7-2008

Strategies and Precise Vocabulary Knowledge: Exploring the Relationships Among Mathematics Vocabulary, Problem Solving, and Confidence

Deb Borgelt
Battle Creek, NE

Strategies and Precise Vocabulary Knowledge: Exploring the Relationships Among Mathematics Vocabulary, Problem Solving, and Confidence

Deb Borgelt
Battle Creek, NE

Math in the Middle Institute Partnership
Action Research Project Report

in partial fulfillment of the MA Degree
Department of Teaching, Learning, and Teacher Education
University of Nebraska-Lincoln
July 2008

Strategies and Precise Vocabulary Knowledge: Exploring the Relationships Among Mathematics Vocabulary, Problem Solving, and Confidence

Abstract

In this action research study I focused on my eighth grade pre-algebra students' abilities to attack problems with enthusiasm and self confidence whether they completely understand the concepts or not. I wanted to teach them specific strategies and introduce and use precise vocabulary as a part of the problem solving process in hopes that I would see students' confidence improve as they worked with mathematics. I used non-routine problems and concept-related open-ended problems to teach and model problem solving strategies. I introduced and practiced communication with specific and precise vocabulary with the goal of increasing student confidence and lowering student anxiety when they were faced with mathematics problem solving. I discovered that although students were working more willingly on problem solving and more inclined to attempt word problems using the strategies introduced in class, they were still reluctant to use specific vocabulary as they communicated to solve problems. As a result of this research, my style of teaching problem solving will evolve so that I focus more specifically on strategies and use precise vocabulary. I will spend more time introducing strategies and necessary vocabulary at the beginning of the year and continue to focus on strategies and process in order to lower my students' anxiety and thus increase their self confidence when it comes to doing mathematics, especially problem solving.

Introduction

I suffer from math-phobia. It is not fatal unless one intends to either be a math teacher or be a successful student of mathematics. As I moved through the battery of classes in my courses at University of Nebraska-Lincoln (UNL), I began to realize just how phobic and anxious I was about the whole issue of problem solving processes of mathematics. I received my middle school language arts/mathematics endorsement through University of Nebraska-Kearney (UNK) some 20 years ago with the idea that I would find a position in a middle school setting and would most likely be teaching 5th or 6th grade math. That level of mathematics did not worry me because I felt comfortable with fractions, adding, subtracting, multiplying and dividing.

However, as my career progressed and the shortage of mathematics teachers opened opportunities for me, I found myself teaching higher levels of mathematics. The higher the level, the higher my anxiety became until I was almost teary eyed at the thought of introducing the quadratic formula. For me, applying for the Math in the Middle Institute (MIM) was a way not only to get a fuller, more rounded, quality background in mathematics and become a better teacher, but it was also a way for me to work on a solution to my mathematics phobia that I had carried with me since my traumatic junior high pre-algebra days.

My seventh grade pre-algebra teacher was an older woman who taught mostly to the upper ability students. I was an average student to begin with, but my grandmother, who I was close to, died the second week of my seventh grade year and I missed most of a week of school. I lost out on the really essential basic building blocks of pre-algebra and the rest of the year was a hopeless struggle trying to get through that class. The teacher would write scathing notes about my work and lack of effort on my paper and I would feel worse and worse. The harder I tried, the worse it seemed to get. By the end of my eighth grade Algebra year I had given up on ever being successful in the field of mathematics. My experience in the MIM Institute has changed all that for me.

As I began my 2006-07 school year, I could see right away that many of my seventh grade algebra students suffered from the same anxiety that plagued me. When the problems got tough they either clammed up, quit or acted up so that it would cover their frustration and anxiety about not knowing how to “do” the math. My first year working with eighth grade pre-algebra students at my current junior high school was no different. That experience prompted me to try to think of a way to help my students to deal with this phobia and anxiety. As a student in MIM I learned that if I only knew some ways to approach problems and had somewhat of an idea as to what some of the terminology meant, I was able to tackle problems that before had evaded my understanding. I wanted to teach my students specific strategies and introduce and use precise vocabulary as a part of the problem solving process and hoped that I would see their confidence improve as they worked with mathematics and I would not have to see them struggle with the shut down that I had seen in students who were frustrated.

My 2007-2008 classroom was diverse in terms of gender, socioeconomic status, and cultures. There were numerous levels of academic abilities and a wide range of confidence issues when it came to mathematics ability. Most of my students struggled with math, vocabulary, comprehension, and self-confidence. Some of their struggles were due to cultural or language barrier issues and some of their struggles were gender related. I knew this because I had a sprinkling of girls who felt that math was just “too hard” for them.

This pre-algebra class had been together since the fall and as I began to think about my topic for research for the spring semester I realized that I shared a commonality with them. Before MIM, I did not feel comfortable discussing or sharing my process of mathematics problem solving. Whether it was lack of self-esteem or lack of vocabulary on my part, I had a tendency to step back into the wallpaper when someone asked for an explanation of a particularly difficult mathematics problem. My students mostly mirrored my phobia. They did not really seem motivated or encouraged to “discuss” mathematics and I found my students were struck deaf and dumb when I tried to engage them in a conversation about how or what we do to solve problems.

By experience, I knew that students who felt frustrated in mathematics were often difficult to deal with both behaviorally and motivationally. It became an important role for me as the teacher/facilitator to endeavor to give students the tools they needed so that they felt more self confident about their abilities to tackle problems. If I could find ways to reach students, they would feel more successful. They would score better in the classroom, meet standards for teachers, and find success in their post-secondary education, as well as the work force. My experience with MIM coursework led me to make the decision to choose to investigate the effects of specific, isolated instruction in strategies of problem solving to enrich students’ mathematics vocabulary and increase their self-confidence to communicate using precise vocabulary.

I valued the transfer of information that I gained in the MIM classrooms to use in real life situations. I have found in the past two years that students, like myself, are not really encouraged to understand the “why” surrounding mathematics. It appeared that they were simply taught that there were rules and formulas and therefore math became simply an exercise in rote memorization of formulas without any meaning behind them. This whole process did not encourage them to know math but only to memorize it. Students did not see any value in knowing how it works; they only saw the value in knowing what formula so that they could plug in the numbers and get the right answer.

Because of the emphasis of getting students to meet the standards, I have seen many teachers who have resorted to instruction that centered solely on students having the skills to meet the standards with very little extra time spent on "discovery" of mathematics concepts. The best practices encouraged by NCTM (2000) are geared towards engaging students in higher-ordered thinking skills, challenging all students, and helping students make connections among math related concepts, across other disciplines and also to everyday activities. My problem addressed all of these best practice goals.

Since my first course, "Math as a Second Language," with Dr. Ken Gross, I have been very intrigued by the whole idea of mathematics as a second language. As a language arts teacher, as well as a mathematics teacher, the whole idea of math as a language intrigued me. One of the first things that I found helpful in Dr. Gross's class was the process of solving problems with written solutions explaining what exactly I did to solve them. I liked that because I was able to write down what I was doing on paper and began to see strategies and vocabulary as an important part of that process. Although Dr. Gross did not specifically teach strategies, I began to see them surface in my work and the work of my classmates. I love to write and I love to talk so being able to write down my thinking and then simply communicating that to another classmate was less threatening to me and that allowed me to be able to make progress in understanding the math.

As I began to work on my project, I originally thought that perhaps I could have students just write about their solutions and perhaps they would come to the same conclusion that I had. I just wanted them to explain the "steps" of a problem solution in words. I hoped that this process would help me to understand my students' thinking and their reasoning behind it. Initially, I thought that perhaps they, as I had, would begin to find their own errors and be able to reevaluate their solutions before they even got to the point that we were ready to check them. I conjectured that through this, the students would come to realize that there are countless ways to solve problems and that there is probably no single way to find a solution to a problem. I had hoped that they would begin to find their self-confidence levels raise as they found solutions to problems on their own using the strategies that we had worked on in class.

Problem Statement

The problem of practice for my research centered on the ability of my students to approach problem solving with confidence because they had the skills they needed to do so. I believed that all students deserved to possess the skills to problem solve without anxiety. Many students today suffer from low self-esteem and the inability to communicate mathematically. Often times teachers have seen behavior and performance issues linked to students' self-esteem. Because of the melting pot culture that has integrated into most of our communities, there are a number of culture and gender equity issues that play into self-confidence. I do not think that I am alone when I say that our students today have a lack of knowledge of problem solving strategies and lack confidence to approach problem solving.

One of the principles that tied in closely to my problem of practice was the principle of problem solving. The National Council of Teachers of Mathematics (NCTM, 2000) said, "Teachers should ask students to reflect on, explain, and justify their answers so that problem solving both leads to and confirms students' understanding of mathematical concepts" (p. 121). This was the heart of my problem. Students could not tell me how to solve problems because they did not know how to solve problems. I hoped that by teaching problem solving strategies, students would be able to discuss their process with me so that I could help them to understand the concepts.

Because this group of students was so diverse, I believed there were issues of equity that I needed to address. In my classroom, as in most classrooms today, there were a number of English Language Learner (ELL) students who struggled with the ability to understand the vocabulary and perhaps did not have the support at home to work through homework because their parents were not English language speakers either. Like many communities in the Midwest, our community has a 40 percent poverty rate and some assumed that there was little chance for these impoverished students to succeed. There were some gender issues. Female students seemed to be less likely to answer questions and exhibited less self-confidence when we were discussing problems that were more difficult. NCTM (2000) states that teachers should hold high expectations for all students regardless of their cultural background, poverty levels or gender. I expected that other teachers would concur that it was important that we made our best attempt to guarantee that all students had access to excellent instruction with solid support for their learning.

Another NCTM (2000) standard that I felt came into play with this problem of practice was the whole process of communication. Related directly to the principle of problem solving, communication required that students could “communicate their mathematical thinking [and strategies] coherently and clearly to peers, teachers, and others” (p. 194). This was exactly what I wanted to see my students be able to accomplish. The best practices for teachers of mathematics encouraged by NCTM was geared towards engaging students in higher-ordered thinking skills, challenging all students and helping students make connections among math related concepts, across other disciplines and also to everyday activities. My problem addressed all of these best practice goals.

Cochran-Smith and Lytle (1990) created a list of knowledge (local and public) that we as teacher researchers should look at before we begin any research. They state, "through inquiry, teacher researchers generate knowledge for their own practice, for the immediate community of teachers, [and] for the larger community of educators" (p. 44). As I looked at my own practices, I wanted to assess how my actions or interactions with students affected their learning. I wanted to evaluate how my students learned and wanted to be able to give rationales for the changes I made in teaching mathematics. My classroom was only a mini-model of many of the Pre-Algebra classrooms throughout my school. I had only a small group of students. My guess was that they were typical of most students in our school system. I would have liked to see a change in how we approached mathematics so that students grasped concepts in a more positive and connecting manner. I would have liked to be able to develop rationales for a change in how we taught mathematics based on this study in my own classroom so that students had a more confident attitude towards math. I was sure that there were many other teachers who were experiencing some of the same frustrations with their students. My hope was that they would find something that I tried in my classroom to be beneficial to their classrooms.

Literature Review

Most likely because I was paying more attention to my students' processes, I noticed more this year than ever that my students struggled with word problems. Their inability to solve problems appeared to stem from a lack of strategies to attack those problems. This inability diminished their self-esteem and self confidence, thus it limited their potential to succeed. With the focus of my project to help my students to be able to attack problems with enthusiasm whether they completely understood the concepts or not, I spent some time looking for research articles that explored how teaching strategies affect students' learning and attitudes.

The best practices encouraged by NCTM are geared toward engaging students in higher-ordered thinking skills, challenging all students and helping students make connections among math related concepts, across other disciplines and everyday activities. I struggled with just how to introduce these strategies and spent time deciding how structured to make the utilization of the strategies which were the center of many of the discussions in the articles I read. Interestingly enough, I did not find one study that duplicated exactly what I intended to do so my study was somewhat unique.

The purpose of my action research project was to investigate the effects of specific, isolated instruction in strategies of problem solving to enrich students' mathematics vocabulary and increase their self-confidence to communicate using that vocabulary. As I read through the research I found that much of what I was reading centered on teaching approaches to problem solving, studying the effects of prescribed problem-solving, developing students' content knowledge and the teacher's role and responsibility to change approaches to teaching problem solving. Probably the most interesting reading I found centered on the different approaches to teaching problem solving.

Teaching Problem Solving

As I delved into the research in the professional community I found several schools of thought that addressed teaching problem solving. Probably the research that I agreed with the most came from Doerr (2006). Doerr examined the ways one teacher saw and interpreted the multiple ways of student thinking in a modeling task on exponential growth and how the teacher's interpretations influenced her practice. The teacher's role was as a listener and observer to identify the different ways students might think about a problem. Secondly, the teacher's role was to support students so that they develop and revise their own solution strategies. The students in the study were middle class students in a suburban area. Doerr found that if the teacher asked for students to explain their thinking, it contributed significantly to the teacher's understanding of the students' thinking. This created a shift from teaching to guiding which allows students to be more engaged and able to revise and refine their own approaches to the tasks they are facing. I used a modification of this as I worked with my students this spring. I worked with students in more of a guide capacity and like Doerr (2006) realized that it was the teacher who needed to examine the work of the students and change his own teaching in order to enable students to learn to use new strategies.

Polya's (1945) work seemed to be behind much of the research that was published in the last ten years. Researchers believed that being able to make generalizations was one of the core learning strategies that teachers should instill in students. Four researchers in this field built their work on the premise that both previous knowledge and the ability to make generalizations were essential for students to become effective problem solvers. I do not think it is any surprise that teachers depended upon students to bring some of the skills inherent to problem solving with them to class. Ollerton (2007) states that the key to student learning was through exploration and thus through their exploration they could make those generalizations that could help them to discover mathematical truths. Ollerton's work focused on observing how teachers could teach mathematics through problem solving. The researcher was interested in finding problem solving approaches that enabled students to process and therefore develop their mathematical content knowledge as a result of that process. The key issue for this researcher was to set up situations in which students discovered and explored mathematical content through problem solving situations. One of the post-observations reports of one

> ...so-called lower achieving pupils achieved more than her peers… Pupils had been given a task where they could make mistakes and quickly move on to find ‘correct’ solutions, they were less conscious of needing to produce accurate results in the first instance. (p. 5)

Hence, students became more effective mathematicians and not just more effective number punchers.

Posing a new problem, looking back at other problems and using the whole process of generalization to begin to solve were all strategies that were just an extension of Polya’s (1945) work. Stephenson (2007), operations director of the Magic Mathworks Traveling Circus referred to Polya (1945) and his work as he revisited an age-old popular problem that has been often referred to as the “handshakes problem.” He presented this problem and other problems to groups of other mathematics teachers. The problem in question was the handshakes problem. Stephenson’s discussion confirmed that for students to be able to problem solve effectively, the whole process of taking a second look at a problem with the previous knowledge, newly learned skills of problem solving and the use of generalization was essential.

Likewise, Cai and Brook (2006) wrote an intriguing article. Cai and Brook referenced Polya (1945) and detailed Polya’s three basic approaches which encouraged students to look back. Those three basic approaches were to generate alternative solutions, pose new problems and make generalizations. Cai and Brook proposed that when students looked back to what they had done previously it promoted relationships between concepts and caused students to reflect on their previous work. This was an interesting approach that I believed most adults use as a matter of course, but it was one that students must have acquired in life before they would be able to be good problem solvers. Being able to look back at previous examples of problems and their solutions that did or did not work was one important aspect of problem solving.

A twist on the same notion was the main focus of another study by Macintyre (2006) asserted that the familiarity with a related problem was an important aspect of problem solving. Macintyre referred to Polya (1945) as well and listed Polya's four step plan. However, Macintyre rewrote it in this way. "What do I know? What do I want? What can I introduce?" (p. 9). Macintyre raised the question as to whether or not the student really took a look at what he knew and understood before he moved forward in his thinking. It was important for the student to gain clarification of the problem and as a result took steps to make a general plan to find a solution based on what the student knew and what he could introduce.

Ollerton (2007) and DiLisi, Eulbert, Lanese and Padovan (2006) focused on the teaching of mathematics through problem solving. The focus of Ollerton's work was to observe how teachers were able to teach mathematics through problem solving. DiLisi, Eulbert, Lanese and Padovan's findings supported the consistent, repetitive teaching of strategies to incorporate them as a part of the student's everyday strategies to approach problems. Macintyre (2006) and Cai and Brook (2006) both had similar approaches to teaching problem solving. Macintyre stated that students needed clarification of the problem and then had to make a general plan to find a solution based on what the student knew and what he could introduce, whereas Cai and Brook believed that encouraging students to look back provided a setting that lead students to want to explore problems more enthusiastically. A different approach, McLeay (2006) indicated that perhaps the acceptance of visualization should be seen as a part of teaching problem solving. Stephenson's (2007) discussion confirmed that the whole process of taking a new look at a problem with the learned skills of problem solving available was essential. Only Doerr (2006) recognized that students were prone give up quickly when presented with problem solving that was unfamiliar to them. She suggested that it was the teacher who needed to examine the work of the students and change his own teaching practices which was closest to what I as a researcher wanted to explore. Doerr's work fit the closest with the focus of my research question.

DiLisi, Eulbert, Lanese and Padovan (2006) studied a group of introductory, non-calculus-based mechanics based physics course in which they were introduced to a problem solving strategy. They wanted to see if they could change student approaches to problem solving. In fact, they wanted to find out if students would use a specific strategy if it were taught and modeled on a consistent basis. Their findings supported the consistent, repetitive teaching of strategies to make them a part of the student's everyday strategies to approach problems.

McLeay (2006) conducted a pilot study to investigate the extent to which students used their ability to visualize or create mental images to solve spatial problems with some interesting findings. The study was conducted with pupils in two schools in Sydney, Australia to investigate to what extent the pupils were able to employ imagery. 119 students were involved in the study at the middle school level school. McLeay asked the questions, "Is imagery important in developing problem solving skills? What is it about spatial ability and solving spatial problems that seems to differ among individuals?" (p. 195). McLeay suggested that one way to improve students' problem solving skills was to encourage students to visualize. The tasks were designed to investigate to what extent the students were able to use visualization strategies taught to them to solve problems. McLeay taught students visualization strategies. Students attempted tasks which required visual imagery and comprised four sequences of image and language processing. McLeay asserted that it is not unreasonable to imagine that accessing the side of the brain which involves visualization would help students in their problem solving ability.

McLeay (2006) found that students enjoyed the problem solving exercises because the visualization exercises were not like normal math. McLeay also indicated that perhaps the acceptance of visualization as a part of teaching problem solving allowed students to not only work with one-dimensional diagrams but also encouraged students to create their own diagrams to solve problems. Thus, McLeay suggested that developing visualization strategies with students will aide them in their approach to problem solving.

Overall, as my reading revealed, teaching problem solving has been divided into three main schools of thought. The whole idea of making generalizations based on strategies students possessed prior to coming into a classroom or strategies that students had learned was essential for students to be able to approach mathematical problems in my classroom. Developing visualization strategies was necessary in my approach to teaching problem solving as evidenced in several of the student solutions I included later in this paper. Lastly, the teacher's role as a listener and observer to identify the different ways students might think about a problem was key because I was able to stop and see where my students were at in their process and was able to rethink my own teaching strategies to support my students so that they were in turn able to develop and revise their own solution strategies.

Studying the Effects of Prescribed Problem-Solving

The whole study of prescribed problem-solving intrigued me, but I was dismayed to read the results of the studies. There seemed to be several schools of thought dealing with the effects of prescribed problem solving instruction. Ollerton (2007) focused on the type of problem. He suggested that because students' speed and ability levels were so different, it was important to offer problems which could be developed at different speeds and levels. He said that if one provides students with problems that contain an element of challenge and puzzlement without the problems which are not overwhelming the students seemed to feel more prepared to tackle a problem without giving up before they started.

The research in this area by Rittle-Johnson and Koedinger (2005) was carried out in three phases. In Phase I, the researchers investigated the students' prior mathematical knowledge. In Phase II, researchers designed and created a specific intervention based on what students already knew, and Phase III was a post-test phase to determine what students learned from the intervention. All students participated in the instructional intervention which was accomplished partly through the use of a computer software tutorial program. I believe that it was important to note that the entire process took only three days. The results were interesting as well as alarming. Because the students were taught specific strategies to solve specific types of problems, they seldom reached out past those strategies to try something new to solve problems that were different and thus made many computational or failure to convert errors. This led me to ask: Does the teaching of specific strategies actually limit students when it comes to trying alternate methods to solve problems? This was troubling and I had to consider carefully how to teach students problem solving strategies that were more generally applicable rather than specific.

Watson (2006) contended that teachers needed to educate their students using more generalized problem solving techniques that would allow them to develop the ability to choose for themselves ways to approach new problems. Exploration and time to explore possible solutions was the keys. Watson stated, "If learners are not given time to explore their conjectures, how do they develop awareness of what is, or what is not, a good line of enquiry?" (p. 198). It was unfortunate that students were often driven through problems without being allowed the time to explore whether or not their own line of thinking was productive or effective. As a result, they did not learn whether their thinking was right.

Watson's (2006) article floats outside the fringes of Polya's (1945) work. If a student worked in one direction trying only one basic strategy to solve the problem without reaching out to try other ways, he would soon give up out of frustration. It was obvious, Watson wrote, that often in problem solving students believed that a specific strategy was the only appropriate approach to solving that problem; this was usually a result of limited specific strategies experience in problem solving.

These researchers all offered unique perspectives on approaching problem solving but basically agreed that teaching one way to problem solve was not effective. Rittle-Johnson and Koedinger (2005) discovered that when students were taught specific strategies to solve specific types of problems, they seldom reached out past those strategies to try something new to solve problems that were different. Ollerton (2007) asserted that providing students with problems that contain an element of challenge and puzzlement without them being overwhelming seemed to allow students to be prepared to tackle a problem without giving up before they started. Likewise, Watson (2006) contended that teachers needed to educate students into more generalized problem solving techniques that would allow them to develop the ability to choose for themselves ways to approach new problems. Student exploration and time to explore were the keys according to the research.

Word Use, Textbooks and Terminology

Up to this point I have written about the entire issue of the specific types of problem solving strategies that should be taught and the results of teaching problem solving strategies. However, I have not discussed what the research showed about two other important aspects of this entire process: the textbooks and vocabulary involved and the teacher's role in creating less stressed problem solvers who feel more successful. Xin (2007) completed an impressive study which compared the textbooks of the United States with textbooks in China.

Xin (2007) found that there was a relationship between textbook word problem task presentation and student success in solving problems. Xin suggested that it might have been directly related to the way that U.S. textbooks were set up. This study included students in grades six through eight from one middle school in the northeastern part of the U.S. and a school which had 54 middle school students in grades six through eight from a public middle school in eastern China. The U.S. school used the 1998 version of Scott-Foresman-Addison-Wesley textbook. The school from China used the unified mathematics textbook series designed for the developed regions in China.

Xin (2007) found through the study that Chinese textbooks provided students with immersion in vocabulary and balanced opportunities to solve various types of comparison word problems, compared to the U.S. textbooks, which offered a more limited vocabulary related to the relatively unbalanced selection of word problems. The Chinese textbooks offered students more opportunities to solve problems with variations of a problem type with the contextual story. Those text books created a problem situation and then exhausted the variations of the same problem in ways to solve it and approach it. It was Polya’s (1945) approach personified. The process encouraged the student to look at a problem, visit it, turn it upside down, look at it again and then look at it another way.

Conceptual understanding and reasoning, rather than rule driven memorization, are one of the key focuses of the NCTM (2000). Xin (2007) appeared to agree when he said that U.S. students needed to communicate in ways that would help them learn the concepts necessary for independent work. However, the majority of the problems in U.S. textbooks, almost 63%, were of one type with fairly consistent language which did not require students to stretch to solve them. Ollerton (2007) agreed and said,

> Giving pupils lots of multiplication calculations to carry out may (and possibly may not) make them better at multiplication. However, when pupils understand both what the multiplication means and when it is sensible to perform a multiplication, they become more effective mathematicians and not just more effective multipliers.(p. 201)

Students who were driven by simply reciting multiplication tables or reciting formulas were simply very effective student memorizers. They did not necessarily have the skills to use the math skills they had to solve problems

Teacher Role and Responsibility

There were two distinct perspectives in the research I read regarding the role and responsibility of the teacher in teaching problem solving. I found that most of the research was looking two different directions. Jacques (2005) studied how teachers recognized how students engaged mathematically with problems and how they developed and applied their mathematical skills to solve those problems. Kurta (2006) looked at the flipside and suggested that perhaps teachers would have better results if teachers were more like tour guides, who would guide their students through mathematics problems solving.

Jacques (2005) detailed a case study which involved the use of the program called In Service Education and Training in Problem Solving (INSET-PS). The INSET packet was designed to teach students to use specific problem solving strategies to solve problems. INSET focused on classifying the problem, naming it using specific vocabulary and following a specific strategy which was taught to the student in order to solve that problem. At first this sounded good to me and was similar to what I had been planning to do with my own classroom; however, the further I read, the more it began to resemble the work of Rittle-Johnson and Koedinger (2005) and I quickly decided that I would rethink my own strategies.

The INSET process took the whole experience of problem solving and regimented it into a series of steps or skills that had to be learned rather than the actual exploration of the problem itself. Students simply learned to follow the dots, use the correct vocabulary, and then they could solve the problem. Problematic to me was the fact that the teacher did not really have role in guiding the students to discover or explore anything. She did what she was told to do. She taught them the new path to success and the children learned the new path. I wondered what happened when there was a roadblock on the path. I surmised that the teacher found that the students were frustrated and confused because they did not know how to deal with it because they did not have any practice dealing with roadblocks. They had been trained only to follow a pre-set path with a pre-set standard box of tools and vocabulary to deal with the problem. This program was designed to help teachers teach problem solving, but it did not work.

Kurta (2006) wrote an article based on his research after he read Jacques' study. INSET was designed, Kurta said, as a, "resource that provides structured support for the learning and teaching of problem solving" (p. 39). The study served as a reminder that teachers needed to provide students with a whole range of problems that cater to different learning styles. Kurta attributed any success at all that INSET might have had with the ability of teachers to go beyond INSET to bring new strategies and opportunities into their classrooms. Teachers who gave their students appropriate experiences beyond the one or two average "problem solving" types of activities provided in the textbooks saw more successes. Kurta continued to say that children must have had the basics before they could move forward into their own exploration. By this, Kurta meant that students should have had some guided practice with their teacher before they were introduced to more complicated problems which required them to poke and prod. Problematic as well was the fact that sometimes teachers were too eager to give students the answer or number of answers possible so that they did not have to struggle so much.

It made sense that the role the teacher assumed in their classroom could be a hindrance, actually inhibiting the student's progress or a help. The teacher's role of a listener and guide was important to Doerr (2006) who conducted a study to "examine student's mathematical thinking as the students developed models for exponential growth and decay" (p. 4). In this study, Doerr suggested that perhaps if teachers would listen to their students and understand their thinking that teachers could change or diversify their teaching so that students would be able move away from the role of student to the role of self-evaluator as they work to solve problems. Doerr said, "Recent research suggests that teachers' examination of students' work may lead to changes in teaching practice that are more effective in terms of students' problem solving activities" (p. 3). She conducted this study because there had not been much research that linked how teachers interpreted the different ways of thinking that students might bring to problem solving tasks and how those interpretations of those students' mathematical thinking influenced teachers' classroom practices.

Doerr (2006) stated that teachers should work to interpret the different ways of thinking that students have brought to problem solving tasks and how those interpretations of those students' mathematical thinking could influence teachers' classroom practices in order to help students' development and revision of their own strategies for solving problems. Students and teachers interaction to find solutions to problems seemed to be a common thread here. Another key element that seemed to affect the ability of students to be successful at problem solving was the general self-esteem of the student and the level of anxiety the student felt as they approached mathematics problem solving.

According to Ruffins (2007), conquering math or problem solving anxiety was really one key to being successful problem solvers. Ruffins (2007), a long time contributor to Diverse Issues in Higher Education and former editor of Crisis Magazine, said that students' math anxiety could have social roots. Ruffins noted that there were minority inequality and gender issues which could negatively affect low ability students in their overall math performance. A lack of language processing skills in students who did not process language well or second language speakers could frustrate students' abilities to interpret the logic of problems.

According to Ruffins (2007), students who worked in groups, were provided role models, and found a way to visually relate the problem, were able to translate the problem into ordinary words were all positive alternate ways to help students who were anxiety-ridden and found themselves unable to work their way through a problem. He even suggested that perhaps students would find it useful to translate the problem into more formal mathematical terms and that this could have helped those who had learned only to solve problems using that terminology. Another way to approach student anxiety and self esteem problems in mathematics problem solving could be the approach that was outlined in Doerr's (2006) work.

Doerr (2006) pointed out that, traditionally, teachers looked at their students' responses to assignments for the purpose of deciding whether the answers were right or wrong. It was an objective approach which had permeated teaching for a very long time. Doerr suggested that if teachers would study, interpret and interact with the work and active problem solving with their students, they would discover the many multiple ways that students approached tasks. Teachers then could readjust their own teaching style so that they were able to best meet their students' needs. Thus, teachers would help students develop effective problem solving strategies that would generally apply in all phases of problem solving.

Doerr's (2006) study was conducted at the secondary level and lasted over two years. Attention was paid to listening to and identifying different ways students might think about problems and supported students so that they could develop and revise their own strategies for solving the problem. I saw a pattern here which related to independent learners who could think for themselves and were not afraid to try new strategies to solve problems. What better way was there to build students self-esteem and make them more eager to try new things?

As I read through the research I found that much of what I read centered on teaching approaches to problem solving, studying the effects of prescribed problem-solving, developing students' content knowledge and the teacher's role and responsibility to change approaches to teaching problem solving. I saw much research that focused on teaching a specific set of strategies for problem solving and the results were dismal for long term results. I read about the lack of diverse problem sets in United States textbooks which may have contributed to lower scores in problem solving assessment. I thought that the most interesting reading came from the study which centered on teachers who evaluated their students' struggles and knowledge and adjusted their own teaching to better meet their students needs.

My study centered on teaching general problem solving strategies which would then increase students' self confidence to approach problem solving and help them to have increased vocabulary with which to discuss the entire problem solving process. I did not see any study that focused on that specifically, but Doerr's (2006) study mirrored most what I wanted to do. I wanted to be able to teach my students new general strategies to solve problems. I also wanted to help those students who struggled to communicate about problems and mathematics in general and help them to find a way to express themselves using precise vocabulary. Lastly, I wanted to observe my students and then I wanted to learn from their struggles so that I could enhance and change the teaching strategies that I used in the classroom.

It was in the struggling that students learned to generalize and re-think old strategies that they had lurking in their boxes of experiences. Once students had used some systematic approaches to solving a problem, students could learn to re-generate that strategy to re-apply it to a new situation. If teachers could provide students with the strategies that they were able to use immediately; those same students could use those same strategies later to sift through any problem that life presented. NCTM (2000) wants students to have conceptual understanding and reasoning skills in order to function in their diverse future. Likewise, teachers do not want their students to be stuck with rigid inappropriate strategies that are not effective for them. The goal of an educator should be for students to be thinkers and doers who can feel confident enough to attempt problems and have sufficient vocabulary to communicate about them to their peers and teachers.

Purpose Statement

The purpose of my action research project was to investigate the effects of specific, isolated instruction in strategies of problem solving to enrich eighth grade students' mathematics vocabulary and increase their self-confidence in their abilities to communicate using that vocabulary. I wanted to investigate the effects of teaching general strategies and specific precise vocabulary to my eighth grade pre-algebra students. Specifically, I wanted to measure the change in their ability to attack problems with enthusiasm and self-confidence whether they completely understood the concepts or not. I wanted to teach them specific strategies and introduce and use precise vocabulary as a part of the problem solving process in hopes that I would see their confidence improve as they work with mathematics.

I examined three variables in seeking to answer my research questions. Those variables included: the number of math strategies students can correctly use to solve word problems; students' accurate and precise use of vocabulary terms in the communication of written as well as oral solutions to mathematical problems; and the number of correct assessment answers on word problems containing precise mathematical vocabulary. I was interested in finding out whether giving specific instruction in problem solving strategies and giving specific instruction in the precise meaning and use of vocabulary would improve students' abilities to attack problems with enthusiasm and self-confidence. I formulated the following research questions:

1. What will happen to students' abilities to solve grade level appropriate problems when taught specific strategies?

2. What will happen to students' abilities to communicate or use correct vocabulary as they work to solve problems?

3. What does my teaching look like when I try to better teach problem solving strategies and more precise vocabulary to my students?

Method

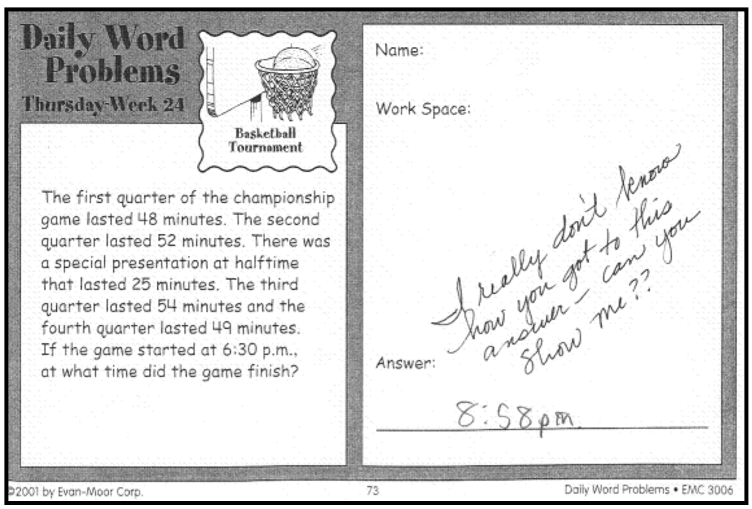
I printed and made copies of all required IRB consent forms. I asked the ninth grade guidance counselor to be the person in charge of consent forms for my research. She and I agreed upon a time for her to come into my classroom to explain to my students (without me present) what would be happen in our classroom the next three months regarding my research project. The guidance counselor read the forms to my students, fielded questions and reminded them that the forms were to be turned in within one week. She and I had agreed that there would be a box to return the forms in that only she would have access to and that she would let me know when students had returned the forms. She made it clear that it was important to return the forms whether they were participating or not so that we were sure that the forms had actually been given to their parents.

One of the problems I had to solve was that the forms were not translated into Spanish. This was a problem because I had several parents who were Spanish-only speakers and readers. Finally, I was able to find a paraprofessional in the building who was willing to translate and type a letter in Spanish to be sent home to the parent. Once school had been dismissed for the summer and grades sent out I found that I had 11 students who had consented to participate out of my class of 17, which was a 65% participation rate.

Early on, I had decided on three types of data that I would collect throughout my project. First, I kept a personal journal of my thoughts, ideas, concerns, and general, overall problem-solving process throughout my project (see Appendix A for journal prompts). Secondly, I collected data from student work. I chose two or three assignments each week to peruse as well as six students whose work I examined carefully. I looked specifically at the strategies my students were using to solve the problems.

In order to choose the six students whose work I examined more carefully, I divided my class into groups based on ability (high, medium, low). I then asked the guidance counselor to choose two students had consented to participate from each of the groups. I focused my analysis on the work of these six students. I collected student work from daily word problems, assignments and a pre/post test which I administered February 5 and April 21, 2008. I had an easy way to collect daily work data because I had a sponge activity that I had begun during first semester. Every day as the students entered the room I had a half sheet of paper lying on the first desk students reached in the classroom. They were to work through that daily word problem showing not only the answer but also the way they solved it. I collected those to score every other day during the weeks of February 5 through April 21, 2008. I used a rubric to determine the ways in which the students approached problem solving (see Appendix B).

One of my criteria was to consider students' approaches to the problem meaning. Did they even attempt it or did they simply give up or just write down an answer? It was unsettling to see that out of 17 students almost half of them just wrote down a number without any justification with the answer often being incorrect. As seen below (Figure 1), Joan[1] simply wrote down a number without any explanation as to how she arrived at the solution.


Daily Word Problems
Thursday-Week 24
Basketball Tournament

The first quarter of the championship game lasted 48 minutes. The second quarter lasted 52 minutes. There was a special presentation at halftime that lasted 25 minutes. The third quarter lasted 54 minutes and the fourth quarter lasted 49 minutes. If the game started at 6:30 p.m., at what time did the game finish?

Name:

Work Space:

I really don't know how you got to this answer – can you show me??

Answer: 8:58pm

©2001 by Evan-Moor Corp. 73 Daily Word Problems • EMC 3006

Figure 1. Joan's work on daily word problem, February 7, 2008

As I evaluated a class set of these solutions, I sometimes found that students used one or more strategies to begin to work on the problem (whether correct or incorrect). However, they failed to complete the problem mostly due to computational errors. As seen below (Figure 2), Cole had the right idea to add the minutes together but failed to realize than there was a difference between base 10 math and using the 60 minute hour to determine the solution.

[1] All names are pseudonyms.

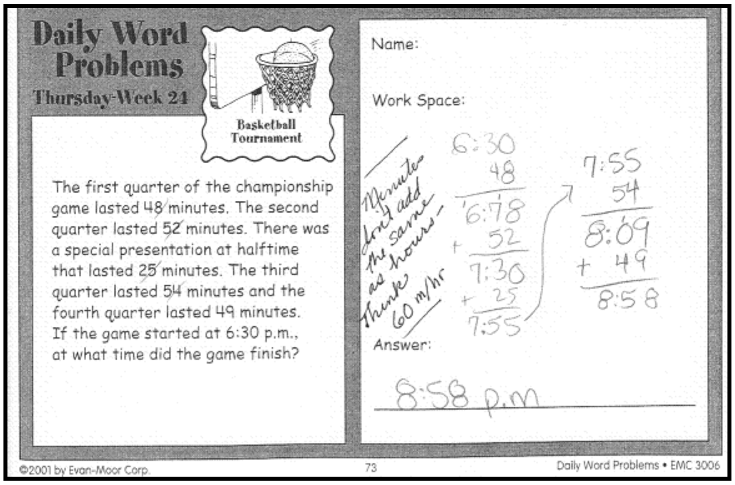


Figure 2. Cole's work on daily word problem, February 7, 2008

Other students used correct strategies and correct computation but did not include some of the important parts of the solution. I did not often find that the method for solving the problem clearly indicated with appropriate strategies, correct computation, and complete thorough answers.

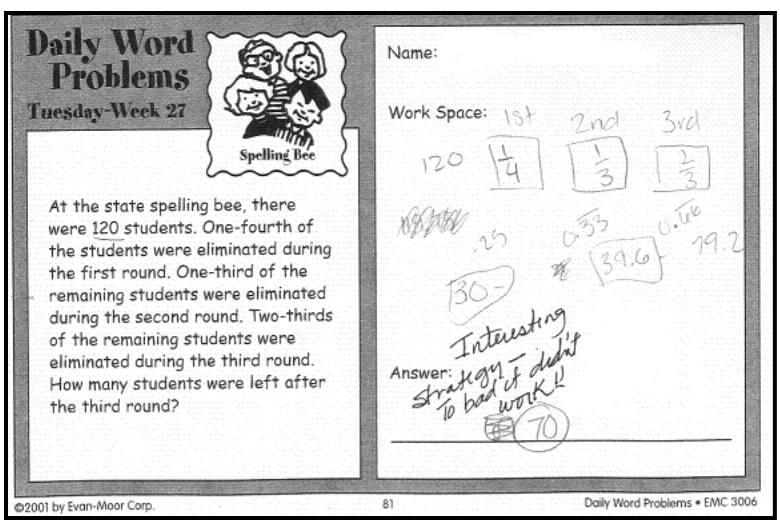


Figure 3. Barbie's work on daily word problem, February 7, 2008

The other element I looked for on the rubric was their explanation of how they solved the problem. As seen in the example of Barbie's work (Figure 3) above, there was some explanation, albeit not in words, but it was difficult to make out and disorganized and incorrect. Sometimes there was no explanation or one that was confusing to understand. Others attempted to explain but their explanation lacked clarity and was disorganized. Forty-four percent of the time, students explained their answer, but the explanation was pretty basic and generic with some basic organization. Very seldom, in fact only seven percent of the time, did I see an explanation that was logical and sequential with precise mathematical vocabulary. I assigned a score based on the rubric and entered those scores into an excel worksheet. Table 1 below provides specific scores achieved by the six focus students during the second semester. This table will be referred to throughout this paper and will be helpful to understand some of the conclusions I reached at the conclusion of this study.

Soon after I selected my focus group of six students, I was ready to collect my third form of data which was through student interviews. I constructed two types of interview questionns. One interview focused primarily on using problem solving strategies to actually solve a specific problem. I asked questions about using strategies. For example, one question asked: Looking at your written explanation, are there strategies that you would not have used to find your solution if you had done this before the strategy work we did in class? Which ones? It also asked which strategies would they have used instead. There were questions that asked how easy it was for them to use problem solving strategies to solve problems and if they felt that the lessons that we had in problem solving strategies had helped them. The answers were not standardized by a number choice but were free open-ended responses. In my other interview, I was able to rewrite it so that it had numbers to choose so they could rate their feelings about their confidence in mathematics (Appendix C). I recorded the class scores in an excel document (see Appendix D) from both surveys taken on February 5 and April 12, 2008.

Table 1: Student Scores from Rubrics

Using Strategies

Weeks of 3/11-3/28/08— 54 papers—6 focus students	1	2	3	4
Approach to the Problem	No evidence of generation strategy to solve problem. Did not try it.	Has used one or more strategies to begin to work on the problem (whether correct or incorrect); however, failed to complete the problem. There are some computational errors.	Uses correct strategies and correction computation but does not include some of the important parts of the solution.	Method for solving the problem is clearly indicated with appropriate strategies, correct computation and complete thorough answers. The method and results are sound.
Student Scores by category	13 24%	24 44%	11 20%	6 11%
Explanation	Very little to no explanation. What explanation there is lacks logic and is confusing.	An attempt to explain is made but lacks clarity and is disorganized.	Explanation is very basic; but lacks elaboration. Uses minimal math vocabulary. Explanation has some organization.	Explanation is logical, sequential and uses precise mathematical vocabulary.
Student Scores by category	16 29%	17 31%	17 31%	4 7%

I collected interview data from my focus group of six during the weeks of February 5, March 12 and April 21, 2008. I had several students who were members of my focus group who were habitually absent first period. Because of bussing issues, I had a difficult time getting students to come in after school for taped interviews. Therefore, I decided to type the questions out for the strategies questionnaire and had students complete them in class during study time (Appendix E). The next day, during study time I had the same students complete the attitudes questionnaire (Appendix F). At the end of class both days, I collected those sheets and the next time the class met I talked to those students one-on-one to clarify answers they wrote down on the questionnaires. I used the same method for all of the interviews with each of the six focus group students so that the methods for gather the data would be consistent.

I organized the data by keeping files in a file box for each set of assignments, assessments and questionnaires I collected or administered. Once I scored an assignment with a rubric, I recorded those results in a spreadsheet. I went through the questionnaires that were number rated and kept a tally sheet for both administration dates and then entered those statistics into a spreadsheet. I was able to keep most of my statistics on the excel program. I recorded the results of the handwritten free answer interviews in my Teacher's Journal.

Findings

Throughout my action research project, I collected and analyzed data both from my whole class and from my focus group of six students. While making these analyses, I attempted to learn whether or not my data provided answers to each of my research questions. In this way, I was able to make assertions based on what I found to be true at each step along the way. In this section, which I have organized according to the research question addressed, I explain my findings of my action research project.

What will happen to students' ability to communicate, using correct vocabulary as they work to solve problems?

My first question for research was specifically: What will happen to students' ability to communicate, using correct vocabulary as they work to solve problems? When I started this research project, I believed I could make a tremendous difference by continued work with students using challenging strategies and infusing precise, appropriate vocabulary. As I planned my units to teach, I selected specific vocabulary words from the textbook which I felt were essential to students' communication and understanding of each topic and would help them to understand the problems involved. I spent time at the beginning and during each unit introducing and reinforcing each vocabulary word. I worked to solidly integrate the words into my teaching as I presented problems each day. This was sometimes a challenge even for me as I was stuck in my ways as a teacher. I wanted my students to recognize and use key vocabulary and yet I found it difficult to remember to use them myself. I put some of the words on quizzes and every time we worked on a review I wrote the words on the board and we defined them; however, the evidence I collected through my interviews found that my students were really not receptive to this change in their ways to communicate about mathematics.

Members of my focus group of six expressed this very clearly as I interviewed them with a student survey April 2, 2008. I asked: As you are explaining problems, would you rather use the words that come naturally to you when explaining your solutions, or would you rather use more precise mathematical language?" Barbie responded with, "I would rather use words that come natural to me because then I would not get confused when I explained it" (Student Survey, 4/2/08). Joan echoed the first response, "Words that are natural, they are easier to understand." Another student, Emee, had a different twist on this question probably because she recognizes what it like to struggle with mathematics herself. She said, "I'd rather use what comes naturally to me, because that mathematical language might be what is hard for someone else to understand." Some students expressed the concern that not only would they be confused but when they tried to explain it to other students, their classmates might also become confused. Most students expressed in their interview that they already had a vocabulary that they had used in the past for mathematical problems and they were comfortable with that and had no desire to change. Looking for more evidence, I turned away from the interview and looked at student work.

I give word problems every day of the week as a regular part of my teaching but during this project I collected word problems from students two or three times a week to score them against a rubric (Appendix B). I looked to see how students approached the problem and how they explained or communicated about it using precise vocabulary. Because it was a real life type of problem and would relate to the students in the spring semester this word problem caught my attention:

> The students at Mitchell Middle School are planning to host a basketball tournament. Only one game can be played at a time and there are 16 teams invited. They will all play a single elimination first round. If there are only 5 hours available to play the first round of the tournament, what is the maximum length allowable for the first game? (Tuttle,1999. p.72)

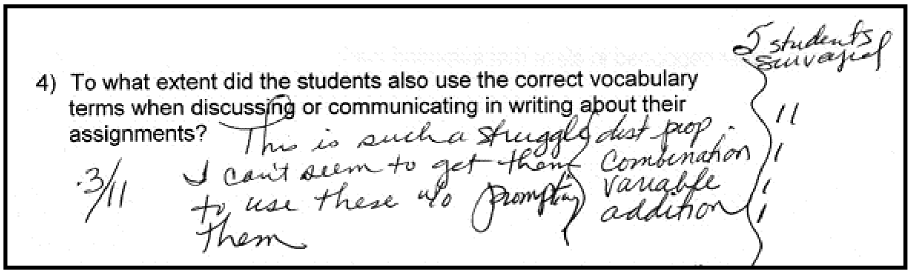
The answer to this question actually boiled down to a number of hours/minutes answer and for some that is the only answer I received. However, the responses were quite varied. I got answers from 2 ½ minutes to 3 hours. Many of the students who wrote 2 ½ minutes did not give any justification at all. In a few cases, I got a pretty standard explanation not marred by any fancy, precise vocabulary. One student multiplied 5 x 60 = 360 and then divided that amount by 16. Their error was that they did not recognize that there would not be 16 games. (Barbie's solution to DWP, Wk. 24) Eddie showed 60 multiplied by 5 and then divided that by 36. His solution ended up doubling the number of teams rather than dividing them. (Eddie's solution to DLP, Wk 24) Probably the most unique and probably most precise solution was both interesting and correct; however, the only explanation was the diagram below and a few numerical notes: (Cole's solution, DWP Wk 24)

1 2 A	9 10 E
3	11

4 B	12 F
5 6 C	13 14 G
7 8 D	15 16 H

By grouping these together Cole determined that there were indeed only 8 games. He labeled each of these sets as A, B, C etc. Cole showed that they multiplied 60 x 5 hrs = 300. In the last step, the he divided 300 by 8 to get the answer of 45 minutes. Not one of these solutions explained the solutions sufficiently. Not one of these solutions used any vocabulary. There is no proof from these solutions that the students have an understanding of the vocabulary required to explain the problem.

As the days on the calendar moved towards March, I was able to observe just a little light at the end of this seemingly dark communication tunnel. In my Teacher’s Journal on March 5, 2008 I wrote, “I see a hint of change coming when I look at how students are explaining problem solving using the vocabulary I use in class. Their usage of appropriate vocabulary becomes more apparent as I continue to question their process.” This was compared to their first efforts in class in February, which was pretty limited as far as vocabulary was concerned. In my Teacher’s Journal, March 11 I recorded the first of several informal surveys by making hash marks in my Teacher’s Journal to indicate how often students used vocabulary words as they explained their method. The first time I used this data method on March 11, we were working on combining like terms. As you can see by the excerpt below from my Teacher’s Journal the data showed that in one class period 5 students used a total of 7 vocabulary words such as distributive property, combination, variable and addition total in an entire class period. I did the same informal survey in my Teacher's Journal the next week on March 18 and found that the same 5 students used 9 vocabulary words as they explained their answers orally.


4) To what extent did the students also use the correct vocabulary terms when discussing or communicating in writing about their assignments? This is such a struggle I can't seem to get them to use these w/o prompting them

3/11

5 students surveyed

dist prop — 11

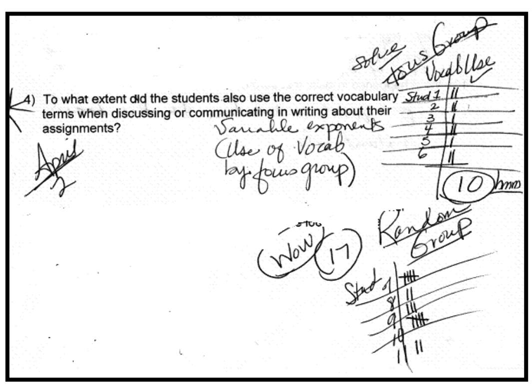
combination — 1

variable — 1

addition — 1

Figure D: Teacher's Journal, 3/11/08

On April 2 I checked on the usage for those five students and then chose 5 other students randomly to check for precise vocabulary usage. We were discussing using variables with exponents. The five students whom I had used before which are the students who are a part of my focus group used 10 vocabulary words as they explained their answers orally. The 5 students I chose randomly to explain their method for solving problems to the rest of the class scored 17 vocabulary words in their explanation of the method they used. This random selection included 3 who were more low level and the other 2 were upper level as you can see from the teacher Teacher's Journal below from April 2, 2008.


4) To what extent did the students also use the correct vocabulary terms when discussing or communicating in writing about their assignments? Variable exponents (Use of Vocab by focus group)

April 2

Focus Group — Vocab Use

10

Random Group

Wow 17

Figure E: Teacher's Journal, 4/2/08

I did not think that actually working word problems had much to do with their resistance against using vocabulary. I found that the students did not rebel against working word problems because I started them working a word problem a day at the beginning of the year so that did not appear to be an impediment to their progress. No matter where the problems were put in a quiz or test, my students did not seem to complain about working with them which was something I did not expect. It appeared that just writing about them on paper using precise vocabulary seemed to be difficult for them. As you see with Joan, (see below) she did work very hard to solve the problem but to explain it was not a part of the solution.

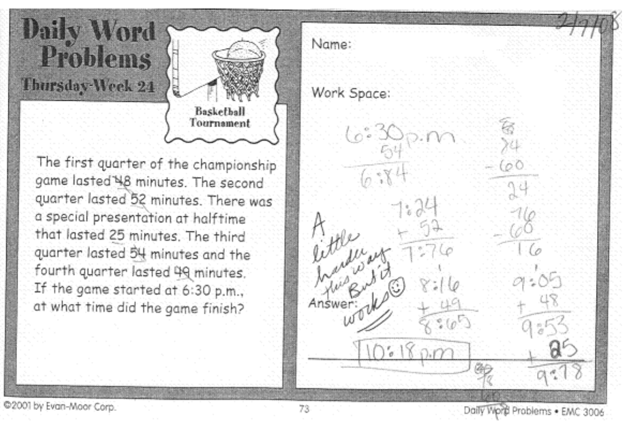


Figure F: Joan's work on daily word problem, 2/7/08

Her use of numbers and the labels of p.m. and the colon to show that she was working with time helped me to understand her answer and the answer was correct; however, she did not explain her process using any type of vocabulary much less precise vocabulary. Another student, Eddie, was asked a specific question which required him to write an answer in words. Again, we see that they have a real issue with using precise vocabulary. Their choice still seems to be with words that they use on a regular basis.

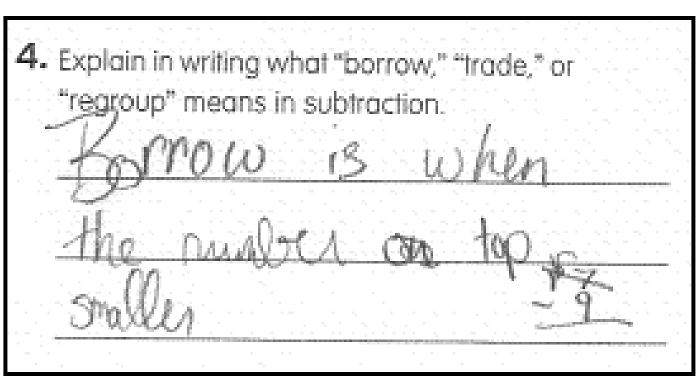


Figure G: Eddie's response on daily word problem, 3/3/08

My interviews did uncover a little evidence that made me wonder about their comprehension. In my interviews with my focus group of six students I asked the following question: When you read a word problem that contains mathematical vocabulary, do you think you know the meanings of those words? Martha replied, "Yes, I think I know some but sometimes may get confused." I think that they lacked of self confidence in their ability to know the meanings of words. I wondered sometimes about their comprehension abilities as was evidenced in Emee's answer. Emee said, "Well I think I do sometimes, but I do not know all the words." Cole commented, "A couple of them I would, but only if we have studied them." In the same student interview on April 2, 2008, three other students, Calvin, Louis and Marty stated that they could figure out the meaning of the some of the words.

February 3rd I wrote in my Teacher's Journal, "I do not think they get the idea that I want them to use those words that I write over and over." On March 7th I wrote in my Teacher's Journal, "I find that if I write the vocabulary word on the board as I work with the problem the students will look up and use it as they discuss the problems—I think I will keep writing them up there." I decided that the repetition of hearing as well as constantly seeing the words displayed made them more accessible to the students and encouraged them to try to use them.

When I surveyed students on March 12th I asked this question: How easy is it to discuss your process using precise mathematical language? Six of 16 students said it was easier, 4 of the 16 thought it was a little easier, 1 said it was the same and 5 said it was harder to use precise mathematical language. I noted in my Teacher's Journal on April 7th, "Something has changed--three students today actually used distributive property as they helped explain what we were solving. It is a great change; however, I still think their preference is to use their own language." In a rating survey I administered on April 12th I asked them to rate their agreement or disagreement with the following statement: "Using precise vocabulary helps me understand problems." The responses were as follows: Strongly Agree 1, Agree 6, Indifferent 7, Disagree 2 and Strongly Disagree 1. All of this left me wondering about the link between low usage and self-confidence about being able to solve problems. They tried to solve the problems but were reluctant to use specific vocabulary to explain them and often did not believe that they would be correct.

In a survey I had the students complete February 5th I found that their confidence levels were closer to the "less than confident" range. In fact, the overall ratings were 1.63 on a scale of 1-5, with 5 being the strongest agreement (Table 2). In their exit survey conducted on April 12, 2008, I did see an overall improvement to 2.72 on a scale of 1-5, with 5 being the strongest agreement. Their attitudes towards using vocabulary, albeit a small improvement, was shown more by my observations of them using vocabulary orally in class rather than seeing them write it down in their answers. I concluded that at the middle school level students were more willing to talk about what they were doing than to write about it. It was easier for them to do. Because of my Language Arts teaching background I made some assumptions that there was most likely a link between the lack of writing skills and the reluctance of my students to write about math. There was also some sort of 'stigma' attached to mathematics that says in math class there will be no writing—we only 'do' numbers. That belief, of course, was erroneous but I think it goes deep into the generations of students before these.

Their reluctance to use specific vocabulary was very apparent. The survey that I administered throughout the study showed that students felt that "Using precise vocabulary helps me understand math" scored 1 strongly agree and 6 agree in the February survey and the April survey showed a slight improvement with 2 students choosing strongly agree and 6 choosing agree with the statement. The same survey showed "learning more vocabulary helps me understand word problems better" scored 3 strongly agree and 6 agree in February and later in April the same question scored 1 strongly agree and 8 agree. It seemed like the students were more willing to use the vocabulary if they were speaking but they did not appear to seem to want to write it down as they solve problems. Looking at word problems given in class I noted that the students were great about drawing pictures to solve word problems but not one of them wrote any specific or precise vocabulary to support their solutions. In my Teacher's Journal on April 17th I wrote the following,

> "I must admit that they [the students] are using the vocabulary to talk about solving problems, which is an improvement but they just do not want to write it down. Call it laziness or apathy—they do not seem to care if it is in print. But they seem to understand what it is I am talking about when I use the vocabulary in class."(Teacher's Journal, 4/17/08)

The students seemed to be willing to use the strategies were introduced in class; however, they did not consistently use the specific vocabulary as they solved and explained their solutions.

What is the link of the use of the vocabulary to the strategies that students used to solve problems?

Use of vocabulary was only one part of my research. I wanted to connect the use of the vocabulary to the strategies that students used to solve problems. All students have strategies, however effective or ineffective, to solve problems that we throw at them. It was their ability to solve those that caused them to feel like they were failures in any mathematics class. Their inability to figure out how to approach a problem did lead to tremendous anxiety. We as classroom teachers needed to figure out how to help our students feel confident to explore problems that we gave them. For that reason, I developed my next research question to come up with a way to study my students' reactions to being taught specific strategies.

What will happen to students' ability to solve age/grade level appropriate problems when taught specific strategies?

My next research question was: What will happen to students' ability to solve age/grade level appropriate problems when taught specific strategies? I had hoped to be able to introduce 5 or 6 specific strategies for my students to practice and use but found that even 5 strategies were too many to wrestle with at first. The strategies I taught in class were: 1) Look for the things you have like important numbers and write them down first, 2) Draw a picture or make a diagram, 3) Ask yourself if this is a subtract, add, multiply, or divide type of problem, 4) What are they asking for? To begin with I did not really ask the students to specifically show any strategies in their homework. True to form, if I did not specifically ask the students to show something they were reluctant to show anything. In fact, in the first 3 or 4 examples I gathered I found that many of the homework assignments I collected to score had just an answer without any explanation. I began to give feedback like, "I do not see any work" or "I can not tell how you got this answer!"

As the year progressed I began to see a few steps. I decided to really give those students some extra incentives to show the steps. In an effort to let other students see what I was looking for I began asking them to show unique ways on the board. In my teaching Teacher's Journal March 13, 2008 I wrote about one of these that backfired.

> "Mary really had a unique way to solve a stacked fraction problem today so I asked her to put it on the board. She is normally very cooperative but today I guess she was embarrassed to show her solution and really balked about it. I tried to push her and should not have—now I am afraid she'll never volunteer to put one up!" (Teacher's Journal, 3/13/08)

Most of the time when we were going over homework or working on a new set of problems I found that students were excited to put their new and different way of solving a problem on the board.

As March progressed, I tried to change angle on solutions to problems. I emphasized the many ways to solve problems as a really important central idea in my classroom. We almost made it a contest to see how many different ways we could solve a problem. I incorporated the strategies into that whole "contest" theme. I am not sure that the students really even realized that I was doing that. Occasionally I would ask questions that reflected the strategies I had taught earlier in February and early March but I did not refer to them as strongly as strategies but more as ways to come up with different solutions. I was pleased to note in my Teacher's Journal on March 27, "Mary volunteered today to put up her unique solution on the board, woohoo we are past that ugly scene two weeks ago!"

As I continued to collect word problems of the day and score those with a rubric I found that I saw students use the strategies 3 of 5 times on the papers I had gathered. One of the most frequently used strategies I saw on papers was drawings. Students seemed to enjoy drawing a pictorial representation of the problem to help them solve it. They also created diagrams. On March 14 I collected an entire class set of word problems in order to look at how students approached the problem. The problem itself was stated this way:

> Sofia is learning to knit. She makes three stitches and then has to undo the last two. She then makes three more stitches and again has to undo the last two. If this pattern continues, how many stitches will Sofia have to make before she has six good stitches? (Tuttle, 1999, p.10)

As I combed through the students' papers I recorded the following. Eight students drew pictures to represent the stitches. Some drew circles and used slashes to mark out the stitches that had been taken out. A few just used hash marks to count the stitches. Mary used a diagram which resembled a row of birds' eyes with slashes through them.

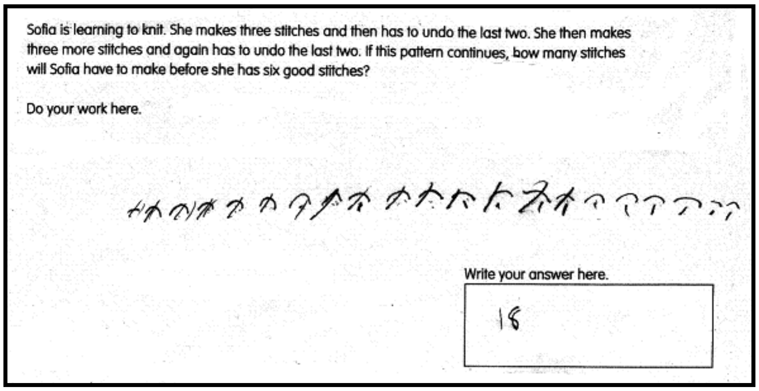


Figure H: Mary's response on daily word problem, 3/14/08

I thought that her solution was unique. Her method helped her to visualize what was going on and she was able to use the hash marks to help her keep track of those that she had to undo. It yielded a correct answer. It was interesting to note that 4 of those 8 or 50% found the correct solution with their method. The next strategy students used was simply a series of additions and subtractions. Eight students used this strategy and only 2 came up with the correct answer. As you can see from the example below, Emee tried to use repeated addition and subtraction to solve this problem rather than drawing a visual picture. It was not successful. Emee often struggled with choosing strategies that worked to help her to solve problems.

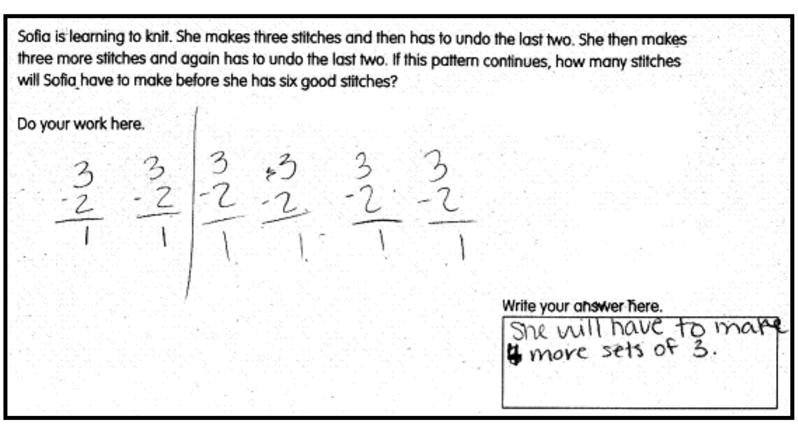


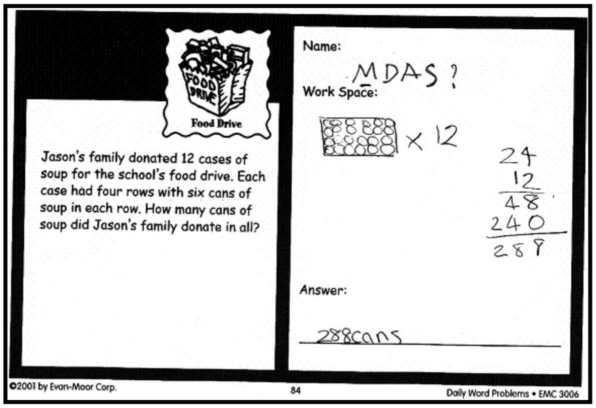
Figure I: Emee’s response on daily word problem, 3/14/08

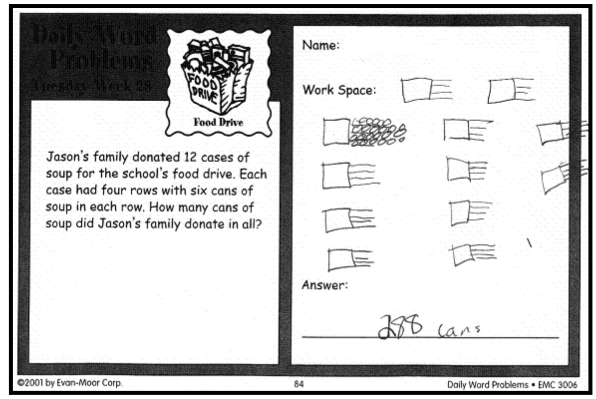
One student wrote nothing down except for the answer so I could not determine his strategy. Incidentally, that student did come up with the correct answer and I was not able to determine whether he copied the answer down from his neighbor or did it in his head.

In a group of 15 papers I sifted through I found the most interesting display of strategies I had ever seen in my class. The question they were to answer was:

> Jason’s family donated 12 cases of soup for the school’s food drive. Each case had four rows with six cans of soup in each row. How many cans of soup did Jason’s family donate in all?(Tuttle, 2001, p. 84)

The strategies I saw were varied. Six students drew diagrams varying from rows of circles to squares with little squiggles sticking out of them in rows. The detail was truly amazing on some of these diagrams. One drawing showed squares with dots coming down from each box representing cans. The drawings were original and detailed which showed that they did indeed have strategies roaming around in their heads but they just were not as formal as I had hoped to find. It was interesting to note that every student’s paper that used a diagram to solve the problem had the correct solution. Four of the other students listed the letters MDAS which used the strategy of deciding whether it was add, subtract, multiply or divide and found the correct solution just by using multiplication. Barbie’s approach Figure J (below on left) to solve the problem is below. It was important to note that she listed MDAS and then decided to use M (multiplication) and then showed her work. Mary’s solution was Figure K (below on the right). The two approaches showed very different strategies but in the end they both came to the same solution. Four others showed little or no work and consequently did not have the correct answer. Unfortunately there were still those who either just wrote a number down with no work or just wrote IDK (I do not know).

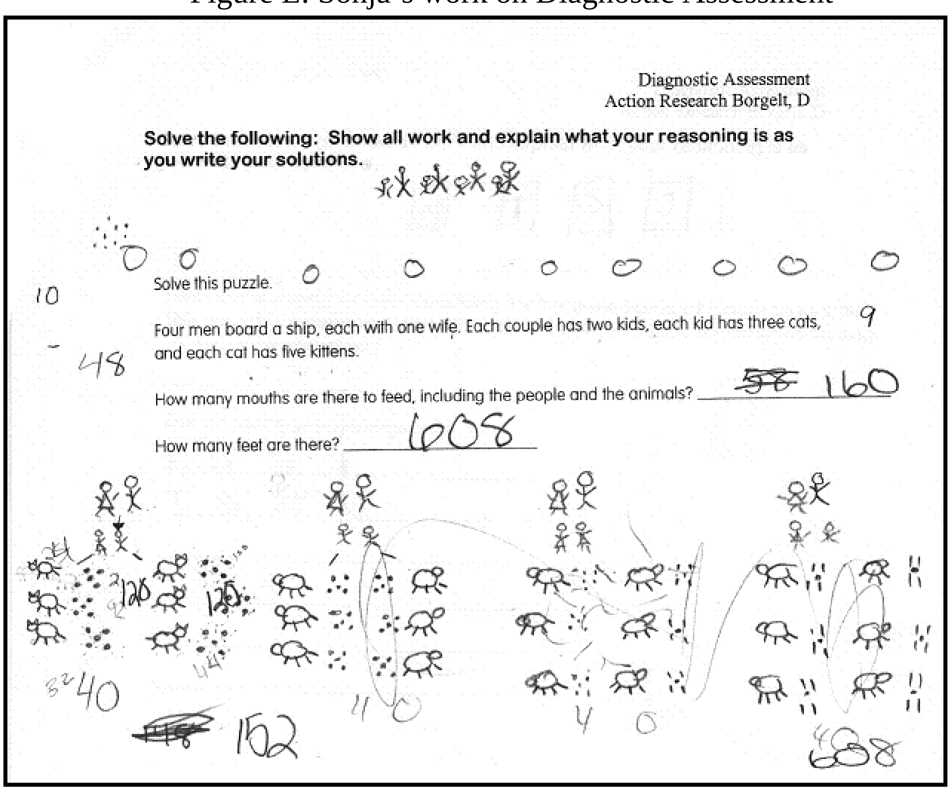




Figures J and K: Barbie's response (left) Mary's response (right) on daily word problem, 3/4/08

At the end of my project April 21, 2008, I gave a diagnostic assessment. One student drew a particularly detailed diagram on their paper. The question asked the students to show all their work and explain their reasoning. What Sonja (see in Figure L) drew for a diagram was truly amazing; sadly, there was no written explanation using vocabulary which was typical of my findings. She was very specific about the number of families and the number of cats. I appreciated the detailed drawing which obviously helped her to make her conclusions.

Figure L: Sonja's work on Diagnostic Assessment



On February 6th I wrote in my Teacher's Journal: "It seems like I see students relying more on strategies that they have developed to cope with problem solving more than what I present in class." Later in my Teacher's Journal on February 28th I wrote,

> As I worked in class today with Barbie, I noticed that she seems to be picking up on the 'is this an addition, subtraction, multiplication or division problem' strategy better now even though she says she does not like to use it." (Teacher's Journal, 2/28/08)

Later in my Teacher's Journal on March 13th I wrote, "Today, when I asked students how they thought they should approach a problem, two students responded right away with 'write down the things you have'."

When I surveyed students on March 12th I asked this question: Do the problem solving strategies make a difference in your ability to explain your thinking in your solutions? Thirteen of 16 students said yes, it did make a difference. In a rating survey conducted on the 12th of April students were asked to rate whether they agreed with the statement "using specific strategies helps me solve problems." A rating of 5 meant that they strongly agreed, 4 meant that they agreed, 3 indicated that they were indifferent, 2 meant that they disagreed and a rating of 1 was strong disagreement. A majority or 8:17 agreed, 2 strongly agreed and 7 were indifferent. I found it interesting to note that on that last survey NONE disagreed. The fact that none disagreed meant that there was a shift in their feelings and attitudes toward solving problems using strategies. In my focus group interviews I asked a similar question and Eddie responded in a unique way.

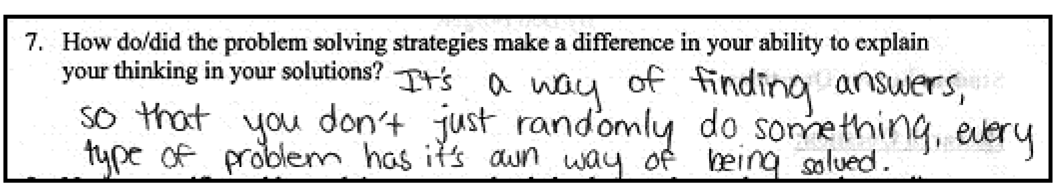

7. How do/did the problem solving strategies make a difference in your ability to explain your thinking in your solutions? It's a way of finding answers, so that you don't just randomly do something, every type of problem has it's own way of being solved.

Figure M: Eddie's response on focus group survey, 3/12/08

After reading this, I realized that this was what I wanted them to realize that not only was using strategies a good way to solve problems but it was also efficient as well. Efficiency was important to these students because they did not want to spend any more extra time than necessary doing homework. Lastly, I wanted to take a look at my teaching.

What does my teaching look like when I try to better teach problem solving strategies and more precise vocabulary to my students?

My last research question was: What does my teaching look like when I try to better teach problem solving strategies and more precise vocabulary to my students? I hoped that my style of teaching problem solving would evolve so that I focused more specifically on strategies and the use of precise vocabulary. On February 17th I wrote in my Teacher's Journal, "I am amazed at how much more I stop and think about what strategies to use to solve problems—I rarely use the book since I have adapted strategies for myself." On February 5th I wrote in my Teacher's Journal, "I really need to think about how I will present and focus on the strategies before I present problems—I need to use them." All of this became food for thought as I moved forward into my project the next two months.

The whole idea of pushing strategies became more important as the semester progressed. In my Teacher's Journal March 7th I wrote, "Today I noticed myself stopping in the middle of a lesson to recap what we've been doing as far as the strategies are concerned. I am actually focusing on the strategies as I teach!" I found myself consciously pushing the use of the strategies and vocabulary with students as I taught daily. I wrote in my Teacher's Journal March

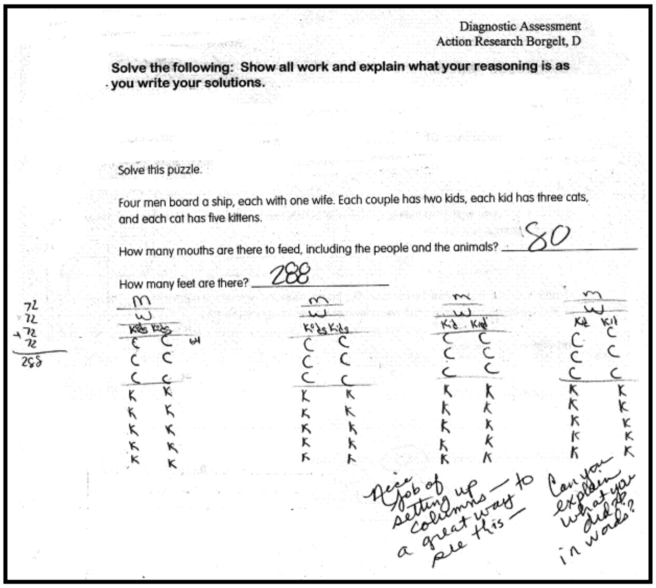
10th that the students were actually using some of the strategies on their own when they were coming in for help during my free period. I found that if I insisted that students stick to using the vocabulary consistently as they worked with problems that the students were able to communicate between themselves more efficiently about problems.

I soon realized that the practice of insisting that students stick to vocabulary enabled the students to speak a common language which in turn helped them to understand each other better as well. I watched a few of my students work together in a group one day in class and what I overheard in the bits and pieces of conversation were shreds and shards of talk with the vocabulary and strategies that I had taught peeking out. My Teacher's Journal for March 28th recorded the following,

> They are talkers—they want to communicate and talk and work together but the whole concept of writing down the vocabulary as they solve problems. But they are talking to each other with vocabulary and strategies I introduced in class. (Teacher's Journal, 3/28/08)

As a result, I adapted a different homework policy in that I did not count the right or wrongness of explanations or even the right or wrongness of the answers in homework. This was all a part of my attempt to encourage them to try to explain and use appropriate vocabulary. With this new policy I evaluated less and less daily assignments and worked harder to have students show work in class in groups and on the board.

This lowered my work level and allowed me to be free to be more of a guide than a dictator in my classroom. When I did evaluate homework I found less errors and more words; however, I still did not see vocabulary rich answers. When I graded a group of homework papers the first week of February the answers were correct 55% of the time. As of April 21, which was the last week I picked up assignments, I saw more than 67% of the answers correct with an adequate (although not vocabulary rich) explanation with their work on paper. See below a paper from Martha (Figure N) that I assessed and wrote some comments. As you can see even through I asked students to clearly explain their strategies, there are clearly strategies to work the problem but the vocabulary used to explain is limited or nonexistent.



Diagnostic Assessment
Action Research Borgelt, D

Solve the following: Show all work and explain what your reasoning is as you write your solutions.

Solve this puzzle.

Four men board a ship, each with one wife. Each couple has two kids, each kid has three cats, and each cat has five kittens.

How many mouths are there to feed, including the people and the animals? 80

How many feet are there? 288

Nice job of setting up columns — a great way to see this —

Can you explain what you did? in words?

Figure N: Martha’s response on Diagnostic Assessment, 4/21/08

In interviews that I conducted March 12th, the question was asked: “As I [Mrs. Borgelt] think about how I will teach problem solving next year, what advice would you give?” Cole responded with, “Just take the steps a little slower on equation problems.” Another response from Joan said, “Explain things more thoroughly.” The other 4 students responded that they really did not see anything to change. Other responses that were elicited from a more informal survey were indifferent or one even suggested that I “do not use such big words” or “be sure that everyone gets it before you go on.”

On March 18th my Teacher’s Journal entry was rather short and cryptic: “I need to slow down—it’s all in my head and I can see it but they are only eighth graders and their minds do not think that fast.” I think I was frustrated that day. In my Teacher’s Journal I added this entry on

April 1st, "I found myself writing questions on the board to focus on strategies rather than problems today…I had not even thought about strategies…it just happened." I found that my classroom atmosphere changed as the semester progressed. I spent more time looking at ways to solve problems than I spent introducing new topics. It was easy though because I had the students' attention so I could lead them into any direction.

I heard myself use vocabulary more regularly and found my instruction being very specific when I explained problems. I found myself asking more and more for my students to explain HOW without giving an answer to begin with. I found myself waiting more for students to answer and allowing them to work an entire problem incorrectly on the board without correcting them just so all students could learn from their mistakes. I noticed that my students were getting braver about "catching" my mistakes. In my classroom this spring I would often make mistakes on purpose just to see if my students were watching. Unfortunately because of the stress of trying to balance research, classroom planning, project work and life in general took its toll towards the end of the semester which caused me to make more than my fair share of errors NOT on purpose.

The interesting discovery that I made through all of this was that I have lost all of the attitude that said "teachers cannot be wrong" that used to embarrass me. I found myself animated more and more as I taught because the kids were adding to their strategies to solve problems. I found that as I pushed vocabulary usage by writing every vocabulary word on the board that my students began to use them in their discussions of problems. Every time I worked with one of the terms, I asked for recall from the students and wrote it again on the board. As I asked students how they solved problems, I found it helpful to actually ask other students to help if the student did not use the correct vocabulary word.

I found that one study really influenced my change in roles in my classroom. In a study conducted by Doerr (2006), he examined the ways one teacher saw and interpreted the multiple ways of student thinking in a modeling task on exponential growth and how the teacher's interpretations influenced her practice. I found it interesting that Doerr described the teacher's role as a listener and observer to identify the different ways students might think about a problem. Secondly, the teacher's role was to support students so that they developed and revised their own solution strategies. I found that this allowed a shift from teaching to guiding which allowed students to be more engaged and able to revise and refine their own approaches to the tasks they faced. This change from teacher to guide was really a positive shift in my teaching style.

I have found myself modeling the strategies as a part of my regular instruction. Two specific strategies were integrated into my everyday work with students. I asked students to look for the important numbers and write them down first. Secondly, I asked students to ask themselves right away if this problem calls for us to subtract, add, multiply or divide. During my interview March 14th of my focus group of six, they spoke of using the strategy: Look for the things you have like important numbers and write them down first. I modeled that strategy in my classroom by asking those questions and writing down the important numbers and the letters MDAS which stand for Multiplication, Division, Addition and Subtraction. It stood for the rule that determined the order of operations which served as a reminder for the students. But for my classes it was a reminder that students needed to look to see what operation needed to come first. In my Teacher's Journal April 12th I wrote, "It must be working for me to stand back and watch because I have not really taught a specific concept this week yet we've worked through several sets of word problems in groups and we're not doing to badly with them. That is a good feeling!"

Not only did I see myself use these strategies more to instruct the students, but I also saw the kids use them more because I constantly modeled them as I worked with them.

Conclusions

As I approached this project I thought that continued vocabulary instruction, teacher modeling, clarifying questions, and written practice would enable my students to more naturally use precise math vocabulary while they communicated their thinking in problem solutions. However, as I looked at the results of my Student Confidence survey (see tables 2,3,4) that I took with my entire class February 5, 2008 and then again at the end of the project on April 12, 2008, I found that what I may have achieved in one area was offset in the other. I found that there were indeed some changes in attitudes of students as to whether or not they felt good at math. It was also obvious that there were changes in their attitudes about the importance of knowing how to solve problems by using specific strategies. I could conclude that there were students who grew to be more comfortable about using vocabulary albeit they were not anxious to write it down.

I believe that these results were positives for the most part. I was discouraged that students did not come to the point that they were willing to write their solutions down using vocabulary which was more specific. Most of the data I collected showed students using vocabulary more often orally but not writing it down. As I reflected on that, I realized that at the beginning of the semester I was struggling to get them to use anything more specific than the top number or bottom number when dealing with fractions. I was excited to hear them regularly use the word distributive property when we worked on that unit. I shuddered to think what term they would have come up with if I had not been pushing that vocabulary at that point. Because I was working hard to incorporate vocabulary into my teaching routine, I conclude that their change in usage, although it was mostly reflected orally, directly reflected the changes I made in my teaching.

The use of strategies was the most obvious change I saw in my classroom this semester. I taught four very specific strategies and reinforced them each day as we solved word problems in class. I included it as a regular part of every day's lesson plan to work at least one word problem in class so that they could practice their strategies. It was apparent from the work I included in this paper that the students in my classroom really grasped the visualization strategy. When the problem merited a visual diagram they were quick to draw a diagram some of which were incredibly detailed. As I wrote earlier, my focus group when interviewed, spoke of using the strategy: Look for the things you have like important numbers and write them down first. Looking at their work, working with them individually during study time and watching them work together in groups convinced me that they were using that strategy. Those students indicated that they felt that the strategies were helpful when they approached problems.

Two other strategies that I emphasized were: Ask yourself if this problem requires you to subtract, add, multiply, or divide, and what are they asking for? I saw evidence that my students used these in their work on paper when I saw the letters MDAS written down at the top of the page and I observed that students asked the question what are they asking for as they worked on problems in groups or individually with me after school or during study hall. I think that the students took to the strategies more quickly because I emphasized that there was no ONE way to solve any problem and they were urged to keep looking for more ways to solve each problem I offered them.

As most of us with the problem of practice to improve communication, problem solving strategies and vocabulary usage, I was looking for the students to change their behavior; but, I am convinced that it is my teaching and classroom approach that changed the most during my research project. I think that I made some difference in the way my kids felt about math but I believe that the changes that most affected my classroom were within me. I was able to introduce strategies and vocabulary that I felt my students could use and then sit back and watch them work with them. My classroom style of teaching moved from dictator to guide. I found myself being more of a tour guide through the labyrinth of mathematics and pre-algebra. I allowed students to discover algebra and problem solving using algebraic equations and formulas rather than dragging them through algebra and shoving the problem solving down their throat as I worked systematically through a textbook.

In the study by Rittle-Johnson and Koedinger (2005) students were taught specific strategies to solve specific types of problems, they seldom reached out past those strategies to try something new to solve problems that were different and thus made many computational or failure to convert errors. I wondered as I read this study, if the teaching of specific strategies actually limits students when it comes to trying alternate methods to solve problems? I was troubled by this so I subsequently adjusted how I taught my students problem solving strategies that were more universally applicable to avoid that problem. I assert that the didactic teaching of strategies exhibited by this study forced students into thinking only one way to solve problems without allowing them to universally apply strategies to other situations which made more sense in the classroom.

In the study by McLeay (2006), the researchers found that students enjoyed the problem solving exercises because the visualization exercises were not like normal math. McLeay indicated that perhaps the acceptance of visualization as a part of teaching problem solving allowed students to not only work with one-dimensional diagrams but also encouraged students to create their own diagrams to solve problems. Thus, McLeay suggested that developing visualization strategies with students would aide them in their approach to problem solving. I too found that students seemed to choose drawing diagrams as a first choice of strategies for problem solving.

Using previous knowledge of strategies and making universal generalizations to solve problems was the center of the study by Cai and Brook (2006). Cai and Brook (2006) reference Polya (1945) and detail Polya's three basic approaches which encouraged students to look back to: generate alternative solutions, pose new problems and make generalizations. Cai and Brook proposed that when students look back to what they had done previously it promoted relationships between concepts and caused students to reflect on their previous work. I concur with their work in that several of my students when interviewed suggested that they used strategies that they had previously used before my class to solve problems; however, as the semester progressed I saw those same students universally apply strategies that I had taught them to solve problems. Their adaptation of these strategies proved that once a student was taught a strategy they included it in with others and then were able to universally apply it to other situations.

Implications

One of the most obvious changes I have made was in my teaching style. I left the dictator behind. I have changed the way in which I approach teaching mathematics. I have left the podium behind and spent a great deal of my time moving about in my classroom. I have become a guide on a safari and worked bring my students along with me as fellow explorers to discover how math IS. I wanted to encourage them to access the information that they already have gather and also be engaged in the process that helps us to realize the importance of mathematics in our world. Students will be encouraged to find as many ways as possible to solve problems. I have adopted an attitude that will encourage creativity and promote risk in my classroom.

I asked my questions differently because I found that if I only asked for number answers then that was just what I got so I found that I had to ask different questions to get different answers. I encouraged students to show me how and why before I ever asked for an answer. I wanted students to realize that it was truly the process and not just the product that was important. I wanted to lower my student’s anxiety in my classroom by making it a more relaxed atmosphere. Although I did not mention it as a part of my research project I have changed my homework policy to include grading for completion but not so much for correctness. I brought in more manipulatives to my classroom so that students could see why ½ is the same as $3/6$ because they then could see relationships and not simply memorize the mathematics. I continued to include the hands on manipulatives because so many of my students reacted to hands on instruction more positively.

I continued to use vocabulary as a regular part of my classroom instruction and have made plans to incorporate a word wall in my classroom this fall. Students seemed to react well to having the words on the board as they work problems. I did not use one this spring but have read work of other members of our cohort that did as a part of their research project and it seemed like it was a proactive choice.

Overall, I have found that I must be more aware of how my students come into my classroom. I have made it a priority to spend time assessing their comfort level in mathematics before I ever begin to teach so that I can work with students who have as much anxiety as I did before I started to work on my master’s degree. I would like avoid traumatizing another student with mathematics for the rest of my teaching career.

References

Cai, J., & Brook, M. (2006). Looking back in problem solving. *MT: Mathematics Teaching*, Retrieved November 22, 2007, from Professional Development Collection Database.

DiLisi, G. A., Eulbert, J. E., Lanese, J. F., & Padovan, P. (2006). Establishing problem-solving habits in introductory science courses. *Teacher's Journal of College Science Teaching, 35(5)*, 42-47.

Doerr, H. (2006). Examining the tasks of teaching when using students' mathematical thinking. *Educational Studies in Mathematics*, *62(1)*, 3-24. Retrieved November 22, 2007, from Professional Development Collection database.

Jacques, L. (2005). Taking the problem out of problem solving? *MT: Mathematics Teaching*, Retrieved November 22, 2007, from Professional Development Collection database.

Kurta, J. (2006). No problem with problem solving. *MT: Mathematics Teaching*, Retrieved November 22, 2007, from Professional Development Collection database.

Macintyre, T. (2006). Su Doku and problem solving. *MT: Mathematics Teaching*, Retrieved November 22, 2007, from Professional Development Collection database.

McLeay, H. (2006). Imagery, spatial ability and problem solving. *MT: Mathematics Teaching*, Retrieved November 22, 2007, from Professional Development Collection database.

Ollerton, M. (2007). Teaching and learning through problem solving. *MT: Mathematics Teaching*, Retrieved November 22, 2007, from Professional Development Collection database.

Polya, G. (1945). How to solve it: A new aspect of mathematical method. Princeton, NJ: Princeton University Press.

Rittle-Johnson, B., & Koedinger, K. (2005). Designing knowledge scaffolds to support mathematical problem solving. *Cognition & Instruction*, *23(3)*, 313-349. Retrieved November 22, 2007, from Professional Development Collection database.

Ruffins, P. (2007). Overcoming math anxiety. *Teacher's Journal of Developmental Education*, 40-41. Retrieved November 22, 2007, from Professional Development Collection database.

Stephenson, P. (2007). On rebecoming unfamiliar. *MT: Mathematics Teaching*, *40-42*. Retrieved November 22, 2007, from Professional Development Collection database.

Tuttle, A. & Tuttle, W. (1999). Daily Math Practice. Monterey, CA: Evan-Moor Corp.

Tuttle, A. & Tuttle, W. (2001). Daily Word Problems. Monterey, CA:Evan-Moor Corp.

Watson, A. (2006). Letting exploration happen. *MT: Mathematics Teaching*, Retrieved November 22, 2007, from Professional Development Collection database.

Xin, Y. (2007). Word Problem Solving Tasks in Textbooks and Their Relation to Student Performance. *Teacher's Journal of Educational Research, 100 (6),* 347-360., Retrieved November 22, 2007, from Professional Development Collection database.

Appendix A

Teacher's Journal Topics

Exploring the Relationships Among Mathematics Vocabulary, Problem Solving, and Confidence in Middle School Students
By Deb Borgelt

Teacher's Journal Prompts to write about:

1) What changes did I see in my students work this week?

2) Did I see improvement (if any) in students' self-choice of strategies to solve problems?

3) To what extent did the students choose a variety of problem solving strategies during class? Did any one student use more strategies than the others?

4) To what extent did the students also use the correct vocabulary terms when discussing or communicating in writing about their assignments?

5) How elaborate were the student's picture drawings in representing a problem solving strategy term? Could anyone looking at the drawings understand the method better?

6) Which students asked fewer questions about their assignments and the directions? Why?

7) The frustrations I felt this week were:

8) A comment one of my students said about my teaching or class was:

9) What happened this week that shows me that I need to change some things in my approach?

10) What happened in class that surprised me?

Appendix B
Rubric for Student Work

Using Strategies

Name:________________
Date:_________________

	1	2	3	4
Approach to the Problem	No evidence of generation strategy to solve problem. Did not try it.	Has used one or more strategies to begin to work on the problem (whether correct or incorrect); however, failed to complete the problem. There are some computational errors.	Uses correct strategies and correction computation but does not include some of the important parts of the solution.	Method for solving the problem is clearly indicated with appropriate strategies, correct computation and complete thorough answers. The method and results are sound.
Explanation	Very little to no explanation. What explanation there is lacks logic and is confusing.	An attempt to explain is made but lacks clarity and is disorganized.	Explanation is very basic; but lacks elaboration. Uses minimal math vocabulary. Explanation has some organization.	Explanation is logical, sequential and uses precise mathematical vocabulary.

Teacher Comments:

Appendix C

Student Interview Questionnaire

Student Questionnaire

Borgelt, Deb
Student Confidence Survey
Spring Semester 2008

Mark one box for each of the following statements.	**Strongly Agree 5**	**Agree 4**	**Indifferent 3**	**Disagree 2**	**Strongly Disagree 1**
I like math.					
I am good at math.					
I often help explain math to other students.					
I complete all assignments.					
It is important to know how to solve word problems.					
I always attempt all word problems.					
Using precise vocabulary helps me understand math.					
Using specific strategies helps me to solve problems.					
Learning vocabulary helps me do my homework.					
Learning more vocabulary helps me understand word problems better.					
I have enough time to complete the tests.					

Appendix D
Table 2

Student Questionnaire about Attitudes

Table for Student Questionnaire -- Attitudes about Problem Solving, Vocabulary and Mathematics Self Confidence

17 students were surveyed on Feb. 5, 2008		
19 students were surveyed on April 12, 2008		

Students were told to mark one box for each of the statements										
Feb. 5, 2008 -- Apr. 12, 2008	Strongly Agree 5	Strongly Agree 5	Agree 4	Agree 4	Indifferent 3	Indifferent 3	Disagree 2	Disagree 2	Strongly Agree 1	Strongly Agree 1
I like math	1	4	5	6	10	5	0	2	1	2
I am good at math	1	2	11	10	3	3	2	3	0	1
I often help explain math to other students	1	4	5	6	3	1	7	6	1	2
I complete all assignments	4	5	8	7	4	4	1	2	0	1
It is important to know how to solve word problems	7	11	9	5	1	3	0	0	0	0
I always attempt all word problems	4	6	7	9	5	3	1	1	0	0
Using precise vocabulary helps me understand math	1	2	6	6	7	7	2	4	1	0
Using specific strategies helps me solve problems	2	4	8	6	7	8	0	0	0	1
Learning vocabulary helps me do my homework	1	3	6	7	8	3	1	5	1	1
Learning more vocabulary helps me understand word problems better	3	1	6	8	5	5	3	5	0	0
I have enough time to complete the tests	6	9	5	7	5	1	1	2	0	0
	31	51	76	77	58	43	18	30	4	8
	2.818182	4.63636	6.909	7	5.2723	3.90909	1.63636	2.7272	0.363	0.72727

Table 3
Graph representing Student Attitudes

February 5, 2008

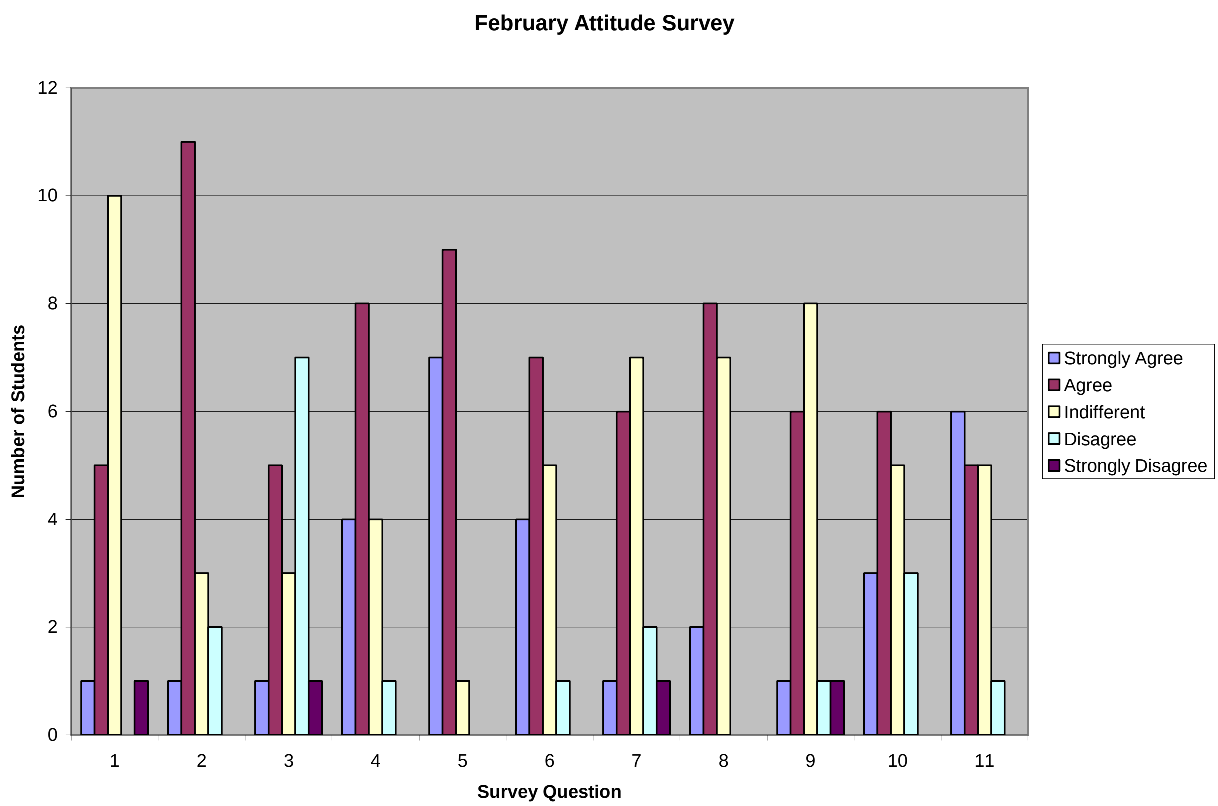
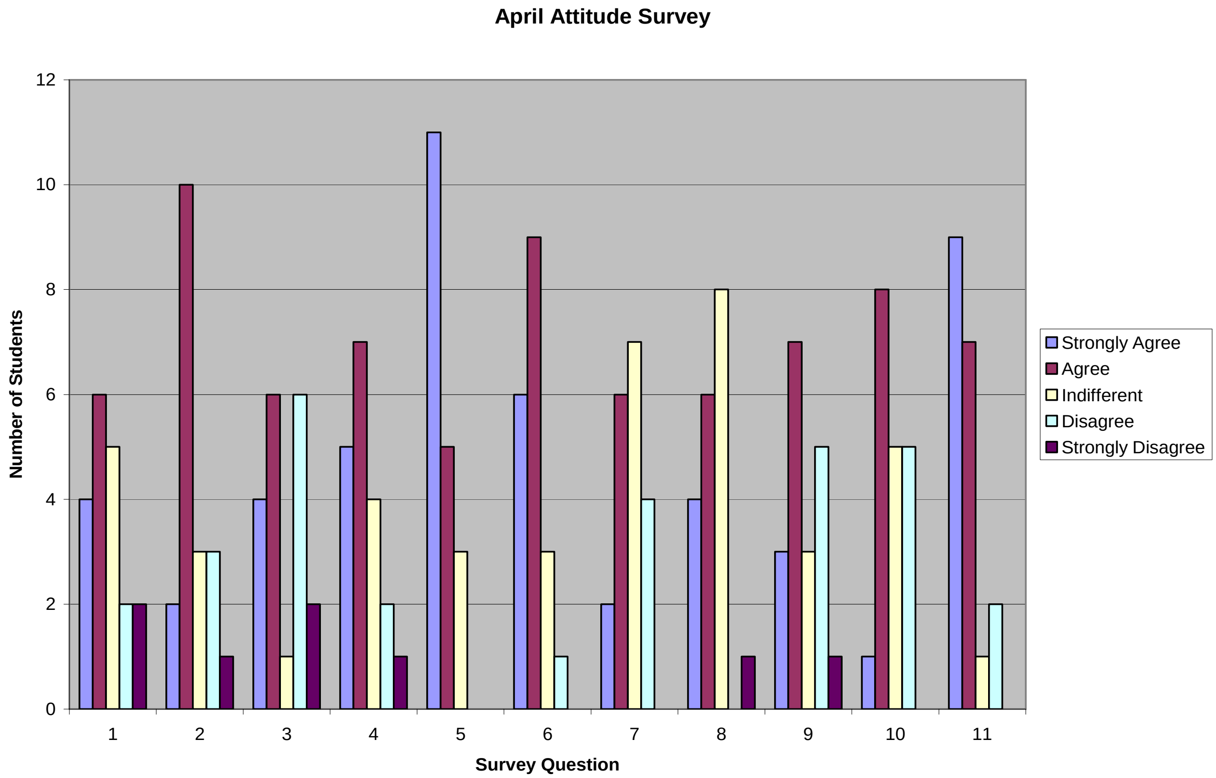


Table 4

Graph representing Student Attitudes

April 12, 2008



Appendix E

Individual Student Interview Questions

Exploring the Relationships Among Mathematics Vocabulary, Problem Solving, and Confidence in Junior High School Students
By Deb Borgelt

Research Question:

What will happen to students' ability to communicate/use correct vocabulary as they work to solve problems?

Purpose of the interview: To ask students about their confidence in their ability to communicate solutions using correct vocabulary after they have used the strategies taught.

Student: Date:

1. In general, do you feel that you understand math? Why do you think that?

2. When you feel like you do not understand math, what is it that makes it difficult to understand?

3. As you work problems using problem solving strategies we've learned in class do you feel that using precise mathematical language helps you to understand or communicate your solutions, or does it make understanding/communicating more difficult? Why?

4. When you are explaining problems, would you rather use the words that come naturally to you when explaining your solutions, or would you rather use more precise mathematical language? Why?

5. Before your math class was taught problem solving strategies which involved the use of precise vocabulary, did you use the terms or did you use your own words?

Appendix E

6. How easy is it now for you to discuss your process using precise mathematical language? Why do you think that is?

7. How do/did the problem solving strategies make a difference in your ability to explain your thinking in your solutions?

8. Name a specific problem solving strategy that helped you to have a better understanding of a math concept.

9. What was it about that lesson that improved your understanding?

10. When you read a word problem that contains mathematical vocabulary, do you think you know the meanings of those words? Please be specific.

11. How has your attitude about working and explaining word problems changed over the second semester?

12. As I think about how I will teach problem solving in my math class next year, what advice would you give me?

13. Is there anything else I should ask you about problem solving or being able to explain problem solutions?

14. Are there any questions you would like to ask me about math vocabulary?

Appendix F

Student Interview with Problem Solving

Exploring the Relationships Among Mathematics Vocabulary, Problem Solving, and Confidence in Middle School Students
By Deb Borgelt

Student Survey Questions

<u>Research Question:</u>
What will happen to students' ability to solve age/grade level appropriate problems when taught specific strategies?

Purpose of the interview: To record observations of students' use of strategies solving a given problem.

Student: ____

1. I would like you to work on this problem, using any problem solving strategy you feel is appropriate. As you work on the problem I would like you to write down you explanation of your process. When you are finished, I will ask you to explain your thinking to me, and I will ask you some questions about what you did.

   Nicole wanted to make note cards by cutting pieces of paper in half. Before starting she got two mare pieces to use. When she was done she had 18 half-pieces of paper. With how many pieces did she start?
   <u>Show work here:</u>

   Write an explanation of how you found your answer:
   ____
   ____
   ____
   ____
   ____

2. Looking at your written explanation, are there strategies that you would not have used to find your solution if you had done this before the strategy work we did in class? Which ones?

3. What strategies would you have used instead?

4. How easy is it now for you to use different problem solving strategies to solve problems?

5. How do/did the problem solving strategy lessons make a difference in your ability to explain your thinking in your solutions?

6. Do you think using these news strategies helps you to communicate your problems?