7-2007

The Importance of Teaching Students How to Read to Comprehend Mathematical Language

Tricia Buchanan
St. Paul, NE

The Importance of Teaching Students How to Read to Comprehend Mathematical Language

Tricia Buchanan
St. Paul, NE

Math in the Middle Institute Partnership
Action Research Project Report

in partial fulfillment of the MAT Degree
Department of Mathematics
University of Nebraska-Lincoln
July 2007

The Importance of Teaching Students How to Read To Comprehend Mathematical Language

Abstract

In this action research study of my classroom of 8th and 9th grade Algebra I students, I investigated if there are any benefits for the students in my class to learn how to read, translate, use, and understand the mathematical language found daily in their math lessons. I discovered that daily use and practice of the mathematical language in both written and verbal form, by not only me but by my students as well, improved their understanding of the textbook instructions, increased their vocabulary and also increased their understanding of their math lessons. I also found that my students remembered the mathematical material better with constant use of mathematical language and terms. As a result of this research, I plan to continue stressing the use of mathematical language and vocabulary in my classroom and will try to develop new ways to help students to read, understand, and remember mathematical language they find daily in their textbooks.

The purpose of my inquiry is to discover if there are any benefits for the students in my class to learn how to read, translate, use, and understand the mathematical language found daily in their math lessons. I also investigated if an increased focus around mathematical language will increase students' comprehension and understanding of their mathematical lessons.

The critical factors that affected the selection of my area of focus were: my students' lack of preparation for their math lessons, lack of understanding of the mathematics language being used daily in their textbook, and lack of being able to translate that language into something they could more easily understand and use. Students did not wish to read, learn vocabulary, or do story problems. They did not seem to have the skills to read and translate the mathematical language in their lessons. Students could not comprehend what was being asked in the directions of their lessons, even if the lessons were just taught, because they could not transform the directions' vocabulary into something they knew and understood. When pushed to read and translate the mathematical words, students would ask why they had to learn reading in mathematics. The majority of my students read and used only the assigned pages of their textbook. They did not read the examples or use their textbook as reference material to find answers to their mathematical questions.

Ideally, students would be able to read and understand the mathematical language (vocabulary) as well as the mathematics problems in each lesson they covered. I wanted students to have a general background and understanding of what they would be learning and discussing each day before class even began. If students were prepared for the lesson, they could help direct the learning through conversation and dialogue. Also, I wanted to spend more time on discussions and challenging material and to have my students become involved and proactive learners instead of uninvolved reactive learners. In addition, I desired for my students to start

using their textbooks as a reference material and to use it to help find answers to their mathematical questions. I wanted students to realize the benefits of reading and translating mathematical language and continue this practice even after the research was done.

In the past I had tried to make the mathematics easier for my students by using the vocabulary in the textbooks the first time I introduced a concept, and then I would choose an easier word that had the same meaning that I would use the rest of the time. I would occasionally use the more difficult word when speaking, but would more often use the easier words so they could understand what I was saying. When directions were confusing I would quickly come to the students' aid by saying, "Oh that is just a fancy way of saying you need to …" and would tell them what to do. As a result of my involvement in Math in the Middle and this research project, I realized that I was not helping my students when doing this like I thought I was, and I was actually doing them a great disservice. I learned that using precise vocabulary is exactly what we needed to be doing instead of "dummying down" the vocabulary for our students. I decided to work more at the vocabulary and language involved in mathematics making myself and my students use the proper terminology they found in their math textbooks.

Problem Statement

My teaching research would generate knowledge on three different levels. The first level would be generating knowledge in my own practice. After doing my research I hoped to gain a better understanding of how high school students learn. Is it better for them to come to class with some idea of what material and mathematical language is being covered each day and to learn to translate that material and vocabulary into something they can understand; or is it better to let them take each day as it comes with no preparation for the new material and limited vocabulary exposure? This would help develop the make up and the requirements for my classes in the

future. Would reading/translating terminology increase my student/teacher interactions and discussions on a daily basis? I was interested, after the required aspect for the students was done, to see if students would find a benefit to translating mathematical language and using note cards, and how many intended to continue the practice even if it was not required. In other words would this become a worthwhile life-long learning skill?

Not only will this research affect my own classroom practices, but as I share my findings with other teachers, both in my school and with Math in the Middle, I anticipate that my findings may affect their classroom practices as well. The advantage of this research is it would not have to be confined to the mathematics classroom. If the research shows a positive outcome with the translating and understanding of terminology and language, it could also be applied to the sciences or other such subjects as well. Teachers may start to approach their classrooms and their students learning and preparation in a different way. If several teachers in the same building approach lessons this way, it could help students realize the benefits of this approach, and it could also help them in the future if they attend college. When I share my findings with a larger community of educators, it could affect how they set up their classrooms and approach their daily lessons. It could benefit both the teachers and the students.

We hear numerous reports that claim students are scoring poorly on mathematics and reading tests. For years educators have looked at these results as two separate problems; low reading scores was one problem, and low math scores was another. Each individual department would normally make changes in the curriculum and/or teaching styles and implement new programs to try to get the students' test scores up for the following year. What we are starting to realize as math educators is that reading is an important aspect of mathematics. We are realizing

that reading and comprehension skills involving mathematical text and vocabulary are important for a student to succeed in mathematics.

Literature Review

One of the first questions that may come to mind is what does reading have to do with mathematics? Another question to pose is why do students need to learn how to read the text in mathematics? Barton and Heidema (2002) discuss why reading and mathematics are so closely related, and why we need to show students how to read mathematics in our classes. Their research reiterates some key ideas stated in the National Council of Teachers of Mathematics new *Principles and Standards for School Mathematics* (NCTM, 2000).

> Students learn to use language to focus on and work through problems, to communicate ideas coherently and clearly, to organize ideas and structure arguments, to extend their thinking and knowledge to encompass other perspectives and experiences, to understand their own problem-solving and thinking processes as well as those of others, and to develop flexibility in representing and interpreting ideas (Barton & Heidema, 2002, p. iii-iv).

Many researchers consider the ability to read mathematics an extremely important and necessary skill for students to master, and that its benefits can be far reaching. Students who can read and comprehend mathematical text and language are better able to understand and succeed in mathematics. However, students need to be taught how to read mathematical text and must realize that comprehending the text takes time to learn. Also, reading such text requires a different reading approach and is a more complicated method of reading than used when reading other textbooks or reading for enjoyment. In their study, Borasi, Siegel, Fonzi and Smith (1998) explored the potential for mathematics instruction using reading strategies based in transactional reading theory. They explain what makes reading mathematics text a more complicated endeavor than reading other types of text as well as what skills are needed to be able to understand it successfully.

> …the key to successful reading of technical mathematics texts lies in the students' abilities to decode the mathematical symbols and language used in such texts so they can extract the information contained in the text and understand the concept or solve the problem (Borasi, Siegel, Fonzi, & Smith, 1998, p. 277).

Being able to read and understand mathematical text would also benefit students in their daily school work, exams, and even college entrance exams or other types of assessments.

"Mathematics is a second language" was a phrase that was found over and over again in the research, but what does the expression mean? Asking teachers where the biggest mathematical difficulties are for their students will many times get similar responses. Kenney, Hancewicz, Heuer, Metsisto, and Tuttle (2005) discuss in their project where one of the problems lie -- within the mathematical language itself. "The students know how to do the math; they just don't understand what the question is asking. … I have to simplify, to reword the questions for my students, and then they can do it" (Kenney, Hancewicz, Heuer, Metsisto, & Tuttle, 2005, chap. 2, para. 5).

How many students are perfectly fine with their numerical mathematics skills but as soon as they hit word problems they flounder? How many students understand the mathematics when the teacher explains it, but cannot comprehend what the textbooks are even asking them to do, even if the lesson was just taught to them? What skill is missing to make the connection between the solving of the mathematics and the textbook's wording of the mathematics? That skill is learning how to read and understand mathematical text. Adetula (1990) found in his study that students performed better when the word problems were presented in a language they could easily understand. "The message is clear. Word problems are reasonable to the children, only when the structure of the language in which the problems are presented is understood by the children" (Adetula, 1990, p. 353). Educators need to teach the skill of *how* to read and understand mathematics as a language to students. One way to do this is by treating mathematics

as a second language that needs to be taught, learned, practiced and understood. Mastering how to read and comprehend mathematical text is not a natural skill, but instead a skill that must be learned. Adams (2003) describes from his article what skills are missing for students to be able to read mathematics.

> …what is often excluded or given little attention is the basic notion of reading mathematics as a language. Reading mathematics is a multifaceted task because the reader is challenged to acquire comprehension and mathematical understanding with fluency and proficiency through the reading of numerals and symbols, in addition to words. … For students across all grade levels, weakness in their mathematics ability is often due in part to the obstacles they face in focusing on these symbols as they attempt to read the 'language of mathematics' (Adams, 2003, p. 786).

It appears the greatest tool for helping students to succeed at reading the mathematical text is to teach students *how* to read the text and then constantly practice this skill.

What seems to go almost hand in hand with understanding mathematics and its text is writing about mathematics. The ability for students to use their skills and knowledge of mathematics and write in words how to go about solving problems is discussed a great deal in the journal articles. Research shows us those students who are unable to write how to solve problems using written language many times will have trouble fully understanding or solving the mathematical problem in the first place. Venne (1989) stated in his journal article that having students use written expression will also help reinforce the mathematical ideas. "We realized that those students who couldn't express the operation often needed help performing the operation. Forcing written expression of the procedure seemed to solidify the understanding of the operation" (Venne, 1989, p. 66). Learning to read mathematical text and write mathematical ideas in written expression seem to have a symbiotic relationship with each other. If a student can do one skill, it appears to make the other skill easier, and visa versa.

Verbalizing mathematics is another skill that many articles mentioned. There is a need for students to routinely participate in dialogue and discussion on math related topics and also to discover methods in mathematics. Many studies, including the one conducted by Siegel and Fonzi (1995), discussed the lack of written and verbal exchange between students and their peers, and also with their teachers within the classroom, and instead portrayed classrooms as a standard input/output situation. “With few exceptions, a typical mathematics classroom begins with a review of homework, followed by a presentation of new material and sample exercises by the teacher and finally practice on similar exercises by the students” (Siegel & Fonzi, 1995, p. 637). Teachers must learn to give up part of the educational reigns of their classroom and allow the students to become more than just passive receivers of the material at which they need to become skilled.

Another aspect of verbalizing mathematics is the use of correct terminology and vocabulary. If students do not speak mathematics, how are they to fully understand the mathematics? Lampert’s (1990) research project summarizes a very simple but important point. “Students and teacher need to be able to have a conversation using terms that are functional, not only for communication but for reasoning” (Lampert, 1990, p. 47). Part of understanding mathematics is being able to use its vocabulary correctly in daily conversation. If we avoid the difficult terminology, the students are missing an important ingredient of their understanding and comprehension of mathematics. It does students no good to “dummy down” the vocabulary.

However, one needs to be aware that learning vocabulary is not just learning definitions. “Just giving students vocabulary lists with definitions, or asking them to look up definitions, isn’t enough for them to develop the conceptual meaning behind the words or to read and use the vocabulary accurately” (Kenney, Hancewicz, Heuer, Metsisto, & Tuttle, 2005, chap. 2, para. 26).

Teachers and students must correctly use the vocabulary daily in their classroom interactions. This inclusion will help make the vocabulary a natural part of a student's spoken language and will aid in their understanding. "Mathematics truly is a foreign language for many students; it is learned almost entirely at school and is not spoken at home. Mathematics is not a 'first' language; that is, it does not originate as a spoken language" (Kenney, Hancewicz, Heuer, Metsisto, & Tuttle, 2005, chap. 1, para. 6).

It is often part of human nature to avoid difficult tasks. Students are no exception to this rule, and often steer clear of skills they perceive as difficult. Of course when they do this, students are avoiding the subject(s) that they are most weak in and are not giving themselves a chance to improve in that given area. Brown (1988) discusses this point in her journal article about students needing to take control of their own learning. "It is not surprising that people tend to avoid situations that tap on their area(s) of weakness, thus conspiring to provide themselves with less practice in areas where it is most needed" (Brown, 1988, p. 319).

Students need to recognize that for them to learn the material they have to become a participant, not an observer, of their education process. They must become active learners. "Students will not become active learners by accident, but by design, through the use of plans that we structure to guide exploration and inquiry" (Siegel, Borasi, & Fonzi, 1998, p. 381). Educators must find ways to involve students, help them take charge, and become active in their learning process. The research of Clarke, Waywood, and Stephens (1993) explored the environment of the mathematics classroom. "Teachers can play a critical role in helping students to assume control over their learning" (Clark, Waywood, & Stephens, 1993, p. 248). It is important that students see that they are the ones who ultimately hold their future in their hands

and what they will and won't achieve in life. Students should not be passive bystanders, but instead need to be active participants in their education.

In light of my research and also what I have witnessed in my own classroom, I saw several areas that I wished to investigate with my own action research. I saw a great need for students to be able to read, comprehend, and translate mathematical text and symbols from their textbook into something that they could better understand. According to research this translation skill involved several aspects including the ability to read mathematical text and symbols (also referred to as the language of mathematics), the understanding and proper use of mathematical vocabulary, the writing down of translations and ideas from the text into their own words, and the sharing of these translations with other students. Research also stated students need to become active and independent learners willing to participate in their learning process for them to gain benefits.

For my own research project I wanted to see if time devoted to learning to read and use the mathematical language would not only increase students' understanding of the material, but also help them start down the path to becoming life-long learners. The problem is that existing research did not indicate *how* to get students to do all of this. There were only studies stating that students needed to learn these skills, how important they were, and how they would continue to struggle in mathematics without them. The quandary I faced was *how* to get students to learn this skill. With the lack of detailed methods being shared in the research, I decided to explore several of my own methods to try to find which ways worked best to teach students these skills. I felt it would be important to explain techniques as well as results in my research.

Purpose Statement

The purpose of my study is to teach my students to learn how to read, translate, use, and comprehend the mathematical language found daily in their math lessons. Questions that I hope to be able to answer by the end of my study are:

- How will increased teacher and student use of written and verbal mathematical language in the classroom affect a student's comprehension and understanding of the material?
- How does learning how to translate and comprehend mathematical language help the student's understanding and performance of the daily material?
- How will translating/comprehending mathematics lessons and increased use of vocabulary change levels of discussion and dialogue among the students?
- How can I best incorporate flash cards into math class?
- How will students respond to requests to create note cards in math class?
- How will students use note cards in math class, both while receiving teacher support to do so and when such teacher support is removed?

I narrowed my research questions down to three main questions.

- How will increased teacher and student use of written and verbal mathematical language in the classroom affect a student's comprehension and understanding of the material?
- What effect can student-made flash cards have in the translation and understanding of the mathematical language? (Students will write down examples of problems on flash cards with textbook language on one side and the translation and how to solve them on the other)
- How does the student's understanding of mathematical language affect their ability to do mathematics?

Method

Conducting the study included several tasks such as getting permission from the parents and students and surveying the students initially to get a baseline of their views on understanding mathematics vocabulary, their use of note cards, and their understanding of the directions found in their textbook. This was followed by starting the actual research project, using the note cards,

learning translation techniques, and surveying students during and after the project, as well as collecting any tests, quizzes and note cards that the students finished.

I surveyed students on their use and opinions of the note cards, if they could read and understand the language in their textbook and if understanding the math language helped them become more successful with their mathematics work. I also interviewed small groups of students about their thoughts and if understanding the math language helped them become more successful with their mathematics work. I kept copies of students' section quizzes and chapter tests to measure mathematics achievement. I also photocopied students' note cards after each quiz or test and used a rubric to score them. I kept a personal journal throughout the study about how students were using their note cards, how the students appeared to feel about the note cards as we progressed, and if I felt the note cards were helping my students understand the mathematical language and material. I also recorded my feelings about the research project and my observations of increased or decreased use of proper mathematical language in the classroom by both the students and myself.

A teacher who teaches next door to me had an open period at the same time as the class on which I did my study. Each time I was to give a verbal survey or a written survey he would come into my room and conduct it for me. I would go into his room and work on other things so that the students felt able to write or discuss openly their views and feelings without me being in the room. Written surveys were collected, paper clipped, and put in a folder. Verbal surveys were recorded, and then I transcribed them later that week. I tried to journal each day of the school week. One day out of each week I would summarize the week's activities and my feelings about them and also the entire research project. After checking any quizzes or tests, the students'

papers were photocopied before being returned. Students' note cards were handed in the same day as quizzes and tests, again photocopied, scored on a rubric, and then returned.

I used a file organizer case to hold and organize all of my papers. As any paper data was collected, it was stamped with the date that the data was collected, stacked in alphabetical order by the students' last names and filed in the appropriate folder in the case. Paper data included any tests or quizzes given, along with student-made note cards. A rubric was used to grade each student's note cards and was color coordinated and dated before being filed. Surveys given in written form were also color coded, with each survey time period being in a different color. Verbal interviews were transcribed and copied. My teacher journaling started out on paper but quickly went to computer. I typed in my journal daily, and then once a week I summarized my week and tried to come up with any new ideas to do for my research. Final journal papers were printed and filed.

My first order of business in February, 2007 was to distribute the IRB forms to the parents. I did this at our Parent Teacher Conferences the second week in February. Parents were given time to ask any questions about the research and forms. I asked that if they and their child wished to participate in my data study to have the forms turned in within the next week. Another teacher that I taught with was in charge of collecting and keeping track of the forms for me as well as giving any and all surveys or interviews. I then started my study with a survey of my students. I asked them their views about understanding mathematical language and vocabulary and if it affects their ability to do mathematics or become more successful with their mathematics work.

A technique I had started earlier in the year was the use of note cards for notes instead of full pages of paper. I had noticed that most of my math students did not want to take notes or did

not know how to take notes. I decided that I would use note cards instead because they are compact and can be quickly taken out to review or study if needed. My thinking was the note cards would help the students when taking notes and also writing down definitions and translations of the vocabulary that they came upon in their math textbook. Each day I handed out a certain number of note cards, and students were required to copy my notes as I taught. They were also encouraged to add more than just what I had written. They were to make extra notes, add thoughts, and make the note cards something that they could understand and use daily. Before starting a new lesson we would review the note cards from the day before and go over any new vocabulary words that they may have encountered previously in the chapter. I must admit that my first thoughts were to tell my students the mathematical terminology and then give them an easier word to use and understand instead. I found as the research went on that it was not the easier math terms that we used that made them understand the mathematical language, but instead it was learning and using, both in written and verbal form, the actual math terms they encountered daily.

After each quiz I would collect their note cards and look at how they were doing for notes, and then as we started the next section I would stress areas that I thought were lacking. I encouraged them to make the note cards their own, to add vocabulary words and to put their own definitions beside them, and finally to review and use their note cards as often as needed.

While listening to the tape after the first interview, I realized that the note cards were very important to my students, but that the reason for my study and using the note cards was being lost. I spent a day discussing strategies for reading mathematical material out of textbooks, and we discussed the importance of being able to use their math textbook as a learning resource. I also decided that my initial technique of making the vocabulary easier for the students was

wrong. My students shouldn't learn an easier word for the difficult mathematical language; instead they should be learning and using the actual words on a daily basis. I realized it is the use and understanding of the language that makes the understanding of the textbooks easier. I decided to increase my efforts and stress the vocabulary words in my daily lessons and also encourage my students to use the correct terminology when discussing the problems with me as well. I would not let them use an easier term when there was a mathematical vocabulary word that would be more appropriate. For example, instead of using "top" when discussing the upper part of a fraction, I would instead ask them for a better mathematical word and lead them toward using "numerator" instead.

With each round of data collection, I learned more about where my students were with their learning and what they were thinking and feeling. I would alter my lessons and stress more those areas where I felt my instruction was insufficient to achieve my goal with my students. While I thought the note cards would mainly be used for translations, they were definitely not. Instead they were mainly notes on a different-sized paper than notebook paper. While some students did write vocabulary and directions down, many did not. What did work was my constant use and stressing of the vocabulary words. We would discuss the vocabulary found earlier in the chapter and sometimes the previous chapter. I started putting vocabulary words on their tests and quizzes for them to define. This really made a difference. Once they saw I was going to make them responsible for actually knowing these words many started paying more attention to the terminology. I then found that students started using the terminology even more in my classroom. Words that I honestly figured an eighth grader would not use in daily conversation they were using and using correctly. By the end I found what I was searching for as an answer to my research; it just was not where I was looking.

Data was collected in a variety of ways. Every time a test or a quiz was given their papers were collected and copied after being scored. Dates of collection were: February 20th Quiz, February 28th Test, March 8th Quiz, March 16th Test, March 30th Test, and April 16th Quiz. I had one student who was absent for several days during the study for surgery and another was gone for two weeks on vacation; one was not required to take one of the quizzes or tests. Note cards were collected after most quizzes or tests. Dates of collection were: March 1st, March 16th, March 30th, and April 13th. Again I had two students absent during this time period, and some of their notes were missing due to a trip. Also, we had a great deal of sickness in our school building, leaving us with multiple missing students; snow days also had an impact. Along with that I was ill several days as well. Also state girls' and boys' basketball tournaments fell into these time periods, causing us to have two weeks of only four days each because of school closings.

Verbal interviews were conducted March 1st, April 2nd, and April 16th. The second interview was given on the only day possible in that time period. However, assessments were also required to be taken that day for my eighth graders. This meant the only students that could take the interview were my 9th graders who had signed permission slips. Only three were interviewed and out of those three, only one actually was using the note card process. The other two were not participating at all. During this interview, a problem with the tape recorder resulted in the tape not starting until question number nine, and so all other questions above it are missing on that dictation.

Written surveys were conducted February 19th, March 29th and April 13th. The last day of the survey students were rushed because they first had to complete a quiz before taking the survey, leaving little time to fill it out. My journaling was done daily from February 5th through

April 16th, and a summary was done weekly as well. Some weeks I had little time to journal, and so I did not write as much as I would have liked on the prompts.

Instruments that were used for data collection included a pre-made script of questions for the verbal interviews that were given to the students (Appendix A) and a pre-made typed paper for the written survey that was given to the students (Appendix B). I decided to use two techniques of interviews, one verbal and the other written. I have found that sometimes people are more forthcoming using a written format for their feelings while others are more honest and open in a verbal setting. I determined that if I used both in my research I may get a more accurate account of what my students were thinking and feeling. Also a rubric was made to score the students' note cards for content and accuracy (Appendix C). I knew that the note cards would be difficult to glance over and score without standardized guidelines; this is why I chose to make a rubric to score them. Finally, I used pre-made journaling prompts to keep my writings focused on specific areas of the research project and give me a place to start my daily writings (Appendix D).

Findings

The first set of data that I studied was the written student surveys. Students answered eight questions on a scale from one to five with one being "Strongly agree" and five being "Strongly disagree." The first survey question stated "I can read and understand the majority of instructions/directions in my math textbook." On the initial survey the mean response was a 2.1 with a standard deviation of 1.1. The second survey done eight days later had a mean response of 2.5 and a standard deviation of 1.0. With this rise it appeared that we were going the wrong way, but with the stress of using the vocabulary words in the classroom students were probably feeling a bit overwhelmed. The third survey taken March 29th had a mean of 2.2 and a standard deviation

of 0.8. I thought it was interesting that the standard deviation was getting smaller each time. The final survey taken April 13th had an average of 1.8 and a standard deviation of 0.4.

During a verbal interview March 1st students were asked if they could learn math by understanding what the book was asking them to do in its directions. Their responses included "no, the book confuses me" and "it's hard to understand the book." When asked April 16th why it was important to know the meanings of vocabulary words one sees in math a student responded, "It's important to know the meanings because if you don't know the meanings you don't know what you are supposed to do." What these sets of data show is that a student's confidence in being able to read and understand the instructions and the directions in their math book increased during the research period ,and they began to realize the importance of the skill as well.

The second statement was "I can reword the majority of math instructions or directions in my textbook into my own words." Scores started at a 2.6 average with a 1.1 standard deviation and ended with a 2.0 average and a 0.5 standard deviation. In my March 6th journal I noted a discussion that was held with the students about vocabulary words and why the textbooks seem to make things much more difficult by using a complex word instead of an easier word. We talked about how the Spanish language seems difficult at first because all the words are new and unknown, but with time the words almost become second nature to them. We discussed that learning mathematics vocabulary is the same; at first it seems foreign and frustrating, but with practice and use it would become second nature. The students seem to respond to this talk, and it helped them to realize that the vocabulary should get easier with time and use. The survey and the discussion shows that the time we took looking over the directions and reading and discussing the vocabulary aloud helped students to become more secure in their ability to read directions and use the vocabulary on their own.

Questions three, four and five centered on the use of the note cards. Question three asked if the note cards helped them understand the instructions/directions in their textbook. Question four asked if the note cards helped them to better understand what they were to do on their math lessons and question five asked if they could find and use their note cards easily. All three questions showed improvements with question three going from a 2.4 average and a 1.7 standard deviation to a 1.5 average and a 0.8 standard deviation. Question four started at a mean score of 2.4 also but a standard deviation of 1.5 and then ended with a mean score also of 1.5 and a standard deviation of 0.7. Question number five started with a 2.2 mean and a standard deviation of 1.5 and finished with a 1.4 mean and a 0.7 standard deviation. What these numbers showed is that the students used their note cards, and that the use of these note cards helped them become more comfortable with the directions and instructions in their textbook as well as helping them do their daily lessons and homework.

When asked during the interviews what had helped them the most this year in mathematics the first and most vocal response on each interview was the note cards. During the April 16th interview students were asked what study skills they had learned in math this year that they felt they would continue to do next year. The responses were “notes” and “note cards”. In my journal I noted a conversation that I had had with the students about their note taking. I asked who started the year out taking notes in math; not a single hand was raised. Then I asked who would take notes of some type next year; all but one raised their hands. I asked what helped them realize that notes were important, and all agreed the note cards helped them realize how to write and use their notes for their studies. The note cards were started as a method to slowly convince students of the importance of note taking and for them to study and learn the mathematics. While the note cards did not help directly with the learning and use of the mathematical language, it

definitely was a help for the students in their daily lessons. When asked in the March 1st interview what study skills the students had learned in math during the year that they felt they would continue to do next year, one student's response stated what I was trying to teach them all year; "I learned that it is actually possible to study for math. I never thought you could. I realize you can study for it."

Question six dealt with students reading the textbook examples before coming to class the next day; however, I was unable to get that part of the project implemented, and so it is not a very useful question. Number seven dealt directly with what this research project was trying to answer. Did the students' skills of being able to read and understand the math vocabulary in their textbook improve? The initial survey scored an average of 2.7 and a standard deviation of 1.1. In the end the mean was 1.5 and the standard deviation of 0.7. This was a marked improvement. Students felt better able to read the vocabulary in their textbook after the research than before. A similar question asked why learning the vocabulary and understanding what the words in the textbook mean are important. A few responses at first included, "I think it can be important, but it doesn't help me that much." In a second survey the same student said, "I now believe they are important because when your [sic] reading the lesson you need to know what they are talking about otherwise your [sic] clueless on what to do on the lesson." This same student in the last survey stated, "I do think it's important because when your [sic] reading your lesson you need to know what to do."

The last question on the survey asked if using the math vocabulary words in class helped the students better understand the meaning of the vocabulary words. Students' responses began with a 2.8 average and a standard deviation of 0.9. They ended with a mean of 1.6 and a standard deviation of 0.7. This again is a great improvement. When asked during the April 16th interview

why it is important to use the vocabulary words one sees in math when speaking or discussing the mathematics, two responses were, “It helps you remember it better,” and “To better understand it more.” Another stated, “It helps to understand directions on tests and on assignments.” Students seemed to realize that using the vocabulary on a daily basis did help them to better understand the vocabulary’s meaning and to be able to comprehend the directions they faced daily.

Students’ note cards were handed in and scored for completeness, organization, legibility, student expansions, accuracy and finally overall use. On a scoring rubric, students could get a score ranging from a zero for not doing the note cards up to a three. The overall average of the students’ rubric scores the first time was a 1.9. Three students did not hand in note cards, resulting in three zeros. The average on the second set of note cards improved mainly because two of those same three this time did do their note cards. The average was 2.4 for the entire class. The third time two people did not turn in note cards, and the average was 2.2. The last and final rubric score was a 2.5, with only one student failing to hand in note cards. Understanding that the zeroes made a big difference in the average, I recalculated the data eliminating those who did not turn in any note cards. The starting note card rubric average was then a 2.7, and the ending average was a 2.8, not a large improvement. I attributed this to several reasons. The first was that we had started using the note cards earlier in the year, and because of this, we had several months of practice trying to improve note taking skills. By the time we actually started the research, the students’ note taking skills had already greatly improved and they were comfortable with the process. I also think a four-point rubric may have given me a greater change in averages to see better improvements in their skills.

Test and quiz scores showed no improvement and sometimes showed a decrease in students' scores instead. Again, I attribute this to the fact that the note cards were already in place before research was started, and so improvement may have already taken place. Also the lack of improvement could be related to the change in subject matter between chapters. One chapter could be more difficult than another, and usually as one progresses through the book the material becomes more complicated as well.

Student interviews were helpful to hear what the students were thinking at that particular time in the research. I found students were more expressive in their views when collected verbally rather than in written form. The first survey helped me realize that the note cards were beneficial for the students to learn and understand their homework, but were not helping them learn the vocabulary. Most comments on the survey related to the students not being able to understand the directions in their textbooks and not knowing the vocabulary as well. When asked if the students understood the math book directions in their lessons, students stated, "I don't understand it unless she (the teacher) uses different words," and "If I look at it first, I don't understand it." I decided to improve my efforts on teaching the vocabulary and push the use of the words more. When asked the same questions later, students showed little improvement on being able to read the directions. The survey results were difficult to analyze because it was not the same students taking the survey each time, and there were only a few students taking each survey. In addition, the second interview was only half recorded. The comments were usually short because students did not want to take the time to complete the survey. This was vocalized to me several times. I would have liked to have changed my questions in the middle of the survey to get more complete answers, but I knew I could not.

What does the data have to say about the research questions? The first question was how will increased teacher and student use of written and verbal mathematical language in the classroom affect a student's comprehension and understanding of the material? As shown, the increased use of the vocabulary did make the students feel that they could comprehend and understand the material better. While test scores may not have shown it, being in the classroom and hearing their responses using correct terminology showed me that they understood the material. What effect can student-made flash cards have in the translation and understanding of the mathematical language? The flash cards made little if any difference in the translation and understanding of the mathematical language. What they did do was help teach the students how to take notes, study their notes and use their notes for their assignments and review. While the note cards did not do what I had initially planned for them to do, I know that they greatly helped the students by the many positive comments voiced by the students.

How does the student's understanding of mathematical language affect their ability to do mathematics? The test and quiz scores did not show an increase in mathematical skills, but the surveys and interviews showed that the students felt more comfortable with the language found in their mathematics textbook and feel better able to read and understand the directions as well. I know that my being able to explain the words using the correct terminology and having the students then be able to follow and contribute to a classroom conversation also makes a bit difference.

Conclusions

My findings show that note cards are useful for some students to help train them for taking mathematical notes. Some students find note cards less cumbersome than regular paper and find them to be a great benefit for their daily homework. My findings also show that students

feel more comfortable with mathematics vocabulary when they can use and understand it. Students are frustrated by the complicated words in their textbook and, unless given a way to filter through them, will often ignore the words completely and wait for the teacher to help. Students feel more confident about mathematics when they are comfortable with the vocabulary, and one way to make them more comfortable is by helping them learn the mathematical language they face daily.

As shown in my findings, mathematical language is not something students naturally understand. As previously stated, “Mathematics truly is a foreign language for many students; it is learned almost entirely at school and is not spoken at home. Mathematics is not a ‘first’ language; that is, it does not originate as a spoken language” (Kenney, Hancewicz, Heuer, Metsisto, & Tuttle, 2005, chap. 1, para. 6). Taking the time to use the vocabulary on a daily basis, both for students and the teacher, is a key ingredient to making the language an understandable one. Learning to use the vocabulary correctly is imperative for students to be able to communicate with the teacher as well as to be able to understand the lessons in the book. If students cannot use the words in conversation, they will not fully understand what the meaning is behind the words and will not fully grasp the lesson. “Students and teacher need to be able to have a conversation using terms that are functional, not only for communication but for reasoning” (Lampert, 1990, p. 47).

As shown, the key to mathematical translation is understanding the vocabulary words themselves, and with that comes the total understanding of the mathematics. Without it, the students are confused and unsure what they are to do to solve the problems. “The students know how to do the math; they just don’t understand what the question is asking. I have to simplify, to reword the questions for my students, and then they can do it” (Kenney, Hancewicz, Heuer,

Metsisto, & Tuttle, 2005, chap. 2, para. 5). Students would much rather be given a light to help find their way out of the mathematical vocabulary darkness; the light is the understanding of the words through conversation and use.

Implications

As a result of my study, I plan to make several changes in my classroom next year. I will continue the practice of using note cards to start teaching my students how to take notes in a math class. It benefits those who have never taken notes before. Note cards are easy to travel with and use for reference for homework outside of class or to review for an upcoming test. I will, however, change to using bigger note cards (4 x 6) compared to the smaller size (3x5) because students could fit several examples on a card at a time, and also this would result in fewer total cards to try to read and organize per chapter. Students' study habits and daily grades have overall improved with the students using the note cards. They studied more before tests and quizzes, learned and understood the material more than those in my class that chose not to use note cards. After students are comfortable taking notes in this way, I will try to graduate them to a notebook/paper approach later on in the year. I would continue to have students hand in their notes as a graded requirement; otherwise, I know that many would choose not to participate.

I know that next year I will continue to push learning and using the mathematical vocabulary words found in the students' textbook and lessons on a daily basis. Vocalizing the mathematical terminology helped students learn the material, and as a result they were able to translate the directions in their textbook and on tests with less effort. As a result, I will increase the quantity of vocabulary words I put on chapter tests and quizzes for my students or will have short separate quizzes on the material. Adding vocabulary words to tests stresses the importance of understanding math terminology to the students. I also sense that it made my students feel

"smart" using the vocabulary words in daily conversation, thereby increasing confidence in the material.

My school system is beginning a new school improvement cycle. The main focus will be reading across the curriculum, with a stress on vocabulary. This will tie into my plans for next year very well. I plan to serve on the committee representing the mathematics department and plan to share my action research with the teachers in my school. I feel it would benefit not only the upper level teachers, but the lower level ones as well. The philosophy behind my research could also stretch into other academic areas. The key is finding ways for students to learn and use the vocabulary they need and use on a daily basis.

I used to "dummy down" the vocabulary words for students thinking I was "doing them a favor." Instead, I was doing them a disservice. Now I realize I am doing them a greater favor if I require them to learn the mathematical terminology and use it regularly. Those vocabulary words are the expressions they are going to *see* in the future. Those are the words they will have to *read* and *understand* in the future. Those are the words they are going to *use* in the future; not my "dummy down" words. By using the proper words and terminology I am teaching them another skill just as important as the actual mathematics. I am teaching them to read and understand the terminology of mathematics.

References

Adams, T. L. (2003). Reading mathematics: More than words can say. *The Reading Teacher, 56*(8), 786-795.

Adetula, L. O. (1990). Language factor: Does it affect children's performance on word problems? *Educational Studies in Mathematics, 21*(4), 351-365.

Barton, M. L., & Heidema, C. (2002). *Teaching reading in mathematics* (2nd ed.). Aurora, Colorado: Mid-continent Research for Education and Learning.

Borasi, R., Siegel, M., Fonzi, J., & Smith, C. F. (1998). Using transactional reading strategies to support sense-making and discussion in mathematics classrooms: An exploratory study. *Journal for Research in Mathematics Education, 29*(3), 275-305.

Brown, A. L. (1988). Motivation to learn and understand: On taking charge of one's own learning. *Cognition and Instruction, 5*(4), 311-321.

Clark, D. J., Waywood, A., & Stephens, M. (1993). Probing the structure of mathematical writing. *Education Studies in Mathematics, 25*(3), 235-250.

Lampert, M. (1990). When the problem is not the question and the solution is not the answer: Mathematical knowing and teaching. *American Educational Research Journal, 27*(1), 29-63.

Kenney, J. M., Hancewicz, E., Heuer, L., Metsisto, D. & Tuttle, C. L. (2005). Mathematics as language. *In Literacy strategies for improving mathematics instruction* (chap. 1). Assn for Supervision & Curriculum.

Kenney, J. M., Hancewicz, E., Heuer, L., Metsisto, D. & Tuttle, C. L. (2005). Reading in the mathematics classroom. *In Literacy strategies for improving mathematics instruction* (chap. 2). Assn for Supervision & Curriculum.

Siegel, M., Borasi, R., & Fonzi, J. (1998). Supporting students' mathematical inquiries through reading. *Journal for Research in Mathematics Education, 29*(4), 378-414.

Siegel, M., & Fonzi, J. M. (1995.). The practice of reading in an inquiry-oriented mathematics class. *Reading Research Quarterly, 30*(4), 632-673.

Venne, G. (1989). High-school students write about math. *The English Journal, 78*(1), 64-66.

Appendix A

Student Interview Questions

Student interviews will be focused on a subset of these questions. Students can expand or explain their answers to each question.

1. How much time on average do you spend looking at the book examples? (per day)
2. Does it help you to learn math by reading through the examples?
3. Does it help you to learn math by having the teacher explain the examples to you?
4. Does it help you to learn math by taking notes or using your note cards?
5. Does it help you to learn math by understanding what the book is asking you to do in its directions?
6. Which of the above 4 methods have helped you the greatest? The least? And why.
7. Do you understand the math book directions in your lessons? Why or why not?
8. Why is it important to know the meanings of vocabulary words you see in math?
9. Why is it important to use the vocabulary words you see in math when speaking or discussing the mathematics?
10. When reading the directions or working a word problem, do you think you know the meaning of most of the vocabulary words in each problem?
11. Has your attitude about math changed during your (8^{th} or 9^{th}) grade year?
12. What has helped you the most this year in mathematics? The least?
13. What makes math easy or difficult for you?
14. What do you like best about math? What do you like least about math?
15. What study skills have you learned in math this year that you feel you will continue to use next year?
16. Is there anything you want to know from me?
17. Is there anything else I should know about you to better understand your views in math or your general math experience?

Appendix B

Student Survey

Please give your honest response to each statement.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I can read and understand the majority of instructions/directions found in my math textbook	1	2	3	4	5
2. I can reword the majority of math instructions or directions in my textbook into my own words	1	2	3	4	5
3. The note cards help me better understand the instructions/directions in my textbook	1	2	3	4	5
4. The note cards help me better understand what I am to do on my math lessons	1	2	3	4	5
5. I can find and use my note cards easily.	1	2	3	4	5
6. Reading over the lesson before we discuss it helps me understand the lesson better.	1	2	3	4	5
7. My skills of being able to read and understand the math vocabulary in my textbook has improved this year.	1	2	3	4	5
8. Using math vocabulary words in class helps me better to understand their meaning	1	2	3	4	5

Please answer the following questions.

9. Do you think you will use note cards again next year in math? Why or why not?

10. Do you use the examples in your book to help you understand your lessons? Why or why not?

11. Do you think that learning the vocabulary and understanding what the words in the textbook mean are important? Why or why not?

Appendix C

Note Card Rubric

Student: _____ Date: _____

	Beginning/Progressing (1pt)	Proficient (2pts)	Advanced (3 pts)	Points
Accurate amount of cards	Has few if any of the note cards done for the chapter	Has around half of the note cards for the chapter	Has almost all or all of the note cards done for the chapter	
Organization	Note cards are unorganized	Note cards show some organization	Note cards are organized	
Legibility	Note cards are hard to read and understand	Note cards can be understood with some effort	Note cards are easy to read and understand	
Student expansions	Students copied exactly from book or teacher, no added information	Student added some information on their own	Student reworded and added extra information on their own	
Accuracy	Several of the student's note cards are not accurate or have mistakes	Student's note cards have a few minor mistakes	Little or no math mistakes on the note cards	
Over all use	Note cards are overall unusable	Note cards could be used with some effort	Note cards are easy to use	
			Total Points	

Appendix D

Guidelines for keeping my weekly journal:

- Each day, I will take 60 seconds and jot down notes of possible things I can write about, related to my research questions (e.g. one student, one math problem, one conversation).

- I will type up my journals on either Wednesday or Thursday after school each week. I will write for approximately 30 minutes per week; 15 minutes on describing the 1-2 events, and then 15 minutes writing the reflection.

- All questions below have to do with my action research of students learning to read, translate, and understand the mathematical text found in their lessons. One method of doing so is the use of note cards.

- *Reminder to self* respond to 1-2 of the questions below. This writing should be part description of the event and part reflection on why I chose this event, how it relates to my research question(s), and what it means to me.

Journaling Reflection Questions

1. Describe two incidents that happened the last week having to do with my action research and how they relate to my action research.

2. What changes (good or bad) have I seen in my students this week having to do with my action research? (e.g. note card use, translating skills, study habits, comments overheard)

3. What surprised me this week or happened that I was not expecting related to my problem of practice (good or bad)?

4. What went really well this week, related to my problem of practice, and why I feel it did?

5. What did not work very well this week, related to my problem of practice, and why don't I feel it did?

6. Any thoughts/plans to try anything new or change things a bit next week based on what has occurred already in my action research?

7. Overall thoughts/feelings/frustrations on how the research is going; do I feel I am succeeding at having the students learn and understand the mathematical text found in their books?