Vocabulary Considerations for Teaching Mathematics

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The importance of rich and meaningful vocabulary knowledge when developing concepts is well documented and widely accepted by classroom teachers; vocabulary provides access to concepts. Because mathematics material is so difficult to read, "with more concepts per word, per sentence, and per paragraph than any other area" (Schell, 1982, p. 544), it is particularly crucial to emphasize vocabulary instruction in this content area.

Necessary Vocabulary for Developing Mathematical Concepts

The vocabulary that teachers should teach to help students develop mathematical concepts can be classified into four categories: *technical, subtechnical, general* and *symbolic.*

Technical Vocabulary. Those words generally viewed as mathematical terminology are called *technical* vocabulary. 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. Because these terms are encountered only in mathematical contexts, and are themselves often defined with other technical terms, they are difficult to learn and remember; learning a technical vocabulary is comparable to learning a foreign language.

Subtechnical Vocabulary. *Subtechnical* terms have more than one meaning; these meanings vary from one content area to another or from a content area to everyday experience. Learners may know and be able to use one or more meanings for a subtechnical term, but may not necessarily know its specific mathematical meaning. Because of their multiple meanings (e.g., the *volume* of a cube, the *volume* control on the television set, the *volume* of world trade), these terms can be especially difficult to conceptualize. Some subtechnical terms have multiple meanings even within a mathematical context (e.g., *degrees* of temperature, *degrees* of an angle), thereby creating additional conceptual problems. Because of this nature, subtechnical terms may be even harder to learn and remember than technical terms.

General Vocabulary. Students encounter *general* vocabulary words in everyday language and in their usual reading experiences. Most elementary mathematics textbooks use a general vocabulary, although these words are not likely to be taught in reading class. 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 about half the words included in mathematics textbooks for the same levels (Stauffer, 1966). Recent research indicates the problem still exists. Panchyshyn and Monroe (1992) found that more than half of the words included in elementary mathematics textbooks were not among those most frequently used in children's reading materials. A mandate for developing general vocabulary in mathematics becomes evident when these and similar findings are considered.

Symbolic Vocabulary. *Symbolic* vocabulary, viewed by some to be the *real* vocabulary of mathematics, presents its own special problems. Most reading ma-

terial uses only alphabet symbols. In mathematics, however, the reader needs to recognize not only the alphabet, but also numerous nonalphabet symbols. Numerals, the most common math symbols, represent numbers, which are themselves so highly abstract that even mathematicians find them difficult to define! In addition, a given numeral can be used to convey many different meanings. For instance, consider the numeral 2 in the following numerical contexts:

52 23 4^2 1/2 2/3 m^2

The 2 conveys a different, and highly abstract, meaning in each context. Furthermore, the numerical expression itself can be read in different ways—4^2 can be read as "four squared," "four to the second power," etc. Adding to the potential for confusion, the same meaning can be conveyed by different symbols. Consider how learners must refocus their thinking when division is presented as $4 \div 2$, $2 \times ? = 4$, or 4/2.

Abbreviations, also classified as symbolic vocabulary, can create more confusion. Possibly no other subject area uses as many abbreviations, and many abbreviations are formed in irregular ways. Abbreviations such as *lb.* for *pound* and *ft.* for either *foot* or *feet*, which can also be expressed as the symbol ', as in 4'11", are especially confusing. Capps and Gage (1987) called attention to these and other problems with mathematical symbols and observed that it is "small wonder that children have difficulty" (p. 5) understanding them.

Planning and Implementing Vocabulary Instruction in Mathematics

Planning vocabulary instruction for concept development in mathematics is not an easy task. Teachers' editions of basal mathematics series are only beginning to offer ideas and activities for developing and extending technical, subtechnical and symbolic vocabulary. General vocabulary, which may comprise the greatest number of unknown words, is usually ignored completely. Furthermore, these textbooks often fail to describe concepts adequately, thereby making teaching even more difficult.

How, then, should a teacher of elementary mathematics plan and implement vocabulary instruction for concept development? Most elementary teachers already have a repertoire of skills that they can use; the methodology and activities they have developed for teaching vocabulary in other areas can be just as appropriate for the mathematics lesson. Each type of vocabulary—technical, subtechnical, general and symbolic—must be considered when planning a specific lesson, but that should not affect the instructional strategy. Decisions regarding an instructional strategy should be based on teachers' knowledge of how their students learn best. The following suggestions—"a baker's dozen" in all—will serve to help teachers begin implementing vocabulary instruction in mathematics.

Each type of vocabulary—technical, subtechnical, general and symbolic—must be considered when planning a math lesson . . .

1) One way to start is by using concrete experiences with manipulatives to develop a concept. Guide oral language development as students work with the manipulatives. For example, cover rectangular regions with square tiles (or crackers or square pieces of paper) and discuss the concept of *area* before asking students to tackle the concept in their mathematics textbooks.

2) Examine the textbook lesson carefully ahead of time to identify terms that will be new for the students. Select a few key terms (technical or subtechnical) that can serve as organizers for the concepts to be taught. Also, be prepared to provide help concerning any symbols and general vocabulary that may create reading problems.

A lesson on adding two-digit whole numbers, for example, may require explanation or review of *addend, sum* and *equal.* Although the symbols + and = should already be familiar, these concepts may need to be extended. Some of the general vocabulary words used in the textbook's introductory example may be unfamiliar and will require special attention.

3) Teach and extend vocabulary in relation to students' real-world experiences. Students enjoy finding examples of geometric shapes in their homes, en route to school and in their classrooms. Remind them of how breakfast cereal is packaged in rectangular boxes, or how stop signs are octagonal. When teaching fractions, express terms like "one-sixth" or "one-eighth" as slices of pizza, and use egg cartons to illustrate relationships among halves, fourths, thirds, sixths and twelfths.

4) Students who do not have enough relevant prior experiences with concepts need prereading activities, such as brainstorming and semantic mapping, to encourage discussion. For instance, ask the

class to brainstorm all known definitions of the word *degree:* degrees of latitude and longitude, degrees of temperature, degrees in an angle, a college degree, etc. Then select and develop the definition that applies to the concept being taught.

Semantic mapping is also useful when introducing a new topic, as it "helps to activate and expand prior knowledge; it also helps students learn new words" (Johnson & Johnson, 1986, p. 625). The following skeleton semantic map can be used when introducing a unit on measurement to 3rd-graders. Active classroom discussion will encourage students to provide labels for the categories given, include additional items and categories, and discuss relationships among the concepts.

Metric Units of Length	_____	_____
centimeters	length	inches
meters	weight	feet
		yards
_____	MEASUREMENT	_____
hours		pounds
days		ounces
_____	_____	_____
grams	customary	pints
kilograms	metric	quarts

5) Take time to teach the "little" words in mathematics class. Even words such as *a* and *the* can be confusing. In the whole number system, the only possibility for *a* number between 7 and 9 is 8; many different possibilities are available, however, for the same interval when working with fractions (e.g., 7 1/4, 8 3/5). When asked for *the* number between 7 and 9, we assume that the only correct answer is the whole number 8.

6) Teach mathematics symbols only after students have the necessary experiential background and language development to understand them. For example, when learning the concepts *is less than* and *is greater than,* students need to work with concrete objects and pictures, accompanied by class discussion, before the highly abstract symbols < and > are introduced.

7) Introduce and develop pertinent vocabulary in *each* mathematics lesson, and then review the terms frequently. A rule of thumb recommended by Capps (1989) is to provide six exposures to a new word during the initial lesson and at least 30 additional exposures during the ensuing month. Remember, new vocabulary should be repeated often in meaningful settings before students will retain and actually use it to construct mathematical concepts.

8) Model the use of appropriate mathematics vocabulary when interacting with students. When discussing examples using addition, for example, ask "How did you find the *sum*?" rather than "How did you find the *answer*?"

9) Give students many opportunities to talk about new mathematical concepts. Discussion will be greatly facilitated through cooperative learning groups and peer tutoring.

10) Use writing assignments to develop mathematics vocabulary. Students will enjoy drawing pictures and writing definitions to create their own math dictionaries. They could also keep journals of mathematical concepts, thus using writing to clarify their thinking. Rewriting a textbook sentence or definition in one's own words can often help clarify a concept and aid retention.

11) Share selections from children's literature. Some books are specifically designed to teach mathematics concepts; however, choices should not be limited to these. Much of children's literature can be used to develop and extend mathematical concepts. For help in getting started, consult sources such as Gailey (1993), Lewis, Long and Mackay (1993), Richardson and Monroe (1989) or Welchman-Tischler (1992).

12) Teach students to read their math textbooks slowly and carefully, stressing that every word and symbol is important to their understanding. Also teach them to use text guides such as boldface print and definitions. Rather than avoiding text because it is difficult to read, students need to learn to use it effectively and to learn concepts independently.

13) As students develop dictionary skills, encourage them to learn new mathematics vocabulary on their own by consulting the glossaries in their mathematics textbooks and, when available, mathematics dictionaries. "Regular" dictionaries can also be helpful, particularly if students are taught the process of "fine tuning," as described by Thomas (1980). When teaching this process, use the numerals on a radio dial as an analogy. Tell students to keep "fine tuning" until they find the definition that best fits the context, just as they fine tune their radios to find their favorite music. Avoid routine assignments, such as looking up words in a glossary or dictionary and writing definitions or sentences. These types of assignments do little to encourage enthusiasm for vocabulary development.

In Summary

Just as vocabulary building enhances literacy development, it is especially important in developing mathematical competency. "... [T]he content of mathematics is not

taught without language" (Capps & Pickreign, 1993, p. 12). Yet, learning the necessary vocabulary may be difficult because of complex terminology, abstraction and the infrequent use of specialized mathematics vocabulary in nonmathematical contexts. The classroom teacher needs to remember that several kinds of vocabulary must be *actively taught* during each mathematics lesson. The teaching methods to be used should not be unique to mathematics. Rather, teachers can draw upon their existing repertoire of strategies to help students construct vocabulary meanings in a variety of subject areas. The "baker's dozen" of suggestions included here are offered simply as ways to help teachers begin.

References

Capps, L. R. (1989, April). *Problem solving: Is language a problem?* Paper presented at the annual meeting of the National Council of Teachers of Mathematics, Orlando, FL.

Capps, L. R., & Gage, M. S. (1987). Mathematics spoken here: A case for language and vocabulary in mathematics. In Houghton Mifflin (Ed.), *Current issues in mathematics* (pp. 4-6). Boston: Author.

Capps, L. R., & Pickreign, J. (1993). Language connections in mathematics: A critical part of mathematics instruction. *Arithmetic Teacher, 41*(1), 8-12.

Gailey, S. K. (1993). The mathematics-children's literature connection. *Arithmetic Teacher, 40*(5), 258-261.

Johnson, D. D., & Johnson, B. (1986). Highlighting vocabulary in inferential comprehension instruction. *Journal of Reading, 29*, 622-625.

Lewis, B. A., Long, R., & Mackay, M. (1993). Fostering communication in mathematics using children's literature. *Arithmetic Teacher, 40*(8), 470-473.

Panchyshyn, R., & Monroe, E. E. (1992, July). *Vocabulary considerations in mathematics instruction.* Paper presented at the fourteenth World Congress on Reading, Maui, HI.

Richardson, M. V., & Monroe, E. E. (1989). Helping young children solve word problems through children's literature. *School Science and Mathematics, 89*(6), 515-518.

Schell, V. J. (1982). Learning partners: Reading and mathematics. *Reading Teacher, 35*, 544-548.

Stauffer, R. G. (1966). A vocabulary study comparing reading, arithmetic, health and science texts. *Reading Teacher, 20*, 141-147.

Thomas, E. L. (1980). *Reading aids for every class.* Boston: Allyn and Bacon.

Welchman-Tischler, R. W. (1992). *How to use children's literature to teach mathematics.* Reston, VA: National Council of Teachers of Mathematics.