

The Effects of Using Schema-Based Instruction in Math Word Problems on Student Performance  
in Third Grade

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## Abstract

The purpose of this study was to examine the effects of using schema-based instruction in solving math word problems for third grade students. The students were assessed on their ability to identify and solve problems using multiplication and division using a four question pre and postassessment. Students were given instruction in both computation and schema-based instruction daily during the math block. A mid-point assessment was administered at the four week mark and a postassessment administered at the six week mark. Findings from the data show that schema-based instruction had a positive effect on student achievement in solving math word problems.

# **CHAPTER I**

## **INTRODUCTION**

### **Overview**

In the instruction of mathematics, emphasis is placed on the solving of real world word problems. In fact, there are eight standards within the Maryland College and Career Ready Standards for third grade that address the solving of word problems. The difficulty for many students lies in what the problem is asking a student to do: add, subtract, multiply, divide, or compare. Students who struggle with reading or language find word problems confusing and rely on keywords such as “more” or “less” to identify a problem type without fully understanding the problem.

The researcher teaches in a Title I school in Anne Arundel County with a high population of English Language Learners. Problem solving is a key focus in the Anne Arundel County curriculum and within the school itself. Since problem solving is a key component of the math standards and the Partnership for Assessment of Readiness for College and Careers (PARCC) assessment, the researcher sought a way to make solving word problems accessible and comprehensible for struggling students.

### **Statement of Problem**

The purpose of this study was to examine the effects of using schema-based instruction in solving math word problems for third grade students.

### **Hypothesis**

The null hypothesis is that the use of schema-based instruction will not affect the achievement of third grade students on the problem solving posttest. The alternative hypothesis

is the use of schema-based instruction will improve the achievement of third grade students on the problem solving posttest.

### **Operational Definitions**

The independent variable in this study is the use of schema-based instruction during the problem solving portion of a third grade math class. Schema-based instruction is operationally defined as an instructional strategy focusing on the structure of the problem, using schematic diagrams. The dependent variable is the change in scores on a problem solving assessment. The change in scores is operationally defined as a change in scores from a multiplication and division problem solving pretest and similar posttest.

## **CHAPTER II**

### **REVIEW OF THE LITERATURE**

#### **Introduction**

Solving word problems in math is a difficult skill in elementary students. Taking concrete, computational concepts and applying them to more abstract situations in solving word problems is a big step for many students, especially in the elementary grades. This is where the foundation of word problem solving begins and needs to be sufficiently developed for success in higher grades. In the world of Common Core and standardized assessments, problem solving is on every educator's radar. While problem solving has become a major focus in schools, 6 to 7% of students in the US perform poorly in this area (Jitendra & Star, 2011). Due to abstract concepts, large language demands, and dependency on background knowledge, this skill becomes a struggle for students with learning disabilities, English language learners, and students from low socio-economic homes. While problem solving initiatives have taken place, it is not enough for these students: more needs to be done to make school mathematics accessible to all students.

This literature review describes the types of instruction educators have implemented when teaching problem solving with math word problems, the components of the instruction, and the difficulties students face when attempting to solve word problems. It also compares traditional instruction with schema-based instruction, explaining why schema-based instruction may be a more effective strategy for students who have difficulties in math. The first section of the literature review explains why students struggle with traditional instruction in math problem solving. The second section defines schema-based instruction and describes the differences in



this type of instruction compared to traditional instruction. The third section summarizes the information and concludes the literature review.

### **The Trouble with Problem Solving**

Traditional methods of teaching problem solving are not effective for all students. If they were, we would not have as many struggling learners. As schools adopt math textbook programs, they may be encouraged to use the strategies implemented in the books. Search for word problem solving strategies on the internet and you will be inundated with anchor charts stressing math "key words". Take a glance into most math teachers' classrooms and you will surely find a chart listing the steps of problem solving. While these strategies may work for some learners, they are not the best instruction for all learners.

Utilizing textbook instruction for word problems in math puts students at a disadvantage for problem solving in the real world. Textbooks are set up with chapters or units, and each section highlights one type of problem or one type of strategy. All of the problems are similar. Without exposure to different types of problems simultaneously, students find it difficult to differentiate between problems. Textbook instruction also restricts exposure to the experience of using different types of procedures for different types of problems (Griffin & Jitendra, 2009). Students need the experience and ability to solve different types of problems in one sitting, as real life and math assessments will not have them solve addition problems in succession.

Reliance on key words to choose an operation is another ineffective strategy. When given word problems, students are taught to circle or underline important numbers and "clue words" to help them decide whether the problem is addition or subtraction. However, this strategy can lead to errors. Students who do not understand the problem may simply focus on the numbers and compute them without taking the context of the problem into consideration. In

this instance, the students' focus is on computation rather than making sense of the problem (Xin, Jitendra, & Deatline-Buchman, 2005). Students looking for "take away" or "together" will not find them in all word problems. They may also be used in a different context, which would cause confusion for a struggling learner. Comparing word problems is a classic example of why key word identification is not always effective. For example, given the word problem *Michael has twenty dollars to spend at the store and his brother John has 15 dollars to spend at the store. How many more dollars does Michael have than John?*, students will immediately notice the key word *more*. They know that *more* is a key word for addition, so they will write and solve an addition operation. However, as this is a comparing problem, they should be looking for the difference and subtracting. Key word identification does not support understanding of the meaning of the problem or the structure in which it is written. Knowing what the structure of a comparing problem is would help clear the confusion brought forth with the use of key words.

Models of problem solving steps have been a staple in classrooms through the years. While the amount of steps may have changed, they all have one thing in common: they are too broad and generalized for struggling learners and have become problematic instead of helpful. Four step models of problem solving often have students read the problem (Read), make a plan (Plan), write an equation (Solve), and review their work (Check). Given in this context, however, these steps do not help a student who does not already have a good understanding of problem solving strategies. Without adequate knowledge of strategies, students will have difficulty making a plan to effectively solve a problem (Jitendra & Star, 2011). Jitendra explains in multiple articles on the subject, that this strategy does not reliably lead to improvements in students' word problem solving performance.

### **Schema-Based Instruction**

Schema-based instruction is a conceptual teaching approach that integrates problem solving in mathematics with reading comprehension strategies (Jitendra, 2008). Rather than relying on key words and problems of similar procedure, problem structure is the focus. By focusing on the structure of the problem, students can categorize the problems by type. The use of semantic cues translate into semantic diagrams when students represent them in diagrams or modeling (Powell, 2011). Semantic cues allow students to make inferences about the relationships between objects in the problem (Jitendra, 2008). The problem solving model used in schema-based instruction is less broad and more specific in its directions: identify problem type, diagram the problem, plan to solve the problem, and solve the problem (Jitendra, George, Sood, & Price, 2010). When identifying the problem, students paraphrase the problem and identify known and unknown information. This allows the students to categorize the problem using schema. Then, they diagram the problem, in which they identify and label sets, identify and write quantities for those sets, and identify the unknown. Planning to solve involves selecting the operation and translating their diagram into a number sentence. When students are ready to solve, they complete the operation, write the answer, and check for reasonableness and accuracy. This process links the idea of the problem to an operation's procedure instead of focusing on procedure only. Research in the use of schema-based instruction has shown its effectiveness with students at risk for math failure and students with learning disabilities. However, much of this research has been focused on addition, subtraction, and algebra word problems rather than problems involving multiplication and division (Jitendra, Dipipi, & Perron-Jones 2002).

### **Summary**

Changes in problem solving instruction need to be made in order to allow all students to access the skill successfully and transfer the skill to a multitude of different problems. Not all students succeed in traditional problem solving instruction, and in order for them to access curriculum and success in math, strategies that work for them must be used, tested, and assessed. Identifying the challenges and intervening in the elementary age may improve math achievement in the intermediate grades.

## **CHAPTER III**

### **METHODS**

The purpose of this study is to investigate the effect of the use of schema-based instruction in math problem solving on the performance of third grade students in problem-solving assessments.

#### **Design**

A pre- and posttest study was used to determine the relationship between schema-based instruction in problem solving and student performance on a problem solving assessment involving multiplication and division word problems. A preassessment was administered to students prior to the use of schema-based instruction in the classroom. During the study period, students were instructed during their problem solving block using schema-based instruction to identify the problem structure as well as the known and unknown information. A postassessment was administered at the end of the study period to determine if student performance improved.

#### **Participants**

This study took place in a Title I elementary school in Anne Arundel County, MD. The student population includes 85% who are identified as English Language Learners (ELLs) and 93% of who qualify for Free and Reduced Meals. The participants consisted of all students in the researcher's third grade classroom, ranging from 8 to 9 years of age. Of the 18 students, 17 are Hispanic, including two students who are newcomers, which is defined as a student who is attending school in the United States for the first time. Additionally, 15 students are ELLs of various language levels. All students qualify for Free and Reduced Meals. There are 9 girls and 9 boys.

## **Instrument**

The first measurement used in this study was the pre- and postassessment created by the school math team to assess student problem solving skills in multiplication and division word problems. It is a county expectation that math instruction is problem based, with daily Pose a Problem questions to promote productive struggle. Additionally, it is an expectation and part of the schools improvement plan to focus on problem solving and computational fluency in math in all grade levels. The preassessment was given to students in the beginning of third grade, after the concept of multiplication was reintroduced. A midpoint assessment will be administered after four weeks and a final postassessment administered after six weeks.

The second instrument used in this study was schema-based instruction, focused on Equal Groups type problems, requiring either multiplication or division to solve. Students were taught the schema for this type of problem and the steps required to solve them and were given daily exposure and practice with various examples of these types of problems.

## **Procedure**

The researcher introduced the schema for equal group problems to the whole class, including vocabulary and creating anchor charts for reference. An equal group problem was posed daily, beginning with teacher modeling and then a gradual release to independence. Using the baseline data from the preassessment and additional observational data taken during schema instruction, the researcher met with students in groups to reinforce the schema for this problem type. Student progress was monitored through teacher observations during this instructional block and through check-in assessments weekly. At the end of six weeks, students were given a postassessment on equal group type problems.

## CHAPTER IV

### RESULTS

The purpose of this study is to investigate the effect the use of schema-based instruction in math problem solving has on the performance of third grade students in problem solving assessments. Preassessment, postassessment, and interim assessment data were collected. For the purposes of this analysis, only the pre and postassessment data were utilized.

The table below depicts both the descriptive data on the pre- and postassessments but also the results of a two tailed dependent or paired t test analysis. The data were significant well beyond the  $p < .0001$  level. Thus, one concludes that the null hypothesis is rejected and the intervention succeeded in impacting student achievement in a positive way.

Table 1

*Descriptive and Statistical Analysis*

t-Test: Paired Two Sample for Means		
	<i>Pre-test</i>	<i>Post-test</i>
Mean	3.941176471	10.76470588
Variance	10.43382353	20.69117647
Observations	17	17
df	16	
t Stat	-9.241414248	
P(T<=t) two-tail	0.0000000813756795*	
t Critical two-tail	2.119905299	

\* $p < .0001$  significance

## **CHAPTER V**

### **DISCUSSION**

The purpose of this study is to investigate the effect the use of schema-based instruction in math problem solving has on the performance of third grade students in problem solving assessments. Preassessment, postassessment, and interim assessment data were collected. As indicated in Chapter IV, statistical significance was achieved and the treatment had a positive impact on student achievement.

#### **Threats to External Validity**

In this study, the purpose was to investigate the progress of third grade students in math problem solving. The sample size was limited to the students in the researcher's classroom, which limits it to 18 students. Additionally, the study was implemented in a Title I school with a high population of English Language Learners, with 75% of the sample size identified as such. While this type of instruction was successful for this group of students, the lack of diversity in the sample size does not allow the researcher to make a generalization that this will be effective for all third grade students.

#### **Threats to Internal Validity**

At the beginning of this study, the participants were just beginning third grade and explicit instruction on multiplication and division. When the pretest was administered, the students had little experience with both types of computation and little exposure to the types of problems. They were then given six weeks of explicit instruction, including targeted fluency instruction daily as per the school's improvement plan. This may account for the large growth in many of the students postassessment scores, as they had little exposure to the content the previous year. Additionally, the study did not utilize a control group to compare the use of



schema-based instruction to a group that did not receive the instruction, so it cannot be generalized that schema-based instruction is the more effective approach to problem solving.

Another threat to the internal validity of the study lies within the pre- and postassessments and the rubric used to score them. Students were given four multiplication and division problems to solve. The assessments were scored using a 5-point rubric: 2 points for representing and labeling the problem, 1 point for the correct answer, 1 point for the correct equation, and 1 point for answering the question in sentence form. The researcher observed that students correctly represented the problems. However, many used multiplication equations for all of the problems, including problems that required division to solve. This shows that while students understand what the problem is asking, they are not making the connection to the correct equation.

### **Relationship to Previous Research**

Many studies have been performed on the use of schema-based instruction and its effects on student performance. Researchers have studied inclusive classrooms and students with learning disabilities using schema-based instruction. The studies have found a positive impact using schema-based instruction, as was found in this study. One study in particular compared schema-based instruction with general strategy instruction using pre- and posttests for both groups. The findings showed positive growth for both types of instruction and concluded that sound strategy instruction produces positive learning effects and teachers should provide opportunities for problem solving and the use of effective strategies (Griffin & Jitendra, 2009). The positive results of this study show its effectiveness, but the misconceptions between the problem and the computational equation show that instruction should not be limited to one type of instruction or strategy.

### **Directions for Future Research**

This study raises several implications for future research. The study was completed during a short period of time within a unit on multiplication and division. However, third grade mathematics goes beyond multiplication and division into other topics. Research could be expanded throughout the school year to see if the students continue to use the strategies effectively. It would also be beneficial to implement this study in other grades, particularly in first or second, where problem solving with addition and subtraction begins and comparing problems are introduced. Finally, a study could be conducted comparing English Language Learners and Native English Speakers to determine the effect of schema-based instruction on students who struggle with language.

### **Summary and Conclusion**

The purpose of this study was to determine if using schema-based instruction would improve problem solving in math for third grade students. The results of this study show that the instruction had a positive impact on student performance, with 77% of the students increasing their score by 5 points or more. Thus, schema-based instruction is an effective tool teachers can use to teach problem solving strategies and can therefore become an effective strategy for students to use.

## References

- Griffin, C., & Jitendra, A. (2009). Word problem-solving instruction in inclusive third-grade mathematics classrooms. *The Journal of Educational Research*, 102(3), 187-202.
- Jitendra, A. (2008). Using schema-based instruction to make appropriate sense of word problems. *Perspectives on Language and Literacy*, 20-24.
- Jitendra, A., Dipipi, C., & Perron-Jones, N. (2002). An exploratory study of schema-based word-problem solving instruction for middle school students with learning disabilities: An emphasis on conceptual and procedural understanding. *The Journal of Special Education*, 36(1), 23-38.
- Jitendra, A., George, M., Sood, S., & Price, K. (2010). Schema-based instruction: Facilitating mathematical word problem solving for students with emotional and behavioral disorders. *Preventing School Failure: Alternative Education for Children and Youth*, 54(3), 145-151.
- Jitendra, A., & Star, J. (2011). Meeting the needs of students with learning disabilities in inclusive mathematics classrooms: The role of schema-based instruction on mathematical problem-solving. *Theory Into Practice*, 50, 12-19.
- Powell, S. (2011). Solving word problems using schemas: A review of the literature. *Learning Disabilities Research & Practice*, 26(2), 94-108.

Xin, Y., Jitendra, A., & Deatline-Buchman, A. (2005). Effects of mathematical word problem solving instruction on middle school students with learning problems. *The Journal of Special Education*, 39(3), 181-192.