 15 was a multi-step problem, it still required the student to apply mathematical vocabulary. Once again, this area was a large part of our discussions throughout the research period.

After discovering four students that missed a question on the post-test that they had answered the corresponding question on the pre-test, I reviewed the two tests to see if I could determine why this occurred. For three of the four students, a computational error was the cause of the change in score. The fourth student's error is unclear. It is possible that the student misread or misunderstood the question since his answer was completely unreasonable.

On the post-test, four of the 16 items were answered correctly by all 18 students. Question 5, 7, and 12 seemed to be the hardest items since half of the students got them incorrect on the post-test. Question 5 was an advanced problem, asking students to deal with a remainder in division. Question 7 used the vocabulary dividend and divisor, which were terms that usually only advanced students had incorporated into their vocabulary. Question 12 dealt with multiplication of decimal numbers that were written in word form. All three of these questions

were considered advanced questions by the test author. Advanced questions were included on the district test to provide information in regards to students performing above the proficient level.

After reviewing the data from the pre-test and post-test and also reviewing the actual written tests, I reached the following conclusion. I contend my students' growth in confidence accounts for some of the improvement. Some of the missed problems on the pre-test were not even attempted. On the post-test, every student attempted every problem.

Summary of Findings

My first assertion was that my classroom environment would evolve to a more student-led atmosphere with my role becoming that of a facilitator. Student interviews, student journal responses and my teacher journal responses supported this assertion.

My second assertion was that I did not have enough evidence to declare the quality of word problems, written by students to match a given equation, to have actually improved . Although my personal opinion was that the quality of word problems did increase, the rubric results did not support that assertion. Many students received the top score in the rubric on their first word problem and maintained that score throughout the research project. Thus, the quality of word problems written by students did not improve in a measureable way, given my methods of data collection.

My final assertion was that students' attitudes toward word problems would become more positive. Student interviews, student survey responses, student ranking of their perceptions of word problems, and my teacher journal responses supported this assertion.

CONCLUSIONS

I discovered a powerful tool to help motivate my students attempt the word problems they encountered in my eighth grade mathematics class, as a result of conducting this action

research project: students writing original story problems. I had been fighting the "IDK" or "I don't know" response while trying to encourage my students to at least attempt word problems. This action research project helped me eliminate those infamous IDK responses. I was not expecting the writing of word problems to be a confidence booster for my students. I had merely hoped it would improve their attitudes toward them; however, I did not expect the attitude improvement to be as drastic as the surveys revealed. My findings remind me as a teacher to continue to explore new ways to help students through difficulties in math rather than just be resigned to the fact that I thought I had done everything I could to help them.

My findings support those of Winograd (1993) who concluded that writers became more enthusiastic in writing their word problems because they had peers to listen to and solve the authors' original problems. Winograd (1993) stated, "I believe the composition of mathematics story problems is a fertile area for research and one that can effectively link innovations in the teaching of writing with the current interest in applications for writing in the mathematics curriculum" (p 392). Hicks (1994) also emphasized the benefits of integrating real world applications of mathematics into the lives of students. I discovered the same enthusiasm in my students that both Winograd and Hicks found in their research. I found, like Winograd, that my students loved having peers listen to their original word problems. I also witnessed students making the connection between real-world applications and school mathematics. I had students for the first time who seemed to have an answer to 'when am I every going to use this?' My students' attitudes toward math and story problems improved.

IMPLICATIONS

As a result of my study, I have gained new insights into students' attitudes toward word problems. I have already decided to incorporate this practice into my eighth grade classroom

next year and have asked for advice from my students in their final journals to ensure the best possible word problems are written. One of my students shared that he went to the grocery store with a calculator when writing a word problem, which required them to include ratios to compare. He shared that he wanted to make sure his numbers were "real." He told me to make sure my future eighth graders knew this stuff really worked on "real stuff." I can only hope that my future students are able to gain the insight into real-world applications of math that this student gained as a result of this project.

Action research was the perfect avenue for me to explore the topic of students writing original word problems. I am looking forward to sharing the information I have learned with my colleagues. During our math department meeting at the beginning of the 2009-2010 school year, I plan to share the process of my action research project as well as the results.

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Appendix A

Student Response Journal

What was the best word problem you heard today from another student?

What was it about that student's word problem that was impressive?

What about writing word problems is easy?

What about writing word problems is hard?

Appendix B

Student Journal #1

When I see a word problem on an assignment or a test, I…

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

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

What key words do you use to recognize different operations when solving a word problem?

Addition:

Subtraction:

Multiplication:

Division

Which of the following elements of story problems are the hardest for you and why do you think that is?

1. **Figuring out which information to use**
2. **Figuring out what to do with the information**
3. **Figuring out what the question is asking**
4. **Figuring out if the answer makes sense**

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

Why do you think Mrs. Ostmeyer is asking you to write your own word problems?

Appendix C

Student Journal FINAL
April 16, 2009

Writing my own word problems has helped me…

When I see a word problem I now think… and how is that different from how you looked at word problems before?

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

Why do you think Mrs. Ostmeyer asked you to write your own word problems?

What changes in the classroom did you see during the process of writing your own word problems?

What changes did you see in Mrs. Ostmeyer's teaching during the process writing your own word problems?

On a scale of 1-5 with 1 being the lowest (didn't like at all) and 5 being the highest (love them), rank your attitudes toward word problems before writing your own word problems and after.

Circle:

Before	**1**	**2**	**3**	**4**	**5**
After	**1**	**2**	**3**	**4**	**5**

What was the best part of writing your own word problems?

If Mrs. Ostmeyer considered having future eighth grade classes write their own word problems, what advice would you give to Mrs. Ostmeyer and what advice would you give to those eighth graders to make sure the best possible word problems are written?

Appendix D

Rubric for student word problems.

	0	1	2
Word problem Matches Equation	No correlation to equation at all	Answer achieves the same result as the equation	Matches the equation exactly
Word problem sensible and reasonable	Word problem makes no sense or scenario presented is unrealistic	Word problem flows but isn't necessarily reasonable	Word problem is easy to follow and the scenario is reasonable
Follows direction	Did not follow directions on how to enhance word problem	Followed some of the directions on how to enhance word problem	Enhanced word problem as directed

Appendix E: Student Attitude Survey Data

Student	Attitude before	Attitude after	Change
A	3	4	+1
B	2	4	+2
C	3	4	+1
D	2	4	+2
E	1	3	+2
F	1	3	+2
H	2	4	+2
I	3	4	+1
K	2	5	+3
M	2	3	+1
P	2	3	+1
T	3	4	+1
V	2	4	+2
X	1	5	+4
Z	3	4	+1
BB	1	5	+4
CC	2	3	+1
DD	1	3	+2
Mean	2	3.83	
Stand. Dev.	.745	.687	

Appendix F

ITEM ANALYSIS FOR PRE-TEST AND POST TEST: 0 for never correct / 1 for correct on Pre-test only / 2 for correct on post test only / 3 for correct on Both																	
		Sixteen Pre- to Post- Test Questions															
Total number of questions that individual students showed an improvement on from pre- to post- test	Student ID - Number of Increases	#1	#2	#3	#4	#5	#6	#7	#8	#9	10	11	12	13	14	15	16
	A - 3	3	3	3	3	0	**2**	3	3	3	3	3	**2**	3	**2**	3	3
	B - 6	0	3	3	1	**2**	3	3	3	3	**2**	**2**	**2**	**2**	**2**	0	3
	C - 4	1	3	3	3	0	0	**2**	**2**	0	3	0	0	1	**2**	3	**2**
	D - 7	**2**	**2**	**2**	**2**	0	0	**2**	**2**	3	3	3	3	3	**2**	0	1
	E - 2	3	3	3	3	**2**	3	**2**	3	3	3	0	0	3	3	3	3
	F - 4	3	3	3	3	**2**	0	**2**	3	3	**2**	3	0	3	**2**	0	0
	H - 5	3	3	3	3	0	**2**	0	3	3	3	**2**	0	**2**	**2**	**2**	3
	I - 0	3	3	3	3	3	3	0	3	3	3	3	0	0	3	3	3
	K - 7	3	3	3	3	**2**	0	3	**2**	3	**2**	**2**	**2**	**2**	**2**	3	3
	M - 5	3	3	3	3	0	3	**2**	3	3	3	3	**2**	**2**	**2**	1	**2**
	P - 3	3	3	3	3	0	0	0	**2**	3	3	3	0	3	**2**	**2**	0
	T - 1	3	3	3	3	3	**2**	3	3	3	3	3	3	3	3	3	3
	V - 6	3	3	3	**2**	3	**2**	0	3	3	**2**	**2**	**2**	**2**	3	0	3
	X - 3	3	3	3	0	0	**2**	0	3	**2**	3	0	0	**2**	0	0	0
	Z - 6	3	3	3	3	3	**2**	0	3	**2**	3	3	**2**	**2**	**2**	0	**2**
	BB - 4	**2**	3	3	3	0	0	0	3	3	3	3	0	**2**	**2**	**2**	0
	CC - 5	3	3	3	3	**2**	3	**2**	3	3	3	**2**	0	3	**2**	**2**	3
	DD - 4	3	3	3	3	0	0	0	**2**	**2**	3	1	0	3	**2**	**2**	0
Number of students showing improvement from pre- to post- test		2	1	1	2	5	6	6	5	3	4	5	6	8	13	5	3
Percent of students showing improvement from pre- to post- test		11.0	5.6	5.6	11.0	27.8	33.3	33.3	27.8	16.7	22.2	27.8	33.3	44.4	72.2	27.8	16.7
Mean		2.611	2.944	2.944	2.611	1.22	1.5	1.33	2.722	2.667	2.778	2.111	1	2.278	2.111	1.611	1.89
Standard Deviation		.85	.236	.236	.85	1.309	1.294	1.283	.46	.767	.428	1.132	1.188	.826	.676	1.29	1.323