Literacy Coaching Clearinghouse

Reading Coaching for Math Word Problems

Sharon A. Edwards, Robert W. Maloy, & Gordon Anderson
University of Massachusetts Amherst

"Math is language, too," Phyllis and David Whitin (2000) remind us in their informative book about reading and writing in the mathematics classroom. This means that students in elementary school math classes are learning two distinct, yet related languages—one of numbers, the other of words. These languages of numbers and words are combined in math word problems, a standard feature of the academic curriculum and a key part of high-stakes math achievement tests for all students.

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. 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. Others may be confused about the math operations needed for the problem. Those who struggle with both the reading and the math face the biggest challenges. These youngsters are the least successful with math word problems, performing worse than students with only math difficulties or students experiencing neither reading nor math difficulties (Fuchs & Fuchs, 2002).

Literacy coaches charged with helping teachers support students as readers, often focus on literary texts. Less attention is given to helping teachers support students to read math. Drawing on our experiences as elementary school teachers, a college faculty member who coordinates a literacy tutoring program, and a computer scientist who works on the design of intelligent tutoring systems, we focus this article on strategies for addressing the reading challenges found in math word problems. Using fourth grade questions from the Massachusetts Comprehensive Assessment System (MCAS) test, we identify seven specific word and math language comprehension challenges. For each challenge, we propose strategies that literacy coaches and teachers can use to support students in understanding and solving math word problems.

We focus on fourth grade test examples because that grade is a crucial mid-point for elementary school students. Math learning at fourth grade establishes a foundation for success in upper elementary school and beyond. In our state, examples from the fourth grade test apply to third grade as well since word problems begin to have more complex formulations at that level. Fifth and sixth grade questions follow the same formats as those at fourth grade. With these ideas as a starting point, we invite you to examine math word problems from your state and school district exams (or school math textbook series), identify word and math language comprehension challenges, and propose other strategies that teachers can use to support elementary school students.

Unfamiliar Vocabulary

Challenge. It is hard for students to solve math word problems containing terms and phrases unfamiliar or unknown to them. For example, questions from recent Massachusetts MCAS tests, an exam given to all public school fourth graders in the state, included words not usually heard in everyday speech such as *item*, *stadium*, *depositing*, *bow*, and *repair*. Reading and understanding these kinds of words pose challenges for some students. They may be more familiar with shopping for milk, bread, or candy rather than for these items. They may not attend events at "stadiums" or have heard adults talk about making a "deposit" on an apartment or into a bank account.

In other questions, unfamiliar phrases confuse young readers. Consider the following example:

> *"Haley swam 22 laps each day for 18 days. Then she swam 25 laps each day for 10 days What was the total number of laps she swam over the 28 days?"* (Massachusetts Department of Education, 2006)

"Swam laps" is a difficult term for young readers, particularly those who do not swim back and forth in a pool. It is possible not to understand what Haley was doing.

Strategy. One strategy is to ignore unfamiliar or confusing words and try solving the problem with the words the child knows. In the Haley question, a youngster can read the problem while ignoring the words *swam* and *laps*. The reader can learn to recognize that Haley did something 22 times each of 18 days and then 25 times each of 10 days. Multiplying 22 x 18 and 25 x 10 and then adding those two totals will produce a correct solution without the student needing to understand what it was that Haley did.

Proper Names

Challenge. Word problems sometimes include proper names that are unfamiliar or unknown to young readers. The 2007 MCAS for fourth graders included 29 proper names in 39 questions, including Mr. Gomez, Ms. Rodriguez, Angelina, Rhonda, Elin, Ms. Lin, Kiki, Pedro, Kyle, Ryan, Rosetta, and Shannon. Unfamiliar names may distract young readers from the essential mathematical information in a problem.

Strategy. Even though students may not be able to read one or more of the names they encounter, most of them recognize that the unknown word is a name. When this happens, teachers can encourage young readers to substitute the first letter of the proper name, their own names, or the names of friends or family members. When names are made familiar or abbreviated to a letter, it is easier to concentrate on the mathematics of the problem.

Sentence Structure and Syntax

Challenge. Word problems on state and national tests and in commercially published math textbooks are written in compositional, not conversational English. As such, they are not easily recognizable for some young readers. Consider the following problem:

> *"Mr. Thomas walks every day. The distance that he walks each day is between 4 miles and 8 miles. Which of the following could be the total number of miles Mr. Thomas will walk in 30 days?"* (Massachusetts Department of Education, 2006)

Strategy. Mathematician George Polya's (1973) classic problem solving framework offers a model for teaching students how to understand word problems. To solve any problem, Polya proposed the following series of steps (Figure 1).

Figure 1: Problem Solving Steps

Step 1	What kind of question is this?	• Identify the question type • Connect to already learned approaches
Step 2	What is the question asking for?	• Find the keywords
Step 3	What information am I given to solve the problem?	• Focus on relevant information • Organize information in a table or drawing
Step 4	How can I solve this problem?	• Use the information already given • See if the problem can be broken down into smaller steps • Eliminate obvious wrong answers
Step 5	Did I solve the problem?	• Decide if you solved what is being asked

In Polya's framework, a problem solver first understands what type of problem is being posed, then clarifies what is being asked for, investigates the problem to see what information is already given, formulates a plan for solving the problem, and checks the computational work for any missteps or errors before finalizing an answer.

While Polya's problem solving steps delineate what to do mathematically, his ideas apply to comprehending problems in order to solve them. When addressing the first three questions in this problem solving sequence ("What type of problem is this?" "What is the problem asking?" and "What do I know to solve the problem?") focus on reading words and numbers. Teachers can use Polya's questions to guide students toward understanding.

Math Terminology

Challenge. Math terminology in word problems is a comprehension as well as a decoding challenge. Students need to understand and recall mathematics terms and concepts expressed in words, such as *total*; *number sentence*; *even and odd numbers*; *equations*; *expressions*; *greatest and least*; *equal*; and *probability*.

Many math language terms have a counterintuitive, conversational meaning. Consider the following problem:

> *"Last month, 3801 people ate at Tony's Pizza. This month, 2765 people ate at Tony's Pizza. How many more people ate at Tony's Pizza last month than this month?"* (Massachusetts Department of Education, 2007)

"How many more" suggests adding to find a total, but "more" in the question requires subtracting the smaller number from the larger to find the correct answer.

Further issues arise in the case of words such as *difference*, *product*, or *represents* whose meanings are different in math language than in everyday language. *Product* is something one buys at the store as well as the answer to a multiplication question. *Difference* is assessed visually or vocally as well as by subtracting. *Represents* is a political term that is not automatically translated as "stands for."

Strategy. Teaching math vocabulary has been shown to improve student performance on math tests (Gifford & Gore, 2008). Teachers can purposefully teach math vocabulary. For example, students can be taught that "Total Number of Different Combinations" problems require multiplication, as in the following question:

> *"Mr. Mitchell is ordering special sweatshirts for his students. The chart below shows his choices for size, color and pattern.*

Choices for Sweatshirts		
Size	Color	Pattern
Small Medium Large	White Yellow	Flowers Plants

What is the total number of different combinations of 1 size, 1 color, and 1 pattern that Mr. Mitchell can order? (Massachusetts Department of Education, 2005)

Mr. Mitchell's combination problem is solved by multiplying 3 sizes x 2 colors x 2 patterns = 12 different combinations, a strategy that students can use whenever they encounter a combinations problem.

A second strategy is to invite students to create their own informational placemats and posters as memory guides to math terminology and strategies. Children can diagram phrases to remind them about key terms—the answer to 4 x 4 is a *product* while the answer to 6 + 6 is a *sum*. A *product* and a *sum* are both a *total*, and a *total* means *all*. Songs and skits, particularly ones students compose themselves, also help students learn math terms and their definitions.

Multiple Math Operations

Challenge. Word problems may involve multiple mathematical operations and when they do, some students may not understand that more than one step is needed. The problem of Haley swimming laps each day requires multiplying twice (22 x 18 and 25 x 10) before adding the subtotals. Students who do realize the need for multiple math operations might make the mistake of adding 22 + 18 + 25 + 10 to get 75, a wrong answer that may be one of the possible answer choices.

Strategy. Invite students to change the text of the problem, but not the numbers. Instead of Haley swimming laps, the text could be Haley shooting basketballs. The basketball fans in the class will relate to the idea of making 22 baskets for 18 days followed by making 25 baskets for 10 days more easily than swimming laps. In this way, those children will recognize that more than one math operation is needed to answer the problem.

Alternatively, as students identify the multiple math operations needed, they can sketch a picture, make a chart, or draw a map displaying what they must do step-by-step. Visuals representations help students understand the need for multiple mathematical operations.

Words and Numbers

Challenge. Math word problems blend words and numbers in ways that can create confusion for young readers. Consider the following problem:

"Mr. Jordon is buying 3 CDs. Each CD costs $18.99 including tax. Which is the best estimate of the cost of the 3 CDs?" (Massachusetts Department of Education, 2001)

The numbers in the problem (3 and $18.99) are embedded within sentences that appear straightforward, yet the two words *including tax* are easily missed, creating an opportunity for students' calculation to be correct while their answer choice is incorrect.

Strategy. Invite students to compose their own math word problems, math comics, and math stories as another way to understand how writers blend words and numbers together to pose questions (Edwards, Maloy & Verock-O'Loughlin, 2002). They can author informative problems using child-engaging language and incorporating child-familiar topics such as shopping, food, music, sports, and pets, as in fourth grader Kelsea's math word problem using fractions.

Kelsea's Fraction Problem

"There were 50 Labrador puppies—16 were chocolate, 12 were yellow, and 22 were black. Then I got 16 golden retriever puppies. There were 66 puppies. What fraction of the total number of puppies were chocolate, yellow and golden?"

As students compose their own problems, teachers or coaches can point out the importance of the information written in the question. Kelsea's word problem results, 16, 12, and 16 equals 44/66, a fraction that can be reduced to two-thirds.

Visual Displays of Information

Challenges. Word problems may require students to read and interpret charts, graphs, pictures, and other visual displays of information. These visual displays can be confusing even to adult readers (Tufte, 2001). Reading visuals involves interpreting both words and numbers presented not in sentences or paragraphs, but in rows, lines, circles and other configurations.

Strategy. Design and construct charts, graphs, and visuals about topics and questions that students want to ask friends and family. To glean ideas about how to visually display information after it is collected, or to find interesting questions to pose, go online to USA TODAY at http://www.usatoday.com/snapshot/news/snapndex.htm. News-related graphs and questions are categorized and displayed. These visual displays of information are easy to read and understand.

Conclusion

Math word problems have been a relatively understudied component of math and literacy learning (Powell, Fuchs, Fuchs, Cirino, & Fletcher, 2009). They present complex and multifaceted issues, including the seven challenges described in this article. While we discussed these challenges one by one, some problems present multiple challenges. Literacy coaches and teachers need wide-ranging strategies in order to support children as they improve their skills in reading and mathematics. By using novelty, flexibility, and creativity of response, together they can help students deepen and broaden an understanding of the languages of words and numbers found in math word problems.

References

Edwards, S. A., Maloy, R. W., & Verock-O'Loughlin, R. (2002). *Ways of writing with young kids: Teaching creativity and conventions unconventionally*. Boston: Allyn & Bacon.

Fuchs, L. S., & Fuchs, D. (2002). Mathematical problem-solving profiles of students with mathematics difficulties with and without comorbid reading difficulties. *Journal of Learning Disabilities*, 35, 563-573.

Gifford, M. & Gore, S. (2008, March). The effects of focused academic vocabulary instruction on underperforming math students. Association for Supervision and Curriculum Development. Retrieved April 22, 2009, from http://www.ascd.org/ASCD/pdf/Building%2520Academic%2520Vocabulary/academic_vocabulary_math_white_paper_web.pdf

Massachusetts Department of Elementary and Secondary Education. (2007). Grade 4 mathematics test. Malden, MA: Massachusetts Department of Elementary and Secondary Education.

Massachusetts Department of Elementary and Secondary Education. (2006). Grade 4 mathematics test. Malden, MA: Massachusetts Department of Elementary and Secondary Education.

Massachusetts Department of Elementary and Secondary Education. (2005). Grade 4 mathematics test. Malden, MA: Massachusetts Department of Elementary and Secondary Education.

Massachusetts Department of Elementary and Secondary Education. (2001). Grade 4 mathematics test. Malden, MA: Massachusetts Department of Elementary and Secondary Education.

Polya, G. (1973). *How to solve it: A new aspect of mathematical method*. Princeton, NJ: Princeton University Press.

Powell, S. R., Fuchs, L. S., Fuchs, D., Cirino, P. T., & Fletcher, J. M. (2009, March/April). Do word-problem features differentially affect problem difficulty as a function of students' mathematics difficulty with and without reading difficulty? *Journal of Learning Disabilities*, 42(2), 99-110.

Tufte, E. R. (2001). *The visual display of quantitative information* (2nd ed). Cheshire, CT: Graphics Press.

Whitin, P. & Whitin, D. J. (2000). *Math is language too: Talking and writing in the mathematics classroom*. Urbana, IL: National Council of Teachers of English.