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Making Better Problem Solvers through Oral and Written Communication

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Abstract

In this action research study of my classroom of eighth grade mathematics, I investigated the impact of oral and written communication on students' problem-solving skills. I collected data to see how emphasizing oral and written communication affected small-group work, usage of precise mathematical vocabulary, and student attitudes toward mathematics. Oral and written communication allowed students to periodically evaluate their own learning and their involvement in math class. I discovered that the vast majority of students enjoyed working in small groups, and when they got to work in small groups, they felt more confident in their solutions to problems. Data on the use of precise mathematical vocabulary showed increased student awareness in the importance of its usage. Student attitudes toward mathematics remained positive, and students grew more confident in their mathematical skills throughout the research. As a result of this research, I plan to continue the use of small-group work, provide instruction in precise mathematical vocabulary, and emphasize oral and written communication strategies.

In this action research study, I investigated how focusing on oral and written communication impacted students' understanding to become better problem solvers. I believed that by learning to express their problem-solving strategies orally or in writing, students would become more aware of problem-solving processes and could use those processes to become more successful learners of mathematics. I wanted students to become better problem solvers while becoming more comfortable and confident in their abilities to solve problems.

In my class at this time, I had some students who struggled with solving problems because they did not have a good grasp of the steps to solve problems, such as looking for key words to identify processes. I wanted my students to also know that there was more than one way to solve problems. Too often students thought there was only one way to solve a problem, and if they did not understand the one way they knew, they gave up. I wanted them to be able to understand the solution methods that worked best for them and be able to explain clearly what they were doing orally and in writing.

I taught an eighth-grade pre-algebra class for the first time in my 15 years of teaching. The concepts were not totally new to me, but it had been awhile since I worked with these concepts. Having not recently thought about pre-algebra concepts and having never taught pre-algebra made it difficult for me to come up with multiple ways to explain the concepts so that everyone understood them. One way I tried to generate more explanations of the concepts was to have the students work on some of the problems together in class, and then I had them get up, put their solutions on the board, and explain to the class their thought processes. This and working in small groups, not only helped some students, but it also helped me to know where they were coming from and what kinds of ideas helped students. For most of my students, boardwork was beneficial. I had some students who were poor writers, so they were more

comfortable with giving their reasoning orally. These students did a better job because they could speak their thoughts rather than having to articulate those thoughts on paper. I wanted to work on getting these students to be better writers and hoped that they would become better problem solvers in the process.

I wanted my students to become better problem solvers, and I wanted them to become successful at math. If students were successful problem solvers this would carry over to other subject areas, and they will be more successful in school. Since teaching pre-algebra was new to me, I believed that teaching my students to become better problem solvers also would help me become better at teaching the topics at the eighth-grade level. Teaching problem-solving skills will help me become aware of the problem spots that may occur from year to year, and, hopefully, help me address these issues in years to come. I was excited to learn new techniques and, sometimes, the best techniques could come from my own students. Allowing the students to become more confident and comfortable with math also was something that I thought was important in working with students. I had students that came to me with low self-esteem, and by having those students communicate orally and in writing, they should become more confident in their mathematical skills.

Problem Statement

This issue of teaching oral and written communication in mathematics relates to the National Council of Teachers of Mathematics (NCTM) Principles, Process Standards and Content Standards in that students will build new mathematical knowledge through problem solving and will apply and adapt a variety of strategies to solve problems while learning strategies to communicate their mathematical thinking coherently and clearly to peers, teachers, and others. My eighth grade students were, overall, a good group of students, but all they wanted

to do was solve for the answer and move on. If they knew the steps for solving the concept, then that was all they wanted to do. They did not want to "dig" into the problem to find the "why" and "how." I wanted my students to be more aware of the concepts important to mathematics and be able to think about the problem before they just went and solve it. I believed that it was important for students to be able to communicate their thoughts and solutions both orally and in written solutions. This would not only help them become better at solving math problems, but also would help them in their other classes as well. Communication between the students and teachers is an important piece in students' lives that will help them beyond high school.

Getting students to write in math and orally communicate their solutions to math problems is an important concept that is overlooked by students, parents and some math educators. When students, parents, and some math educators think math class, they do not think about writing or journaling. Instead they think about numbers, solving problems, and getting to the solution in the easiest, quickest way possible. I wanted my students to be able to communicate their solutions effectively both in written form and by orally communicating them with their peers.

Literature Review

The focus of my action research project was communication in the mathematics classroom. I wanted to know how oral communication and written communication impacted the learning of my students and how they felt about their understanding of math when using oral and written communication in the classroom. With the NCTM standards, students are being asked to write as part of their mathematics experience, and teachers are encouraged to implement various writing opportunities into their instruction. Communication is an essential part in students' daily lives and in the classroom. "All educators should teach communication skills to students"

(Bratina & Lipkin, 2003, p. 3). My research focused on applying different techniques to improve my students' communication skills while improving their problem-solving skills. I want my students to be able to communicate their mathematical thinking both orally and in writing. By doing this I believe that students will have a better understanding of mathematical concepts and find more success in their problem-solving skills. This also will help me as a teacher to understand my students' strengths and weaknesses.

Through my review of current research, four themes were common among the articles I read: the importance of written and oral communication, communication and problem-solving achievement, the importance of vocabulary in mathematics communication, and journaling.

The Importance of Written and Verbal Communication

Written and oral communication are not only ways for students to present their solutions and understanding of mathematical concepts, but also they are ways for students to express their thoughts, feelings, fears, or successes in the mathematics classrooms. While written communication can be less threatening to students, oral communication is important to successful written communication. Burton and Morgan (2000) focused on the language used in 53 published mathematics research papers. Seventy research mathematicians were interviewed in the broader study. The study focused on the natural language of mathematics including symbols and the special vocabulary. The focus of mathematics teaching and learning is not to just teach the facts and skills but to also introduce students to mathematical writing. While teaching the writing, teachers also must use mathematical language in their classrooms, both in large- and small-group discussions and in their writing.

Pugalee (2004) compared oral and written descriptions of problem-solving processes. His study focused on the importance of written words to support a deeper understanding of

mathematical concepts. Students involved in this two-week study kept a journal describing their thought processes during problem solving. Oral explanations of their problem-solving processes also were videotaped. Pugalee used the four categories of behavior involved in performing a mathematical task identified by Garofalo and Lester (1985): orientation, organization, execution, and verification. This study revealed notable differences in achievement with both practices (verbal-think-aloud and written). However, those students who wrote out their processes produced correct solutions at a higher rate than those who orally presented their solutions.

McNair (2000) encouraged "classroom discussion as a form of socially constructed knowledge" (p.197). In his study, he focused on two major parts of a classroom discussion that could be refined. The first part was the text of the discussion, and the second consisted of how the students participated. Refining comes in through the text as student participation increases.

Communication and Problem Solving Achievement

Another theme found in the literature was a connection between communication and problem-solving achievement. A characterization of many of the research reports featured the idea that

> [t]he act of writing serves as a mode for students to reflect on their thinking. This method of communication allows them to convey ideas, feelings, and experiences that can lead to the development of higher cognitive functions, including critical thinking, sound reasoning, and problem-solving. (Albert, 2000, p. 109)

Albert also asserts that "[o]ral language is the tool used to shape the discourse in collaborative problem solving; however, at an independent level of learning and development, writing is the tool students can use to shape their thinking" (p.116). A related study by Borasi and Rose (1989) suggests "by writing in journals, students make use of writing as a learning tool in the context of mathematics" (p. 362).

Importance of Vocabulary in Communication

The reviewed literature also acknowledged the importance of understanding necessary mathematical vocabulary in order to increase learning. Bratina and Lipkin (2003) reported that students needed to communicate mathematical concepts and skills well.

> Ask a student for the exact definition of a term (e.g., perimeter, speed, prime number) that appears in the reading. If the student is unable to define the term exactly, there is little chance that the problem will be solved. Even if it is solved, a numerical answer may be devoid of meaning. (p. 3)

Many students did not realize the importance of reading for comprehension when they tried to learn new mathematics or solve word problems.

A study by Jackson and Phillips (1983) looked at whether seventh graders' achievement in a unit on ratio and proportion would be aided by an emphasis on vocabulary during the instruction of the topic. Three experimental classes and three control classes from three suburban schools in Pinellas County, Florida, participated in the four-week study. Both groups used the same textbooks, materials, and procedures, except that the vocabulary-oriented activities were used for 5-10 minutes a day with the experimental groups while the control group worked computational problems. One important conclusion was the concentration on the meaning of a few terms and symbols for a few minutes daily could result in increased achievement.

Writing Journals

Borasi and Rose (1989) defined the term journal as: "the keeping of a log or personal notebook, where students can write down any thought related to their mathematics learning, throughout the whole course" (p. 348). The setting for Borasi and Rose's study was a regular college mathematics course of 29 students taught by one of them in a small four-year liberal arts college in the United States. It was explained to the students that the journals were to be used to reflect on mathematical ideas, to express feeling about the mathematic content and course, to

provide input to the teacher, and to have dialogue with the teacher. During the course, the students were encouraged to write in their journals three times a week and hand them into the instructor on Fridays. The instructor would return them on Monday along with a response. It was found that by writing in journals, students could use their writing as a learning tool in mathematics. By writing expressively, the students could open up and reveal their feelings, problems, and beliefs, but better yet, the teacher was able to learn from the responses and improve her teaching (Borasi & Rose, 1989).

A study by Clarke, Waywood, and Stephens (1993) focused on a four-year teaching experiment. To avoid the limitation that the study by Borasi and Rose suffered from because "the sample of work was too small to yield stable results" (Clarke et al., 1993, p. 236), Clarke et al.'s study involved approximately 500 students in grades 7-11 in a particular Victorian secondary school. In 1986 the students were introduced to journal writing as an experiment, and starting in 1988, student journals were a central component of the mathematics classrooms beginning with grade 7. Students were expected to summarize what had been taught, tell what they learned, formulate questions, and gather examples after every math lesson. It was also noted that the teachers in the study were expected to assess and report on each journal.

Both Borasi and Rose (1989) and Clark et al. (1993) believed that there was lack of sufficient evidence that journal writing in the mathematics classroom made a significant impact on student achievement and success. However, in both studies, the students showed progress in many areas, such as gaining a better understanding for mathematical concepts. Journal writing also helped the teachers to understand the various learning styles of their students and to make any needed adjustments in their instruction of mathematical concepts.

There was a definite agreement in the literature concerning the importance of written and oral communication in the mathematics classroom. However, the value of them was observed in many classroom settings. Training the students in written and oral communication skills has proven to be critical to student success.

Summary

The importance of written and oral communication should be studied to gain knowledge of how children learn and communicate their thinking process in mathematics. My research will look at the importance of students' use of precise mathematical vocabulary, written and oral communication skills, and student attitude when solving a mathematics problem. Borasi and Rose (1989) and Clark et.al (1993) suggested that it was important for children to be able to communicate what they were thinking in a written form, so my study looked at journal writing. As authors Bratina and Lipkin (2003) recommended, I implemented a word wall to emphasize the importance of precise mathematical vocabulary, allowing the students to creatively design the words and their definitions. I looked at how students progressed in the mathematics classroom when they were taught specific mathematical vocabulary and asked to give written and oral solutions to their problem-solving processes.

Purpose Statement

The purpose of this study was to explore the relationship between written and oral communication and students' problem-solving strategies. It was intended to examine the impact written and oral communication has on students' problem-solving skills, usage of precise mathematical vocabulary, and students' attitudes toward mathematics. I looked to see if students' mathematical communication skills improved, and if their confidence and attitudes toward

mathematics improved. Another thing that I looked at was if teaching precise mathematical vocabulary increased students' understanding of the mathematical processes in problem solving.

I began by investigating the research questions:

- What will happen to students' vocabulary usage in written journals after they receive specific vocabulary instruction?
- What will happen to students' verbal communication skills in small group work after they receive specific vocabulary instruction?
- What happens to my mathematics teaching when I model problem-solving techniques and vocabulary usage in my eighth grade mathematics classroom?

Through my data analysis, I realized that I was seeing changes in student attitude and problem-solving skills. Thus, I added an additional research question:

- What will happen to student attitude and problem-solving skills when given specific written and oral communication skills?

Method

A variety of methods were used to collect data for this research project. This action research was performed during the spring semester of the 2008-2009 school year. The class consisted of 10 students, with nine participating in the study. Of the nine students from whom data was collected, five were boys and four were girls. One male and one female student were classified as resource or special-education students.

All of the research questions were addressed by using a pre- and post-research survey dealing with mathematics in general (see Appendix A). Individual and group interviews (see Appendices B and C) were utilized to assess the impact of written and oral communication strategies on group work and students' problem-solving strategies. I used a *Vocabulary Tally*

Form (see Appendix D) each week to monitor the usage of precise mathematical vocabulary in student journals and during small-group work. A weekly *Student Self-Assessment Form* (see Appendix E) was completed each week by the students to collect information on students' general attitudes toward math and on attitudes toward writing to communicate their solutions and communicating orally about solutions in a small-group setting. A teacher journal was maintained throughout the research to record observations of students' oral presentations of solutions and students' attitudes and interaction in small groups. Lastly, a "word wall" was implemented into daily lessons. Throughout the study, as new mathematical vocabulary was introduced in a lesson, the vocabulary would be added to the wall creatively to help students remember the terms and their meanings.

I began my data collection by giving out the "Math Survey" to the whole class on February 5, 2009. I gave the same survey to them again on April 15, 2009. A Likert scale of 1 (*strongly agree*) to 5 (*strongly disagree*) was used, and the mean and standard deviation for six of the statements was found. Change in mean and standard deviation was utilized to note commonalities and differences between pre- and post-surveys. I designed the survey questions as a means of gathering data on how students felt in general about math and their abilities to solve problems in math class.

Student interview responses were audio-recorded and transcribed. Interviews were conducted four times throughout the research (Feb. 18, March 9, March 25, and April 15) after the students' problem-solving activity. Each interview consisted of three students chosen randomly by my principal. The students were interviewed by me, and each student was interviewed individually using the questions in Appendix B. Students were interviewed during their Study Skills class, which was either their eighth or ninth school period of the day, so that

they were not taken out of instructional time to complete the interviews. The interviews were recorded and comments were then documented in my teaching journal. I listened to each interview two to three times to get precise documentation.

The additional post-interview questions focused on reactions to how they felt about journaling and writing in math class, and included whether they felt that small-group problem-solving days were beneficial and whether their attitudes toward working word problems in groups changed during their eighth grade year. I conducted the post-interview on April 15, 2009. This interview involved a group of four students, two of whom were lower-achieving students and two of whom were higher-achieving students chosen randomly by my principal. The interview was recorded, and I documented student comments in my teaching journal.

I kept a *vocabulary tally form* when I monitored the students working on problem solving in small groups, when students were presenting their solutions to the class, and when I read the students journals. The results were then noted in my teacher journal, which also was used to monitor what occurred throughout the research study. Weekly entries were made and documented student participation, attitudes in the classroom, and any interruptions in research due to school-related issues or illness.

Students also were given a “student self-assessment” form each week of the study after they completed their problem solving/journaling day in class. This form asked them to rate how they felt group work went for each week again using the Likert scale of 1 to 5. This form helped me monitor the students’ feelings toward working in groups and if they felt it was worthwhile. It also helped me monitor what group members worked well together and which ones were not giving much input.

To accommodate the interviews and surveys that were given throughout the research, once per week problem-solving days were implemented, and students were required to keep their written solutions and feelings in a student journal, be prepared to present their solutions orally to the class, and continue to creatively construct the already implemented "word wall." To reinforce student understanding of the requirements, I needed to constantly and consistently model problem solving. A four-part problem-solving method was modeled: restate the problem, plan (How will you solve the problem? What do you know? What do you want to know? etc.), solve, and explain (What did you do to solve the problem?).

Findings

The setting for my research took place in a small Class D school in south central Nebraska. The junior high and high school students are consolidated into one building in one town, and the elementary building is in another town 17 miles away. The school is also part of a unification with a larger school district, which is another 17-20 miles from either building site.

This past year some teaching assignment changes allowed me to move from teaching a combination classroom of fifth and sixth graders at the elementary school to teaching at the junior-high level in the combined junior and high school building. Having only taught at different levels in the elementary setting, the opportunity to teach in a junior high setting was one that I was excited about, yet nervous to try. I was assigned to teach an eighth-grade Pre-Algebra course, which was the source of my research. Knowing that the concepts at the eighth-grade level would be different and higher level than what I was accustomed to teaching, I wanted to create a learning environment that would be relaxed and exciting for my students. Being a part of the University of Nebraska-Lincoln's Math in the Middle Institute gave me the opportunity to research teaching techniques and methods in the mathematics classroom. Through my research, I

explored problem solving, how I could make my students better problem solvers, and how to improve student attitude toward mathematics.

The word wall project was implemented into the classroom at the beginning of the school year to help students become aware of how important it was to know and understand the mathematical vocabulary. The students were allowed to creatively design the words on construction paper and add them to the word wall as they were introduced in class throughout the year. The word wall project brought some feeling of ownership and excitement into the classroom.

During the spring semester, problem-solving days were implemented into the curriculum once a week. The class period in which the research took place was the fourth period of the school day from 10:50 to 11:40. At first the problem-solving day was implemented on Fridays, but with scheduled school vacations and state sports events occurring, we were missing too many Fridays, and consequently the day seemed to fluctuate from week to week as to what worked best with the school schedule and the students' schedules. The students were very flexible with this issue and were helpful in making sure the problem-solving day was implemented each week. The students would be made aware of the problem-solving day scheduled on Monday of each week. It was important to the students that they know what day they would be doing group problem solving and journaling.

A typical problem-solving day would be as follows. Upon entering the classroom, students would pick up their journals from my desk. I would then assign their small groups and the students would gather their group and begin working on the problems assigned for that day. Students were reminded of the four-part model for problem solving. As students worked in their small groups, I monitored their progress by listening for and documenting precise mathematical

vocabulary. I also would monitor group behaviors, such as whether all students were participating in the group discussion, if all group members were on task, and how the group members worked together. After 30 minutes of group work, the students were given five minutes to wrap up their thoughts and solutions in their journals. When groups were finished, oral presentations of the problems were given by each group. Presentations were given by an individual from the group chosen by the teacher. Once the individual would present their solution then their fellow group members could add any discussion they thought was important to the solution of their problem. Following the group's discussion the class could offer constructive comments and questions about their problem. We quickly found out that 15 minutes for presentations was not enough time, so our solution was to carry over presentations to the next day for wrap-up.

My research findings indicate that written and oral communication strategies along with precise mathematical vocabulary instruction had a positive effect on student problem solving in the classroom. The students had a more positive attitude towards group problem-solving activities. Solutions had more precise explanations, and oral explanations showed knowledge and confidence in their solutions.

My first research question was: What will happen to students' vocabulary usage in written journals after they receive specific vocabulary instruction? My first assertion was that after specific vocabulary instruction, the students would use the vocabulary at that time but may not use it as often in their written journals later in the week. The students did understand the importance of specific math vocabulary and used the word wall frequently, but if not prompted to use specific vocabulary, they failed to use it in their written journals. My second assertion was

that students who have been given multiple opportunities to reflect on their use of math vocabulary were using math vocabulary in their written journals.

Evidence to support these assertions was gathered from student interviews and journals, teacher journals, and the continued use and excitement of the word wall that the students created. In my teacher journal dated February 16, I had written, “I need to remind students to use the word wall and remember to use the specific vocabulary in their write-ups.” I found that I was doing this each time we did problem solving write-ups and journaling for the first few weeks of the study. I also noted that the students were using the word wall several times. When new vocabulary would be used, students would also point out that we had a word that we needed to add to the word wall and proceed to add it to the wall. In a journal entry after 7 to 8 weeks of problem solving and journaling, I noted, “students are writing more each week and they are using more math vocabulary in their writing.”

Student interviews and journals showed evidence of my assertions also. In an interview dated March 9, when asked why it is important to know the meanings of vocabulary words in math, a student responded, “It helps you to know the vocabulary so you know what is going on in the problem and understand what the problem is asking you to do.” Another student responded, “When we use the words in our journal it helps me understand their meaning, and I am able to use them more in my written solutions." Students also commented on how the word wall increased not only their knowledge of the many vocabulary words but their interest in the concepts as well. When the words were on the wall, students saw them daily, and tended to use the words more in their daily processing. The students’ journals consisted of their solutions to the weekly problem solving tasks that are given (see Figures 1 and 2).

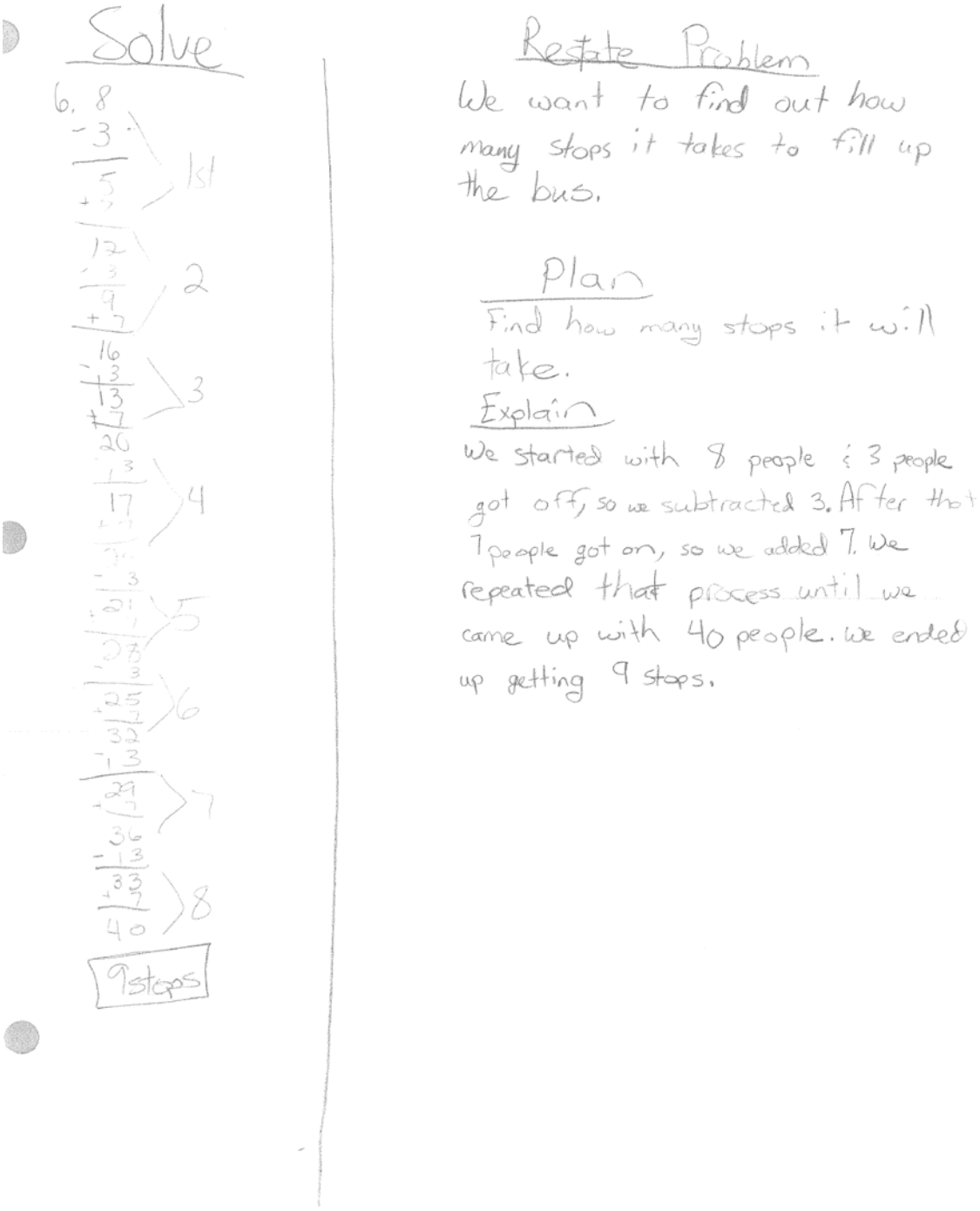

Figure 1. Beginning example of student work.

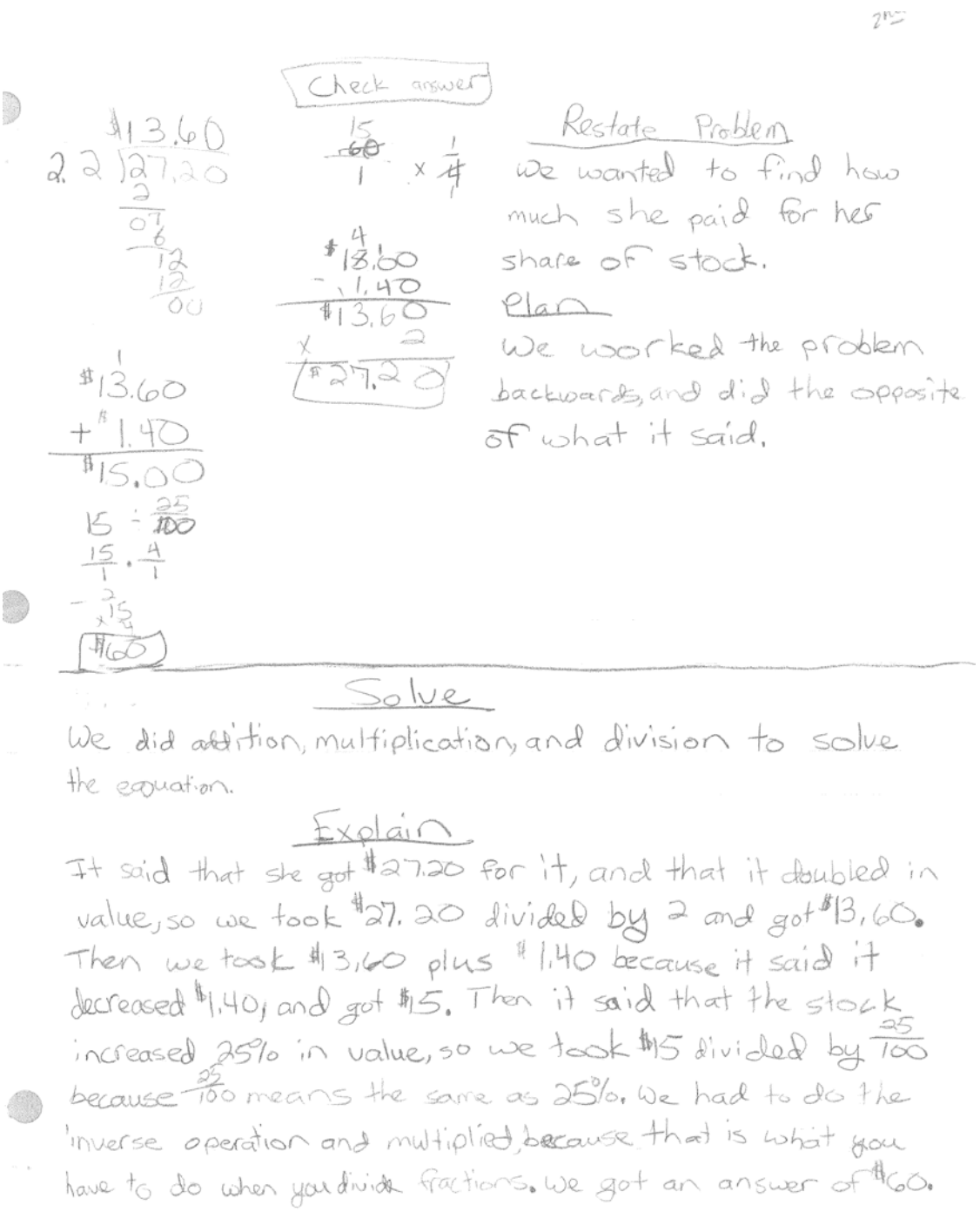

Figure 2. Ending example of student work.

As shown in this student's work, as my study progressed, I noticed that the students were writing more in their journals each week and using more math vocabulary in their written solutions. Throughout my study, I kept track of the number of times I heard students orally use

precise mathematical vocabulary and how many times they used slang vocabulary. I also charted the vocabulary usage from their journals. Figure 3 represents the number of times I charted vocabulary usage during the 10 weeks of my study.

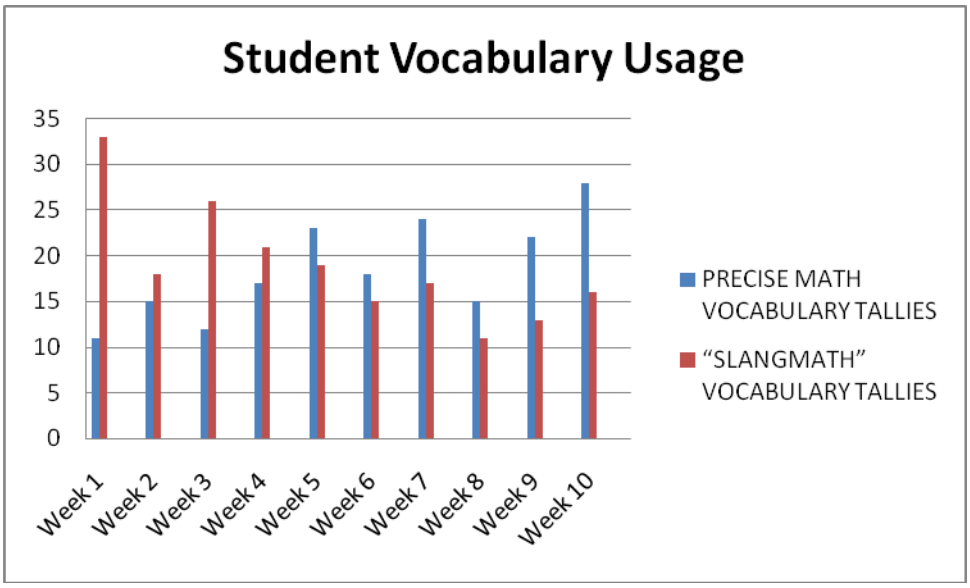

Figure 3. Vocabulary Usage Results

The use of the word wall continued to grow throughout the year, and the students really looked forward to putting words up as they are introduced in their lessons. This excitement was a rewarding teaching moment. Students were becoming more aware of the specific math vocabulary used on a daily basis and retained it if it is used on many occasions. Vocabulary that was not used regularly tended to be lost for a moment until they spotted it on the word wall. Students did recall using specific vocabulary but did not always retain their meanings.

My second research question asked: What will happen to students' oral communication skills in small group work after they receive specific vocabulary instruction? My assertions were: when given multiple opportunities to solve problems and present their solutions in class, students become more conscientious of the specific math vocabulary and are more specific in their

presentations; students who have been given multiple opportunities to use math vocabulary in small group and class discussions are becoming more aware of their usage of math vocabulary in their discussions.

Evidence gathered from my teacher journal of weekly observations and vocabulary-usage-tally forms noted that "students will make a point to use mathematical vocabulary in their verbal discussions and will correct each other." I used my vocabulary tally forms when monitoring group discussions and noticed that students were gradually using more specific math vocabulary each problem solving and journaling session done on a weekly basis throughout the study (see Figure 1).

Students interviewed in April noted that the practice of presenting solutions in class had made them more aware of the specific vocabulary; additionally, a student said, "solution presentations make me think about how I am going to communicate my solutions." Another student stated, "The word wall was a daily reminder to me to use the words and I used the word wall about 2-3 times a week."

The pre-survey given on February 5, 2009, and the post-survey given on April 15, 2009, showed that students became more comfortable and confident in sharing their solutions to problems with their peers. On the Pre-Survey students were asked to respond to *I like to share my answers to question asked in math class.* Students responded, *Strongly Agree*, *Agree*, *Neutral*, *Disagree*, and *Strongly Disagree*. Out of nine students, four students responded *Agree*, and five students responded *Neutral*. On the Post-Survey, students were asked to respond to, *I feel comfortable sharing my mathematical solutions when we are in groups.* Again students were asked to respond using the same choices. This time I received eight surveys back and the responses were four *Strongly Agree* and four *Agree*. Even though these two questions were

worded slightly differently, it is possible that this answer progression from pre- to post-survey is representative of growing comfort and confidence in my students as a result of being given multiple opportunities throughout the semester to present solutions.

My third research question asked: What happens to my mathematics teaching when I model proper problem-solving techniques and vocabulary usage in my eighth-grade mathematics classroom? My assertions were: modeling proper problem-solving techniques and vocabulary usage on a daily basis stresses the importance of precise mathematical vocabulary and makes me more aware of the concepts I am teaching; and using a variety of problem-solving techniques and teaching strategies makes me more aware of the concepts I am teaching and in turn raises my expectations of my students.

On problem-solving days, my teaching was more student-centered than it was on non-problem-solving days. I was able to step back and watch student behaviors when working in a group setting and assess my teaching role. This gave me the chance to give oral feedback to students individually about their active participation during problem solving. I also was able to deliberate on the best way to encourage participation from all students in a small-group setting solving problems. I then chose to reassign students to groups that better fit their needs. I had noted in my journal dated February 20: “Some students are not actively participating in group discussions and problem solving.” I also noted: “For the next problem-solving session on February 25 I will arrange the groups by engagement and try to put the ones who do not share as much in a group to see if they will interact more amongst themselves.” This was not an immediate success, but with prompting from me and a little encouragement, they did work better as time went on. “Today all of the groups were having active discussions, even the group that I am most concerned about” (Teacher Journal, April 8, 2009).

Early in my study I anticipated that the students would talk amongst themselves and use quite a bit of slang mathematical vocabulary. By the end of the study my expectations changed as I expected the students to be using mostly precise mathematical vocabulary. In my journal dated, March 27 I noted: “Students are beginning to use more precise vocabulary in their writing and in their discussions.” By using the precise vocabulary myself in my instruction students were starting to pick up on the vocabulary, and concepts were becoming clearer to them. In one of my journals I stated, “Today I had 23 precise mathematical vocabulary words used in group discussions and presentations, this is GREAT now I know they can do it!” (March 11, 2009). Students interviewed noted that to help them understand math better, it was beneficial to them when I used the precise vocabulary in my presentations of new material. “Because I heard you say integer so many times this week in class now I am saying it too” (Student Interview, March 9, 2009).

I was more aware of the vocabulary in my curriculum and the concepts to which they were related. This was displayed by the number of vocabulary words on the word wall. The number of vocabulary words on the wall grew both on problem-solving days and regular class days. Before my study began, the number of words on the wall was 25. By the end of my study, the amount of words increased to 73. Looking at these words as I placed them on the wall each day made me very conscious of the various ways I could relate mathematical concepts to one another.

My final research question asked: What will happen to student attitude and problem-solving skills when given specific written and oral communication skills? This question was added to my research as my surveys and interviews indicated some change in student attitudes toward math and problem solving. Attitudes concerning math and problem-solving skills

remained positive throughout the research study as noted in my journal: “all students worked well in groups” and “nearly all were contributing in some way.” Additionally students indicated in journals that they felt more confident and successful when we worked in groups to solve problems: “working in groups helped me to understand the problem better,” “I liked being able to check my answer with my classmates,” and “I understand my work better” (Student journals throughout the research). Data from the interviews taken four different times throughout the year illustrated attitudes remained positive or improved. Students responded: “it is fun to work with classmates on problems,” “I feel better about my work when I can do it in a group,” and “it’s fun to get other people’s opinions about how to solve the problems” (Student interviews). I also noted in my teacher journal that I believed the students were more positive about our problem solving and group work in the later weeks of my research: “students are showing progress, those who did not participate as actively in the beginning are starting to give some input in their group discussions and are more willing to give input in whole-class discussions.” They seemed more willing to contribute, and the lower-level learners were not as timid in the group and shared thoughts and ideas in whole-class discussions. One student stated in a journal: “I feel working in groups helps me improve and understand what I’m doing. I like comparing answers to see if I got the right answer, this made me feel more confident when I presented my solutions.” Another student’s final journal noted: “Solving in groups is really fun, the more I learn how to do the work, I start to catch on and can solve the problems on my own.”A math survey (see Appendix A) was given to the students on February 5 before I started my research and then again on April 15, at the end of my research. This form was used to gather data on how my students felt about math in general and their abilities to solve problems in math class. The surveys did not show a significant change in student attitude but there was change in most areas. Students felt that math

skills were important and, in the post survey, more students felt they were good at math compared to the pre-research survey. There was a slight decrease in the number of students who felt they were able to show their work to solve math problems. This could be due to a number of reasons such as their interpretation of the question. However, overall, I believe that the students had a more positive attitude in the post-survey than in the pre-survey even though the differences were small.

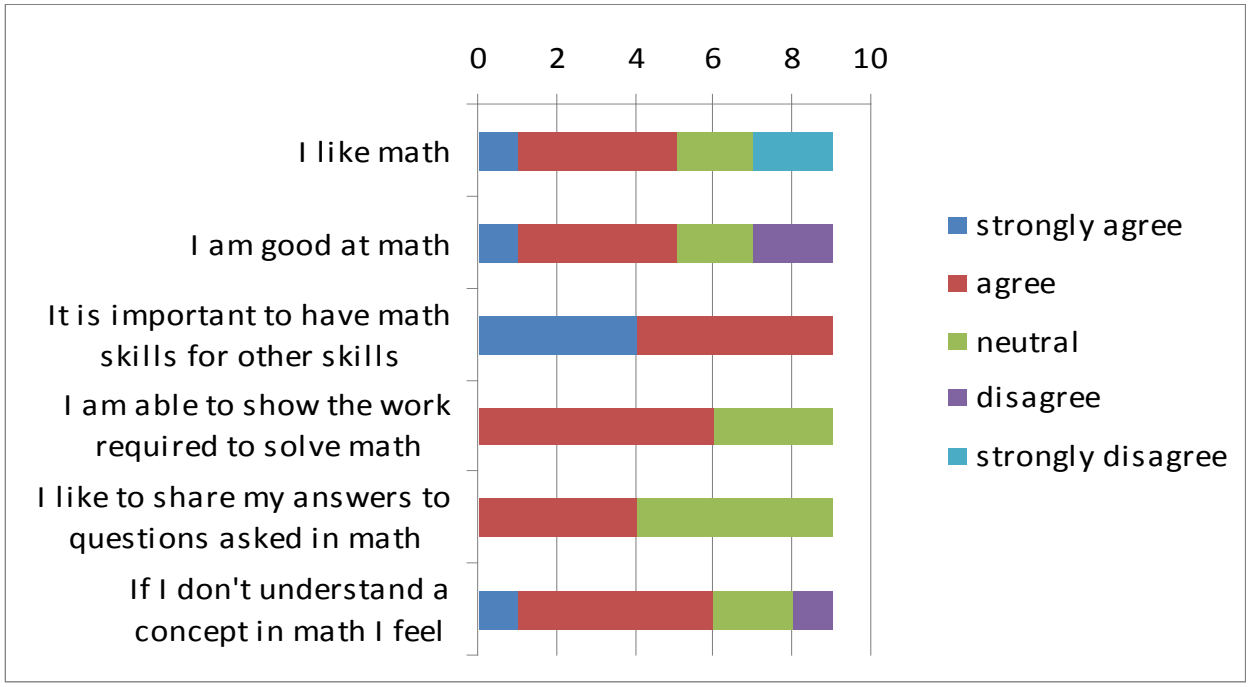

Figure 4. Pre-Survey Data

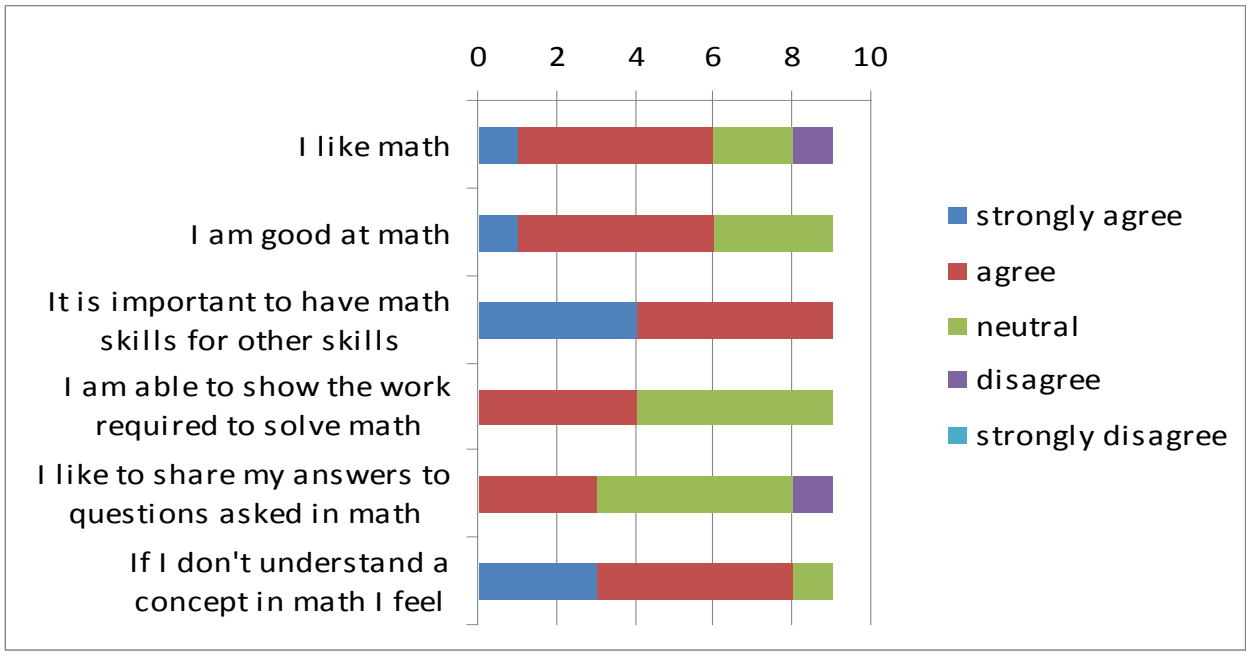

Figure 5. Post Survey Data.

Conclusion

Working with students on their written and oral communication skills in the mathematics classroom and focusing on not only their problem-solving skills and precise mathematical vocabulary, but also their attitude toward written and oral communication in the classroom, I found that students like to learn from one another and will take the opportunity to interact in math class. Students also came to realize the importance and frequency of precise mathematical vocabulary in math class. There did seem to be a link between written and oral communication in the mathematics classroom and understanding of precise mathematical vocabulary. Consequently my research was consistent with other research that suggested students who were given the opportunity to write or speak out loud in mathematics discussion demonstrated more success and understanding in the mathematics classroom. “Writing about a mathematical topic can help

identify learning difficulties and problems, and recognize connections previously unrealized." (Borasi & Rose, p. 355, 1989).

An inspiration for me as I researched articles was not a study itself, but an article by Bratina and Lipkin (2003) whose purpose was to motivate teachers to apply communication techniques within the context of studying mathematics. As noted earlier, one of their suggested techniques included a word wall to present important vocabulary words in mathematics. My study indicated students' use of precise mathematical vocabulary in their written journals and verbal presentations increased, and this could be partially due to students' use of a personally constructed word wall.

In looking back at the research reviewed for my study, I wanted to know if any other researchers noticed any changes in student attitudes toward mathematics, problem solving in particular. Studies conducted by Pugalee (2004), Shield and Galbraith (1998), Bratina and Lipkin (2003), Clark et.al. (1993), Burton and Morgan (2000), Albert (2000), McNair (2000), and Jackson and Phillips (1983), dealt mainly with the written and oral communication and did not directly address attitude in their studies. However, Borasi and Rose (1989) and Ruffel et.al (1998), commented on improved grades and students who were more willing to contribute to class discussions when they understood the topics being taught. I believe that willingness to contribute had a lot to do with student attitude. If students were seeing improved grades and beginning to participate more in class then I believe that they also earned a more positive attitude toward math than they had before. Ruffell, Mason, and Allen (1998) supported Ajzen's (1988) definition of attitude in their study as "a disposition to respond favourably or unfavourably to an object, person, institution or event" (p.3). Ruffell et al. stated in their study that "teachers *can* influence students' performance: the underlying problem is seen to be to determine how causes

produce effects, so that teachers can be more effective" (p. 1). As teachers can influence student performance, I believe that students influence the effectiveness of their teachers. As a first-year teacher at the eighth-grade level, there were a lot of times when I was not sure how to teach some of the concepts, and the students would come up with ideas and solutions that not only helped their peers to understand but also me as their teacher. This helped reintroduce me to the concepts and understand better where my students were in their learning. As teachers, I believe it is important that we sometimes take a step back and let our students be the leaders and take the role of the teacher. I think that this has a big influence on a student and how they learn and how others around them learn.

Implications

Written and oral communication in the mathematics classroom is a way for teachers to monitor and assess student learning and attitude toward math. Using a variety of pedagogical techniques and tools such as the word wall and small-group problem-solving days are ways to bolster student attitude toward problem solving, pay closer attention to precise math vocabulary, and complete math assignments.

Because of my study I plan to continue to use a small-group setting, learning precise mathematical vocabulary, writing out solutions, and presenting solutions in class. I would like to encourage my students to have a better understanding of the concepts they learn and to contribute ideas in class. I plan to watch problem-solving skills in particular. By learning the importance of precise mathematical vocabulary and communicating their solutions in a positive, non-threatening environment, students will become more aware of the mathematical concepts being taught.

Next year I plan to continue the use of a student-generated word wall and to continue to model and teach the importance of communicating their thoughts and solutions in class from the very beginning. Hopefully, they will feel more comfortable and confident in math class and in their solutions. I also will continue the weekly problem-solving/journaling while teaching the problem-solving strategies and emphasizing the importance of using precise mathematical vocabulary in their written and oral solutions. A small-group setting will be used weekly to encourage communication. I will use the student self-assessment forms two or three times a month to help monitor student interaction and participation. Hopefully, I will see an increase in what they understand and retain. One thing that I want to add to my plan for next year is the addition of quizzes to test the retention of the precise math vocabulary. From my study, I saw improvement in skills when students started taking ownership of the words on the word wall, and this started to carry over into their written and oral solutions.

The last things I plan to do are talk with the other math teachers in my district and show them the findings of my research. I believe that if lower elementary teachers can start teaching precise mathematical vocabulary and how important it is for students to be able to write out their thoughts and solutions, then hopefully when I get students in the eighth grade, they will have a better understanding of precise mathematical vocabulary and written and oral communication strategies.

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Appendix A

Math Survey

I used this at the beginning of the project and then again at the end to see if the students' attitude toward math changed any over the course of the project.

	Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
1. I like math.					
2. I am good at math.					
3. It is important to have math skills for other skills.					
4. I am able to show the work required to solve math problems.					
5. I like to share my answers to questions asked in math class.					
6. If I don't understand a concept in math I feel comfortable asking questions.					

7. My favorite math topic is…

8. The best thing that has ever happened to me in math class is…

9. The worst thing that has ever happened to me in math class is…

10. One thing I wish my math teacher knew about me is…

11. The best way for me to remember a concept is…

Appendix B

Student Interview Questions: Questions for Pre-Project Interview

1. In math class we will be working in groups. Does working in groups make you more comfortable with solving math problems? Why or why not?

2. What makes working in groups frustrating?

3. What makes working in groups fun?

4. How does working in a group help you justify your answers?

5. Do you think journaling in the math classroom will benefit your math abilities? Why or why not?

6. How might writing in the math classroom be beneficial to the student and the teacher?

7. Why is it important to know the meanings of vocabulary words you see in math?

8. What do you like about journaling?

9. What don't you like about journaling?

10. What can your teacher do to help you understand math better?

11. Is there anything else I should know about you to better understand your problem solving in math or your general math experience?

Appendix C

Student Interview Questions: Questions for Post-Project Interview

1. Tell how you feel about journaling in math class about math problems.
2. How has keeping a journal in math class this semester helped you as a math student?
3. How would you describe yourself as a math student?
4. After doing group work in math class this semester, how do you feel about working on math problems and solutions in groups?
5. What went well for you while working in groups?
6. What did not go well while working in groups?
7. Do you feel differently about math class after this semester?
8. What do you think about when your teacher asks questions during Math class?
9. What makes math easy or difficult for you?
10. What could teachers do to help students in math?
11. Has your attitude about working word problems in groups changed during your eighth grade year? If so, why?
12. What would you tell someone who is new to our class what it takes to be successful in this math class?
13. Is there anything you want to know from me?
14. Is there anything else I should know about you to better understand your problem solving in math or your general math experience?

Appendix D

Vocabulary Tally Form

I will use this form when reading the students' journals to keep track of the precise math vocabulary used and the "slang" math vocabulary used.

Precise Vocabulary Used	"Slang" Vocabulary Used

Appendix E

Student Self-Assessment Form

Students will fill this form out to rate how group work went for each week.

Please give an honest response to each statement.

	Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
1. I like to work in groups in math class.					
2. I ask questions of my group members when we are in groups.					
3. It is easier for me to understand math concepts when I work in a group.					
4. Other members of my group ask me questions during group work.					
5. Working in groups helps me to complete my work on time.					
6. I feel comfortable sharing my mathematical solutions when we are in groups.					

7. If you could choose two people to work with in groups, who would they be and why?

8. What do you like best about working in groups?

9. What do you dislike about working in groups?

10. Do you feel more comfortable with the mathematic concepts this week? Explain your answer.