The Impact of Using Visualization with Third Grade Students Solving Multiplication Word Problems

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Table of Contents

List of Tables

Abstract

The purpose of this study was to determine whether improving reading skills, specifically through visualization, impacts the success of third grade students solving mathematical multiplication word problems. The participants of this study were third graders enrolled in an Anne Arundel County school for the 2013-2014 school year. Participants were given a multiplication word problems assessment to determine areas of weakness or errors made when solving word problems. For six weeks, from February to March of 2014, students received instruction three days a week on how to use the reading strategy, visualization, when solving mathematical problems. This study involved a posttest design to compare data after the interventions were completed to data from February 2014. The hypothesis was not supported for this study since there was a significant difference between the pretest and posttest data after the intervention was administered. The findings in this study validate the importance of improving students' reading abilities and strategies such as through the use of visualization. This study also suggests that further research is needed in the area of using reading strategies when solving mathematical problems. Research should continue into the best methods to help provide struggling elementary students with additional assistance and strategies to improve their skills in interpreting and solving mathematical word problems.

CHAPTER 1

INTRODUCTION

Overview

The ability to solve mathematical problems is an important skill that students in third grade need to acquire and become successful at solving. The Common Core State Standards (CCSS) clearly define an expectation for third grade students to learn how to solve multiplication and division word problems in situations involving equal groups, arrays, and measurement quantities (National Governors Association, 2010.) Therefore, students need to acquire vocabulary, decode unknown words, and comprehend what they need to solve or prove. This process involves using reading strategies and vocabulary to be successful at mathematics.

Currently, students in third grade are exposed to about one hour of math instruction daily. Students constantly are analyzing word problems related to multiple forms of operations. The researcher has found that many other educators express a concern with students having difficulty with figuring out what operations or strategies they may need to solve a word problem. As educators find ways to assess students' mathematical abilities, it is important to see that when students are examining a word problem they are not only using mathematical knowledge but their reading abilities as well (Edwards, Maloy, & Anderson, 2009).

Research has shown that young readers cannot solve word problems and do the necessary operation because they are unaware of what the problem is asking them to do. For example, students may get confused by everyday language, math words, or a combination of both (Edwards et al., 2009). It is important for students to learn and acquire the vocabulary that is stated in a math problem in order to solve that problem. Research shows that general reading ability and computation ability have a significant effect on problem-solving ability. Students who

do not have strategies for solving math word problems are less successful than students who are taught some type of strategy for solving math word problems (Cloer, 1981).

Many times students can find an answer to a mathematical problem, but they cannot explain the procedures they used and also cannot monitor their problem solving. Students who struggle with "knowing what to do" after reading the problem will perform poorly even though they may be proficient with computation skills. Students cannot apply these skills if they do not know which operation to use or step to take in order to get the correct answer.

The struggles shown by students with reading and comprehending math problems have become a topic of interest for the researcher and her colleagues. Comprehending the mathematical word problem is the first step in solving it (Edwards et al., 2009). Teaching reading strategies, such as visualizing or mental modeling, could aid students with solving mathematical word problems (Foster, 2007). Students can analyze, read, manipulate, and draw story problems to give a better understanding of what the math word problem was asking as well as what information the problem was providing. Using a visualization strategy from reading can help students illustrate their thinking and connect with the text as they solve mathematical problems (Foster, 2007).

When using the reading strategy visualization, students picture in their mind what is happening in the story to help them comprehend the text. This strategy can be applied to mathematical word problems. Students can picture in their mind and then draw what they visualized in the problem. This allows students to connect with the text just like when reading a story. By creating a visual to go along with a math word problem, students can get a better understanding of what the problem is asking as well as the information the problem was providing. The student's picture shows his or her understanding of the problem (Foster, 2007).

Statement of Problem

This study was designed to determine whether improving reading skills, specifically visualizing, would have an impact on the success of third grade students solving mathematical multiplication word problems.

Hypothesis

For this study, the null hypothesis was assumed: There will be no difference in solving math word problems involving multiplication after using visualization to improve reading the problem.

Operational Definitions

The following terms are used throughout this study.

Mathematical word problems relate to math problems on a third grade reading level that involve students having to multiply to find the answer to the question being asked.

Measuring Solving Math Word Problems: An answer key created by Anne Arundel County Public Schools related to the Common Core Standards for mathematical practice will be used to measure students' ability to solve problems correctly.

Multiplication relates in this study to the ability able to multiply two numbers in the range of 0-10.

Visualizing refers to a reading strategy where a reader creates a picture in his or her mind as he or she reads to gain comprehension.

CHAPTER II

REVIEW OF THE LITERATURE

Students face many challenges when solving mathematical word problems. They need to acquire vocabulary, decode unknown words, and comprehend what they need to solve or prove. This process involves using reading strategies and vocabulary to be successful at mathematics. As educators find ways to assess students' mathematical abilities, it is important to see that when students are examining a word problem, they are not only using mathematical knowledge but their reading abilities as well (Edwards et al., 2009).

The new Common Core State Standards place an even greater emphasis on students' ability to show their thinking when solving mathematical problems. As such, section one of this review of the literature will review math instruction components. Section two will focus on the importance of reading to solve word problems. Section three will cover the influence of reading ability on understanding word problems, and the final section, section four, will examine interventions that can increase students' skills when solving mathematical problems.

Mathematical Instruction Components

Mathematical Practices

Common Core Standards for mathematics define what students should be able to accomplish and understand at each grade level. There are domains, which are larger groups or related standards, and then there are "clusters" that summarize groups of related standards (National Governors Association, 2010). It is important to note "that standards from different clusters may sometimes be closely related, because mathematics is a connected subject" (National Governors Association, 2010, p. 1). Based on the Common Core Standards for Mathematical Practice, students' success is based on their ability to justify why a mathematical

statement is correct or true and support their ideas mathematical through writing, drawings, symbols, labels, etc. (National Governors Association, 2010).

Students are encouraged to solve problems in various ways, and teachers should provide opportunities for students to share their varied thinking so the students, in turn, can understand that there are different ways to come to a mathematical conclusion. Students can only begin to process the mathematical problem and begin to formulate ideas on how to solve word problems if they can truly understand what is being asked of them to solve (Helms & Helms, 2010). Therefore, the connection between reading and math is critical when it comes to solving mathematical word problems. Students need to decode unknown words and acquire new mathematical terms in order to comprehend what the problem they are trying to solve is asking of them (Glenberg, Willford, Gibson, Goldberg, & Zhu, 2012).

Vocabulary

Many students are unsuccessful at solving word problems in mathematics because they have difficulty with mathematical language and notation (Helms & Helms, 2010). Monroe and Panchyshyn (1995) argue that mathematical material is one of the most difficult types of information to read, and they stress how crucial it is to emphasize vocabulary instruction in the mathematical content area. Mathematical vocabulary can be classified into four categories: technical, subtechnical, general, and symbolic. According to Monroe and Panchyshyn, "Technical terms convey mathematical concepts that are difficult, if not impossible, to express in everyday language. Each technical term (e.g., integer, quadrilateral) has only one meaning, which is specific to mathematics" (p. 80). These terms are difficult to learn and remember, according to Monroe and Panchyshyn, because they are only encountered in mathematical contexts. Subtechnical vocabulary involves words that have more than one meaning. "Because

of their multiple meanings (e.g., the *volume* of a cube, the *volume* control on the television set, the *volume* of the world trade), these terms can be especially difficult to conceptualize" (Monroe & Panchyshyn, 1995, p. 80). General vocabulary is the words that students encounter in their everyday language. Although many of these words are found in mathematics textbooks, they are not taught during reading class (Monroe & Panchyshyn, 1995). Monroe and Panchyshyn found that more than half of the words included in elementary textbooks were not among those frequently used in children's reading materials. "One 1966 study found that even if students were taught all the words presented in seven different reading series at the primary level, they would be exposed to only half the words included in mathematics textbooks for the same levels" (Monroe & Panchyshyn, 1995, p. 80).

Importance of Reading when Solving Word Problems

When solving word problems, students must learn two languages, the language of numbers and the language of words (Edwards et al., 2009). According to Edwards et al. (2009), "Math word problems are intricate language constructions–they contain unfamiliar words, complex combinations of text and numbers, and considerable amounts of information to decode and organize" (p. 1). Research has shown that young readers cannot solve word problems and do the necessary operation because they are unaware of what the problem is asking them to do. For example, students may get confused by everyday language, math words, or a combination of both (Edwards et al., 2009). It is important for students to learn and acquire the vocabulary that is stated in a math problem in order to solve that problem. For example, students may see the word "stadium" in a math problem. However, those students may never have attended an event at a "stadium." These unfamiliar phrases may confuse children (Edwards et al., 2009).

Students may also face the challenge of reading proper names that are unknown to them. These unfamiliar names can distract students from the important mathematical information in the problem (Edwards et al., 2009). "The 2007 MCAS for fourth graders included Mr. Gomez, Ms. Rodriguez, Angelina, Rhonda, Elin, Ms. Lin, Kiki, Pedro, Kyle, Ryan, Rosetta, and Shannon" (Edwards et al., 2009, p. 2).

Research has shown that many state and national tests, as well as textbooks, are not written in conversational English; consequently, the language is not easily recognizable for all students (Edwards et al., 2009) and students' reading ability is challenged. Finally, the comprehension of math terminology affects a student's ability to read and comprehend. Many terms in math language differ from everyday language. For example, "How many more" suggests adding to find a total, but "more" in some math word problems requires students to subtract the smaller number from the larger number to find the correct answer (Edwards et al., 2009).

Comprehension Problems when Reading Math Problems

Research has shown that when children make errors in solving mathematical story problems, those errors are not necessarily in numerical calculations. Instead, there is difficulty with language comprehension skills (Glenberg et al., 2012). "Young readers who are confused and distracted by everyday language, math words, or combinations of both may know how to do the necessary math operations, yet answer incorrectly because they do not clearly comprehend what the question is asking them to do" (Edwards et al., 2009, p. 2). On the other hand, some students may be unsuccessful at problem solving because they are incorrect in their math operations. Students who struggle with reading and math computation face the greatest challenge and are the least successful when attempting to solve word problems (Edwards et al., 2009).

Mathematics texts present challenging reading because this content area has "more concepts per word, per sentence, and per paragraph than any other area" (Harmon, Hedrick, & Wood, 2005, p. 266). According to Cloer (1981), there is no significant agreement between the mathematical vocabulary in textbooks and standard reading word lists. There is evidence that there is a large number of unfamiliar words in math textbooks used by young students and readability levels of mathematic textbooks are above the assigned grade level (Cloer, 1981). Chase (as cited in Cloer, 1981) concluded that, "the ability to compute, skill in noting details in reading, and a knowledge of arithmetic concepts were the best three predictors of problem solving efficiency" (p. 13).

The existing research on vocabulary and mathematics indicates "a concern and curiosity about the nature of mathematical words and instructional interventions" (Harmon et al., 2005, p. 267). Research shows that general reading ability and computation ability have a significant effect on problem-solving ability. Students who do not have strategies for solving math word problems are less successful than students who are taught some type of strategy for solving math word problems (Cloer, 1981).

Ways to Increase Students' Skills when Solving Mathematical Problems

Glenberg et al. (2012) argue that children who act out sentences or words remember much more of what they read than children who just read and reread words or sentences. Several researchers (Glenberg et al., 2012; Edwards et al., 2009) have found that visual representations, sketching pictures, making charts, acting it out, or using a series of steps can help students understand mathematical word problems. Foster (2007) found that when her class created visualizations to go along with word problems, it gave them a better understanding of what the problems were asking as well as what information the problems were providing. "Using a

visualization strategy from reading helped them illustrate the information given. It also allowed each student to connect with the text. The students' pictures showed their understanding" (Foster, 2007, p. 200). Students should also be given opportunities to write their own story problems in order to understand how writers blend words and numbers together to create questions (Edwards et al., 2009). "As students compose their own problems, teachers or coaches can point out the importance of the information written in the question" (Edwards et al., 2009, p. 3).

Educators can also teach students mathematical vocabulary with explicit instruction (Harmon et al., 2005). First, instruction must relate newly acquired words to other words and concepts. Students need to make connections and form relationships between new words and their existing knowledge (Harmon et al., 2005). The use of repetition involves students having adequate practice with using the word so that they automatically access the meaning during reading (Harmon et al., 2005). The third feature, meaningful use, involves the level at which students are actively engaged in using the word meanings. The higher the level of processing, the more likely students will learn and retain word meanings (Harmon et al., 2005). Harmon et al. (2005) state that, "teachers need to make students aware of the different terminology and how the mathematics context can change the meaning of even the simplest of terms" (p. 268). Harmon et al. also argue that "teachers should acknowledge the close relationship between conceptual understanding and vocabulary knowledge, providing numerous opportunities for students to apply their newly acquired understandings and vocabulary in varied language modes, such as in writing, speaking, and visual representations" (p. 268). Cloer (1981), too, supports the idea of teaching vocabulary by stating, "Vanderine (1964) and Lyda and Duncan (1967) collected data which demonstrated that the direct study of math vocabulary alone produced a significant growth

in elementary students' problem-solving abilities" (p. 2). In contrast, Edwards et al. (2009) suggest having students ignore unknown or confusing words and instead try to solve the problem with the words they know.

Students who are challenged by decoding proper names can be encouraged by their teachers to just recognize that it is a name and substitute the name with their name or a friend's name (Edwards et al., 2009). "When names are made familiar or abbreviated to a letter, it is easier to concentrate on the mathematics of the problem" (Edwards et al., 2009, p. 2). Students can also use this same strategy but change the text instead of the numbers. For example, instead of someone swimming laps, the text could be shooting basketballs. Another strategy students can use when trying to comprehend math problems is using some type of problem solving framework. This is a series of steps students can take to figure out what they know and what they need to still find out (Edwards et al., 2009).

According to Whitin and Whitin (2000), students can improve their success on solving mathematical word problems when they collaborate with others by talking and sharing ideas. Students can compare pictures, words, and numeric solutions for consistency (Van Garderen, 2004). Several researchers (Whitin & Whitin, 2000; Van Garderen, 2004) have stated that collaboration has shown to be beneficial for young learners. Students can benefit from opportunities where they are given a story problem to solve as a group. They can depict the problem through a drawing and discuss and check the drawing for accuracy. Students can decode what is being asked in the problem by underlining or highlighting important words and discussing as a group any unknown words (Goularte & MarcoPolo, 2003).

Another strategy to aid students in solving word problems is using the QAR (question-answer-relationship) for word problems that relate to a graphic or table. Students can determine

whether mathematical calculations are required to formulate a correct response by following the QAR framework (Mesmer & Hutchins, 2002). "Answering questions that relate to a graphic or table involves a complex, multistep process that includes understanding the question, determining how a response can be mathematically formulated, analyzing the graphic, and offering a response that rests upon sound mathematical principles" (Beyersdorfer & MarcoPolo, 2003, p. 2). Research shows that identifying the type of QAR supports mathematical reasoning skills and helps students to be successful with test-taking (Beyersdorfer & MarcoPolo, 2003).

Reciprocal teaching, most commonly used in reading where students become the teacher in small group reading sessions and lead dialogue about what has been read, can be applied in mathematics as another method that can be useful in aiding students with solving word problems (Van Garderen, 2004). Van Garderen (2004) identifies the strategy of reciprocal teaching where students clarify vocabulary and phrases by having group members teach each other the meanings of words. Students use questions to identify key parts of the problem. Next, students summarize the purpose of the problem by highlighting important information and drawing diagrams or visual representations. Lastly, students devise a plan to solve the problem by listing the steps and operations needed to solve the problem. It is also important for students to check to make sure their plan makes sense (Van Garderen, 2004).

Helms and Helms (2010) conducted a study using note launchers to aid students in active reading of mathematic textbooks. The study was used to analyze how students used this tool and if it was effective and useful to their learning. Helms and Helms concluded that "Note launchers, an instructor-designed reading guide, model how to select, decide, and focus upon what textbook material is important to learn. Reading guides are specially-designed study aids that can steer students through difficult parts of assigned readings" (p. 109). Reading guides bridge the time

between when students read and when they are accountable for that reading during subsequent class meetings (Helms & Helms, 2010.) This tool has proven to assist students in being more efficient studiers and more active during the reading process (Helms & Helms, 2010).

Summary

Reading comprehension plays a role in the overall success of students decoding, understanding, and solving mathematical word problems. There are many challenges students face as they try to solve a problem. However, teachers can use reading strategies and other techniques to help students be successful with mathematical vocabulary and story problems.

CHAPTER III

METHODS

The purpose of this study was to determine whether improving reading skills by using visualization would impact the success of third grade students solving mathematical word problems.

Subjects

The participants in this study attended third grade in an Anne Arundel County, Maryland elementary school. The school is located in the western part of Anne Arundel County and serves approximately 736 students. The school's demographics are as follows: 106 Asian students, 328 African American students, 59 Hispanic students, 166 Caucasian students, and 73 students who are of two or more races. There are 366 males and 370 females enrolled at this school.

For this study, the researcher used 24 students in her third grade classroom. Of the students in the third grade classroom, 15 were African American students, two were Caucasian, one was Hispanic, three were Asian, and the remaining three were multiracial students. Five out of 24 students are special education students who receive accommodations according to their IEPs. Three students also have accommodations according to their 504 plans. This elementary school's school improvement plan focuses on improving students' success in mathematics.

Instrument

One instrument that was used in this study was a multiplication word problem assessment. The word problems selected for the assessment came from various Anne Arundel County third grade mathematical assessments from marking period 1 and marking period 2 that align with Common Core State Standards (CCSS). Each word problem selected for the quiz was taken from an Anne Arundel County math assessment that aligns with the CCSS standard

3.OA.A.3 which reads “Use multiplication and division within 100 to solve word problems in situations involving equal groups, arrays, and measurements quantities” and 3.OA.A.1 which asks students to “Interpret products of whole numbers.” Students were given the assessment to complete independently; however, students with Individualized Education Plans (IEPs) were given their proper accommodations. An answer key with accepted responses to these third grade mathematical word problems was used to score students’ responses. The total correct out of the total questions was used to calculate an average score and corresponding letter grade. A copy of the multiplication word problem assessment is attached as Appendix A.

Procedure

This research study began in February 2014 when the researcher administered the multiplication word problems assessment to all 24 students in the class. The researcher then analyzed the data and concluded that students who scored higher on the pre-assessment had drawn pictures to help them solve the mathematical word problem. She also noticed that many students struggled with a specific problem that involved answering more than one question. Some students answered problems incorrectly by making mistakes with computation or incorrectly reading or interpreting what was being asked in the question. The teacher gave the students the opportunity to share what was confusing and how they interpreted the problems.

The researcher then took opportunities throughout the school week to model the reading strategy, visualization, to help students solve multiplication word problems. The strategy was used three times a week for eight weeks. The intervention was used at various times throughout the school day, specifically during morning work, reading groups, or during a math lesson. Students focused on one word problem. They then closed their eyes and pictured in their mind what was happening in the problem. Each student shared with a partner or with the class what he

or she visualized by giving details and descriptions. Students were asked to share which words in the word problem were important and which words helped them to visualize. Students then sketched a drawing to show their visualizations. After their visualizations were drawn, students then solved the problem and wrote their responses. Participants then took the multiplication word problems post-assessment at the end of March. The post-assessment measured the same standards as the pre-assessment. An example of a word problem and sketched visualization is attached as Appendix B.

CHAPTER IV

RESULTS

The purpose of this study was to determine whether improving reading skills by using visualization would enhance the success of third grade students solving mathematical word problems. Pre- and posttests of mathematical word problem solving were analyzed using a *t* test for paired subjects. The results are presented in Table 1 below.

Table I

Pre- and Posttest Results in Third Graders when Using Visualizing to Solve Multiplication Word Problems

Test	**Mean**	**N**	**Standard Deviation**	**t**	**Significance**
Pretest	67.7	22	30.54	4.18	0.000 *
Posttest	89.1	22	21.58		

* $P < 0.000$

The hypothesis that there will be no difference in solving math word problems involving multiplication after using visualization to improve reading the problem is rejected.

CHAPTER V

DISCUSSION

The hypothesis that there will be no difference in solving math word problems involving multiplication after using visualization to improve reading the problem was rejected. The analyzed data from a pre- and posttest for 22 students who were taught and used visualization as a strategy to solve mathematical multiplication word problems showed a significant change in their scores. On the pretest, the third grade students scored a mean score of 67.7 compared to the posttest which showed improvement with the students scoring a mean score of 89.1. The scores on the pre- and posttest demonstrate that there is a benefit to teaching students to visualize when solving multiplication word problems.

Implications

The results in this research study suggest that there is a significant difference in students' ability to solve mathematical word problems when using visualization as a strategy. These findings validate the importance of improving students' reading abilities and strategies, such as through the use visualization. These types of strategies can help students increase their mathematical problem solving skills.

This study also supports the notion that reading demands are involved when solving problems. After students were taught visualization as a strategy to solve multiplication problems, many students began using this strategy when solving other types of word problems such as those involving elapsed time, division, addition, and subtraction. Visualizing became a tool that students used whenever they were reading, regardless of the topic. They were able to see the connection in all content areas. The information from this study can be presented to the researcher's staff and colleagues as a way to help students improve their problem solving skills

in mathematics. Visualizing can also be a strategy that a reading specialist shares with staff as a way for teachers to help students in all subject areas, especially in Primary Years Program (PYP) schools where all subject areas are integrated.

Threats to Validity

Throughout this study, there were some threats to validity. There was no control group in this study to compare the data of students who received instruction on using visualization when solving math word problems to students who did not receive the instruction. Also, two students were not able to complete the posttest in order to compare their data. Another threat to validity could have been the short period of time in which this study was conducted. Also, the increase in students' success could have partially been to a natural progression of skills over time. Some students may have improved their computation skills when solving multiplication problems. Lastly, the environment could play a role in students' success since there were many snow days when students were off of school during this study. To address the threats to validity, it may be beneficial to look at the effects of using visualization over a longer period of time.

Connections to Previous Studies

The findings in this research connect to the ideas of several researchers (Whitin & Whitin, 2000; Van Garderen, 2004) who have stated that students can benefit from opportunities where they are given a story problem to solve as a group. Students in this type of setting can then depict the problem through a drawing and discuss and check the drawing for accuracy. Students can decode what is being asked in the problem by underlining or highlighting important words and discussing as a group any unknown words (Goularte & MarcoPolo, 2003).

With her class, the researcher's findings mesh with those of Foster (2007) who found that when her class created visualizations to go along with word problems, it gave them a better

understanding of what the problems were asking as well as what information the problems were providing. According to Foster, "Using a visualization strategy from reading helped them illustrate the information given. It also allowed each student to connect with the text. The students' pictures showed their understanding" (p. 200).

Implications for Future Research

This research study lends itself to further investigation into how improving reading strategies can aid students in solving mathematical word problems more effectively. Researchers can look at other types of reading strategies that may help students improve their math skills. A study could also be conducted to determine whether there is a correlation between students' reading levels and their success with mathematical word problems. Research could also be conducted to explore whether using visualization helps students with solving not only multiplication word problems but all types of mathematical problems. A similar study could be conducted with a control group to compare students who used visualization to students who did not use visualization to solve mathematical word problems.

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Name:_____ Date:_____

Multiplication Word Problems

1. Chase is buying juice boxes for his lunch. He buys 8 packages of juice. Each package has 6 juice boxes. How many juice boxes does he have in all?

2. Andy is setting up for his party. First, Andy set up chairs for the magic show. He set up enough so that he and his friends will all have a chair. He set up 2 rows with 10 chairs in each row. How many chairs did Andrew set up?

3. Maggie has 5 teachers. She gave each teacher 10 flowers. How many flowers did Maggie give out in all?

4. There are 5 tables in Mrs. Mierzwa 's classroom. There are 4 students sitting at each table. Each student has a bag of 10 counters.

Part A

How many counters are at each table? _____

Part B

How many counters does Mrs. Mierzwa's class have in total?

5. Spencer has 7 bags with 4 cookies in each bag. How many total cookies does Spencer have?

6. There are 9 rows of pencils with 3 pencils in each row. How many pencils?

7. Kami's bookshelf has 8 rows of books with 7 books in each row. How many books in all?

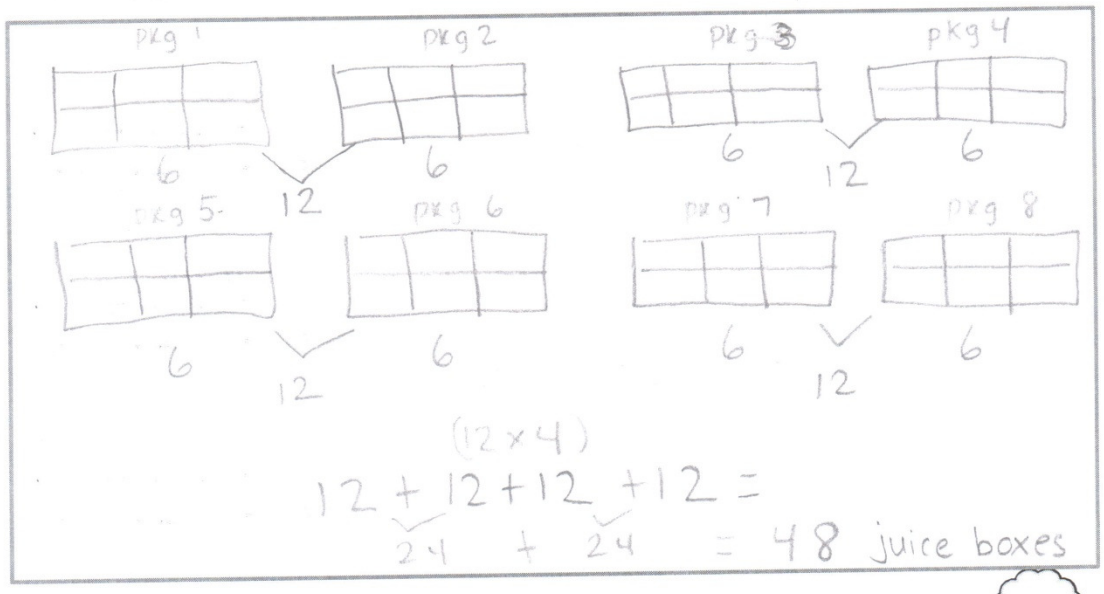
8. Camden is buying heart cookies for the Valentine's Day party. He buys 7 packages of cookies. Each package has 6 cookies. How many cookies does he have in all?

9. Ms. Val is setting up for the band and strings concert. First, she sets up chairs for the concert. She set up enough so that everyone will have a chair. She set up 8 rows with 10 chairs in each row. How many chairs did Ms. Val set up?

Name: Example Date:

Using Visualization to solve Math Problems

Chase is buying juice boxes for his lunch. He buys 8 packages of juice. Each package has 6 juice boxes. How many juice boxes does he have in all?



Answer: 48 juice boxes