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Teaching Literacy Strategies in Math

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by

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Abstract

This study sought to determine the effectiveness of incorporating literacy strategies during math instruction. In distinct lessons, a class of sixteen students was given instruction in the strategies of using key words, visualization, and graphic organizers to solve word problems. The students rated the difficulty of the problems on a scale of "too easy", "just right", and "too hard" both before and after the reading strategy lessons to assess if the use of the strategy changed their perception. The test-retest with equivalent forms method of estimating reliability was used to give a measure of stability and equivalence. A matched pair analysis using the t test of significance was performed to determine if there was a significant correlation between the pre-test and the post-test after instruction in the use of comprehension strategies for solving math word problems. Triangulation of the data was used to establish the validity of the results. Each student's independently assessed reading level was examined to determine if there was a relationship between reading proficiency and the results of the mathematics assessment. Previous math assessment was examined for a correlation with current scores. The students' perception of the difficulty they experienced in their attempt to solve the word problems was analyzed for a possible correlation with their test results. Students demonstrated an increase in performance level scores for each strategy between pre-test and post-test. The second trial of visualization produced a significant change from pre-test to post-test scores. Most students preferred using visualization as a strategy to help solve mathematical word problems. Future research using a larger and more diverse student population could lead to a better understanding of the relationship between literacy strategies and mathematical reasoning.

Chapter I

Statement of the Problem

Introduction

Literacy skills are essential for success across the school curriculum. The inclusion of reading and writing skills on standardized math tests illustrates the value placed on the ability to communicate mathematical concepts effectively. The *Curriculum and Evaluation Standards for School Mathematics,* first published by The National Council of Teachers of Mathematics (NCTM) in March, 1989, and revised in 2000 includes a communication process standard that states "instructional programs from prekindergarten – grade 12 should enable all students to organize and consolidate their mathematical thinking through communication" (p.60). What role do reading strategies play in helping students communicate their mathematical thinking?

Background

This study seeks to determine whether the use of reading strategies in math class is effective in helping students become more successful mathematicians. The study was conducted in an urban elementary school consisting of 201 students in Pre-K through 4th grade. Data was collected for a specific class consisting of 16 students in 4th grade, 10 girls and six boys. One student qualified for a reduced price for lunch and the remainder of the class received free lunches. Two of the students were designated as having English as a second language (ESL). Fifteen of the sixteen students were classified as requiring

Academic Intervention Services (AIS) based on the previous year's Stanford Nine Performance Standard scores in math.

The Research Question

Does the teaching of literacy strategies in mathematics, specifically the identification and comprehension of key words, visualization of problems, and the use of graphic organizers, improve students' performance on math tests?

Method

An extensive literature review was conducted to investigate the types of literacy strategies that have been employed in the teaching of mathematics and the various degrees of success that resulted from the use of these strategies. Student cumulative records were examined to ascertain results from prior reading and math standardized tests. Current reading assessments were also utilized to determine level of reading during the experimental period.

The students were taught, in distinct lessons, the strategies of using key words, visualization, and the use of a graphic organizer to solve word problems. A statistical analysis was performed to determine if there was a significant correlation between a pre-test and a post-test. Students were asked to rate the difficulty of the problems on a scale of "easy", "just right", and "hard" before and after being taught a reading strategy to assess if the use of the strategy changed their perception of their ability to solve the problems. A final assessment for the unit was given and the word problems scored using a rubric. A statistical analysis was performed to determine if there was a significant change in test scores with the use of literacy strategies in solving math word problems. Students filled out a post survey regarding their preference for use of literacy strategies.

Limitations

This study was conducted in one fourth grade classroom in one urban elementary school. There were only 16 students involved in this study and one instructor. Of the 16 students, 15 were classified as in need of Academic Intervention Services (A.I.S.) in math, and half of the class was also classified for A.I.S. in reading. The results of this study are specific for this classroom and cannot be generalized to a larger population of students with differences in economic status, social background, instructional support, and geographical setting.

Definition of Terms

For the purpose of this study, the following definitions will be used:

- Literacy - "the ability to read and write," mathematical literacy includes "the ability to read and write with numbers"
- Key words - specific words that guide the reader to determine the organizational structure and content focus of the written text
- Visualization - the use of mental images derived from the reading of a text to assist in understanding
- Graphic organizer - a visual representation of key concepts and related terms
- Investigations in Number, Data, and Space - A K-5 mathematical program developed by TERC (formerly known as Technical Education Research Centers) and implemented in many school districts across the country.

Chapter II

Review of the Literature

Introduction

Students are expected to demonstrate literacy in mathematics. In today's ever-changing world, the ability to understand, utilize, and communicate mathematical concepts and procedures is essential for success. Educators need to be aware of the importance of their students' mathematical proficiency and provide the instruction and experiences necessary for the development of this competency.

Reading is an integral part of all content areas. The incorporation of reading into every subject is considered to be an essential component of curriculum standards. Specific reading instruction within content areas is sometimes deficient. Mathematics, as will be discussed, presents distinctive challenges to reading instruction. The development of literacy in mathematics necessitates an examination of the special requirements for reading comprehension presented by the content area. Techniques and strategies that teachers can present to their students for increasing their proficiency in mathematics also need to be determined and evaluated.

Literacy

Literacy is defined by The Oxford English Dictionary, 2nd Ed. (1989) as 1) the quality or state of being literate (i.e. educated), and 2) the ability to read and write (p.

1028). A review of the literature contains many variations of these definitions, often specifically related to a certain subject or discipline.

Literacy in mathematics is described as "numeracy," meaning the "ability with or knowledge of numbers" (The Oxford English Dictionary, 2nd Ed. 1989, p.595).The communications standards included in the NCTM Standards deal with the process of teaching and acquiring the language of mathematics. Language serves as a means to link a representation of an idea to its verbal and symbolic representation. The content of mathematics is not taught without language. Therefore literacy in mathematics includes reading, writing, and oral communication skills (Capps & Pickreign, 1993).

Reading and Comprehension

Reading is a basic characteristic of literacy. According to Baker (2001), "Reading literacy is commonly considered a linguistic process that is not a simple matter of seeing letters, decoding them, and translating them into an oral equivalent" (p. 160). Goodman (1967) describes at least three linguistic cueing systems to make meaning of text: the graphophonic (letter and sound relationships in a text), semantic (meaning), and syntactic (grammar). A fourth cueing system, the pragmatic, refers to the reader's background, his/her lifetime of experience, social expectations, and an ability and desire to comprehend a text. Harste (1994) proposed a fifth cueing system based on "semiotic theory". He stated, "To mediate our world we have created systems – art, music, dance, gesture, story, and the list goes on … The essential act of thought is symbolization. Symbols and meaning make our world" (p. 1225-1226).

The process of reading is, therefore, both constructive and shaped by multiple contexts.

Decoding and comprehension skills are both necessary for reading literacy but neither is sufficient (Helwig, et al., 1999). Skilled readers are able to direct attention to comprehension because of their ability to decode automatically. Those students that need to concentrate their skills on decoding the text will demonstrate less ability to understand what they are reading and will be less able to respond to its meaning.

Reading Comprehension in Mathematics

The goal of reading is comprehension of written text. Comprehension is the employment of higher level thinking to infer the meaning of text, consider its implications, and decide on applications (Flick & Lederman, 2002).

The reading of mathematics requires unique skills and knowledge not encountered in other content areas. Decoding skills involve not only words but also numeric and nonnumeric symbols. The convention of reading from left to right is lost when a student is reading an integer number line. Tables are read from top to bottom, bottom to top, or even diagonally. The vocabulary used in mathematics is both technical and specialized. Students must be able to constantly translate between word symbols and number symbols (Barton & Heidema, 2002; Burns, et al, 2002; Elliott, 1981).

Several comprehension skills are necessary for a successful reading of mathematic story problems. These include determining main ideas and details, seeing relationships among details, making inferences, drawing conclusions, analyzing critically, and following directions (Burns, Roe, & Smith, 2002). The organization of story problems is often unfamiliar to young students. Facts and details are usually at the beginning of the problem and the topic sentence appears at the end. Students who have been taught that the main idea is found at the beginning of a paragraph can no longer use this strategy in a math word problem. Barton & Heidema (2002) noted that the complexity of reading mathematics is also increased by its conceptual density and the intricate overlap between mathematics vocabulary and the vocabulary used in "ordinary" English. Fuentes (1998) noted that "because mathematics writing is unique with its combination of words and symbols and compact style, children not reading at grade level, or children whose primary language is not English, are often at a disadvantage" (p. 82).

Solving Mathematical Word Problems

Reading critically and thinking abstractly are skills involved in the solving of mathematical word problems. This necessitates the simultaneous use of two separate language systems, both of which require active and directed thinking. Students must learn to integrate basic reading skills and computational skills. They cannot be expected to think mathematically unless they can read the material (Blanton, 1991).

According to Polya (1957) the first step to solving a math problem is to understand the problem. For this to occur, a student must be able to comprehend the words used to present the problem. It is useless to attempt to solve a problem that is not understood in the first place. Once the problem is understood, the student can then proceed to the following steps of devising a plan for solution, carrying out the computations, and examining the obtained solution.

Earle (1976) suggests a slightly different approach to solving word problems. His first step is to read the problem quickly, without concern for the numbers, and then to try to visualize the problem. The next step is to try to understand exactly what is being asked by the problem. Once the student understands the problem, then he/she takes note of the exact numbers used, examines the relationship of the information given to the task, translates the problem into mathematical terms, completes the computations, and then reviews the results to determine if they make sense.

Metacognitive Theory

Metacognition is awareness and understanding of how one thinks. "Our goal in teaching comprehension strategies is to move readers from the tacit level of understanding to a greater awareness of how to think while reading" (Harvey & Goudvis, 2000, p.17).

According to Borkowski (1992), "Self-regulation and the motivational beliefs associated with strategy use are major components of metacognitive theory" (p. 253). Self-regulation is the control process that determines which factors surround the implementation of a task. General knowledge about the execution of a task does not necessarily imply there is subject comprehension (Cornoldi and Lucangel, 1997). For example, being able to perform the calculations required to solve a given problem correctly is different than knowing why an operation is necessary and appropriate. A student may be able to read the words of a math text or problem but not know what operation is necessary to obtain a solution to that problem. Additionally, a student who is able to recognize that his logic is incorrect has greater metacognitive abilities than one without that realization. Cornoldi and Lucangel (1997) suggest that "the assessment and teaching of metacognitive skills should have a significant space in instructional practices. Metacognition proved to be a critical variable in predicting mathematical abilities." (p. 131).

Specific Reading Strategies

The complexity and uniqueness of mathematical text presents a challenging task for the young reader. Explicit instruction in specific reading strategies gives students tools with which they can approach and analyze the content found in mathematical word problems (Montgomery County Public Schools, Maryland, 2000). A student needs to be able to understand the written passage before attempting to solve the problem mathematically (Blanton, 1991).

Key Words

"Key words" are defined as specific words that guide the reader to determine the organizational structure and content focus of the written text (Montgomery County Public Schools, Maryland, 2000). Accurate recognition of words is one of the first steps in successful reading. A student must be able to decode the words included in the passage in order to continue in the problem solving process. A word or term that is essential to a given understanding must be read successfully by every student (Earle, 1976).

The identification of key words is valuable to the comprehension skills that need to be developed. Elimination of all unnecessary components in a word problem will allow for the recognition of the words crucial to the resolution of the task. The question, "Are any of these words specific concepts or difficult vocabulary?" will inform the teacher of what terms need to be explicitly defined and explained to the students (Kress, 1984).

Braselton and Decker (1994) maintain that words such as *in all, total, left, and remain* in conjunction with the numerical relationships found in specific word problems are crucial in determining which operations to use. This study indicated that students who were taught the strategy of locating key words showed marked improvement in problem solving and that this strategy was effectively used by students of all ability levels. This finding supports the research by Fairbanks and Stahl (1986) which indicated that student achievement increased by 33 percentile points when vocabulary instruction focused on specific words that were important to what the students were learning.

Kepner and Smith (1981) assert that "mathematics teachers have an obligation to help students acquire proficiency with words, symbols, and expressions" (p. 23). A student who cannot sufficiently decode word problems is at a distinct disadvantage in comprehending and solving problems (Aiken, 1972).

Visualization

Visualization, or the use of mental images derived from the reading of a text to assist in understanding, is often utilized as a strategy to develop better comprehension of a written passage. A "dual-coding" theory of information storage was discussed by Paivio (1990). He stated that knowledge is stored in two forms, both in a linguistic mode and an imagery form. According to Marzano, Pickering, and Pollock (2001), "the more we use both systems of representation-linguistic and nonlinguistic-the better we are able to think about and recall knowledge" (p.73). Nonlinguistic representations of knowledge are generated by the drawing of pictures or pictographs (i.e., symbolic pictures). The transformation of new material into meaningful visual images of information allows students to further develop their own knowledge base (Hodges, 1992). The conversion of words into pictures allows students to clarify their thinking and "see" what they are trying to solve. Their understanding of the problem may be enhanced through visualization.

According to Harvey and Goudvis (2000), "When we visualize, we are in fact inferring, but with mental images rather than words and thoughts. Visualizing and inferring are strategies that enhance understanding…" (p. 114). By using different senses, proficient readers create images to better understand what they read. Visualization assists in the organization of ideas, creation of categories or groups, and clarification of connections. Students can be directed to read the mathematical word problem, close their eyes and create a picture in their mind, and then draw a representation of that picture on paper. The picture that was created by the student can be compared with the written information in the word problem and checked for accuracy. If the visual representation does not properly depict the written problem, then modifications can be made at this stage. Visual imagery is a strategy that has the potential for assisting students in comprehension (Hodges, 1992).

Graphic Organizers

A graphic organizer is a visual representation of key concepts and related terms. This tool helps students see relationships among ideas and shows how ideas link together. The use of this strategy combines both the knowledge of key words and ideas with visualization techniques to further increase the students' ability to comprehend meaning in the mathematical word problem. "Graphic organizers combine the linguistic mode in that they use words and phrases, and the nonlinguistic mode in that they use symbols and arrows to represent relationships" (Marzano, Pickering, & Pollock, 2001 p. 75).

Graphic organizers help develop the understanding of concepts by engaging students in their use and by placing an emphasis on a greater comprehension of the words used in the problem. The organizer serves as retrieval cues for information and makes possible the transition to a higher level of thinking (Monroe, 1997).

Braselton and Decker (1994) found that students using a graphic organizer demonstrated marked improvement in problem solving. This strategy was shown to be effective for students of all ability levels. A graphic organizer provides a more systematic approach to the analysis of story problems. Students are required to slow down and think through each problem.

The problem-solving process is illustrated through visual organization when represented graphically. "This serves to reduce a learner's cognitive processing load and make available mental resources for engaging in problem analysis and solution" (Jitendra, 2002, p.34). As an educational strategy, it is an effective tool for thinking, note taking, and learning. The graphic organizer helps students make connections, explain relationships, and elaborate on what they have learned (Barton & Heidema, 2002).

Conclusion

"Suddenly, for the student being introduced to word problems, math involves reading, determining the problem for oneself, identifying the problem's components, and developing a problem-solving plan – all new skills for the most elementary students" (Perini, Silver, & Strong, 2000, p.71). Students are often unable to solve mathematical word problems because of their inability to comprehend them.

The aim of good strategy instruction is to provide opportunities for students to personalize instruction. Different readers rely on different strategies to help them gain better understanding. The techniques may overlap and interact. Students possibly will utilize one or several skills to gain understanding and fluency. Students want to be successful, but they need to be given the tools.

Teachers must constantly be aware of opportunities to reinforce mathematical language and concepts in all subjects (Capps & Pickreign, 1993). True mathematical literacy for all students can be achieved only through a curriculum that furnishes abundant opportunities for listening, speaking, reading, and writing mathematics.

In this study, the researcher taught the reading comprehension skills of identification and comprehension of key words, visualization of problems, and the use of graphic organizers in the context of mathematics. Tests were administered before instruction in each specific strategy. Students were taught a specific skill and a post test was given. Data from these tests were analyzed to determine if an improvement in scores was observed.

Chapter III

Methodology

Introduction

The importance of reading in the content areas has been widely investigated. Reading is now recognized as a fundamental skill for the development of literacy in mathematics. The unique and complex style of text found in mathematics suggests that the teaching of specific reading comprehension strategies may help to improve students' understanding of mathematical language. This research is an attempt to answer the question: Does the teaching of specific literacy strategies for mathematics such as the identification and comprehension of key words, visualization of problems, and the use of graphic organizers improve students' performance on math tests?

Subjects

The school in which this research took place is located in an urban setting. In 2003-2004 the school serviced 201 students in Pre-K through 4th grade. The ethnic background was as follows: 119 Black, 1 Asian, 68 Hispanic, and 13 White. The poverty level of the students is reflected by the fact that 153 students received free lunches, and 17 had a reduced price for lunch. Two students were classified as homeless according to the standards of the McKinney-Vento Homeless Asst. Act. It was determined that 26 students were "Limited English Proficient" (LEP), 18 of those were a 1st time classification. The attendance rate was 91.4%. The school had 45 computers for 23 classrooms.

The specific subjects used for this study came from a class of 16 students in 4th grade, 10 girls and six boys. One student qualified for a reduced price for lunch and the remainder of the class received free lunches. Two of the students were designated as having English as a second language (ESL). Eight of the sixteen students were classified as requiring Academic Intervention Services (AIS) based on the previous year's Stanford Nine Performance Standard scores in reading. Fifteen of the sixteen students were classified as requiring Academic Intervention Services (AIS) based on the previous year's Stanford Nine Performance Standard scores in math.

Research Design

First, an extensive literature review was undertaken to examine previous research and findings in the area of reading and mathematics. Consent to conduct the study in the elementary school was then requested of, and approved by, the school's administration. After authorization was obtained, a proposal was presented to the Department of Education and Human Development for review and approval. An additional proposal regarding the human subjects involved in this study was submitted to the Institutional Review Board. Upon written approval from both the Department of Education and Human Development and the Institutional Review Board, parents were notified about the study and written permission obtained (Appendix A). The data collection and research officially began once this was completed.

The reading specialist and mathematics specialist from the school were questioned regarding previous testing and assessment of the students involved in this study. Performance Standard scores from the previous year's Stanford Nine standardized tests were obtained for both reading and mathematics.

A mathematics test involving reading word problems was administered to the students prior to any specific reading instruction (Appendix B-1). This test was part of a standard unit assessment included in the TERC Investigations curriculum. Using the rubric recommended by TERC for assessing word problems (Appendix C), a baseline proficiency score was obtained for each student.

During the following eight week period, specific reading strategies were incorporated directly into the mathematics instruction. The strategy of using "key words" was taught during two separate sessions, then the strategy of using "visualization" was taught during two distinct sessions, and finally the use of a graphic organizer (Appendix D) was integrated into two instruction periods.

Prior to instruction on solving word problems using a specific reading strategy, the students took a pre-test consisting of one word problem. The students indicated their perception of the difficulty of the problem by writing either "easy", "just right", or "too hard" on their paper. The specific reading strategy was then taught including modeling by the teacher, directed practice, and individual practice. Following the instruction, the students took a post-test which included the pre-test problem (Appendices B-2 through B-9). They again specified their opinion about the difficulty they had in solving the problem.

After the three comprehension strategies were taught, a comprehensive teacher-generated assessment was administered (Appendix B-10). The students were again asked to indicate their perception of the level of difficulty they experienced in solving the problem. They were then asked in a questionnaire if they utilized any or a combination of the reading strategies they had learned (Appendix E).

Data Analysis

All the information needed to complete this study was collected and analyzed by this researcher. There were no interrater reliability issues to address.

The assessments were based on a rubric suggested by TERC *Investigations.* All assessments were analyzed according to the same rubric.

The test-retest with equivalent forms method of estimating reliability was used to give a measure of stability and equivalence. The assessment scores were correlated and the resulting correlation coefficient determined.

Triangulation of the data was used to establish the validity of the results. Each student's independently assessed reading level was examined to determine if there was a relationship between reading proficiency and the results of the mathematics assessment. Previous math assessment was examined for a correlation with current scores. The students' perception of the difficulty they experienced in their attempt to solve the word problems was analyzed for a possible correlation with their test results.

A matched pair analysis using the t test of significance was performed to determine if there was a significant correlation between the pre-test and the post-test after instruction in the use of comprehension strategies for solving math word problems.

Summary

Students received instruction on using specific reading comprehension strategies during math class to help solve mathematical word problems. The student's ability to solve problems correctly before and after the comprehension strategy instruction was assessed using a rubric. The results were analyzed to determine if the instruction influenced the students' success in attempting to solve word problems.

Chapter IV

Findings

Introduction

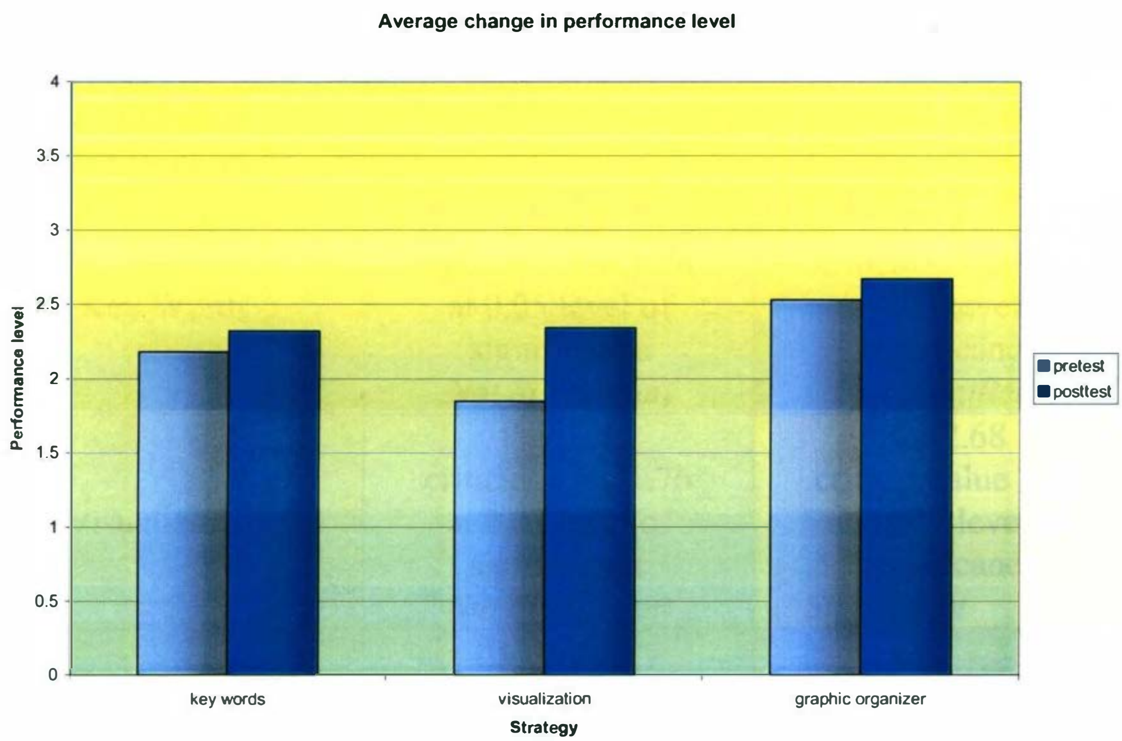
This study focused on determining the effectiveness of using literacy strategies during mathematics instruction. The specific strategies investigated included the identification and comprehension of key words, visualization of problems, and the use of graphic organizers. Scores from a TERC *Investigations* assessment administered prior to the study were compiled. TERC *Investigations* assessments and teacher-generated assessments were used during and after the study. From these, data were collected and analyzed. The following generalizations and conclusions were drawn from this analysis.

Generalizations

- *Generalization*: A significant overall increase was found between demonstrated proficiency on assessment prior to this study and assessment at the conclusion of this study.
    - A matched pair analysis using the t test of significance was performed on the difference between pre-study assessment scores and post-study assessment scores.
    - The critical value of t for df = 13 and level of significance of .05 = 2.16. The calculated value of t was 2.29. Since it is greater than 2.16, it can be said that the chance that the difference is a random result is less than 5%.

- *Generalization*: Students demonstrated an increase in performance level scores for each strategy between pre-test and post-test.
  - When the results of the first trial and second trial were averaged for each strategy, the post-test scores were higher than the pre-test scores
  - The trials using visualization showed the greatest increase.

Graph 1



  - The change in scores was significant only for the second trial of visualization. This analysis was done using two matched groups and the t-test of significance. The calculated t value of the second trial for visualization was 2.68. The critical value of t for df = 11 and level of significance of .05 = 1.80. The chance that the difference in the pre-test score and the post-test score is a random result is less than 5%. This is also confirmed at the stricter level of .025 where the critical value of t = 2.20. None of these other trials resulted in a significant outcome.

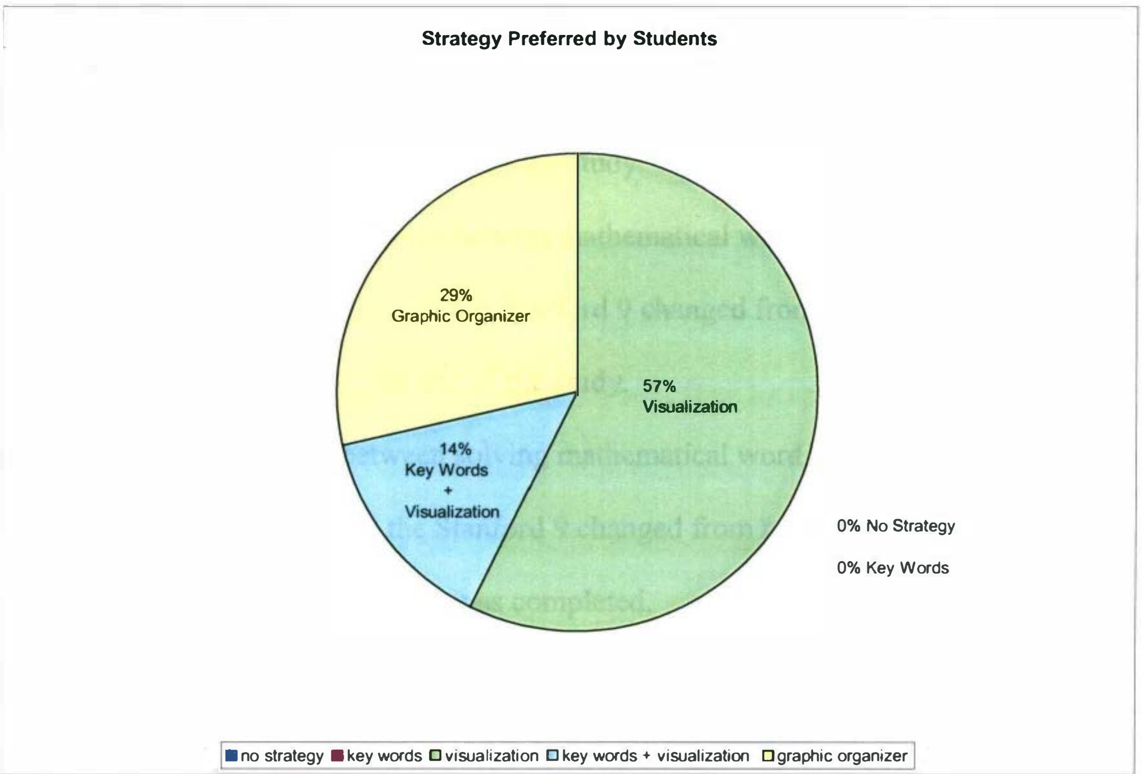
Table 1

Statistical Analysis
Change in Scores for Individual Trials

	Trial 1	Trial 2
Key Words	t = 0.5 critical value 1.76 at 0.05 level of significance *Not Significant*	t = 1.4 critical value 1.77 at 0.05 level of significance *Not Significant*
Visualization	t = 1.18 critical value 1.76 at 0.05 level of significance *Not Significant*	t = 2.68 critical value 2.20 at 0.025 level of significance *Significant*
Graphic Organizer	t = 0.53 critical value 1.76 at 0.05 level of significance *Not Significant*	t = 1.22 critical value 1.76 at 0.05 level of significance *Not Significant*

- *Generalization*: Most students preferred using visualization as a strategy to help solve mathematical word problems.
  - A survey given to students after the final assessment showed that all students used at least one type of strategy to help them solve the mathematical word problems.
  - None of the students indicated that they used only the "key words" strategy.
  - As illustrated in the following chart, 57% stated they used only visualization, 29% used only the graphic organizer, and 14% used a combination of key words and visualization.

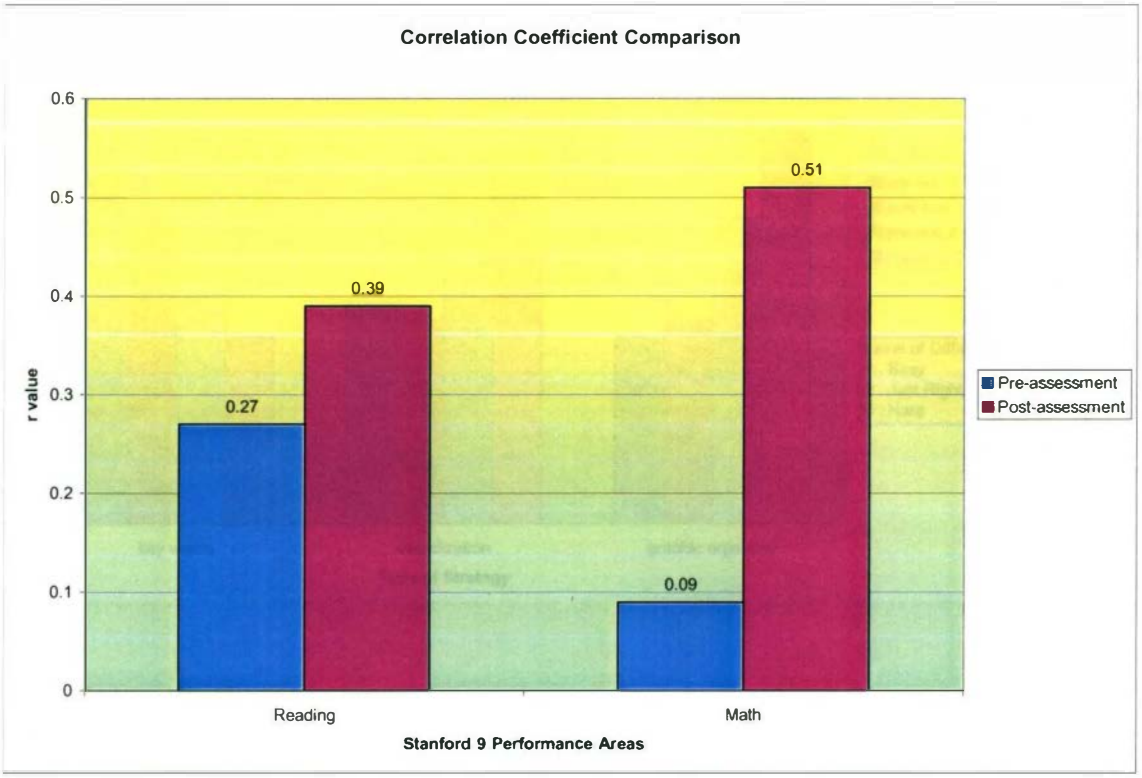
Graph 2



- Sample comments by students indicating the reasons they chose their particular strategy include:
  - "So I could do my best to get the right answer." (key words and visualization)
  - "I used it (graphic organizer) because on my last problem I didn't understand it and with the graphic organizer it was easy."
  - "I choosed to use a strategy because it would help me instead of just staying there and doing nothing." (visualization)
  - "I use key words because it helps me out. I used visualization because it is easy to work with." (key words and visualization)

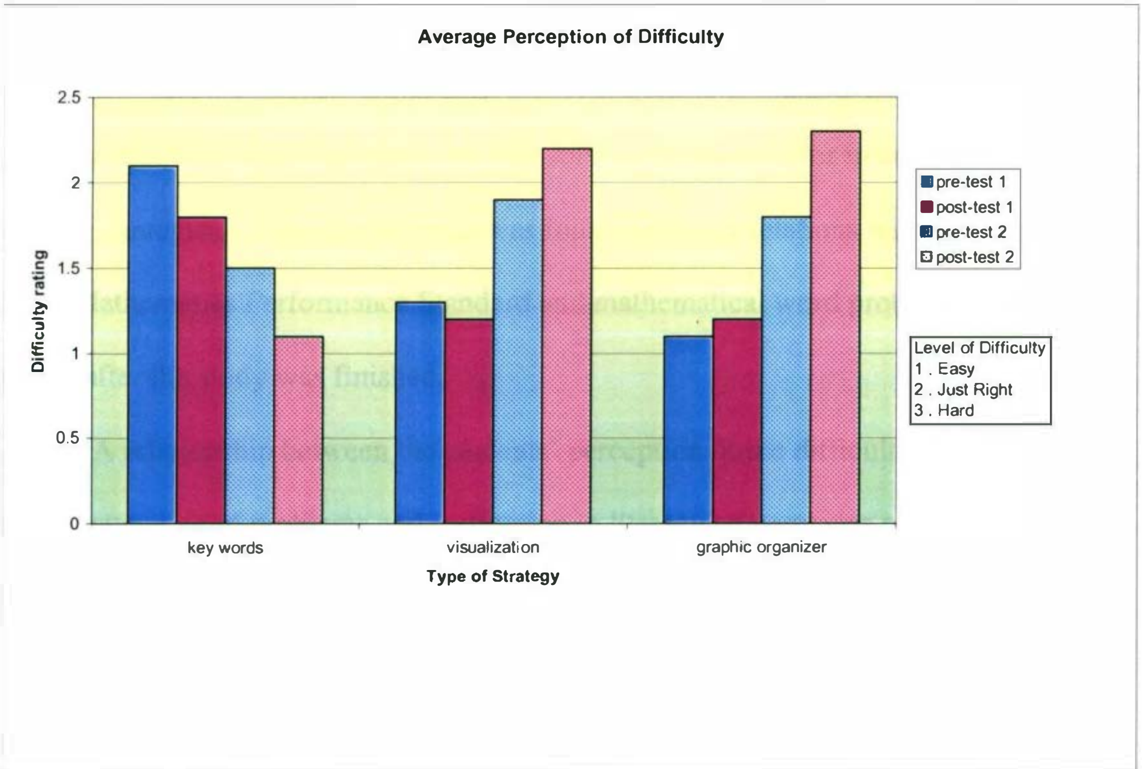
- *Generalization*: There was an increased correlation between 3rd grade Stanford 9 proficiency results and student achievement on mathematical word problem assessment seen at the completion of the study.
  - The correlation between solving mathematical word problems and the total reading score from the Stanford 9 changed from $r = .27$ prior to the study to $r = .39$ at the end of the study.
  - The correlation between solving mathematical word problems and the total math score on the Stanford 9 changed from $r = .09$ prior to the study to $r = .51$ when the study was completed.

Graph 3



- *Generalization*: No relationship could be determined between instruction in literacy strategy and students' perception of word problem difficulty.
    - Students perceived problems as less difficult as they proceeded through the key word strategy lessons, they had mixed reactions for the visualization assessments, and their perception was that the problems became more difficult as they proceeded with the graphic organizer lessons.

Graph 4



- No correlation was found between average perceived difficulty and average actual demonstrated proficiency at mathematical word problems.
- Two students stated the problems were "easy" eight out of twelve times although they scored a 1 or 2 on the assessments.

Conclusion

There was a significant increase in the demonstrated ability to solve mathematical word problems as shown in the difference between the assessment done prior to the study and the final assessment. It is not evident that any one specific literacy strategy was responsible for this increase, although scores did significantly improve after the second lesson using visualization.

The correlations between the Stanford 9 Total Reading Performance Standard and demonstrated mathematical word problem solving increased after instruction in specific literacy strategies. A greater increase was found in the correlations with the Stanford 9 Total Mathematics Performance Standard and mathematical word problem assessment scores after the study was finished.

A relationship between the students' perception of the difficulty level of the mathematical word problems and instruction in literacy strategy was not discovered. Some students indicated that the problems were "easy" even though they showed no or minimal understanding in how to solve them. Other students were fairly accurate in assessing their level of difficulty in solving the problems.

The majority of students indicated a preference for using the visualization strategy at the end of the study. As previously noted, this strategy was the only one that made a significant difference in the individual trials. All students stated they used at least one reading strategy to help them in solving the mathematical word problems.

Students respond positively to using strategies to solve mathematical word problems. Differences in ability levels and learning styles suggest teaching various types of strategies in order to meet individual needs. Continued research in this area combined with teacher education should benefit all students and increase the probability of success.

Chapter V

Implications

Introduction

The researcher collected data before, during, and after instruction of specific literacy strategies incorporated into math lessons. The purpose of collecting this data was to determine whether the identification and comprehension of key words, visualization of problems, and the use of graphic organizers improves students' performance on math tests.

Implications

- Reading comprehension is an integral component for success in solving mathematical word problems.
- The incorporation of literacy strategies into the math curriculum provides modeling and practice in using these tools to help students solve math problems.
- Providing different strategies allows students with diverse learning styles to choose the one(s) most effective for them.
- Visualization is a technique preferred by the students and has been shown to be effective. Making this strategy available for use by all students and applying it in various circumstances may improve math scores and provide further opportunity for success.

Suggestions for Future Research

- How do other reading comprehension strategies such as compare and contrast, prediction, or SQRQCQ (survey, question, reread, question, compute, and question) affect students' performance on solving mathematical word problems?
- Do students from diverse demographic populations respond differently to various literacy strategies?
- Is the effectiveness of specific literacy strategies dependent on the reading level of the students?
- Students may have experienced fatigue after doing a pre-test, an instructional lesson, and then a post-test in one sitting. Do the results of the pre-test and post-test difference vary with the student's level of engagement?
- What part does metacognition play in the ability to be successful in solving mathematical word problems?

Appendices

Appendix A

Statement of Informed Consent: Parent/Guardian

Dear Parents,

As you know, the Rochester City School District began a new math program this year called "*Investigations in Number, Data, and Space*". Your child spends around one hour every class day exploring and learning about mathematical ideas and concepts. An important part of knowing how to do math is being able to read a math problem and understand what he or she needs to figure out.

During the next several weeks, we will be teaching some reading strategies during math class and keeping track of whether these lessons help the students score better on tests that involve math word problems. This research will not change any part of the math program for your student. We will simply be looking at which reading skills may be important in understanding math.

We hope that you will give us your permission for the use of your child's work as part of this research project. Even if you give your permission, you have the option of withdrawing your child from this study at any time. Participating or not participating in this study will have no impact on your child's grade or participation in class activities. If you have any questions you may contact:

Researcher:	**Faculty Advisor**
Terri Keenan	Betsy Balzano
School #25	Dept. of Education and Human Development
(585)288-3654 (Room 132)	(585) 395-5549

Thank you for your help!

Child's Name

____

Parent Signature

____**Date**______________

Print Parent Name____

Name Date

Assessment Master 7

End-of-Unit Assessment Tasks

3. 52 students will be attending a performance in the school auditorium. Each row of the auditorium seats 8 students.

How many rows will need to be saved for these 52 students? Write an equation for the problem and solve the problem. Then show how you solved it, using pictures or words.

Appendix B-2
Key word pre-test 1

Name ______________________________ Date ____________

Show how you found your solution.

1. Chris needs to buy 300 cookies for the class party. The cookies come in bags of 25. How many bags does Chris need to buy?

This problem was EASY JUST RIGHT TOO HARD

TERC. (2004). Grade 4, Investigation 2, Session 5. Student Sheet 11, *Landmarks in the Thousands,* Scott Foresman, Cambridge MA, p.93.

Appendix B-3
Key word post-test 1

Name ________________________________ Date _____________

Show how you found your solution.

1. Chris needs to buy 300 cookies for the class party. The cookies come in bags of 25. How many bags does Chris need to buy?

2. In Kim's school, each student is on a team that does a clean-up job every week around the school. There are 4 students on each team and 240 students in the school. How many clean-up teams are there?

This problem was EASY JUST RIGHT TOO HARD

TERC. (2004). Grade 4, Investigation 2, Session 5. Student Sheet 11, *Landmarks in the Thousands*, Scott Foresman, Cambridge MA, p.93.

Appendix B-4
Key word pre- and post-test 2

Name ______________________________Date ____________

Show how you found your solution.

The fourth and fifth graders are going to the aquarium. A bus holds 40 people, and there are 360 people going on the trip. How many buses will they need?

This problem was EASY JUST RIGHT TOO HARD

TERC. (2004). Grade 4 End-of-Unit Assessment Task: Assessment Master 19, *Landmarks in the Thousands,* Scott Foresman, Cambridge MA, p.74.

Appendix B-5
Visualization pre-test 1

Name ______________________________ Date ____________

Show how you found your solution.

1. There were 18 family members going on a picnic at the park in various cars. Each car holds 5 people. How many cars will be needed?

This problem was EASY JUST RIGHT TOO HARD

Appendix B-6
Visualization post-test 1

Name ______________________________Date ____________

Show how you found your solution.

1. There were 18 family members going on a picnic at the park in various cars. Each car holds 5 people. How many cars will be needed?

2. There are 4 pies at the picnic. The pies are equally divided into fourths. If there are 8 people at the picnic, how many pieces of pie can each person have?

This problem was EASY JUST RIGHT TOO HARD

Appendix B-7
Visualization pre-test 2

Name ______________________________ Date ____________

Show how you found your solution.

1. My mom is planning her shopping for the next 28 days. She buys juice in 9-packs. If my brother and I each drink a juice every day, how many 9-packs will my mom need to buy?

This problem was EASY JUST RIGHT TOO HARD

Appendix B-8
Visualization post-test 2

Name ______________________________ Date ____________

Show how you found your solution.

1. My mom is planning her shopping for the next 28 days. She buys juice in 9-packs. If my brother and I each drink a juice every day, how many 9-packs will my mom need to buy?

2. My mom will also buy fruit cups. They come in 6-packs. I don't like them, but my brother does. How many 6-packs will she need to buy if he eats one every day?

This problem was EASY JUST RIGHT TOO HARD

Appendix B-9
Graphic organizer pre- and post-test 1

Name ______________________________Date ____________

Show how you found your solution.

There are 27 students going on a field trip to The Genesee Country Village and Museum. 4 adults are also going on the trip. 1 van holds 6 people. How many vans are needed to take everyone on the field trip?

This problem was EASY JUST RIGHT TOO HARD

Appendix B-10
Graphic organizer pre-test 2

Name ______________________________Date ____________

Show how you found your solution.

1. Five family members are making sandwiches for a picnic. How many sandwiches should each one make to feed the 18 people who are going on the picnic?

This problem was EASY JUST RIGHT TOO HARD

Appendix B-11
Graphic organizer post-test 2

Name ________________________________ Date ______________

Show how you found your solution.

1. Five family members are making sandwiches for a picnic. How many sandwiches should each one make to feed the 18 people who are going on the picnic?

2. The 18 family members who are going to the picnic want to drink lemonade. The group takes along five pitchers of lemonade. How many people should each pitcher be able to serve?

This problem was EASY JUST RIGHT TOO HARD

Appendix B-12
Final assessment

Name ______________________ Date____________

1. Jan's mother bought cans of juice packaged in groups of 6 cans each. If Jan's mother bought 3 packages, how many cans did she buy all together?

Show your work

Answer _______ cans

EASY JUST RIGHT HARD

2. Michael has 2 erasers. He has 6 more pencils than erasers. He has 2 fewer markers than pencils. How many markers does Michael have?

Show your work

Answer _______ markers

EASY JUST RIGHT HARD

Name ______________________ Date____________

3. Every morning Carolyn collects the newly laid eggs from the chickens on her family's farm. She puts the eggs in cartons that hold 12 eggs each. On Monday, Carolyn collected 29 eggs. How many ***more*** eggs does she need to completely fill her last carton?

Show your work

Answer _______ more eggs.

EASY JUST RIGHT HARD

BONUS PROBLEM

Angelo and Carlos are baking cupcakes for their 2 fourth-grade classes at school. Each class has 16 students. How many cookies should they bake to give 3 cookies to each student?

Show your work

Answer ____________cookies

EASY JUST RIGHT HARD

WORD PROBLEM RUBRIC

Advanced	• Student arrives at correct answer • Student is able to communicate in organized, clear, detailed manner his or her explanation of how problem was solved.
Proficient	• Student arrives at correct answer • Student is able to communicate in logical manner that can be easily followed how problem was solved
Nearing Proficient	• Student's answer may contain computational errors. • Student attempts to explain his or her thinking, but information is not organized or clearly presented.
Needs Improvement	• Student's work contains computational errors. • Student does not record/document his or her thinking.

Organizer 2-C

Name: ______________________________

Math Notes

The Facts

What are the facts?

What is missing?

The Steps

What steps can we take to solve the problem?

The Question

What question(s) needs to be answered?

Are there any hidden questions that need to
Be answered?

The Diagram

How can we represent the problem visually?

Now use the back of this page to solve the problem.

Appendix E

Student Questionnaire

1. Did you use any of the reading strategies we have been practicing to help you with these math problems?

a. Yes
b. No

2. Which strategy did you use? (Circle all that you used)

a. Graphic organizer
b. Visualization
c. Key words
d. I didn't use any strategy

3. If you did use a strategy, why did you choose to use it?

____
____
____

4. How do you think you did on these problems?

____
____
____

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