DOCUMENT RESUME

ED 451 481 CS 014 323

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TITLE Mathematical Word Problem Comprehension.
PUB DATE 2000-05-00
NOTE 36p.; Master of Arts Thesis, Kean University.
PUB TYPE Dissertations/Theses - Masters Theses (042)
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Content Area Reading; Grade 4; *Instructional Effectiveness; Intermediate Grades; *Mathematics Instruction; *Problem Solving; *Reading Strategies; *Word Problems (Mathematics)

ABSTRACT

This study is on the importance of reading in mathematics. The hypothesis is that reading word problems affects the outcome of problem solving. Students, 44 fourth-graders in two different math classes taught by the same teacher, were given computation problems and other students received the same computation problems within a story problem. The results suggest that students can perform about equally well in computation and story problems. Though the computational sample appears to have an easier task, the mean differences between the sample results were not significant. (Contains 19 references and a table of data. Appendixes contain a figure of data, a letter to parents, and nine sets of mathematical story problems.) (Author/RS)

Mathematical Word Problem Comprehension

By,
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Accepted 4/10/01

In partial submission of the requirements
for the Masters of Arts Degree

Kean University

May, 2001

Acknowledgements

I would like to acknowledge my parents, Dinny and Jack, for all their support. If it weren't for them I would not have begun. I owe them my life.

I would also like to acknowledge my husband, Dan, who put up with a lot while I was working on this study.

Thank you Dr. M for all your help and guidance through these months of research.

Abstract

This study is on the importance of reading in mathematics. The hypothesis is that reading word problems affects the outcome of problem solving. Students were given computation problems and other students received the same computation problems with in a story problem. The results suggest that students can perform about equally well in computation and story problems. Though the computational sample appears to have an easier task, the mean differences between the sample results were not significant.

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Comprehension is always of concern among educators. Most discussions and research, in the literature, centers around reading comprehension. Much of the research has been done on reading comprehension in narrative material. However, there are also many comprehension problems in the content areas, especially mathematics. Comprehension problems in math have been researched as far back as the 1930s (Vanderlinde, 1964). The research has shown that not much information has been found about the errors that students make (Muth, 1992). Much of the data shows that students do not do as well on problem solving tasks as they do on straight computation problems (Vanderlinde, 1964). Some problems students may be "the inability to read or careless reading, lack of interest, lack of computational ability, lack of knowledge of fundamentals and essential facts, lack of method for attacking problems, inadequate knowledge of vocabulary, and poor teaching" (Vanderlinde, 1964). There is limited research on what exactly causes the problems in solving word problems (Muth, 1992). Sometimes problems in comprehension only occur in math, the same student may be able to comprehend a novel.

One problem might be the lack of teaching. Fennema, Peterson, Chiang, and Loef (1989) found that teachers do not have the knowledge they need to teach students to be better problem solvers. They found that when teachers were trained in teaching students strategies, their students were more successful in solving mathematical problems (Fennema, Peterson, Chiang, and Loef, 1989).

One of the major problems is attributed to the lack of vocabulary comprehension. Vanderlinde (1964) believed that vocabulary instruction was the key to problem solving success. Students have trouble determining the correct operation because they do not understand the vocabulary in the problem (Tate and Starver, 1964). Today's research shows that teachers need to focus on teaching math vocabulary (Adler, 1999). Vanderlinde (1964) and Maw (1959) found that students exposed to more math vocabulary words achieved higher scores than the students that were not exposed to vocabulary instruction. Vanderlinde (1964) also found that teaching vocabulary did not hinder student achievement in math. Students need to be taught vocabulary in order to be successful when solving math problems.

Hypothesis

To add to the body of knowledge on this subject, the following study was undertaken. It was hypothesized that students have the ability to solve computation problems in isolation, but are unable to solve the same computation problem in the context of a word problem. Students have difficulty solving math word problems because they are unable to comprehend the vocabulary.

Procedures

Forty-four fourth grade students were selected from two different math classes taught by the same teacher. The students were heterogeneously grouped. The students' levels ranged from below average to above average. The population is diverse with students from below poverty to wealthy. There were twenty-two girls and twenty-two boys involved in the study. Half of the students were black and the other half white.

These students have been taught with a curriculum was based on real world problem solving. The curriculum stresses problem solving rather than straight computation.

One class was the control group. This group received straight computation problems. The experimental class had the same computation problems within a word problem. The computation problems ranged from easy to difficult. All students had background knowledge of the computation problems and problem-solving skills had been taught through the curriculum.

Each student completed five problems per day for a total of 45 problems. Students were not allowed to ask the teacher any questions. The mean achievement of the samples was assessed to determine which group had a better percentage correct and whether this difference was significant.

Results

As can be seen in Table I, there was a difference of 7.3 between the means in favor of the control sample at the conclusion of the study. This difference was statistically not significant.

The control group had a slightly easier time solving the problems. However, there is no statistical difference between the experimental group and the control group.

Table I
Means, Standard Deviations and t of the
Samples' Post Experiment Scores

Sample	M	SD	t
Experimental	62.99	9.71	1.81
Control	70.27	7.14	

Conclusion

The results show no significant difference between the control group and the experimental group. It was believed at the onset of the experiment that the experimental group was brighter than the control group. It seems that brightness was not a factor in the statistical outcome. While the results are approaching significance at the .09% level, the mean difference between the samples was not significant because the results do not fall between the 1 and 5% percent level.

It was noted that those students that incorrectly answered problems struggled with the vocabulary within the problem. Many times they were unsure of what operation they needed. Other times they were unable to comprehend the problem. Several times after the students took the test,

the vocabulary was explained and once the students understood the vocabulary they were able to solve the problems much easier.

Math teachers must understand that they are reading teachers as well. They need to learn how to teach strategies for vocabulary and comprehension. It is not enough that our students know how to solve straight comprehension problems. I still believe that students have trouble solving word problems. More studies need to be conducted to prove this hypothesis.

Implications

In order for our students to be successful they need to know how to read. Human beings need to be able to read in order to survive in our society. Math teachers need to realize that they are reading teachers as well. Many of our students need assistance with reading in content areas such as math. All teachers need to learn how to teach their students how to read within their content area.

One way to help students is by activating their prior knowledge (Bryant, Ugel, Thompson, Hamff, 1999). By using background knowledge students can build bridges to prior knowledge and this will allow them to

comprehend mathematical language. By teaching our students different ways to keep information in their minds, they will be more successful content area readers (Fuentes, 1998). Guillaume (1998) recommends using the hands on experience when building background knowledge. Students will be able to use their experience with the hands on activity to add on to more difficult concepts.

It is important to recognize that many of the strategies used to teach reading comprehension could also be used to teach comprehension in math. For example, the Directed Reading Activity may be used to help students develop vocabulary, build background knowledge, create a purpose for reading, questioning techniques, and reading out loud (Cunningham, Moore, Cunningham, J.W., and Moore D.W., 1983). Using journal writing can help students facilitate long-term memories about a specific topic (Guillaume, 1998).

Teachers should recognize that they need to teach their students strategies to be successful. Many strategies that are used in reading class can be used to help students be successful in mathematics.

Mathematical Word Problem Comprehension:
Related Research

As far back as the 1920s educators have been struggling with comprehension problems when students solve mathematical word problems. Recently, teachers in New Jersey are focusing on teaching how to solve real world problems because the statewide Elementary School Proficiency Assessment assesses problem-solving skills. Researchers have complied many studies that have determined that even though students do not have comprehension problems, they still have problems understanding word problems. Even to this day there are no answers to help those students that struggle. How do we help out students overcome this problem?

Newcomb (1922) found that teachers work hard to achieve successful result when they teach word problems. In the same year Osburn (1922) studied story problem that are asked orally and he determined that there were six problems when he studied the answers. Three of them are "failure to comprehend, errors in fundamentals, and partial response." Many of these problems are still very prevalent with today's problem solvers. Even in 1922 the researchers did not have the answer to help students solve word problems.

When looking for solutions Stretch (1931) found that students taught how to tell what is given, what is called for, give the correct solution, check

work were more successful than the control group. Johnson (1944) did a study with 316 students. Some of the students in the experimental group were taught specific mathematical terms. The results found that the experimental group scored higher than the control group. Johnson concluded, "that the use of instructional materials in mathematical vocabulary leads to growth in the knowledge of the specific terms included in these materials, and in the ability to solve numerical problems involving the use of these terms."

Vanderlinde (1964) found that in the 1950s and 1960s an objective of the math teachers was to teach their students word problems. However, the research still showed that many students still did not achieve as well on the story problems as they did on straight computation (Vanderlinde, 1964). Vanderlinde's research showed that students become aggravated and perplexed. Vanderlinde found there to be many of the same reasons Osburn (1922) found as to why students fail problem-solving tasks. Among them are physical and mental defects, inability to read or careless reading, lack of interest, lack of computational ability, and poor teaching. The largest problem seemed to be the inability to comprehend what the question was

asking. Students had trouble with understanding vocabulary and being able to relate it to the word problem.

In their own study Hansen (1944) and Treacy (1944) found that vocabulary is essential to create good problem solvers. Vanderlinde (1964) did a study on teaching vocabulary in math class to improve problem solving. He states that studies have shown that direct vocabulary instruction is more effective than an indirect style of teaching vocabulary. "The analyses of results invariably support the conclusion that vocabulary is a vital, if not the most important, factor in the comprehension and solution of written problems." He reported that the classes with direct vocabulary instruction scored better than the students without direct vocabulary instruction. From his study he determined that vocabulary should be made part of the mathematical curriculum. Vocabulary instruction will not interfere with regular math instruction. However, it was still not clear how teaching vocabulary increased scores on problem solving tasks (Vanderlinde, 1964).

Hegarty, Mayer, and Monk (1995) hypothesized that comprehension plays a major role in finding the answers to word problems. They believed that unsuccessful problem solvers use the information incorrectly in the problem to find a solution. Many students find it difficult to construct a

representation or model for the problem (Cardelle-Elawar, 1992). They do not have the skills to plan their solutions. Good problem solvers are able to plan their solution by constructing a mental model. Most students need to be taught how to create these representations.

Tate and Stainer (1964) found another problem with solving word problems. They determined that students have problems distinguishing between sufficient and necessary information. K. Denise Muth (1992) did a study that found the same results. The study was on the extraneous information and extra steps in word problems. Muth believed that problems with extra information and extra steps would be difficult because students are "susceptible to misconceptions about solving word problems." One misconception students have with word problems is that they believe that they need to use all the numbers in the problem to find the answer. After the experiment was complete it was found that "extraneous information and extra steps do hinder students' problem solving" (Muth, 1992). Students get confused when they see information that is not related to the problem they are asked to solve. They feel that their original idea how to solve the problem is altered because they feel they need to use all the information in the problem. They need to be taught strategies to solve these types of

word problems. Muth suggests exposing students to many different types of word problems to get them used to seeing problems with extra information and extra steps (Muth, 1992).

Maw (1959) found that students "can improve their performance on critical-thinking tests through study of materials on selecting relevant facts, judging the reliability of data, making inferences and generalizations, and evaluating arguments." Students need to be taught how to do these things in order to be successful. It cannot be assumed that they will learn to problem solve. Asking higher order thinking questions is a strategy found to help students achieve higher scores (Brown and Kean, 1988). The author found that when preschool students discovered something on their own they could verbalize the concept better than students who are just told. Asking "why" questions also were found to promote higher order learning (Brown and Kean, 1988).

In their 1993 article Perry, VanderStoep, and Yu reported that first and fifth grade students in the United States scored lower than students from Taiwan and Japan in mathematics. Although improving mathematical problem-solving skills of students is one of the six national educational goals, there is research that shows that American students are not keeping pace

with other industrialized nations (Lapointe, Mead, and Phillips, 1989). Perry, VanderStoep, and Yu (1993) found that Japanese textbooks covered more material than American textbooks. The researchers also found that students in China were taught to relate the problem solving questions to familiar things and they were taught to use manipulatives. It was also found that Asian teachers expected their students to deal with complex problems where as American teachers did not. Asian teachers believe that their students can be successful problem solvers and American teachers did not believe that their students would be successful. The authors want their article to explain the differences to help American teachers learn how to help their students successful in solving word problems.

Sedlak (1974) looked for strategies that students used to solve problems. He found that students use cue words to determine what operation they need. In a similar study Goodstein, Cawley, Gordon, Helfgott (1971) created the label "rote computational habit" for students who use only cue words as an aid to solve problems. Plugging numbers into a word problem will not work most of the time. Students need to be taught how to not use their habit as a way to solve problems. In his experiment, Sedlak (1974) used the cloze strategy to find good problem solvers. Good problem

solvers, he believed, would be more successful completing the cloze passage. In the experiment the students had to choose the correct numerical information to fit in the word passage to make the passage complete. The results supported Sedlak's hypothesis. The better problem solvers scored higher than the poor problem solvers, showing that vocabulary plays a significant role in solving word problems.

It is obvious that the solution to our problem of low mathematical ability is to learn to teach our students how to problem solve. In the Twenty-First century it has become critical for our future leaders to be able to problem solve. It is becoming critical for them to learn problem solving. In order for teachers to prepare our students and catch them up to the rest of the industrialized world they need to be taught how to teach their students. First we may need to get the message across to all content area teachers that they are also reading teachers.

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Appendix

Figure 1
The Means for Each Test

Test Number	Control Group (Mean)	Experimental Group (Mean)
1	76.6%	67.3%
2	71.6%	82.2%
3	68%	58.9%
4	58.2%	56.4%
5	68%	65.7%
6	62.8%	63.6%
7	70.9%	47.2%
8	74.3%	57.8%
9	82%	67.8%
Average Mean	70.1%	62.6%

January 2, 2001

Dear Parents/Guardians,

As many of you may already know, I am working on completing my thesis for a Reading Specialization degree. I have chosen to do research on reading in math and how it affects student performance. Up until this point in time I have only been researching the topic. I would like to integrate your child into the practical stage of the research. I will be testing them on how much reading word problems affects their math performance. The tests are part of the Everyday Math Curriculum and will not disrupt the progression of their learning. The students will not realize that they are doing something different from the norm of math class. (The tests will be anonymous.)

If you have any questions or comments please feel free to contact me. My telephone number is 378-7696.

Thank you,

Mrs. Diegnan

Problems of the Day (1)

1. 15 * 3

2. 987 - 453

3. 80 * 60

4. 45/9

5. Double 8

Problems of the Day (1)

1. The students in Mrs. Diegnan's class were rewarded with 15 table stars each day. By the end of the third day the students wondered how many stars they had. How many stars did they have?

2. Each year in Maplewood there is a 3K run to raise money for the PTA. At the start of the race 987 people began running. By the end of the race only 453 people were left. How many people dropped out of the race?

3. The Duke Blue Devils scored 80 points in each of their 60 games. How many points did they score all season?

4. Shaniqua and her family went to Six Flags. Their tickets cost $45. If 9 people went, how much was each ticket?

5. Marcelle went to Six Flags at the same time. She and her brother went on 8 rides each. How many did they ride all together?

Problems of the Day (2)

1. Mrs. Diegnan's favorite college basketball team is the Duke Blue Devils. They have been her favorite team since 1990. How many years has she been a fan?

2. Ramone decided he was going to buy 4 tickets to the game for his family. Each ticket cost $20. How much did he spend?

3. At the game Elaine wanted a hot dog. Each hot dog costs $3. Then she wanted a soda for $2. For dessert she wanted a cookie for $1.50. How much did her meal cost? If she gave the cashier $10, how much change did she receive?

4. At halftime Duke was beating Boston College by 12 points. If Duke has 47 points, how many points did B.C. have?

5. The Duke Blue Devils beat Boston College 74 - 63. How many points did the Blue Devils beat B.C.?

Problems of the Day (2)

1. 2001 - 1991 2. 20 * 4 3. $10 - ($3 + $2 + $1.50)

4. 47 - 12 5. 74 - 63

Problem of the Day (3)

1. Mrs. Lynch keeps 37 monthly magazines and 12 weekly magazines in the library. How many magazines can you choose from in the library?

2. Ben has a luxury apartment in a building on Park Avenue in New York City. In the Handcock Center apartments begin on the 45th story. Ben's building is 47 stories higher. How high is Ben's building?

3. Matt's towing company needs to ship 175 cars to the dealers. One of his trucks can carry 8 cars. How many trucks will he need to complete this order?

4. Elaine is running a trip to Paris. Each of the 372 people on the tour had 2 suitcases. How many suitcases were there in all?

5. The Maplewood swimming pool is 25 meters long. Efa swam this distance 6 times. How many meters did she swim?

Problem of the Day (3)

1. 37 +12

2. 45 + 47

3. 175/8

4. 372 * 2

5. 25 * 6

Problem of the Day (4)

1. Mr. and Mrs. Diegnan went on a trip to Hawley, PA this weekend. It took them 112 miles to get there. How many miles did they drive to and from Hawley?

2. They left at 9:45am and arrived at 1:05pm. How long did the trip take?

3. It cost $195 per person to stay at the lodge. Six people went on the trip. How much did the trip cost?

4. Mr. and Mrs. Diegnan and his two sisters went snow tubing. They each went down the hill 3 times. How many runs did they do all together?

5. For lunch they went to the Clubhouse. 2 people had the club sandwich fro $3.95. One person had a ham and cheese sandwich for $2.60. Another person had the soup and sandwich special for $4.00. The drink total was $6.50. How much did they spend at the Clubhouse?

Problem of the Day (4)

1. 112 * 2

2. Started at 9:45am
   Ended at 1:05pm

3. 195 * 6

4. 4 * 3

5. 3.95 * 2 + 2.60 + 4.00 + 6.50

Problem of the Day (5)

1. Laurel is a fabulous gymnast. In her routine she completes 2 back hand springs in each of her tumble passes. If she has 4 tumble passes in her routine, how many back hand springs does she complete?

2. Kelsey loves to draw. She drew for 3 hours and 25 minute on Saturday. If she started at 10:00am, what time did she finish?

3. Taahir is a fraction wiz kid. He knows that if a green rod is 2/3 of the whole and he adds one more green rod he has _____.

4. Conor was absent from school for 4 days. If we are in school for six hours, how many hours of school did he miss?

5. Brian moved to South Orange from Saint Louis, MO. Each day his family split up the trip mileage. The first day they drove 560 miles. The second day they drove 309 miles. The third and fourth day they drove 280 each day. About how many miles did they drive to arrive in South Orange?

Problem of the Day (5)

1. 2 * 4

2. 10:00 + 3 hours and 25 minutes

3. 2/3 + 1/3

4. 4 * 6

5. 560 + 309 + (280 *2)

Problem of the day (6)

1. Mallory was curious about how many minutes she spent reading this week. She read 30 minutes on Monday, 45 minutes on Tuesday, 50 minutes on Wednesday, and 20 minutes on Thursday. How many minutes did she spend reading?

2. Alex started reading Harry Potter on Tuesday. He finished 3 weeks later. How many days did it take him to read the book?

3. Anna baby-sat her neighbor's dogs. She was paid $4 per dog per day. If there are 3 dogs and she worked for 5 days, how much money did she earn?

4. Max is a very quiet student. His teacher decided to chart the minutes that he didn't speak for one week. On Monday it was 15 minutes, 32 minutes on Tuesday, 5 minutes on Wednesday, 41 minutes on Thursday, and 18 minutes on Friday. How many minutes was he silent?

5. Dayle wanted to know how much Golden Delicious Apples cost her mother. She read the sign that said, "Apples $3.45 a pound." Her mother weighed the apples and found that she had 3 pounds. How much did the apples cost?

Problem of the day (6)

1. 30 minutes + 45 minutes + 50 minutes + 20 minutes =

2. Tuesday + 3 weeks later is how many days?

3. 3 * 4 * 5 =

4. 15 minutes + 32 minutes + 5 minutes + 41 minutes + 18 minutes =

5. $3.45 a pound * 3 pounds =

Problem of the Day (7)

1. Ramsay has stirrup socks in every color: blue, red, yellow, green, and purple. If he has 3 pairs of each color how many stirrup socks does he have?

2. Richard had 4 boxes of hearts from Valentine's Day. In each box there are 40 hearts. He decided to eat all four boxes at one time. How many hearts did he eat?

3. Warren told the class that a baby blue whale gains about 4 kilograms per hour. How many kilograms would the whale gain in one day?

4. Amanda helped Mrs. Diegnan everyday after school for an hour. She came for two weeks (only school days). How many minutes did she help after school?

5. To go on our trip to Sandy Hook there were 25 busloads of people. Each bus holds 48 people. Assuming that the busses were full, how many people went to Sandy Hook?

Problem of the Day (7)

1. 5 * 3 = 2. 40 * 4 = 3. 4 * 24 =

4. 60 * 7 = 5. 25 * 48 =

Problem of the Day (8)

1. 914 people went to the circus on Thursday. 1,376 people went on Friday and 1,642 people went on Saturday. How many more people went on Saturday than on Thursday?

2. An art class cost $5.95. A dance class costs $5.75, and a guitar class costs $6.50. What is the total cost of an art class and a guitar class?

3. An infant's heart beats about 140 times a minute. An adult's heart beats about 80 times a minute. An infant's heart beats about how many more times a minute than an adult's heart?

4. Samuel Morse invented a telegraph system in 1837. He sent his first Morse code message 7 years later. In what year was his message sent?

5. A pony express rider earned $25.00 a week in 1860. If he spend $4.79 for food during the week, how much money did he have left?

Problem of the Day (8)

1. 1,376 + 1,642 =

2. $5.95 + $6.50 =

3. 140 - 80

4. 7 years later than 1837 =

5. 25.00 - 4.79 =

Problem of the Day (9)

1. A bristle cone pine tree is about 4900 years old. A giant redwood tree is about 3800 years old. The bristle cone pine is about how many years older than the redwood?

2. An astronaut needs 0.95 kilograms of oxygen, 0.73 kilograms of food, and 2.22 kilograms of water a day in space. How many kilograms of food and water does an astronaut need for one day?

3. There were 8 dogs on a team. If each dog pulled a load of 92 kilograms, how much was the total weight of the load?

4. Each day for a week Mrs. Diegnan ran 4 miles. How many miles did she run for 2 weeks?

5. Mrs. Diegnan loves to work out at her gym. She usually spends 2 hours there every night. How much time does she spend there in a week?

Problem of the Day (9)

1. 4900 - 3800 =

2. 0.73 + 2.22 =

3. 92 * 8 =

4. 4 * 14 =

5. 2 * 7 =

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Author(s): Jennifer Maikos-Diegnan

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