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Problem Solving Strategies: Helping Students Develop a Conceptual Understanding of Word Problems

Julia Gattuso

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University of Mary Washington

Abstract

Over the past few years, teachers have seen a decline in students' mathematical understanding due to a shift from procedural to conceptual knowledge (Griffin & Jitendra, 2008). Many students struggle with comprehending word problems due to being taught strategies that do not emphasize reading comprehension. Various problem solving strategies have been created to help students gain a conceptual understanding of word problems. This study examined three different strategies in order to examine the effects it has on students' understanding of word problems. Students were taught the Reciprocal Teaching Strategy, Schema Based Instruction Strategy, and Visual Strategies. These strategies used different methods to help students understand word problems. This study used both qualitative and quantitative methods to examine students' understanding of word problems using these three strategies. Results show that the problem solving strategies helped students to gain a better understanding of word problems but did not affect how students verbally explained how they solved the word problems.

Keywords: problem solving strategies, multi step word problems, conceptual understanding, math

Table of Contents

Problem Solving Strategies: Helping Students Develop a Conceptual Understanding of Word Problems

Problem solving strategies has been an area of interest for a long time. As I went through elementary school I always struggled with understanding word problems. Comprehending the language of word problems always was difficult for me. Throughout my time with the education program I have noticed that students in my practicum placements also seem to struggle with word problems. Many teachers have explained to me that the reason why students struggle is because word problems require students to think critically. I wanted to study problem solving in hopes that I could shed light on why so many students struggle. With this research I hope to find strategies that can help students gain a conceptual understanding of word problems.

Literature Review

Over the past few years, teachers have seen a decline in student's mathematical understanding due to a shift from procedural to conceptual knowledge (Griffin & Jitendra, 2008). According to Jitendra and Star (2011), about seven percent of students struggle with mathematics and as a result demonstrate poor achievement in various topics of math. Students with learning difficulties also struggle with problem solving since they have difficulties with various mathematical concepts (Jitendra & Star, 2011). One area of math that students seem to struggle with is problem solving due to the fact that word problems are more complex. Story problems require students to have knowledge about "semantic structure and mathematical relations as well as knowledge of basic numerical skills and strategies" (Griffin and Jitendra, 2008, p. 187). Research shows that textbooks do not provide students with the necessary skills needed to solve word problems (Griffin

and Jitendra, 2008). Many times textbooks present word problems in such a way that once a student learns how to solve one problem on a page they automatically know how to solve the rest of the problems on that same page because they are plugging in the same formula for each problem. This method of teaching is not beneficial since it does not provide students with the opportunity "to discriminate among problems that require different solutions" (Jitendra & Star, 2011, p. 13). Another aspect that affects student's understanding of word problems is the use of key words.

The key word approach used to solve problems is a strategy that gives students a list of words that mean a specific computation. Student then look for these key words in word problems to figure out what computation they should use. Teaching students to use key words as a problem solving method for word problems does not help students develop a conceptual understanding. Jitendra and Star (2011), explain that the keyword method does not allow students to focus on the meaning and structure of the problem which prevents them from fully understanding what they are reading. When students are taught the keyword approach, they are taught to look for specific words to give them a clue which operation they should use. Another problem that arises when students rely on the keyword approach is that not all word problems have key words in them. This can cause students to be very confused when presented with a problem without keywords since they have not developed a conceptual understanding through the key word approach (Griffin and Jitendra, 2008). Many times when students use the keyword approach they end up choosing the wrong operation because they have not analyzed the keywords in relation to the rest of the problem.

Another approach that some students especially students with disabilities engage in which is similar to the key word approach is number grabbing. Number grabbing can be defined as "selecting numbers from text without regard to the number's relationship to the problem's meaning" (Swanson, Orosco, Lussier, 2014 p. 151). Students continue to use these approaches as they advance to upper elementary school. Instead of analyzing and conceptually understanding each word problem they read, students end up trying to find key words and numbers that will indicate what operation they should use to solve the problem (Csikos Szitányi, Kelemen, 2008).

In order for students to be able to fully understand word problems, they need to have adequate language skills. Assessments have shown that students have difficulties discriminating between relevant and irrelevant facts in word problems (Swanson et.al, 2014, p. 150). In order for students to be able to interpret and understand the word problems they read, they need to be able to understand the "words, sentences, propositions and phrases" (Jitendra, Rodriguez, Kanive, Huang, Church, Corroy, Zaslofsky, 2013, p.21). The mathematical strategies that students are currently being taught in schools focus on rote learning in which students are expected to recall facts and procedures(Abdullah Halim, Zakaria, 2013). Teaching students strategies that focuses on rote learning does not allow students to be able to think critically which in turn affects students' problem solving capabilities (Abdullah Halim, Zakaria, 2013). Students need to be able to think critically in order to understand and solve word problems. Prior knowledge such as number sense can also have an impact on student's ability to solve word problems.

Number sense can be defined as a general understanding of numbers. Students who have good number sense have the ability to think about numbers in a variety of ways as well as "understand their meanings and the relationships among them" (Sengul, 2013, p. 1966). Researchers have found that poor number sense in primary grades can predict mathematical achievement in upper elementary grades. Several researchers conducted a longitudinal study in which they analyzed student's number sense during kindergarten, first and third grade. From this study, researchers found that "number sense can be reliably measured in young children and is predictive of later math achievement" (Jorden, Glutting, Ramineni, Watkins, 2010, p.183). Students who have poor number sense seem to struggle with all aspects of math including story problems. Many problem solving strategies have been developed and are now being researched in hopes to help students improve their conceptual understanding of word problems.

Many instructional strategies have been created to help students understand and solve word problems. Many of these strategies have similar beliefs in regards to what will help a student develop conceptual understanding. One important factor in helping students to utilize various strategies is to help them recognize when to apply certain strategies to the problems they are working on (Jitendra et. al, 2013, p. 22). According to Griffin and Jitendra (2011), many instructional strategies that are used to help students struggling in math include "depicting problems visually and graphically, teaching math concepts and principals by using explicit instruction, and using peer assisted learning and activities during math instruction" (p. 188). Researchers have found evidence that shows that the use of visuals, manipulatives and concrete objects helps students to have better comprehension and more engagement (Myer, 2014). Students can also benefit from

constructing drawings based on the problem they are working on (Csikos et. al, 2012). One important part of solving story problems is to have students summarize the problem first and then create a visual before they attempt to solve the problem (Swanson et. al, 2012). Literature also shows that student think- alouds and partner work in which groups focus on problem details helps students improve their learning in math (Jitendra and Star, 2011). When students work together in small groups, and are encouraged to think aloud and give their partner feedback on their work, they develop a deeper understanding of their work (Jitendra et. al, 2013). Some strategies that are used to help students understand word problems and problem solving involve multiple steps.

Multiple strategies that are used to help students understand word problems focus on dividing the word problem into different sections. In the Schema Based Instruction Strategy, problems are grouped into "change, group, compare, restate, and vary problems (Jitendra and Star, 2011, p. 14). With this strategy students are able to break apart each problem into parts in order to analyze it. Schema based instruction along with other similar strategies also use visuals and manipulatives to help students develop a conceptual understanding of the problem. In a study that was conducted using Schema Based Instruction, Griffin and Jitendra (2008), found that students who received this instruction "maintained the positive learning effect 12 weeks later" (p. 198). Research shows that not only do these types of strategies improve student's comprehension; students' confidence levels went up as they worked on word problems (Myer, 2014). In order for students to be able to successfully problem solve they need to be able to comprehend the problems they are reading.

Reading plays an integral part in students being able to understand and comprehend word problems. Swanson (2014) explains how text comprehension strategies are not being taught as a method of improving student's understanding of problem solving. Evidence has shown that reading comprehension is "highly predictive of solution accuracy" (Swanson et. al, 2014 p. 203). Student's math performance is enhanced when they are taught both verbal and visual spatial strategies (Jitendra & Star, 2011). Csikos (2012) explains that in order for students to be able to understand word problems they need to be able to visualize the data as well as comprehend the words they read. Prior studies have shown that "students with disabilities can successfully learn problem-solving skills when instruction is designed to promote understanding" (Jitendra & Star, 2011. p. 18). One researcher describes how strategies that involve both a thinking component as well as a visualization component help influence student's achievement (Abdullah et. al, 2011).

Prior research suggests that problem solving strategies have a direct impact on student's understanding of word problems. In the reciprocal teaching strategy, teachers use role cards to guide students through multiple steps as they solve a word problem. Teachers who used used the reciprocal teaching strategy state that students' assessment scores improved in all areas (Myer, 2014). Beginning research suggests that the Reciprocal teaching strategy may help students gain a conceptual understanding of word problems (Myer, 2014). With the Schema based instruction strategy, teachers teach students how to divide word problems into different parts. Students then learn how to analyze the different parts so that they can solve it. Research found that when teachers use this approach in the classroom, students use the strategy even after instruction has

ended (Griffin and Jitendra, 2008). Using visuals and drawings is another way to help improve students' understanding of word problems (Csikos et. al, 2011). Teachers who use visuals and drawings teach students how to represent the word problem in a picture.

This study seeks to examine the effects problem solving strategies have on student's understanding of word problems. While there is so much research on various problem solving strategies, there is not as much research on individual specific strategies. Many problem solving strategies that have been created need to be researched more in order to examine the full effects of each strategy. This study will be replicating prior studies in order to help support or disprove prior findings. Based on prior research, students struggle with problem solving because they are so complex. Number sense also seems to have an impact on how well students understand the mathematical concepts they are learning about. Over the years, students have been taught strategies such as the key word approach strategy which does not allow students to develop a conceptual understanding of the problems they are working on. Strategies that incorporate a visual component, help students develop a conceptual understanding of problem solving. Many strategies that have been found successful, guide students in breaking up the problem into parts until they find the answer to the problem they are working on. These particular strategies help students develop a conceptual understanding because students focus on one part of a word problem at a time. For this study, we will be examining student's prior understanding of word problems and their understanding after problem solving strategies have been implemented. Problem solving can be defined as being able to read and comprehend a word problem, solve the problem, and be able to use the correct operations.

I will be seeking to answer two research questions through this study. The first question I will be analyzing is: In what ways can problem solving strategies help improve student's understanding of word problems? I will be answering this question looking at quantitative data from pre- assessment data and post- assessment data. The second research question I will be looking at is can problem solving strategies help student verbally explain how they solve word problems? For the second research question I will be seeking to answer it using qualitative data that will be collected from interviews.

Methodology

Participants

Participants were recruited from an elementary school located in a county in central Virginia. These students were in third grade. There were 23 students in the study with 12 females and 11 males. There were 2 students with disabilities, 10 students who were in the gifted program and 12 students who were in the general education program. Students were selected as a convenience sample due to their placement in the classroom with a student teacher. Parents were asked to give permission for their child to participate in the study.

Procedure

Participants were students in a third grade classroom where there was a student teacher with a mentor teacher. Once parents gave permission for their child to participate, the students began the study. Students were first given a pre-test of twelve questions on mathematics word problems. These problems were multi- step problems which required students to perform multiple steps in order to find the answer. The pre-assessment contained three different types of word problems: "join" problems or addition

problems, "separate" problems or subtraction problems, and "multiplication" problems. With join problems, a person has to join two or more quantities whereas with separate problems a person is separating quantities. Participants were interviewed and asked to describe how they solved each word problem. Each student was interviewed individually and in person. Twelve students were randomly selected using a random choice generator. Students were interviewed after they complete the pre-assessment. Once the pre assessment data was collected students were taught different problem solving strategies. Students were taught how to solve word problems using the Reciprocal Teaching Strategy, Schema Based Instruction Strategy, and Visual Strategies. Each strategy was taught over the course of a week and students had the opportunity to practice each strategy with various types of mathematics word problems. These strategies were taught during the math block to small groups for 20 minutes. Each strategy was integrated into the mathematics curriculum that was being taught that week. Each strategy was taught similarly starting with an introduction on the first day, practice throughout the week, and ending with a review and post-test at the end of the week. The instruction for each strategy varied depending on materials that were needed for each strategy. At the end of each week, students took a post test of five multi-step questions on that specific strategy. Students got a point if they correctly answered the word problem and if they correctly applied the strategy that was taught. Students then took a short survey about the specific strategy they learned that week. Each of these students were asked how they solved each problem, if they liked using the strategy, and whether or not they felt the strategy helped them understand mathematics word problems. After the introduction and teaching of each of the strategies, the students took a post test which contained various types of

mathematics word problems. The post- assessment was similar to the pre-assessment and contained three different types of multi-step word problems: "join" problems, "separate" problems, and "multiplication" problems. Questions to be included on the pre-assessment and post-assessment tests are included in Appendix A. The pre-assessment and post-assessment was scored based on the number of questions students correctly out of the total number of questions. Twelve students, who were randomly selected for the pre- test interviews, were interviewed again and asked how they solved each word problem. Students were also asked to identify which problem solving strategy they used and why they decided to use that strategy. During the interview students were also asked which strategy helped them understand word problems.

The researcher hoped to gain more of an understanding of word problems and how students solve them. From this data we hoped to find which problem solving strategies benefit students and which strategies helped students develop a conceptual understanding of word problems. We also looked at how student's explanations of word problems changed as they learned the various problem solving strategies.

Results

Data from this study shows that the students made learning gains from the pre-assessment to the post assessment. This study sought to answer two research questions: In what ways can problem solving strategies help improve student's understanding of word problems? To answer this question, quantitative data from the pre and post assessments were analyzed. Each pre and post assessment was scored based on the number of questions the students answered correctly out of the total number of questions. The data from both sets of assessments were analyzed to see if the students made learning

gains. The second research question I sought to answer was: Can problem solving strategies help students verbally explain how they solve word problems? In order to answer this research question, qualitative data from the interviews were analyzed. Interview responses were coded and analyzed for recurring themes.

Quantitative data from the pre and post assessments were analyzed to examine learning gains. Both the pre and post assessments consisted of multi-step word problems in which the students had to use addition, subtraction, or multiplication in order to solve the word problems. The first result that was examined was the average scores for both the pre- and post assessments for the class. Overall, students made a nine point learning gain from the pre-assessment to the post assessment.

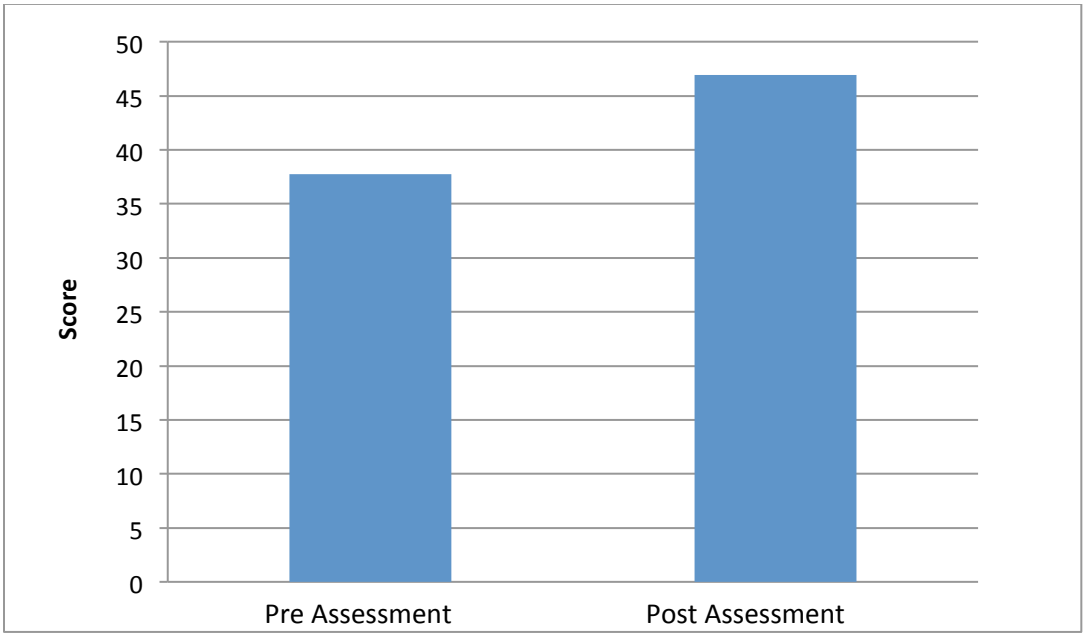

Figure 1. The bar graph shows the average scores on the pre and post assessment.

Figure 1 shows the average score for all the participants on both the pre- assessment and the post assessment. The average score for the pre-assessment was 38%, and the average score on the post assessment was 47% resulting in a nine point gain overall for all the

participants. After each of the three different strategies was taught, participants took a short post assessment which included four multi- step word problems. Participants' scores on the three post assessments were also analyzed to see if there were any learning gains. The average scores increased by 16 points from the first posttest to the last posttest.

Figure 2. Bar graph showing average scores on the strategy post assessments.

The first strategy taught to the participants was the visual strategy. As shown in Figure 2 above, the average scores for all of the participants was 36%. The second strategy that was taught was the Schema Based Instruction strategy. The participants scored 46% overall on the second post test, resulting in a 10 point gain from the first post test. The last strategy that the students learned was the Reciprocal Teaching Strategy. The average score on the last post test was 53%, resulting in a 7 point gain on the third post test from the second post test, and a 17 point gain from the first post test.

Student's individual scores were also assessed to examine gains from the pre-assessment to the post assessment. Thirteen students made learning gains from the pre-assessment to the post assessment while 9 students either did not improve or did not do as well on the post assessment as they did on the pre-assessment. The graph below shows the pre and post assessment scores for all students.

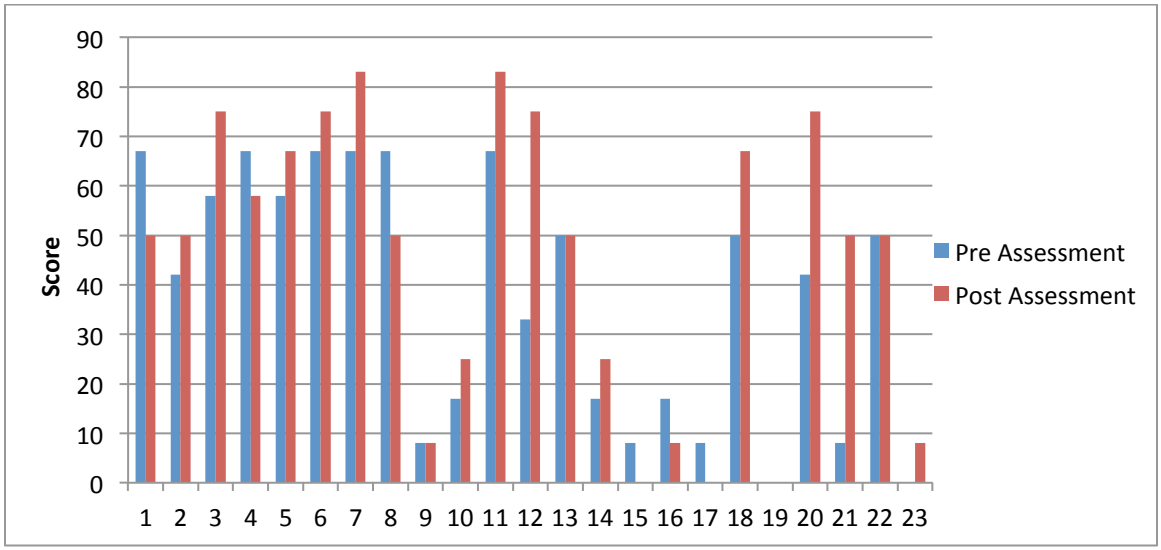

Figure 3. The bar graph shows pre and post assessment scores for all participants.

The graph above shows that students 12 and 21 made the most progress from the pre and post assessment. Both of these students' scored 42 points higher on the post-assessment than they did on the pre-assessment. Students 9, 13, 19, and 22 did not make any gains from the pre-assessment to the post- assessment. One of these students did not complete the post assessment, while another student was in the hospital for over a week missing half of the study.

Table 1

Student's Pre and Post Assessment Scores

Student	Pre-Assessment Score	Post Assessment Score	Learning Gains
1	8/12= 67%	6/12= 50%	- 17%
2	5/12= 42%	6/12= 50%	+ 8%
3	7/12= 50%	9/12= 75%	+ 25%
4	8/12= 67%	7/12= 58%	-9%
5	7/12= 58%	8/12= 67%	+ 9%
6	8/12= 67%	9/12= 75%	+ 8%
7	8/12= 67%	10/12= 83%	+ 16%
8	8/12= 67%	6/12= 50%	- 17%
9	1/12= 8%	1/12= 8%	+0
10	2/12= 17%	3/12= 25%	+8%
11	8/12= 67%	10/12= 83%	+ 16%
12	4/12= 33%	9/12= 75%	+ 42%
13	6/12= 50%	6/12= 50%	+0
14	2/12= 17%	3/12= 25%	+8%
15	1/12= 8%	Moved Away	N/A
16	2/12= 17%	1/12= 8%	-9%
17	1/12= 8%	0/12= 0%	-8%
18	6/12= 50%	8/12= 67%	+17%

19	0/12= 0%	0/12= 0%	+0%
20	5/12= 42%	9/12= 75%	+33%
21	1/12= 8%	6/12= 50%	+ 42%
22	6/12= 50%	6/12=50%	+0
23	0/12=0%	1/12=8%	+8%

Table 1 shows the pre and post assessment scores as well as learning gains for all students participating in the study. The learning gains column shows that 13 of the students made learning gains from the pre-assessment to the post-assessment. Four of the students did not make any learning gains while five of the students did not do as well on the post-assessment as they did on the pre-assessment. One of these students missed a week of the study due to being away on vacation while another student was unable to finish the post assessment. Overall, four of the participants were unable to finish the post-assessment. Students only had one week to complete the post-assessment, compared with two weeks that they had to complete the pre-assessment.

Qualitative data from the interviews was coded for themes and then analyzed. Ten students were randomly selected to be interviewed after the pre and post assessment was administered. The interviews were semi-structured and students were asked questions about how they solved the word-problems, strategies that were used, and difficulty of the problems. One of the first questions that the students answered was how they solved the word problems and the steps that they took. During the first interview the main themes surrounding solving the word problems included highlighting or circling specific words and using different operations in order to solve the word problems. Five

out of the ten students mentioned that they used a highlighter on the pre-assessment. Four of the five students mentioned that they were highlighting either numbers or key words in the word problems. All of the ten students mentioned that they added and subtracted in order to solve each of the word problems while one student mentioned that they needed to use multiplication to solve some of the problems.

Another theme that came up during the first interview was the difficulty of the problems. As students were talking about various problems on the pre-assessment, they mentioned how some of the problems were difficult. Nine out of the ten students mentioned that some of the problems were confusing, tricky, difficult, hard, or challenging. Six of the nine students explained that the problems were difficult for them because they didn't know what to do after the first step, didn't know what the words meant, the numbers were too big, or there were too many steps in the problems.

The same interview questions were asked to the same group of students after the final post-assessment was given. One of the students moved away in the middle of the study resulting in only nine students being able to be interviewed during the second interview. Responses were coded to identify themes and then analyzed. Students were asked how they solved the word problems on the post assessment. Many students responded with similar answers to the first interview and stated the operations that they used to solve the word problems. Three of the students mentioned that they used one of the strategies they learned to solve some of their word problems. None of the students mentioned using a highlighter or underlining any numbers or key words during the second interview.

Two of the students mentioned that they felt they did better on the post assessment than they did on the pre-assessment. Six of the students mentioned that they used some of the strategies to solve some of the problems. They felt that the strategies helped them to understand the problems. One student mentioned that the strategies made the problems "easier because they didn't have to focus on the entire problem at once". Another student stated that the strategies helped them "understand because it broke the problems apart". Students were also asked which strategy they liked the most out of all three strategies that were taught. Four of the students stated that they liked the picture strategy the most because it helped them to visualize the word problem. Two students stated that they liked the Schema Based Instruction strategy because it allowed them to focus on part of a word problem at once. Another two students explained that they liked the Reciprocal Teaching Strategy the best because it allowed them to talk to their peers about the word problems and ask their peers any questions they may have about the problems they were working on. Students were also prompted to explain how the problem solving strategies helped them to understand the word problems. The answers varied from the strategies helping the student to visualize the word problem to helping the student break the problem apart into smaller manageable parts. Two students also mentioned that practicing solving word problems helped them to gain a better understanding of the word problems they were working with.

At the end of the three sub post assessments, students answered three open ended survey questions. The three questions were: What steps did you take to solve the word problems, did you like the strategy that we used this week, and did this strategy that you learned help you to understand how to solve word problems. Looking at the answers for

the Visual Strategy, eleven students stated they liked the strategy while six students said they did not like the strategy. Nine students said that this strategy helped them to understand the world problems, while seven students felt that it did not help them to understand the word problems. Ten students stated that they liked the Schema based instruction strategy while ten students said they did not like the strategy. Seven students said that the Schema based instruction strategy helped them to understand word problems while eleven students said it did not help them to understand. Seven students said that they liked the Reciprocal teaching strategy while eight students did not like the strategy. Five students felt that the strategy helped them to understand word problems while eleven students felt it did not help them.

Discussion

This study was not executed as originally planned in the method section. Snow days as well as other unforeseeable events significantly shortened the length of this study. Originally each strategy was supposed to be taught over the course of four days with the post assessment given on the fifth day. Due to the vast amount of testing and assessments that are required to be given to the third grade students, each strategy was only taught for two to three days. The snow days prevented the study from starting on time which resulted in shortening the length of time the students had to complete the post-assessment. Students were given two weeks to complete the pre-assessment, while given only one week to complete the post-assessment. Due to time limitations the number of students interviewed was reduced to ten students instead of 12 as originally planned.

The first strategy that was that was taught was the Visual Strategy. The students were taught this strategy over the course of two days and then assessed on the third day. One thing that was that discovered after beginning this study was that the students had previously been taught how to use visuals to solve word problems. As a result of the students already having had previous knowledge of this strategy, it was decided to shorten the length of the implementation of this strategy. The second strategy that was implemented was the Schema Based Instruction strategy. This strategy was taught for two days as well, with the post assessment given on the third day. The length of the implantation of this strategy was shortened due to a required third grade assessment that needed to be given to the students. The last strategy that was taught to the students was the Reciprocal Teaching Strategy. This strategy was was taught for three days with the post assessment given on the fourth day. The implementation was shortened by a day due to the need for whole group instruction. The students were only given a week to complete the post-assessment due to time restrictions. Originally it was planned to teach the strategies over the course of 60 minutes to the entire class. Upon entering the classroom it was discovered that the math block was taught in small groups with the groups rotating around between the mentor teacher and the special education teacher. Consequently, the strategies were implemented to small groups for 20 minutes.

Scoring for the post-assessment also changed from what was originally stated in the method section. Originally it was planned to give the students a point on the pre and post assessment for demonstrating how they solved each word problem and another point for correctly answering the word problems. As the pre and post assessments were being administered, it was noticed that many of the students were doing the work for the word

problems on their desk with a dry erase marker, and then writing the final answer on their paper. As a result, there was no record of some of the student's work. It was decided to change the scoring for the pre and post assessment to show the number of questions the student correctly answered over the total number of questions that were on the assessment.

Looking at the results, the students made progress from the pre-assessment to the post-assessment. Even though as a class the average scores did not improve by a significant amount, the class made learning gains. It appears that the problem solving strategies helped students to gain a better understanding of word problems. This quantitative data supports the first research question: In what ways can problem solving strategies help students understand word problems? The data from the three smaller post assessments that were given after each strategy was taught, supports the idea that problem solving strategies can help students gain a better understanding of word problems. Students' scores significantly increased after the Schema based Instruction and Reciprocal Teaching Strategy were taught. Both of these strategies helped the students to think about the word problems in parts, as well as break down the word problems into manageable parts. It appears that having the students think about the word problems in sections helps them to better understand the word problems than when looking at the word problems as a whole like in the visual strategy.

The second question this study was seeking to answer was can problem solving strategies help student verbally explain how they solve word problems? Looking at the qualitative data from the two interviews, the responses between the first interview and the second interview did not change that much. The students gave similar responses for how

they solved the word problems for both interviews. One difference that the students gave in their answers was that some students mentioned using the strategies in order to solve the word problems. It appears though that the students did not struggle with explaining how they solved the word problems in either the pre or post assessment interview. As a result teaching the problem solving strategies did not have an impact on how they verbally explained how they solved the word problems.

Limitations

This study had a few limitations which affected the outcome of the study. The assessments and snow days significantly shortened the length of the study, decreasing the length of time that was originally planned to teach the strategies. This may have impacted how much the students learned. Some of the students throughout the study mentioned that they didn't know the strategies that well because they didn't have enough time to practice and learn them. Teaching the strategies for a longer length of time may have helped some of the students fully understand how to use the strategies. Another limitation was the fact that the strategies were not taught to the students over a consecutive time period. Many of the interruptions due to testing happened in the middle of the week, causing the teaching of the strategies to become very sporadic throughout each week.

Conclusion and Implications for Future Research

Results from this study indicate that the problem solving strategies helped students to gain a better understanding of word problems. Student's scores improved overall from the pre-assessment to the post-assessment. The results from this study support previous research that has been conducted on problem solving strategies.

Previous research states that problem solving strategies help students to gain a conceptual understanding of word problems. Future research still needs to be conducted in this area to further support how the problem solving strategies help students gain a conceptual understanding. Future research can focus on implementing one problem solving strategy for a longer period of time to evaluate the effects. In conclusion, this study helps demonstrate that problem solving strategies are beneficial in helping students gain a conceptual understanding of word problems.

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Appendix A

Questions that will be used during the Pre and Post assessments: questions come from http://www.ixl.com/math/grade-3/multi-step-word-problems and http://www.commoncoresheets.com/Multistep.php

1) Lucy saved up $39. Then she got $14 for her allowance. Lucy spent $10 on a pair of gloves, $5 on a winter hat, and $24 on a scarf. How much money does Lucy have left?

2) Erin had 26 toy cars. Then she bought 20 cars from the toy store and got 24 cars for her birthday. Erin gave 2 of the toy cars to her sister and 66 to her friend Nancy. How many toy cars does Erin have left?

3) Spencer needs 111 cupcakes for a birthday party. He already has 29 chocolate cupcakes and 37 vanilla cupcakes. How many more cupcakes should Spencer buy?

4) Camille made 4 stacks of wooden blocks. The first stack was 4 blocks tall. The second stack was 5 blocks taller than the first. The third stack was 6 blocks shorter than the second stack, and the last stack was 9 blocks taller than the third stack. How many blocks did Camille use in all?

5) Scarlett needs 19 cartons of berries to make a berry cobbler. She already has 8 cartons of strawberries and 2 cartons of blueberries. How many more cartons of berries should Scarlett buy?

6) A parking garage near Allie's house is 4 stories tall. There are 27 open parking spots on the first level. There are 8 more open parking spots on the second level than on the first level, and there are 5 more open parking spots on the third level than on the second

level. There are 29 open parking spots on the fourth level. How many open parking spots are there in all?

7) In Julie's toy bin there are 21 red blocks. There are 17 more yellow blocks than red blocks. There are also 6 more blue blocks than red blocks. How many blocks are there in all?

8) At the town carnival Billy rode the ferris wheel seven times and the bumper cars three times. If each ride cost five tickets, how many tickets did he use?

9) Chloe was unboxing some of her old winter clothes. She found four boxes of clothing and inside each box there were two scarves and six mittens. How many pieces of winter clothing did Chloe have total?

10) Wendy was playing a video game where she scores five points for each treasure she finds. If she found four treasures on the first level and three on the second, what would her score be?

11) Isabel had two pages of math homework and four pages of reading homework. If each page had five problems on it, how many problems did she have to complete total?

12) Rachel was organizing her book case making sure each of the shelves had exactly nine books on it. If she had six shelves of mystery books and two shelves of picture books, how many books did she have total?

13) Kaleb had 34 books. If he sold 17 of them and used the money he earned to buy 7 new books, how many books would Kaleb have?

14) Oliver had 33 dollars in January. By March he had spent 4 dollars. If he got

another 32 dollars from his mom, how much money would he have?

15) A book store had 41 books in the bargin bin. If they sold 33 books, but then put 2 more in the bin, how many books would be in the bin?

16) Oliver was packing up his old toys. He filled 8 boxes with action figures and 6 boxes with old games. How many boxes did he pack total?

17) An airline lets each passenger take 2 pieces of luggage. If there were 8 people flying, how many bags could they take?

18) Wendy's mom was buying extra school supplies for her and her siblings. If she bought 3 packs of glue sticks with 9 glue sticks in each pack, how many did she get total?

19) Yoshi had $11. Then he saved $6 from his allowance and spent $5 on a comic book and $5 on a puzzle. How much money does Yoshi have left?

20) Abe saved $22 in June, $34 in July, and $44 in August. Then Abe spent $12 on school supplies and $13 on new clothes. How much money does Abe have left?

Appendix B

Interview/Survey Questions

1) How did you solve these word problems?

2) What steps did you take to solve word problems?

3) Did you like the strategy that we used this week? Why?

4) Did this strategy that you learned help you to understand how to solve word problems? Why?

5) Which strategy did you like the best?

6) Which strategy did you decide to use?

7) Which strategy helped you the most with understanding word problems?

Appendix C

Dear Parent or Guardian,

My name is Julia Gattuso and I will be student teaching in your students' classroom this semester. I am currently a student at the University of Mary Washington pursuing my Master's in Elementary Education. One of the requirements of this program is for all students to complete an action research project. I am inviting your child to participate in this research study. Participation in this study is voluntary so you may choose to have your child participate or not. I am now going to explain the study to you in hopes to answer any questions you may have.

I am interested in learning about how problem solving strategies can help students develop a conceptual understanding of word problems. This study will take place over the course of five weeks. Over the course of the study your child will be learning different problem solving strategies. I will also be randomly selecting students to interview to find out more information about how students solve word problems. I will be integrating these strategies into the mathematics curriculum. I am requesting permission to be able to interview your child and give them pre and post assessments to monitor their progress.

Your child's work will be kept confidential. His or her name will not appear on any papers that will be turned in. I will change all students' names in order to keep your child's privacy. At the end of the study all work that has been handed in will be destroyed. Participation in this study will not affect your child's grade in anyway. Participation in this study is completely voluntary and you will have the right to pull your child out of the study at any time.

The benefit of this research is that it will help me to understand which problem solving strategies help students to develop a conceptual understanding of word problems. There are a few risks to participating in this study. Your child may become frustrated when taking the assessment tests. Your child may also feel uncomfortable during the interviews. These risks will be minimized by informing students that the assessments are not for a grade. I will also interview students in the back of the classroom so that they feel more comfortable sharing information with me.

If you have any other questions or concerns, please feel free to contact my university supervisor Dr. Roberta Gentry at rgentry@umw.edu or myself at jgattuso@mail.umw.edu. I am looking forward to working with you and your child. Thank you for your time.

Julia Gattuso

I have read the above letter and give my child, _____, permission to participate in this project.

_____

(Parent/Guardian Signature)

Appendix D

Your research proposal titled "Problem Solving Strategies: Helping Students Develop a Conceptual Understanding of Word Problems" has been approved through an expedited procedure by the UMW IRB. Your research falls into the following category, making it eligible for an expedited approval:

- Clinical studies of drugs and medical devices meeting conditions described by federal code.
- Collection of blood samples by finger stick, heel stick, ear stick, or venipuncture. The participants meet the federal codes description for eligibility under expedited review.
- Prospective collection of biological specimens for research purposes by noninvasive means.
- Collection of data through noninvasive procedures (not involving general anesthesia or sedation) routinely employed in clinical practice, excluding procedures involving x-rays or microwaves.
- Research involving materials (data, documents, records, or specimens) that have been collected, or will be collected solely for nonresearch purposes (such as medical treatment or diagnosis).
- Collection of data from voice, video, digital, or image recordings made for research purposes.
- Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

This IRB approval expires on **January 19, 2016.** If your research is to continue after the expiration date you will need to submit a letter asking for an extension. If your research methodology changes, please submit a new application. However, if the change to the research protocol is minor (such as adding one question to a survey), you may submit a letter to the IRB chair explaining the changes and how the research continues to meet the criteria indicated above.

Best of luck with your research,

Janine S. Davis
Member, UMW IRB

1301 College Avenue
Fredericksburg, VA 22401-5358 www.umw.edu