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ELEMENTARY SCHOOL MATH INSTRUCTION: CAN READING SPECIALISTS ASSIST?

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While experts in the field of reading increasingly agree on the importance of direct instruction in vocabulary building, professionals in the field of elementary school mathematics tend to emphasize the use of concrete, manipulative materials and informal math language development over direct, specific instruction in technical terms or verbalizations of concepts. Today's elementary classroom teachers find contradictory recommendations when they seek to make decisions about teaching the meanings of technical words in their mathematics classes. This article presents a discussion of the contradictions and some suggestions for practical resolution of disagreements, which will enable school reading specialists to provide both background and practical help to classroom teachers.

Vocabulary Research in Reading and Math

One of the strongest expressions of the necessity for vocabulary building is stated by Readance, Bean, & Baldwin: "As students progress through texts, reading comprehension can diminish to the point of extinction if students have failed to master the words which symbolize important concepts, even when the concepts themselves have been mastered" (1985, p. 86). In addition, the entire April (1986) issue of Journal of Reading focuses on the importance of and methods for developing children's vocabularies. General considerations which can be applied to developing an effective mathematics vocabulary include: ensuring student engagement in the process of learning the new terms; teaching the methods of learning new terms to students so that they will continue the practice on their own; and drawing out their background knowledge of the terms as a first step in instruction, tying that knowledge into their expanding definitions.

In the field of elementary school mathematics, however,

a survey of two levels of seven elementary school mathematics series indicates that clear statements about the need and strategies for direct vocabulary instruction are lacking, although the vocabulary load for each unit in the textbook is presented in the teacher's manual and a glossary is provided in the back of the student text. A search through college textbooks on teaching elementary school mathematics and related professional journals shows variation in the amount of emphasis they give to teaching vocabulary, many barely mentioning it and a few devoting serious attention to it.

While Problem Solving is the first of the Ten Basic Skills in Mathematics delineated by the National Council of Teachers of Mathematics, the National Assessment of Educational Progress reports that test scores in problem solving have gone down in the past decade. Eizen and Dowshen (1985) state that, in school, problem solving exercises are most likely to be presented in written form, and reading comprehension of mathematical terms is a high priority task. Garbe (1985) reports that some students have very imprecise knowledge of mathematical terms (e.g., confusing angle with ankle). He recommends that such confusion be eliminated by precise instruction. He presents evidence that, for the two groups under study, reading ability was a larger factor in understanding math concepts than was ability in mathematics.

In general, then, expert advice seems to be that knowledge of word meanings is highly important to mastery kof a topic, further learning in that subject area, and even general cognitive ability. At the same time, there are warnings about leaving the world of concrete materials too soon to seal solely with symbols and learning words without adequate conceptual background. Reading specialists, knowledgeable about the advisability of vocabulary building and effective methods for doing so, can offer informed help on decisions concerning math instruction.

Which Words to Teach?

There are published lists of mathematical terms available (e.g., Earle, 1976) for teacher guidance. In addition, the results of a study of the vocabulary in student glossaries of seven mathematics textbook series at levels three and five are presented in Table 1 at the end of this article.

Terms which are used in three or more of the student glossaries are displayed. Technical terms which appear at both levels 3 and 5 are starred on the Third Level list and do not reappear on the list for "Fifth Level Only". These words are excellent candidates for vocabulary instruction. Reading specialists can advise classroom teachers who use textbook series from other publishers on making adaptations.

When to Teach Them?

Allocating specific times during the math period for vocabulary instruction is appropriate. Twenty minutes a weeks, for example, would be useful by fourth grade. Setting aside special time for vocabulary study enables teachers to separate the teaching of highly developed knowledge of word meanings from the earlier stages of mathematical learning--concrete exploration or gradual increase in the use of symbols for mathematical concepts. If scheduling demands are tight, the time alloted to development of mathematics vocabulary may be considered part of Language Arts or Reading, because content area vocabulary development is clearly part of a good language arts or reading curriculum.

How Can They Be Taught?

Strategies for developing verbal concepts in children begin in the concrete world and develop slowly to the abstract, and many of the terms appearing in Table 1 have concrete representations. Both Baratta-Lorton books (Baratta-Lorton, M., 1976; Baratta-Lorton, R., 1977) offer ways for students to make concrete the meanings behind mathematical terms, ways such as the manipulation of groups of objects or groups of students.

Other terms have multiple meanings, only one of which relates to math; the non-math meanings are often already in the children's vocabularies. Frequent lessons in the multiple meanings of words are useful in expanding mathematics vocabulary. Some of the words in Table 1 which lend themselves to this kind of development are: acute, angle, area, average, chord, circle, common, cone, cube, cup, degree, difference, even, face, family line, obtuse, odd, ordered, place, point, prime, ray, remainder, right, round, scale, square, and whole.

Semantic feature analysis focuses not only on the simi-

larities between concepts but also their differences. Several concepts are selected, for example, geometric forms. Characteristics are elicited from the children, who are handling models of the forms. An example of comparison of the figures is shown in Figure 1. In such activities children practice analyzing and specifying, thinking and communicating about mathematical models while they consolidate their knowledge of technical words.

	CURVED	FLAT SURFACE	HEIGHT	LENGTH	WIDTH	ONLY TWO DIMENSIONS	THREE DIMENSIONS	ANGLES	PERPENDICULAR LINES
CONE	+	+	+	-	+	-	+	-	-
CUBE	-	+	+	+	+	-	+	+	+
CYLINDER	+	+	+	+	+	-	+	-	+
PENTAGON	-	+	+	-	+	+	-	+	+
POINT	-	-	-	-	-	-	-	-	-
PYRAMID	-	+	+	+	+	-	+	+	-
SPHERE	+	-	-	-	-	-	+	-	-
SQUARE	-	+	-	+	+	+	-	+	+
TRIANGLE	-	+	+	-	+	+	-	+	?

Figure 1. Semantic feature analysis: Example of geometric terms.

Other recommendations include student discussion groups: students join in giving positive and negative examples, offer synonyms, critique those offered, and investigate definitions provided by the teacher. Attention is given to developing schemata for the new words, and relating the words to as many known words as possible. These relationships can be made visual by drawing diagrams which categorize the new terms with known ones. In addition to the semantic map of "fraction" represented in Figure 2, other terms from the glossaries may be used to

create schemata; terms of measurement or geometric terms could each be the unifying concept for a schema to be developed in class.

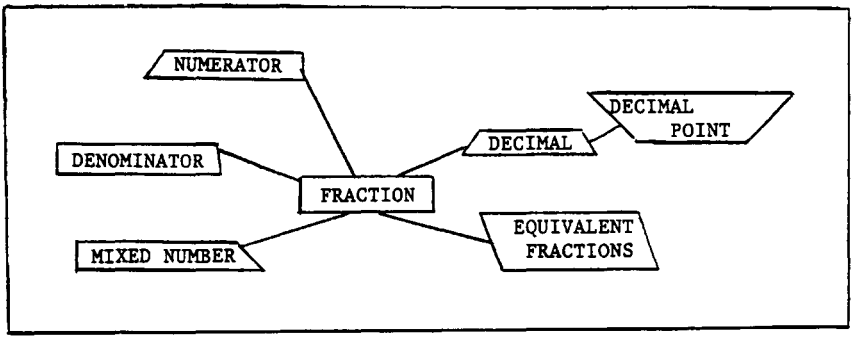

Figure 2. Semantic mapping: Example of "fraction" and related terms.

There are many levels of concreteness and abstraction for the reading specialist to offer to the teacher who decides to emphasize vocabulary development in connection with the study of mathematics. Games such as card games that match a picture of an object or process with an example, a label, and a definition are more abstract than manipulation of people or objects. In the very abstract realm, analogies seem to help students of fifth grade and above to learn definitions (Wolff, Desberg, and Marsh, 1985).

Reading specialists can become an important adjunct to the elementary math program by acquainting teachers with recent research in vocabulary development, modeling varied methods of vocabulary instruction, and pointing out that children who lack an adequate mathematics vocabulary are seriously handicapped in their study of that subject.

The publishers and dates of publication of the seven textbook series examined in this article are:
1. D. C. Heath and Co. (1985).
2. Holt, Rinehart and Winston, Publ. (1981).
3. Houghton Mifflin Co. (1985).
4. Macmillan Publishing Co. (1985).
5. The Riverside Publishing Co. (1985).
6. Scott, Foresman and Co. (1985).
7. Silver Burdett Co. (1981).

Table 1 - VOCABULARY COMMON TO THREE OR MORE ELEMENTARY MATH TEXTS

Third level

*addend(s)
A.M.
*area
bar graph
centimeter
*circle
*cone
*congruent (figures)
*cube
cup(s)
*cylinder
*decimal
decimal point
*degree(s)
degree Celsius
degree Fahrenheit
*denominator
*diameter
*difference
*digit
equation
*equivalent fraction
*estimate
*even number
*factor(s)
family of facts
*fraction
*gram
*graph
*greater than
*hexagon
input
Kilogram
Kilometer
*less than
*line
*line of symmetry
*line segment
*liter
*meter
metric system
*mixed number
*multiple
number sentence
*numerator
*odd number
order property
ordinal (number)
output
*pentagon
*perimeter
*pictograph
*place value
*polygon
*product
*pyramid
*quadrilateral
*quotient
*radius
*rectangle
*rectangular prism
*remainder
*right angle
*round(ing)
segment
*sphere
*square
*sum
*triangle
*volume
*whole number

* indicates words appearing on both the 3rd and 5th levels

FIFTH LEVEL ONLY

acute angle
angle
average
chord
circumference
common denominator
common factor
common multiple
diagonal
distributive property
dividend
divisor
edge
flow chart
greatest common factor
grouping property
intersecting lines
isosceles triangle
least common denominator
least common multiple
lowest terms (fraction)
negative integer (number)
number line
number sentence
numeral
percent
perpendicular lines
point(s)
prime factor
prime number
probability
product
protractor
ratio
ray
rhombus
right triangle

equal fractions
equal (equivalent) ratios
equilateral triangle
expanded form (numeral)
exponent
face
obtuse angle
octagon
opposite(s; operations)
ordered pair
parallel lines
parallelogram
Roman numeral(s)
scale drawing
scalene triangle
similar figures (polygon)
standard numeral
trapezoid
vertex

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