Incorporating Vocabulary into Math to Support Student Comprehension

by
Kasey Gharet
August 2007

A thesis submitted to the Department of Education and Human Development of the State University of New York College at Brockport in partial fulfillment of the requirements for the degree of Master of Science in Education

Incorporating Vocabulary into Math to Support Student Comprehension

by

Kasey Gharet

APPROVED BY:

Betsy Ann Balzano — Advisor — 7/17/07 — Date

Linda Kramer-Schlosser — Second Reader — 7/17/07 — Date

[illegible] — Director, Graduate Programs — 7-18-07 — Date

Table of Contents

Tables

Abstract

The purpose of this research was to find out if incorporating vocabulary into math improved student comprehension of mathematical concepts. The researcher used several instructional strategies to incorporate vocabulary directly into the math curriculum in an urban school. Data was collected from a focus group as well as the whole class. Observation checklists and math manipulative bags were used to collect data from the focus group. A vocabulary pre and post-test, weekly math quizzes, and a math pre and post-test were used to collect data from the whole group.

The results of this research support that the incorporation of math vocabulary into the mathematics curriculum increases students' comprehension of mathematical concepts. Student verbal use of these words increased, as well as their test scores.

CHAPTER 1

Introduction

Significance of the Problem

This research seeks to identify the effectiveness of integrating vocabulary into the third grade math curriculum through direct instruction on a daily basis. The term effectiveness in this study will be measured by student capability to use the vocabulary words in proper context in everyday math discussion, and by whether the proper use of vocabulary will help students understand mathematical concepts better and therefore, help them achieve. This study will seek to determine whether the direct teaching and repetition of mathematical vocabulary promotes comprehension as measured by student test scores.

Purpose of the Study

How does incorporating vocabulary into math through the use of direct instruction support student comprehension?

Rationale

Research done for this study was conducted during the 2006-2007 school year in an urban elementary school. The researcher was a graduate student completing her master's degree in childhood education at the State University of New York College at Brockport. This research was done in a third grade general education class where the researcher taught approximately four hours every day under the supervision of a mentor teacher. This classroom included twenty-one students: thirteen girls and eight boys. The classroom diversity statistics were as follows: thirteen African American students, seven Hispanic students, and one Caucasian student.

The researcher's rationale for conducting the study stemmed from the problems students in the classroom had expressing themselves mathematically, which led to the students' poor understanding of mathematical concepts. In order for these particular students to be successful in mathematics, it is crucial that they understand the vocabulary that is used throughout the curriculum. Comprehending this vocabulary will enable students to gain a better understanding of mathematical concepts, as well as use vocabulary words to express themselves mathematically.

Limitations

This study was conducted in a third grade classroom in an urban elementary school. Twenty-one students participated in this study because it was incorporated into their math program. However, data was collected only on the thirteen students that returned informed consent forms. Observation checklists and use of manipulative bags was completed only on a focus group of four students. This focus group was randomly selected based on student's math levels. The results of this data are specific for this classroom only and cannot be generalized to other populations.

Definition of Terms

Investigations- a complete K-5 mathematics curriculum, developed at TERC in Cambridge, Massachusetts. It is designed to help all children understand the fundamental ideas of number and arithmetic, geometry, data, measurement and early algebra. This curriculum is implemented by many school districts throughout the country. (http://investigations.terc.edu/).

New York State Standards- Standards that are designed and used in New York state to guide curriculum planning and assessment. (http://www.emsc.nysed.gov/nysatl/standards.html).

State Math Test- The New York State Education Department has developed the *New York State Testing Program Grades 3-8* - providing schools, teachers, and parents with an additional measure by which to assess the progress students are making in achieving the learning standards.

Direct Instruction- a specific teaching style that is very effective for procedures that are typically harder for students to discover on their own. The teacher teaches the lesson to the whole class and uses questions and guided practice to check for understanding.

Effectiveness- In this study, effectiveness will be measured by student capability to use the vocabulary words in proper context in everyday math discussion.

Comprehension- In this study comprehension will be measured by students' ability to identify and correctly use the taught vocabulary words on a weekly assessment developed by the researcher and the classroom teacher.

CHAPTER 2

Review of the Literature

Introduction

Students' poor understanding of mathematical vocabulary is a growing concern among school districts. Mathematics has its own vocabulary, a vocabulary that is essential for students to know in order to be successful in their academic achievement in math. Students' underexposure to math vocabulary delays mathematical development and understanding of mathematical concepts. The following literature review is organized into three categories: (1) why vocabulary instruction is critical, (2) mathematical comprehension and, (3) implementing vocabulary into math instruction to support student comprehension.

Vocabulary Instruction is Critical

Many children have difficulty communicating mathematically. The reason for this is that they often do not understand the language of math or perhaps were never even taught it (Green, 1995). Students' knowledge is insignificant when they are unable to recognize and understand mathematical symbols and terminology. Learning vocabulary helps children justify their thinking and sharpen their understanding of concepts and procedures (Cathcart, Pothier & Vance, 1994).

Data collected by Huggins and Maiste (1999) indicate that communication in math, with the exception of signs and symbols, has been clearly neglected. Mathematics is language, and without the knowledge of that language, students cannot develop the ability to do math (Clark-Kenschaft, 2006). Blessman and Myszczak (2001) found that students do not know the vocabulary necessary to express their ideas in mathematics.

Therefore, students cannot be expected to think mathematically if they do not understand the content vocabulary (Blanton, 1991). For example, students may be able to read the words of a math text or a math problem but not know what operation is necessary to obtain the solution to that problem, or they may be able to develop a solution but not know the proper steps that they should take to come up with that solution. For a teacher to see how well a student can think mathematically, the student must be able to explain his/her answer.

As long ago as 1957, Polya found that the very first step in solving a math problem is being able to understand that problem. Students must be able to decode and comprehend the words that are used to present that problem. Current research continues to support the importance of vocabulary instruction (Aiken, 1972; Clark-Kenschaft, 2006; Blessman & Myszczak, 2001; Blanton, 1991).

One of the significant reasons that vocabulary instruction in math is vital is because, in mathematics, directions and problems are compressed into very few words. The use of symbols further reduces the number of words in a math problem, therefore, each word or symbol becomes extremely important (Prindle, 2003). Also, it is fundamental that students understand the meanings of math vocabulary words and be able to use them in the proper context. This is important because if they are going to become capable users of mathematics, they need to comprehend the principles behind the techniques, and knowing vocabulary will help students to further their development in math (Tobias, 1987). It is also crucial to incorporate mathematical vocabulary into the curriculum because the only way that a teacher can really be certain that a student has mastered mathematical principles presented is by how well, or poorly, they solve

problems (Tobias, 1987). This leads to the failure of many students because they just do not know how to communicate effectively using words, pictures, and numbers to solve a math problem. A common vocabulary is essential for any type of successful communication in mathematics (May, 1995).

Kepner and Smith (1981) declare that math teachers have an obligation to help students acquire proficiency with words, symbols, and expressions. It is important that educators are made aware of this situation because the more words students know, the more likely they will score high on standardized math exams (Clark-Kenschaft, 2006). Furthermore, knowing language improves academic performance, and makes the whole learning experience for the students more enjoyable (Green, 1995). This is an important factor because the more students enjoy what they are doing, the more they will want to do it. In reality, these same students will be required to take courses in math throughout their educational careers, therefore, an in-depth understanding of concepts and skills is necessary.

Vocabulary instruction is critical because students have a difficult time communicating mathematically if they do not know the proper meanings of mathematical terms. It is important for teachers to incorporate vocabulary into math because without knowing the meanings of mathematical terminology, students' mathematical comprehension will be diminished. In essence, students need to internalize mathematical vocabulary so that they can apply the concepts rather than just mimic a procedure (Fletcher, 2003).

Mathematical Comprehension

Comprehension is the employment of higher level thinking to infer the meaning of a text, consider its implications, and decide on appropriate applications (Flick & Lederman, 2002). Comprehension is also a set of skills that includes decoding and concentration (Jenson, 2003). These skills are critical to successful achievement in mathematics because, in the absence of mathematical language, mathematical concepts are not developed (Lilburn & Rawson, 1994). Students do learn math through the use of language, however, they may not completely understand that language or they may not use it correctly, this therefore, will lead to being unsuccessful in math (Moyer, 2000).

It is important for teachers to understand that students cannot just piggyback off of someone else's understandings of math, they must construct that meaning for themselves. Activities that require communication allow students to construct, refine, and consolidate their understanding of mathematics (Phillips & Crespo, 1995). It is important to teach students not just to read math problems or facts for memorization, but to read math for understanding so that they can make their own meaning of it.

Students do math through the use of numbers and symbols. However, the vocabulary in mathematics is both technical and specialized. Students must be able to constantly transition between word symbols and number symbols (Barton & Heidema, 2002; Burns et al., 2002; Elliot, 1981). In mathematics, words and symbols are continuously combined and students' comprehension depends on their ability to recognize the relationship between those words and symbols (Curry, 1989). Therefore, it is critical that students understand the proper vocabulary and terms that go along with those symbols in order for them to complete problems correctly. This also goes along

with the fact that specific words, in conjunction with the numerical relationships found in word problems, are crucial in determining which operations to use (Braselton & Decker, 1994). When it comes to solving word problems, more often than not, students just read the problem; they do not habitually try to bring in different mathematical vocabulary that will help them to solve those problems. This is why it is essential for students to be able to relate the use of numbers and symbols to relevant vocabulary. A student needs to be able to fully grasp the written passage before he/she can attempt to solve the problem mathematically (Blanton, 1991). The researchers, Blessman and Myszczak (2001), indicated that the students' lack of a strong mathematical vocabulary affected their ability to convey mathematical thoughts.

Another way in which students learn math is through class or small group discussions as well as through the use of language among their peers. In fact, students enjoy discussing math with other students as well as with teachers (Artzt, 1994). Speaking and writing about mathematics problems are beneficial to students because they contribute significantly to students' understanding (LeGere, 1991). The ability to read, write, listen, think creatively, and communicate about problems will develop and deepen students' understanding of mathematics (NCTM, 1989).This is why it is so crucial for teachers to let math emerge frequently in conversations with students. If students are not using the mathematical terms in the proper context, they are hurting their mathematical knowledge as well as that of their peers.

There are many reasons that it is important for students to understand math vocabulary. Communication with peers as well as teachers, along with the understanding

of the mathematical language in relation to the concepts, is what makes it essential for students to learn mathematical vocabulary.

Implementing Vocabulary in Math Instruction to Support Student Comprehension

Patricia Clark-Kenschaft (2006) says that memorizing sums is much easier for students to do after they understand the purpose and the meaning. Therefore, educators who believe that math should just be memorization of facts need to realize that no matter the desired outcome, it is essential for students to understand math. In order to do so, it is important that teachers provide their students with the proper tools to be successful.

Research done by Blessman and Myszczak (2001) targeted 5th grade students in a rapidly growing suburban community. Their research project was designed to improve comprehension of content vocabulary in mathematics that interfered with mathematical issues and academic growth. When vocabulary words were introduced directly, the results showed that students exhibited an increase in comprehension and use of mathematical vocabulary in math performance, and in communication about math ideas. Also, research done by Fairbanks and Stahl (1986) indicated that student achievement increased by 33 percentile points when vocabulary instruction focused on specific words that were important to what students were learning.

Justine Schwarz (1999) implemented math vocabulary journals and a math vocabulary word wall in her study. The outcome was that all students who participated in the study increased their vocabulary knowledge level. Her post observation data also showed an increase in understanding and use of mathematical vocabulary in math performance tasks and in communication of mathematical issues.

Research done by Schoenberger and Liming (2001) found that improving mathematical vocabulary helped students solve multi-step problems and word problems. They also found that if students knew their vocabulary and how to communicate the mathematics effectively, their problem solving skills were improved.

Other research done in this area concluded that when vocabulary is incorporated into math, student comprehension is increased. Hackett and Wilson (1995) completed a study in which their objective was to increase student use of mathematical vocabulary through the use of speaking and writing. The target population for this study consisted of high school students in a growing, middle and upper-middle class suburban community. Based on presentation and analysis in their study, students' understanding of math and use of mathematical language was improved when more writing and vocabulary was incorporated into the math curriculum. Prior to their intervention, student interviews revealed that 67% of students used mathematical vocabulary incorrectly or not at all, 22% of students attempted to use math vocabulary while speaking, and only 11% of students used the vocabulary correctly. After incorporating more vocabulary and writing, post-intervention data showed that only 13% of students were not using math vocabulary while speaking, 42% of students used vocabulary incorrectly, 30% of students attempted to use the vocabulary, and 15% of students used the mathematical vocabulary words correctly.

Summary

Based on research related to the relationship between vocabulary instruction and student comprehension, it appears that vocabulary instruction does have a significant effect on comprehension of mathematical concepts. By focusing on incorporating reading

and writing into math classrooms, student comprehension of mathematical concepts can be increased, they will retain mathematical information longer, and form authentic mathematical connections (Blessman & Myszczak, 2001).

CHAPTER 3

Methods and Procedures

Introduction

This study will seek to determine whether the use and repetition of mathematical vocabulary is effective in aiding student comprehension of mathematical concepts as measured by student test scores. In this study, mathematics vocabulary was integrated into the third grade math curriculum through direct instruction on a daily basis. The researcher attempted to answer the following question: How does incorporating vocabulary into math through the use of direct instruction support student comprehension?

Participants

This study was carried out in an elementary school (Grades K-6) located in an urban school district during the 2006-2007 school year. The specific subjects used for this study came from a class of twenty-one students in third grade, thirteen girls and eight boys. The classroom diversity statistics were as follows: thirteen African American students, seven Hispanic students, and one Caucasian student. The entire class benefited from this study because the vocabulary was incorporated into the curriculum. However, data was collected only on thirteen students, and on a focus group of four students. This was because parent permission to use the data that was collected was only collected from those thirteen students.

Assumptions

Prior to the study of the impact of incorporating vocabulary into math on student comprehension, the researcher had assumed some results. For example, the researcher thought that the students who were at a higher level of math would make less improvement than students at a lower level. This was because the researcher assumed that those students who worked at a higher math level already knew the proper vocabulary to support mathematical concepts since they were already successful in math. The researcher was also aware of the fact that a teacher's observation of her class versus an

outsider's observation of the same class may alter test results. This could have possibly altered test results because the researcher was more familiar with the students being studied. Also, a teacher's philosophy can change observations. To control bias in this study, data was collected from multiple sources. Research done by Blessman and Myszczak (2001), Schwarz (1999), and Schoenberger and Liming (2001) led the researcher to assume that students who participated in this study would benefit because they would become more familiar with conceptual understandings in math through the use of mathematical vocabulary.

Data Collection

This study was designed to identify the effectiveness of integrating vocabulary into the third grade math curriculum on a daily basis using direct teaching strategies. Direct teaching rather than indirect teaching was used because direct teaching is a commonly accepted way to teach new skills or concepts. Since third grade is a crucial year (multiplication, fractions, and addition are introduced) in the development of mathematical skills, it was essential for the researcher to do as much as possible to help students figure out a way that will improve their understanding of mathematical concepts.

Prior to the start of data collection, the researcher completed a review of the literature to analyze previous findings and research in the areas of mathematics and vocabulary. Permission to complete this study was given to the researcher by the schools' administration. After this was approved, a proposal was submitted to the Institutional Review Board. Upon written approval from the Institutional Review Board, parents and students were notified about the study and written permission was obtained (Appendix

A). Thirteen parents agreed that data collected could be used in this study. The researcher began to collect data and research once this was completed.

To determine which words were essential for students to know and which words would be the most beneficial for students to understand, the researcher examined the Math Investigations units that would be completed throughout the four weeks of data collection as well as previous New York State third grade math tests. Some words that were identified as being significant for students to know were multiple, factor, numerator, denominator, bar graph (title the graph, label both axis, and graph all data), estimate, and round. A math test that was used to assess the students' prior knowledge of mathematical concepts and vocabulary was administered. This same test would be given upon completion of this study to see if student's scores improved (Appendix B).

Prior to each math lesson, the researcher used a variety of direct teaching strategies to either teach or to reinforce the mathematical vocabulary for the unit. As the researcher proceeded with the lesson, these words were incorporated into class discussion. As the students completed their work, either individually or as a group, the researcher walked around to check for understanding of those particular terms. The level of understanding was through observation of student work and student discussion.

As each new vocabulary word was introduced, students made a vocabulary card. The cards included the meaning of the word as well as a picture to which students were able to connect that word. At the end of each week, students were given a math quiz (Appendix B) that tested their knowledge and comprehension of the vocabulary words that were introduced for that week.

The focus group worked individually with the researcher to work with "math manipulative bags". These bags consisted of a math problem (Appendix C) as well as a math manipulative and the students were asked to talk the researcher through the problem using mathematical vocabulary as well as the manipulative provided. Observation checklists were completed on the focus group as well (Appendix D). The researcher observed these students as they completed tasks either individually or as a group. Upon completion of the four weeks, the researcher administered the pre-test again, this time using the data as post data analysis.

Table 1- Triangulation of Data

Question	Data Source 1	Data Source 2	Data Source 3
1.Preexisting Knowledge	STAR Math Scores	Pre-test	
2. Do students use words properly?	Observation Checklist (focus group only)	Manipulative bags(focus group only)	
3. Do students understand words?	Observation checklist (focus group only)	Manipulative bags(focus group only)	Weekly Quizzes and post-test
4. Does incorporating vocabulary support student comprehension?	Post-test	Weekly quizzes	

Data Analysis

Data was analyzed thoroughly numerous times to find habitual themes and generalizations. As illustrated in the triangulation table above, data was triangulated to ensure validity and reliability. The researcher was looking for generalizations related to student understanding of vocabulary words, student use of vocabulary words in proper context, and

student comprehension of mathematical concepts after vocabulary was introduced and reinforced.

Focus Group

The focus group was made up of students who were at different math levels. The researcher chose to use a focus group in this study because it would have been very difficult to complete an observation checklist for an entire class period on each group in which the students worked. These observation checklists were carefully analyzed to determine if those students were using the words properly and to check for understanding of words. This was done through the researcher's observation on the focus group while th
(Appendix D).

The manipulative bag data collection tool was another strategy that was used only by the focus group. This was also because it was hard to have each student in the class complete four manipulative bag problems. The researcher worked one-on-one with each of the four students as they solved four different math problems while talking through them. The researcher used this to collect data based on the language that the students used to solve the given problems (Appendix C).

All Students

Students took weekly quizzes on the vocabulary that was introduced for that week. The researcher used this data to analyze if the students understood the mathematical vocabulary that was introduced. The pre-test and post-test were the most beneficial form of data collection because it showed the researcher how much the incorporation of vocabulary into math supported student comprehension and how much student achievement was increased (Appendix B).

Limitations

The study of the incorporation of vocabulary into math was conducted in a third grade classroom in an urban elementary school. There were twenty-one students involved in this study but data was collected only on thirteen and observation checklists and use of manipulative bags was completed only on four students. The results of this data are specific for this classroom only and cannot be generalized to other populations.

CHAPTER 4

Results

Introduction

How does incorporating vocabulary into math lessons using direct instruction support student comprehension? The researcher examined four main areas relevant to the incorporation of vocabulary into math: students' preexisting knowledge of math vocabulary, students' use of math vocabulary, students' understanding of vocabulary, and the incorporation of vocabulary in math lessons to support student comprehension. Data from observation checklists, pre and post tests, manipulative bags, and weekly quizzes were analyzed to uncover generalizations and draw conclusions.

Data was collected on two groups. First, a focus group, which consisted of four students, participated in the use of math manipulative bags (Appendix C). Observation checklists were completed for the focus group when they worked together in small groups (Appendix D). The remaining data was collected on the thirteen students who returned their informed consent form. Although data was collected only on these 13 students, all students took part in this study because the vocabulary was incorporated directly into the math curriculum. The scores from the students' pre and post tests, and the weekly quizzes were part of the whole group data collection.

Generalizations

Generalization 1- Weekly direct instruction on math vocabulary enabled all focus group students to use words properly during small group discussion and when problem solving.

Approximately 3-4 words were introduced to the class each week and they were incorporated into thirty-five to forty-five minute math lessons each day. The words were

all introduced on the first day of the week. After direct instruction of math vocabulary into the mathematics curriculum, all students in the focus group were able to use words properly during small group discussion and throughout the problem solving process. During five, thirty minute observations of the focus group, the researcher collected the following data:

Table 2- Observation Checklist Data

	Student X	Student D	Student M	Student W
Uses terms in small group discussion	39 times	42 times	32 times	34 times
Uses terms in proper context	37 times	39 times	22 times	31 times
Work in groups reflects he/she knows meanings	Yes 5/5	Yes 4/5	Yes 3/5	Yes 5/5
Can communicate the definition	Yes 5/5	Yes 5/5	Yes 3/5	Yes 4/5
Can explain the definition to peers	Yes 5/5	Yes 5/5	No 0/5	Yes 3/5

Each student in this focus group used the vocabulary words that were reinforced in small group discussion numerous times, and the majority of the time, the students used the vocabulary words in proper context. Two out of four students completed work that reflected that they knew the meaning of the vocabulary words during all five observations. One out of the four completed work that reflected that he/she understood the terms four out of five times. Finally, one out of four students completed work that reflected that he/she knew the meanings of the words three out of five times.

Based on the data collected, the majority of the focus group was able to communicate the definition of the vocabulary words orally. Also, for the most part, the

focus group was able to explain the meaning of those words to their peers. Only one student was not able to explain the definition to classmates. Overall, the more that vocabulary was reinforced, the more students used words in proper context, were able to communicate definitions, and were able to explain those definitions to peers.

Generalization 2- Brief direct instruction of vocabulary followed by a 10 minute drill, increases the number of math vocabulary words that students retain.

Students in this study exhibited an increase in word retention and concept development in the area of math when math vocabulary words were introduced and integrated directly into the math curriculum. Students were given weekly quizzes based on the focused vocabulary words for the week. Also, students were given a math vocabulary quiz prior to the direct instruction of the vocabulary as well as after this study was completed. For the most part, student scores increased after the math vocabulary was incorporated directly into the mathematics curriculum. On the post vocabulary quiz, nine students out of thirteen increased their score from the first quiz. Only one out of thirteen students' scores decreased, and three out of thirteen students scored the same on both vocabulary quizzes (See graph A in Appendix E).

The use of the math manipulative bags by the focus group proved as well that student retention increased after the integration of vocabulary into math. All four of the focus group students used the mathematical vocabulary in proper context while they were problem solving. Two out of four students used the words more than the other two, but, in general all used the words correctly (See graphs B and C in Appendix E).

Generalization 3- Incorporating vocabulary into the mathematics curriculum supports students' comprehension of mathematical concepts.

Based on the data that was collected from the weekly quizzes, the pre-test, and the post-test, the researcher concluded that incorporating vocabulary into math supported student comprehension of mathematical concepts. Almost all of the students who participated in this study increased their test score after the integration of vocabulary into math. On the overall test score, there was an 8% increase in student test scores, for part one of the test, there was a 32% increase; part two, a 37% increase; part three, a 55% increase; and for the vocabulary quiz scores, there was a 19% increase in student test scores.

Table 3- Percent Increase in Average Test Scores

Test	**Average test score Pre-test**	**Average test score Post- test**	**Percent increase**
Overall Score	70	76.6	8%
Part One	56	82	32%
Part Two	39	62	37%
Part Three	27	60	55%
Vocabulary Quiz	65.7	82	19%

* All students' scores were added together and divided by the number of students to come up with the average test scores. Then the first average test score was subtracted from the second average test score and that answer was divided by the second test score to come up with the percent increase.

Overall differences in pre and post-test scores (See graph D in Appendix E)

- Twelve out of thirteen students increased their overall test score at the end of this study.
- One student out of thirteen had the same pre-test score as the post test score.

Part one of the test - Multiple Choice- (See graph D in Appendix E)

- Twelve out of thirteen students increased their score.
- One student's score stayed the same.

Part two- Short answer (See graph D in Appendix E)

- Eight out of thirteen students increased their score.
- Four students scores decreased.
- One student's score remained the same.

Part three- Short answer (See graph D in Appendix E)

- Ten out of thirteen students increased their scores.
- One student's score decreased.
- Two students' scores remained the same.

Conclusion

There was a definite increase in students' test scores after vocabulary was incorporated directly into math over several weeks. Several different strategies were used by the researcher to effectively incorporate vocabulary into math. The use of word and picture flash cards was used, a Jeopardy game which quizzed the students on the words that they had learned was incorporated, and reinforcing the meaning as well as the use of those words were all strategies used. It is not evident that any one instructional strategy was responsible for this increase. Students responded positively to this study and their academic achievement benefited from this study.

CHAPTER 5

Implications and Recommendations

Summary and Conclusions

In this study of incorporating vocabulary into math to support students' comprehension, the researcher observed an increase in student achievement. The results of this study can be compared to that of research done by Blessman and Myszczak (2001). These researchers discovered that when vocabulary words were introduced directly, students exhibited an increase in comprehension and use of mathematical vocabulary in math performance, and in communication about math ideas. Also, research done by Fairbanks and Stahl (1986) indicated that student achievement increased by 33 percentile points when vocabulary instruction focused on specific words that were important to what students were learning. These findings supported the researcher's data that the incorporation of vocabulary into math does in fact increase student comprehension of mathematical concepts.

Implications

- Weekly direct instruction of math vocabulary enables students to use words properly during small group discussion and when problem solving.
- Brief direct instruction of vocabulary followed by a 10 minute drill increases the number of math vocabulary words that students retain.
- Students exhibit an increase in word retention and concept development in the area of math when math vocabulary words are introduced and integrated directly into the math curriculum.

- Incorporating vocabulary into the mathematics curriculum supports students' comprehension of mathematical concepts.

Recommendations

This study was in one classroom over a two month period. In order to gain a more complete understanding, additional questions should be asked.

- Do students who are at a higher math level respond differently to the incorporation of math vocabulary?
- Would it make a difference if this study was conducted in the beginning of the year rather than at the end?
- If this study began at the beginning of the school year and ended at the conclusion of the school year, how much would student comprehension of mathematical concepts increase?

References

Aiken, L.R., Jr. (1972). *Language factors in learning mathematics.* Review of Educational Research, 42, 359- 385.

Artzt, A.F. (1994). *Integrating writing and cooperative learning in the mathematics class.* Mathematics Teacher, 87. 80-85.

Barton, M.L. & Heidema, C. (2002). *Teaching Reading in Mathematics (2nd Ed.).* Aurora, CO: Mid-continent Research for Education and Learning.

Blanton, M. (1991). *Teaching Reading in the Math Classroom.* Clearing House, 64 (3), 162-165.

Blessman, J. & Myszczak, B. (2001). Mathematics Vocabulary and its Effects on Student Comprehension 2001. (Illinios: Master of Arts Action Research Project, St. Xavier University). *ERIC Database, ED455112* .

Braselton, S. & Decker, B.C. (1994). *Using graphic organizers to improve the reading of mathematics.* The Reading Teacher, 48, 276-281.

Burns, P.C., Roe, B.D. & Smith, S.H. (2002). *Teaching reading in today's elementary schools (8th Ed.).* New York: Houghton Mifflin Company.

Cathcart, W., Pothier, Y. & Vance, J. (1994). *Learning mathematics in elementary and middle schools.* Scarborough, Ontario: Allyn & Bacon Canada.

Clark-Kenschaft, P. (2005). *Math Power: How to Help Your Child Love Math Even Though You Don't.* New York: New York.

Curry, J.F. (1989). *Content Area Reading and Learning Instructional Strategies: The role of reading and writing instruction in mathematics.* Englewood Cliffs, NJ: Prentice Hall.

Elliott, P.G. (1981). *Begin reading in-service with math teachers.* Educational Leadership, 38, 412.

Fairbanks, M.M & Stahl, S.A. (1986). The effects of vocabulary instruction: A model-based meta-analysis. Review of Educational Research, 56, 72-110.

Fletcher, M. (2003). Reading to learn concepts in mathematics: An action research project. Masters Thesis, University of South Alabama.

Flick, L.B. & Lederman, N.G. (2002). *The value of teaching reading in the context of science and mathematics.* School Science and Mathematics, 102 (3), 105-106.

Green, G.W. (1995). *Helping your child to learn math.* Carol Publishing Group: New Jersey.

Hackett, K. & Wilson, T. (1995). *Improving writing and speaking skills using mathematical language.* Illinois: Master of Arts Action Research Project, St. Xavier University. Retrieved November 2006.

Jensen, E. (2003). *Student Success Secrets,* 5th edition. New York: Barron's Educational Series.

Kepner, H.S. Jr. & Smith, C.F., Jr. (1981). *Reading in the mathematics classroom.* Washington, DC: National Education Association of the United States.

LeGere, A. (1991). *Collaboration and writing in the mathematics classroom.* Mathematics Teacher, 84. 166-171.

Lilburn, P. & Rawson, P. (1994). Let's talk math: Encouraging children to explore ideas. Portsmouth, NH: Heinemann.

May, L. (1995, Nov-Dec). *Teaching math: Speaking of math.* Teaching PreK-8, 26(3), 24-25.

Mongan-Rallis, H Dr. Helen Mongan-Rallis Associate professor of education. Retrieved January 6, 2007, Web site: http://www.d.umn.edu/~hrallis/

Moyer, P. (2000). *Communicating Mathematically, Children's Literature as a Natural Connection.* The Reading Teacher. 54, 246-255.

National Council of Teachers of Mathematics. (1989). Curriculum and Evaluation Standards for School Mathematics. Reston, VA.: Author.

New York state academy for teaching and learning. Retrieved December 14, 2006, Web site: http://www.emsc.nysed.gov/nysatl/standards.html

Philips, E. & Crespo, S. (1995). Math penpals! Developing written communication in mathematics. Paper presented at the Annual Meeting of the American Research Association, San Fransisco, CA.

Polya, G. (1957). *How to Solve It (2nd ed.).* Princeton, NJ: Princeton University Press.

Prindle, A., & Prindle, K. (2003). *Math The Easy Way, 4th edition.* New York: Barron's Educational Series.

Schoenberger, K. & Liming, L. (2001). Improving students' mathematical thinking skills through improved use of mathematics vocabulary and numerical equations. St Xavier University, Chicago, Illinois.

Schwarz, J. (Ed.). Vocabulary and its effects on mathematics instruction. (1999). Illinois: St. Xavier University & IRI/ Skylight.

Tobias, S. (1987). *Succeed With Math: Every Student's Guide to Conquering Math Anxiety.* New York: College Entrance Examination Board.

(2006). Retrieved December 14, 2006, from Investigations in number, data, and space Web site: http://investigations.terc.edu

APPENDICES

Appendix A

Dear Parent or Guardian,

This letter is to inform you that I will be collecting data in our classroom throughout the next few months. Each week, new math vocabulary words such as, estimate, round, factor, product, and axes will be introduced to the students. The data that I will collect through the use of audiotaping, student work, and observation will help me to see if introducing these words help students' comprehension of math skills and to see if there is a relationship between student progress and the introduction of these vocabulary words. Throughout this process, all of the data collected will be locked in a filing cabinet and I will be the only one looking at it. All of the students' identity will be completely confidential throughout this study. Upon completion of this, all tapes, student work, and observation notes will be destroyed. Also, the data collected will be completely confidential because I will be the only one with access to it.

By signing this form, you are giving me permission to tape your child and collect work done by them. Your child is free to not participate in this study. Also, he or she may choose not to or discontinue participation at any time with no penalty and no effect upon the child's educational experience. If you have any questions, please let me know. Thank you in advance for your cooperation.

The use of this data is for completion of my master's project for my master's degree in Education at SUNY Brockport.

Sincerely,

Kasey Gharet

Kasey Gharet
Kgha0318@brockport.edu

Dr. Betsy Balzano, Distinguished Service Professor
Education and Human Development
bbalzano@brockport.edu
395-5549

I am allowing my child to participate in Miss Gharet's data collection

_____ _____

Signature Date

Name_____

Word Bank- cross out the words as you use them

A key	Title	Denominator	Numerator
8 x 3	Words	Numbers	Ruler
Rounded	Borrow	Factors	Multiple
Estimate	Pictures	Title	Label both axes
Graph Data	Decimal	Label one axis	Graph Data
Dollar Sign	Add	Subtract	Rectangle
Cylinder	24 ÷3	Add	An Array

1. 5 x 2 = 10, what do we call the numbers 5 and 2 in this number sentence? _____

2. 6 x 6 = 36, what do we call the number 36 in this number sentence?
   _____

3. A good guess is also called an _____

4. What 3 things do you have to show me when you answer a word problem?

   1. 2. 3.

5. When you make a bar graph, what 3 things do you need?

   1. 2. 3.

6. When you make a pictograph, what 4 things do you need?

   1. 2. 3. 4.

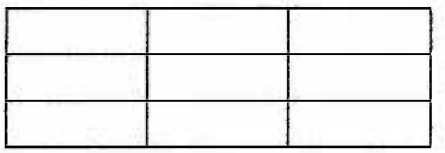
7. If this is an amount of money, 552, what 2 things am I missing?

   1. 2.

8. The word difference tells us to _____

9. The words all together tell us to _____

10. This is called what?



11. When you see the word combine, you should _____

12. Show me 24 split up into 3 groups and write the number sentence that goes with it.

13. What shape is this? 

14. What shape is this? 

15. The bottom of a fraction is the _____

16. The top of a fraction is the _____

17. Show me 8 groups of 3 and write the number sentence that goes with it.

18. What can I use to measure a pencil?

19. If I had this amount of money, $1.21, and I changed it to $1.00, what did I do?

20. If I have this subtraction problem, 56-29, what will I have to do since I can't take 9 away from 6?

Name_____

1. Put a square around the factors in this number sentence and a circle around the multiple.

   4 x 3 = 12

2. What are the factors of 24?

3. What are 5 multiples of 3?

Name_____

1. Circle the numerator in this fraction and put a square around the denominator. $\frac{1}{2}$

2. If I gave you one-half of a brownie and I gave Mary one-fourth of a brownie, did I give you both a fair share?

3. If I have 6 brown dogs and 2 gray dogs, what fraction of those dogs are gray? What fraction of the dogs are brown?

Name _____

Our class took a survey on favorite seasons.
10 people like summer best
3 people like fall best
4 people like spring best
1 person likes winter best

Make a **bar graph** showing this data. In your graph you must **title the graph, label the axes**, and **graph all of the data.**

Name _____

	Real Price	Rounded to the nearest dollar
Candy Bar	$0.90	_____
Puzzle	$2.99	_____
Sucker	$0.25	_____
YoYo	$1.05	_____
Balloons	$2.35	_____
Ice Cream Bar	$1.75	_____

You have $5.00 to spend at the store and you must spend at least $4.00. Choose from the list 3 things that you could buy. First, **round** each amount to the nearest dollar and then **estimate** what your total will be.

Appendix B6

Rochester City School District

Grade 3 Mathematics Mid-Year Foundational Assessment – 2006

Student Name_____

Date_____

Performance Level_____

Part 1		Points
Number correct		x 2 =
Part 2		
#16	Use the state rubric, this question is worth 2 points	
#17	Use the state rubric, this question is worth 2 points	
#18	Use the state rubric, this question is worth 3 points	
Part 3		
#19	Use the state rubric, this question is worth 2 points	
#20	Use the state rubric, this question is worth 3 points	
	Total Points	_____

~~1~~ Performance ~~Level~~	~~0-10~~ Raw Score
4	42-36
3	35-22
2	21-11

Directions: Pick the letter that best answers the question.

1. Mrs. Sloan's class made 5 fruit baskets to donate. They wanted to put 9 pieces of fruit in each basket. How many pieces of fruit do they need?

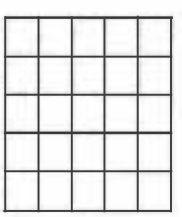
   A. 55
   B. 35
   C. 65
   D. 45

2. Carla has 24 dolls. She put them on 3 shelves in her bedroom. Each shelf has the same number of dolls. How many dolls are on each shelf?

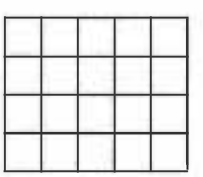
   A. 9
   B. 8
   C. 7
   D. 6

3. Tom made a rectangle that had 5 rows and 5 tiles in each row. Which rectangle did Tom make?

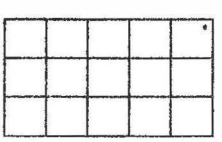
   A.

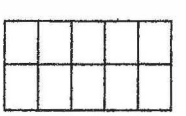
   B.

   C.

   D.

4. Dan had 51 marbles. He gave 23 away to his friend Kyle. Which number sentence can be used to find the number Dan still has?

   A. 51 x 23= ___

   B. 51 + 23= ___

   C. 51 – 23= ___

   D. 51 ÷ 23= ___

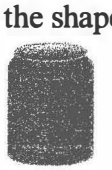
5. Mrs. Leach's students read 258 books last year. Mrs. Page's students read 317 books. How many books did they read last year?

   A. 575
   B. 465
   C. 475
   D. 565

6. Davis bowled a score of 147. Max bowled a score of 196. What is the difference in the two scores?

   A. 41
   B. 49
   C. 51
   D. 59

7. What is the shape of the can shown below?



   A. cylinder
   B. cone
   C. sphere
   D. cube

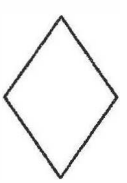
8. The school library has 48 chairs. If each table in the library has 8 chairs, how many tables are in the library?

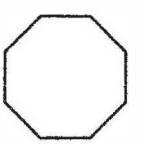
   A. 9
   B. 7
   C. 8
   D. 6

9. Which number represents two hundred eighteen?

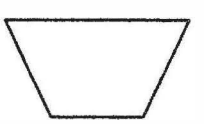
   A. 821
   B. 128
   C. 218
   D. 812

10. Which of these shapes in a hexagon?

A. 

B. 

C. 

D. 

.

11. Which of these numbers is an odd number?

   A. 52
   B. 38
   C. 79
   D. 64

12. Ellen bought 7 packs of stickers. There were 6 stickers in each pack. How many stickers did Ellen get?

A. 42
B. 54
C. 48
D. 36

13. There are 26 M&M's in a bag. Kim ate 19 of them. How many are still in the bag?

A. 6
B. 9
C. 7
D. 8

14. What number belongs in the box to make this number sentence true?

$$73 + 4 = 4 + \square$$

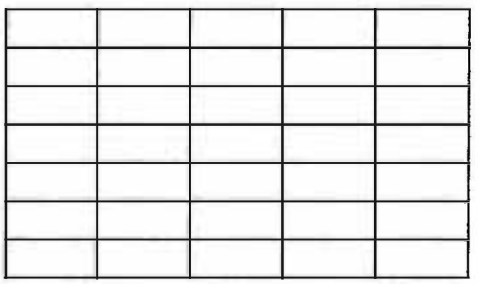
A. 77
B. 81
C. 69
D. 73

15. If one box of crayons costs $0.21, what is the cost of 4 boxes?

A. $0.84
B. $0.74
C. $0.64
D. $0.94

Part 2

16. What multiplication fact does this array show?



Use pictures, words, or numbers to explain your answer.

17. Hunter wants to show that 4 x 6 = 24.

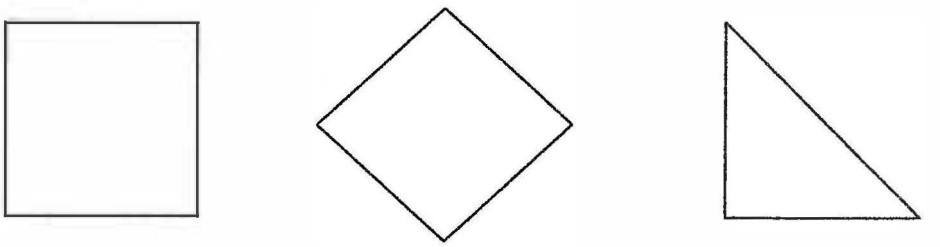
Part A.

Make a model that Hunter could use.

Part B.

Use what you know about multiplication to explain why your model is correct. Use words and/or numbers in your explanation.

18. Look at these shapes.

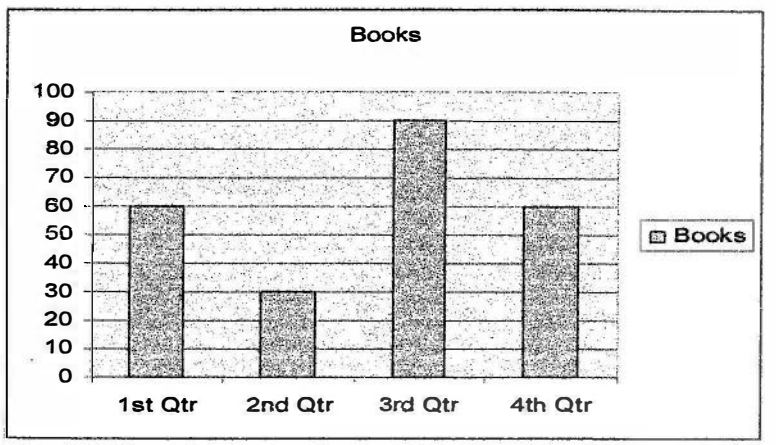


Part A.
Use two or three of these shapes to draw a design that has a pattern.

Part B.
Describe the pattern you used.

Part 3

19. This bar graph shows how many books were read by third grade students. Use the graph to answer Part A and Part B.



Part A.
In what quarter were the most books read?

_____ Books read

Part B.
What two quarters was the same amount of books read?

_____ Books read

19. John and Amanda used their rulers to measure the line segment below.

Amanda said the line segment was 5 inches long.
John said the line segment was 5 ½ inches long.

Part A.
Could both Amanda and John be correct?

_____ Answer

Part B.
Explain why your answer is correct. Use words and/or pictures in your explanation.

Explain your answer.

Appendix C

Manipulative Bag Problems

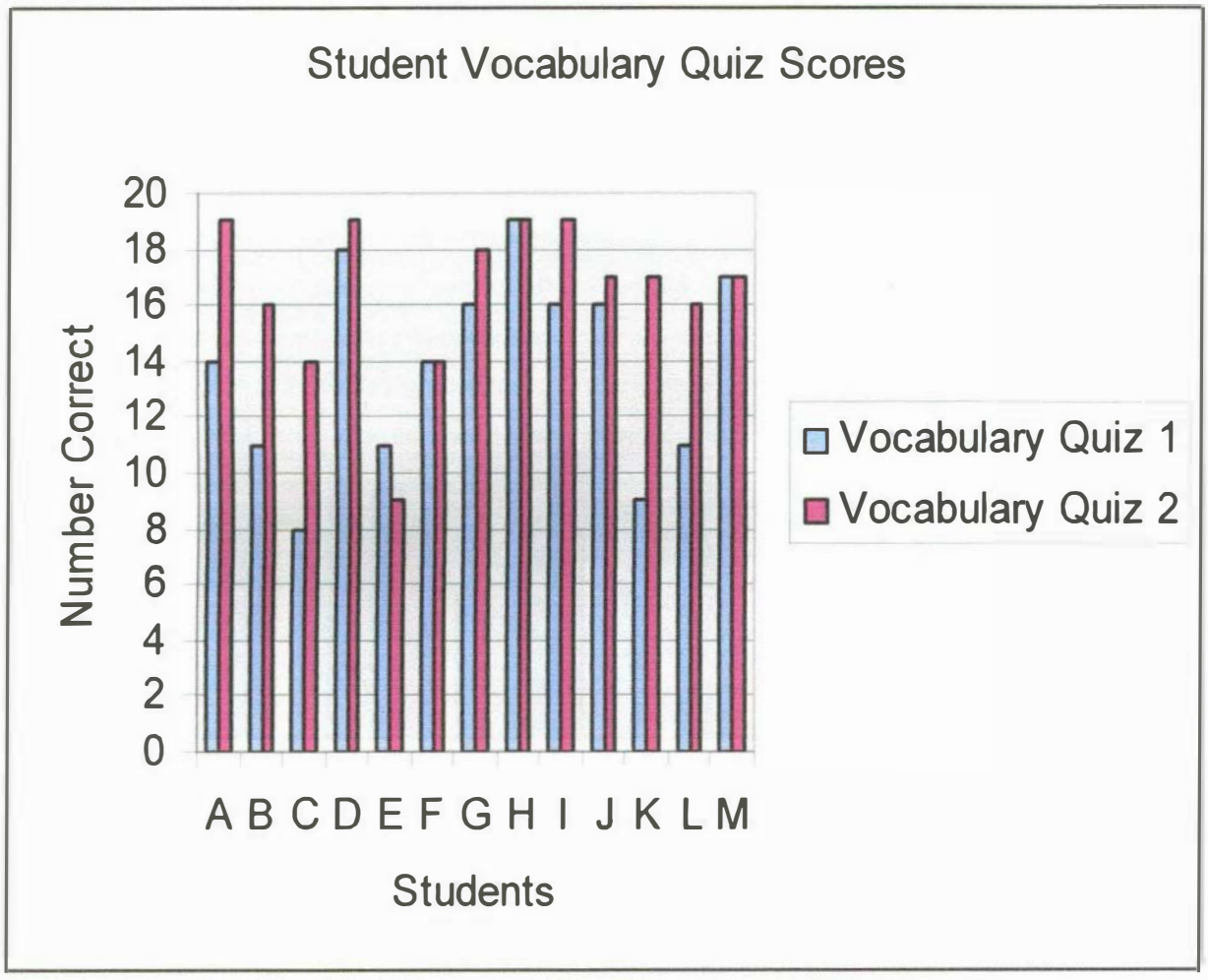
1. Use these 20 blocks to make 4 people have fair shares.
2. Use these blocks to show me 6 x 3.
3. About how many blocks do you think are in this bag?
4. Create a bar graph using the colors of these blocks.

Appendix D

Action	Student X	Student D	Student M	Student W
Student uses terms In small group discussion				
Student uses terms in proper context that reflect the meaning of those words				
Student work in groups shows evidence which reflects that he/she knows the meanings of the terms (this means that the student can use words, pictures and numbers to convey that they know HOW they came up with the answer)				
Student can communicate orally the definitions of the words				
During small group presentation, the student can explain to the class what those words mean and any strategy that they may use to remember those words.				
Additional comments				

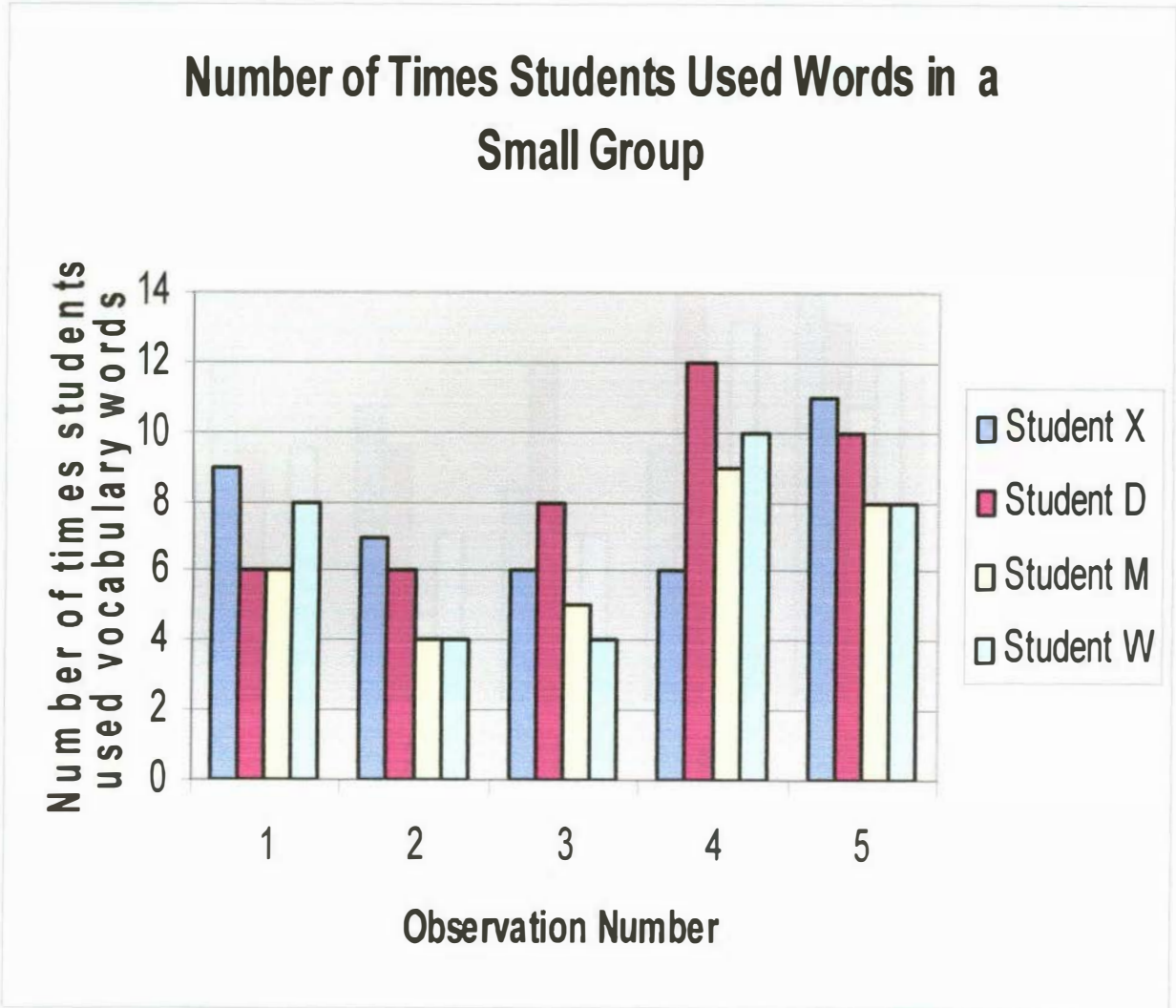
Appendix E1

GRAPH A



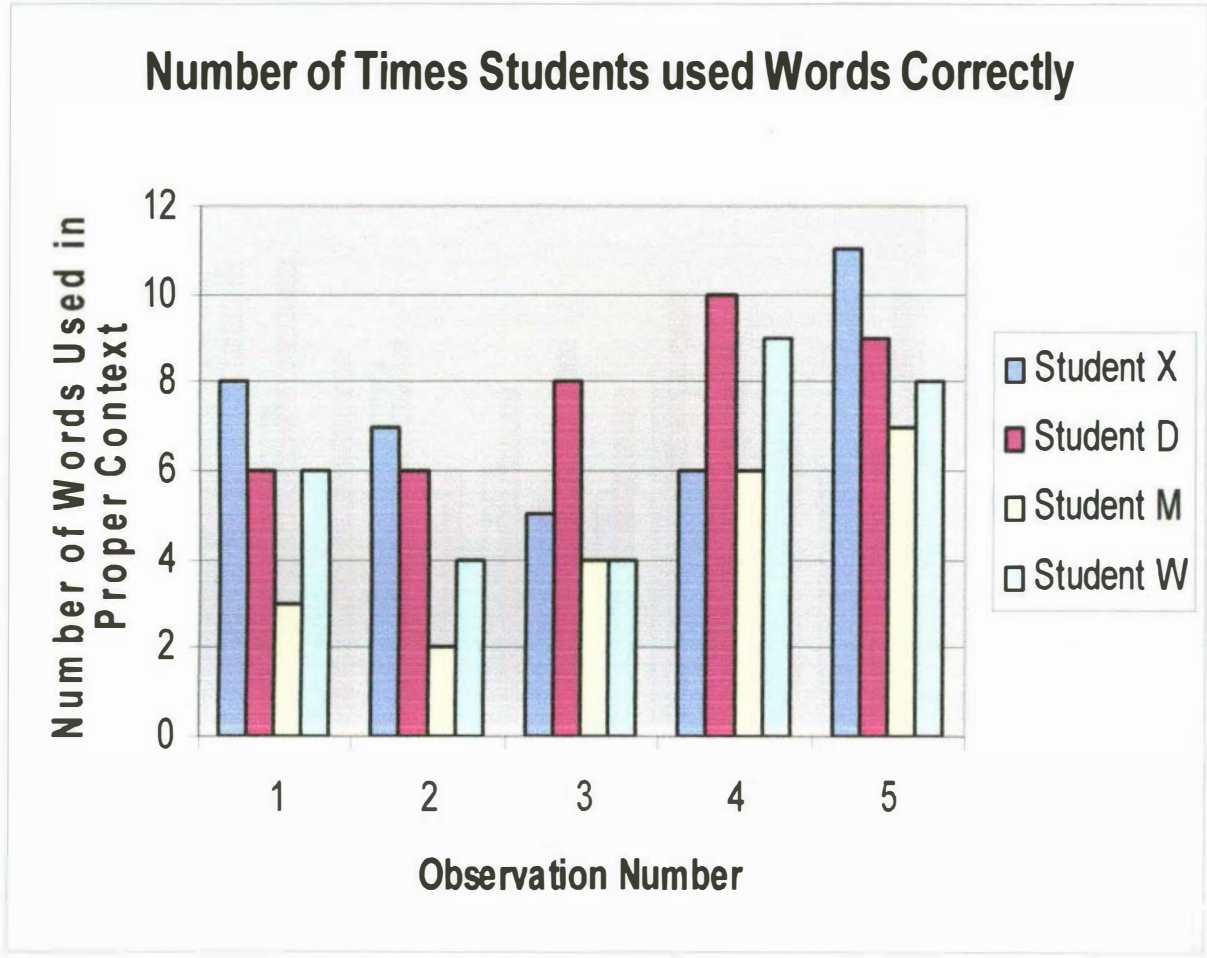
Appendix E2

GRAPH B
FOCUS GROUP



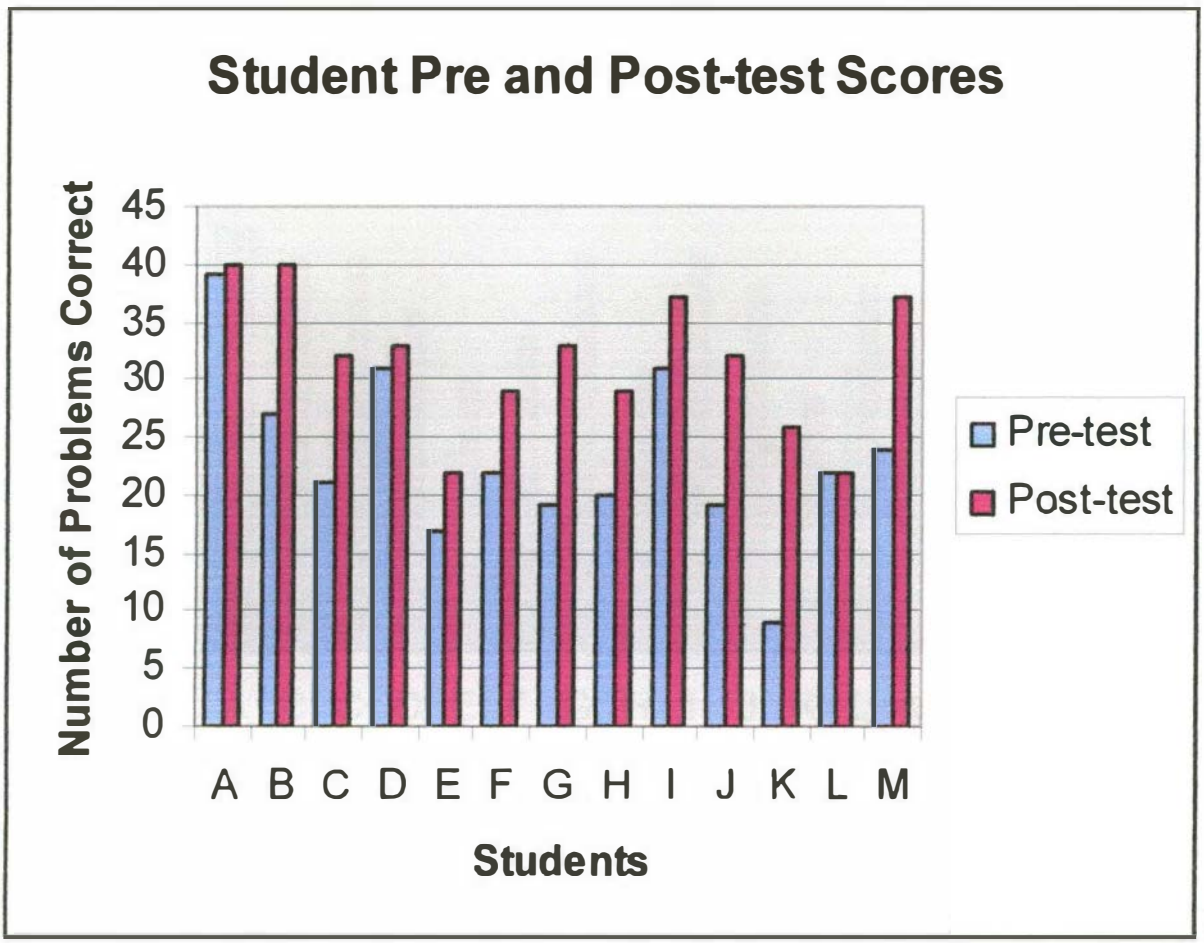
Appendix E3

GRAPH C
FOCUS GROUP



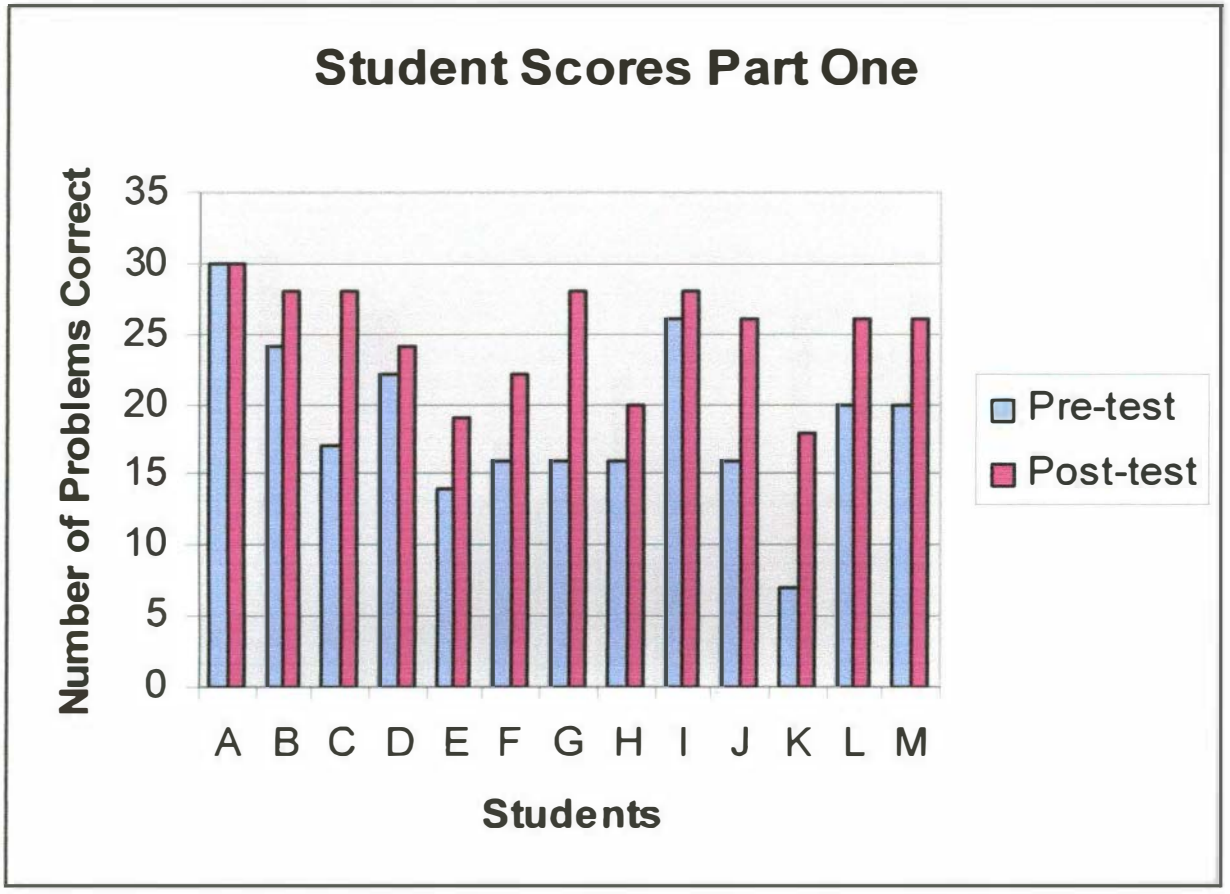
Appendix E4

GRAPH D



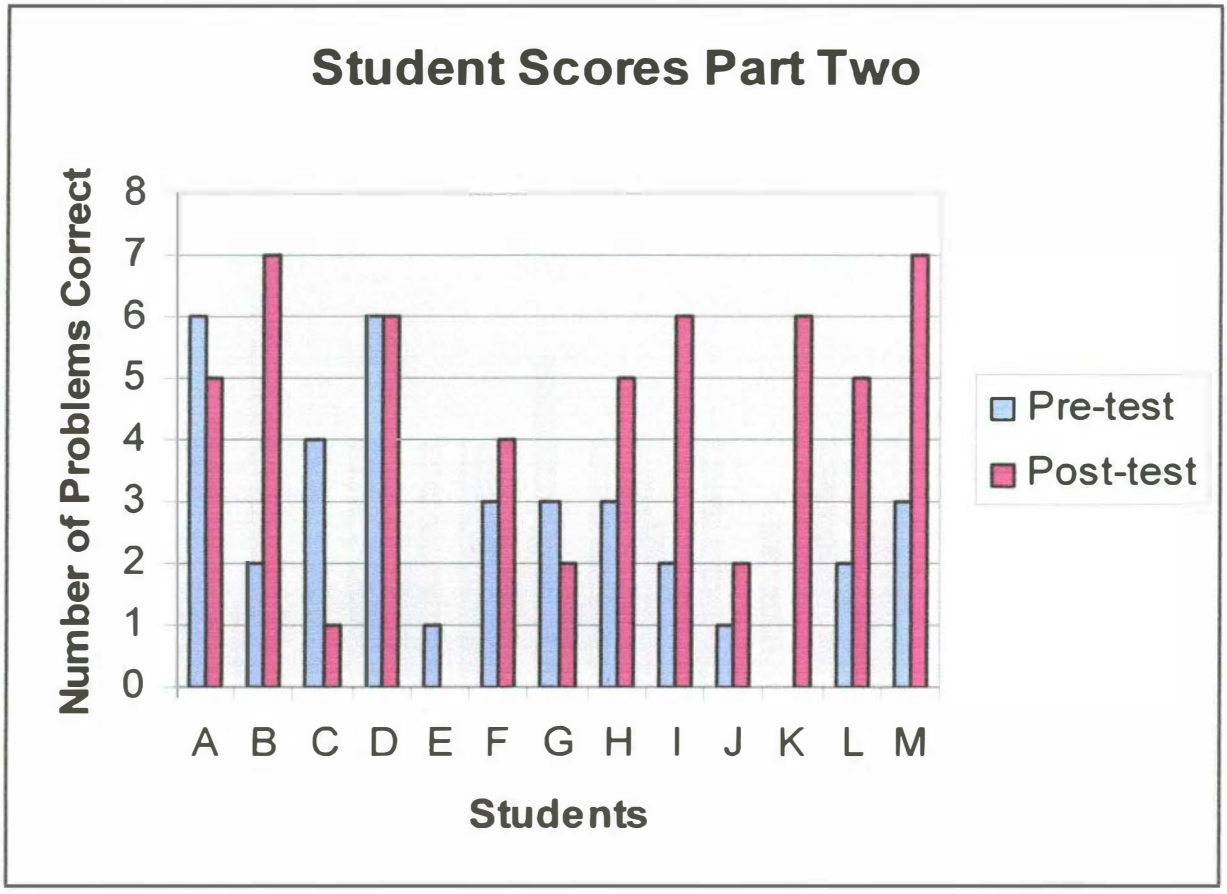
Appendix E5

GRAPH E



Appendix E6

GRAPH F



Appendix E7

GRAPH G