Designing Vocabulary Instruction in Mathematics

Margaret E. Pierce, L. Melena Fontaine

Elementary school teachers have become aware in recent years of the critical role that vocabulary knowledge plays in the academic lives of their students. The report of the National Reading Panel (National Institute of Child Health and Human Development, 2000) intensified the spotlight by identifying vocabulary as a key component of effective reading instruction. This oft-cited report concluded that vocabulary instruction, when carefully tailored to the age and ability of the reader, leads to gains in reading comprehension. In response to this research, teachers have had to become experts on methods for promoting vocabulary development in the language arts. But does the facilitating effect of vocabulary knowledge extend beyond the domain of reading?

Language skills have become increasingly important in mathematics classrooms. The National Council of Teachers of Mathematics' (NCTM; 2000) *Principles and Standards for School Mathematics* now includes Communication as a process strand. Students need to be able to explain their problem-solving methods orally and in written form, both in the classroom and on high-stakes tests. Students are also expected to engage in conversations about mathematical ideas and through these conversations to "develop a language for expressing mathematical ideas and an appreciation of the need for precision in that language" (NCTM, 2000, p. 60). This focus on language is reflected in many state high-stakes math tests, which present students with complex word problems. Preliminary findings from research being conducted on the complexity of vocabulary within high-stakes tests indicate that students are expected to understand words that fall along a continuum from those that are used in many contexts to those that are very specific to mathematics (Pierce & Fontaine, 2008). The depth and breadth of a child's mathematical vocabulary is more likely than ever to influence a child's success in math. Yet few elementary school teachers bring effective vocabulary instruction into their math lessons.

What can elementary school teachers do to support their students in meeting the language demands of new mathematics curricula and high-stakes tests? First, teachers need to identify math vocabulary words. Next, they can apply research-based principles for vocabulary instruction in the mathematics classroom. To support elementary school teachers in these endeavors, we begin by reviewing best practices in vocabulary instruction. Next, we offer one way to analyze state high-stakes math tests to identify those words that children would benefit most from learning. Finally, we provide an example of how to apply robust vocabulary instruction in math.

Robust Vocabulary Instruction

In their hallmark book *Bringing Words to Life: Robust Vocabulary Development*, Beck, McKeown, and Kucan (2002) described research-based instructional strategies for promoting vocabulary development with children from the early grades through high school. A key finding in the book is that vocabulary instruction should be rich and lively so that students "develop an interest and awareness in words beyond vocabulary school assignments in order to adequately build their vocabulary repertoires" (p. 13). They made several recommendations for how to design what they call robust vocabulary instruction. First, Beck and colleagues advised that teachers should provide "student-friendly explanations" (p. 35) of the word rather than dictionary definitions. These explanations should explain the meaning of the word in everyday language, and they should characterize the word and how it is typically used. Second, teachers should engage the students in "rich and lively" (p. 13) activities that encourage deep processing of the word's meaning. These activities have been shown

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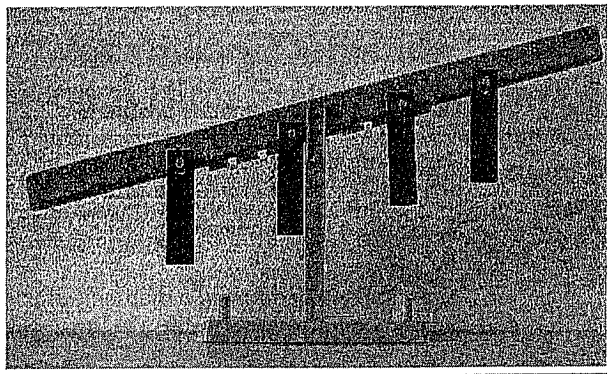
Figure 1
Number Balance Showing an Untrue Number Sequence



Note. Photograph by M.E. Pierce.

The first two principles of vocabulary instruction offered by Beck and colleagues (2002) recommend the development of student-friendly definitions and opportunities for deep processing of word meanings. According to Beck et al., these definitions should explain the meaning of the word in everyday language and characterize how the word is typically used. Students should also engage in activities that encourage deep processing of the word's meaning rather than simple repetition of the definition. These two principles of instruction are illustrated in the following fictional vignette, which shows how a teacher might help her students learn the subtechnical vocabulary word *true*.

Mrs. Lewis's Class Explores Truth in Mathematics

Mrs. Lewis was concerned that her third-grade students lacked deep appreciation of the meaning of the word *true*. The word *true* has a mathematical denotation that varies somewhat from its common meaning, and Mrs. Lewis decided it was important to make this point explicitly with her students. She started her lesson by asking the students to help her come up with a student-friendly definition of the word *true*. After some discussion, the class decided upon the following: *something that really happened or a fact, the opposite of false*. Mrs. Lewis reminded the class that most words have several meanings, depending on the situation in which the word is used. Then she introduced a second meaning of *true: a word used to describe a number sentence where the value on the left of the equal sign is the same as the value on the right of the equal sign*. Together, the class brainstormed examples of number sentences that were true (e.g., $4 + 3 = 7$, $5 \times 4 = 2 \times 10$) and number sentences that were not true (e.g., $1 + 2 = 5$; $3 \times 4 = 7$). The students then wrote the term, its everyday meaning, and its math definition in their math glossaries, while the teacher recorded it on their math word wall.

To provide her students with an opportunity for deep processing of this meaning of the word *true*, Mrs. Lewis engaged her students in a small group exercise using number balances. Together, the students in each group evaluated a series of number sentences to determine whether they were true or not true. True number sentences resulted in the number balance resting parallel to the ground, indicating that the value of the two sides was equal. Untrue number sentences resulted in the balance resting at an angle, indicating that one side of the number sentence had a higher (and thus a heavier) value. Figure 1 shows a number balance displaying an untrue number sentence: $3 \times 5 + 1 = 2 \times 6 + 3$. To represent $3 \times 5 + 1$, students placed 3 weights on peg 5 of the scale and 1 weight on peg 1 of the scale. To represent $2 \times 6 + 3$, students placed 2 weights on peg 6 of the scale and 1 weight on peg 3. The balance rested with the left arm lower than the right arm, indicating that the number sentence was untrue—the values on the two sides of the number sentence were not the same.

Bringing It All Together

Reading research has provided the field of education with invaluable insight to effective methods of teaching vocabulary, an endeavor of critical importance to our students' reading comprehension. However, the importance of vocabulary knowledge extends well beyond the domain of the language arts. In particular, proficiency in mathematics has increasingly hinged upon a child's ability to understand and use two kinds of math vocabulary words: math-specific words and ambiguous, multiple-meaning words with math denotations. Elementary school teachers can identify these words and design lessons that provide student-friendly definitions and offer opportunities for deep processing of word meanings. These efforts will help students to use the language of math.