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ABSTRACT

Reading the language of mathematics textbooks is very different from reading the narrative in traditional basal textbooks, and children should be taught how to read in a mathematics course; teachers should not assume a transfer of skills will occur. Specific skills, such as noting details, following directions, and seeing relationships, should be taught. Students should be shown how to modify their flexible narrative reading styles to one of great deliberation, in order to understand mathematics reading material. The specialized vocabulary of mathematics and the special mathematical symbols must also be specifically taught, beginning with concrete examples when possible. Suggestions for instruction include getting the students to discuss the expository material or the verbal problem, in order to understand their thinking processes; being careful, as an instructor, not to talk too much; being sure that students understand the technical vocabulary; and preparing short-answer, multiple-choice tests to use as pretests before instruction in a particular concept. (MKM)

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READING THE SPECIAL LANGUAGE OF MATHEMATICS

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READING THE SPECIAL LANGUAGE OF MATHEMATICS

It is generally agreed that the primary function of a textbook is to impart knowledge to the student. In order for this function to be realized, the student must be able to read the book. The term "read" as employed here must be considered as synonymous with "comprehend."

In the secondary school, approximately 85% of the learning which takes place is based on reading. Yet, today we are retaining in schools many students who, in former years, would have dropped out because of their inability to read adequately. Textbooks in the content areas are becoming increasingly difficult as new discoveries, new developments, and new concepts are added to or replace former information. The youngster who has difficulty in reading the sports page, in which he or she is interested, is expected to read math textbooks which may not be particularly meaningful to this individual.

While there are many students who cannot recognize the words in their assigned texts, most content teachers acknowledge that far too many of those who can fluently make the text audible still do not understand the mes-

sage the author is attempting to convey. If the author's message is lost upon the student, that student has not been able to read the text.

Nevertheless, content teachers often make little attempt to teach their students the skills necessary to understand the information contained in their texts. There are two primary reasons for this neglect of reading instruction in the content areas. The first is that content teachers contend that their obligation is to teach the stuff of their field and that it is the duty of others, elementary teachers and reading specialists, to teach the student how to read the content area books. The second reason is that even when the content teacher realizes that reading teachers are no longer available to the students and that she or he is the only source of reading instruction available, the content teacher does not have the requisite skills to teach the specialized techniques pertinent to that particular content field.

Specific Versus General Reading Skills

How does the sad situation come about in which the student is expected to cope with a complex task in which he or she has received virtually no instruction? Elementary classroom teachers are versed primarily in the

teaching of general reading skills more related to narrative than to expository materials. The basal reader, which forms the cornerstone of the elementary school reading program, consists mostly of narrative material. Yet, many researchers contend that success in the reading of mathematical material is related to specific rather than to general reading skills. Bond (1941) described the kinds of reading necessary in mathematics as: noting details, weighing the importance of details, following directions, organizing facts, making inferences, and discriminating between the relevant and the irrelevant. The ability to see relationships is also considered vital to success in math (Treacy, 1944). Too often math teachers focus upon the details in the text asking such questions as: What is given? What is wanted? The students must have this information but it is the understanding of how the parts relate to the whole that is the crux of the matter. These skills could and should be taught to students reading non-mathematical material at the elementary level as well as at higher levels.

Elementary teachers have made the assumption that words are words no matter in what kind of material they are printed and if a child can read the basal reader,

he or she can read textbooks in the content areas. They have depended upon the questionable concept of transfer of learning to take care of the gaps they inadvertently did not help their students fill. When faced with a math text, students have difficulty because they do not possess the new skills required or the flexibility to apply old skills to new situations. How many math teachers can read a chemistry or electrical wiring text with ease and understanding? Yet we expect our math students to be able to read material unfamiliar in both content and format. Students need to be taught how to read materials in each of the different content areas. For the most part, we don't do this teaching. We assume that the student already has the necessary skills and then we wonder why trouble develops.

True, there are content texts in the elementary classroom. But most elementary classroom teachers have not taken the course "Reading in the Content Areas" or one similarly entitled. In fact, too few secondary level teachers have had this important course. Therefore, when the middle school or high school teacher gets the youngster in a content course, nobody has taught that student how to read a textbook.

The problem is particularly severe in courses dealing with math, science, and industrial arts as these

areas deal with symbols and equipment with which the student is not generally familiar. These subjects, as are all others, are concerned with ideas and the communication of ideas. But communication in these subjects is presented in a language with which the student is only partly familiar.

Modification of Reading Style

Math material is concise, densely packed with information which is often only peripherally related to the preceding and following portions of text. There is virtually no description and usually no extraneous information. It is next to impossible to make use of context clues because of the sparseness of language employed. Additionally, those context clues which may be available may be couched in such technical vocabulary that the student is unable to recognize them.

In order to read narrative material properly, the student has been taught to skim, scan, look for key words and, generally, to focus upon only main ideas and key elements in the text. The reading of mathematical material requires a drastic alteration of this reading style and pace. Mathematical material must be read with great deliberation (Axelrod, 1947). Because of the density of information, each word is usually vital to

the comprehension of the message. Omission of a single word may cause a complete lack of understanding of the text as in the following verbal problem:

> For the school fair, Miss Winter's class spent $7.14 for 42 plants. They wish to sell the plants for 29¢ each. If the sell them all, how much profit will they make?

Omission of the single word "each" makes the entire problem meaningless.

Another major difference in the style of reading mathematical material consists in the necessity for several rereadings of both instructional material and of verbal arithmetic problems. A highly structured reading/study method, called PQ4R, developed by Thomas and Robinson (1972) and modified by Maffei (1973) for use with wor problems encourages students to Preview, Question, Read, Reflect, Rewrite, and Review while attempting a solution.

The Several Languages of Mathematics

The math text attempts to present the author's ideas in a combination of languages only one of which the student has been taught to cope with, that of traditional English. The student has had consider-

able instruction in dealing with the vocabulary and structure of this particular language pattern. Much of the text, however, consists of combined terminology in which words are employed having both a traditional and a mathematical meaning (Morgenstern, 1969). For example, the words proof, area, relationships, root, table, positive, applications, mean, and net have specific mathematical meanings as well as more familiar meanings in traditional English. The student is also presented with a set of technical terminology specific to math. Such words as angle, cube, half-line, prism, secant, diameter, diagonal, radius, polygon, and decagon are solely mathematical terms. Additionally, the student is faced with a set of non-verbal expressions of meaning such as these: =, ¢, %, ≠, +, ", ', $, @. Abbreviations such as sq., ft., in., G.C.D., L.C.D., min., and lb. comprise another aspect of the language found in the math text. To make the task still more difficult, several facets of communication are frequently combined into a single sentence such as the following: To understand the division property for equations, you must recognize that if a=b is true, then $\frac{a}{c}=\frac{b}{c}$ is also true for all numbers, a, b, and c ($c\neq 0$). Yet compared to the following, the former sentence must be considered as very simple from a mathe-

matical standpoint: Any particle that moves back and forth between the endpoints of a line segment and whose position on the segment at any time t can be determined by means of an equation of the form $y=a \cdot \cos(wt+b)$ or $y=a \cdot \sin(wt+b)$ is said to be in simple harmonic motion. To the uninitiated, the latter is pure gibberish.

Certainly the math teacher can and should teach the student the meaning of the specialized vocabulary, the meaning of the mathematical symbole, and the concepts involved. However, if all this is to be solely the responsibility of the teacher, what need is there for a math text? The text is used as a supplement to classroom presentation of information; it is a teacher's aid. If the student is not specifically taught to read the textbook, the teacher is forcing the student to rely solely on oral instruction. However, in effect, this is what happens frequently as they learn that their students are unable to cope with the texts without assistance and find that they are unable to provide this assistance. Teachers avoid use of the texts instead of teaching the students how to cope with them. The student is deprived of the guidance of the text both in school and at home. Thus, the problem becomes compounded.

Instruction in understanding the language of mathematics, presented in oral form, is a prerequisite to understanding it in written form. Such instruction should begin when formal mathematics is introduced, usually at the kindergarten or first grade levels. The result of the union of a set of three items with a set of two items, symbolized in the mathematical sentence 3+2= can be taught to young children as long as they are actually engaged in the joining of these two sets. Their physical engagement in this act, their simultaneous oral statement of what they are doing (If I have three crayons and put two more crayons with them, I will have ______ crayons.) can be accompanied by the teacher's written presentation, thus providing direct translation of these behaviors into mathematical symbols. With the manipulation of concrete objects, accompanied by the direct translation into the special language of mathematics at this very early stage, the youngster is able to develop a firm base for the learning of this new and technical language. The classroom teacher must bear in mind, however, that one or two such experiences is far from sufficient to develop either the mathematical concepts or the mathematical language involved in the activity described above. Too

many teachers find student participation with other than pencil and paper too much trouble and go through the motions of manipulating concrete objects a few times, check it off mentally as an appropriate learning experience for their students, and go on to dealing only with the abstraction of the written mathematical sentence. Far too many youngsters don't really understand the relationship between the joining of a set of three objects with a set of two objects and the mathematical sentence which they are told depicts this union. Without a firm background in these rudimentary understandings and relationships, how can the student be expected to comprehend the far more complex mathematics encountered at the middle and high school levels?

After the student has attained a firm understanding of the fact that numbers represent objects and that algorithms are mathematical sentences describing the relationships of sets of objects to one another, the student is ready to acquire information from a math text. Math texts are abstract representations of reality. For the learner to understand the vicarious experience described, he or she must have had the actual experience of manipulating real objects. The learner must also have had some experience with the more traditional

forms of written English communication. This serves as an aid to the student faced, in the math text, with new uses of familiar words as well as with unfamiliar words, symbols, and abbreviations.

Specific Teaching Techniques

Listed below are just a few methods which can be employed by the teacher who realizes that instruction in math is related to comprehension of language. Once the teacher recognizes this relationship, he or she can devise many more techniques directly based upon the needs of the students currently being instructed.

1. Get the students to discuss the expository material or the verbal problem with which they are expected to deal.* This allows the teacher to understand their thought processes and learn where their thinking deviates from routes leading to the correct response. Notice that routes is in the plural as there are many ways to obtain a correct response and the teacher must respect all of them. Verbalization also allows the students to restate the message in their own, more familiar, terms and therefore makes it more meaningful. A discussion of the author's printed message allows the teacher to gain insight into the process by which stu-

dents arrive at their product. Too often math teachers are only concerned with product at the expense of process (Hollander, 1973).

2. Check to see that you don't talk too much. The person talking is more actively involved in the learning process than the person passively listening. The talker clarifies concepts and learns. It is far more important for the student to be doing this than for the teacher.

3. Be sure that students are well versed in the meaning of the technical vocabulary,symbols, and abbreviations. Telling the students themeanings a few times does not ensure their understanding. The instructor should examine the reading material when writing the lesson plan to identify terms that might cause trouble. These can then be jotted in the margin of the teacher's copy of the text. An alternate method would be to have the students read the material and jot down terms that aren't understood. Thus, the students are involved in reading the material and are assuming part of the responsibility for their learning. The glossary is another aid for students in improving their math vocabulary. Its purpose and method of use should be thoroughly explained and it should be referred to regularly in the classroom situation.

4. Make short answer multiple choice pre-tests of material important to the understanding of concepts and vocabulary.

A) Selecting a definition of a term.

A denominator is

a) the numeral you multiply by

b) the top numeral in a fraction

c) the bottom numeral in a subtraction example

d) the bottom numeral in a fraction

B) Selecting an example of a term.

In which is a denominator shown?

a) 4 x 6 b) $\frac{8}{9}$

c) 6 - 2 d) 2 + 7

C) Selecting the meaning of a symbol.

What does $>$ mean?

a) equal to b) greater than

c) parallel to d) less than

D) Selecting the meaning of an abbreviation.

What does in. mean?

a) into b) inch

c) in d) instead

E) Writing a number phrase from a combined language form.

At the primary level:

Rewrite the following using only numerals and symbols.

a) 7 added to 9

b) 19 multiplied by 36

c) 14 taken from 196

d) 13 more than 72

At the middle and high school levels:

a) the sum of 8 times a certain number and 14

b) the difference when 17 is subtracted from 3 times a certain number

F) Writing a combined language form from a number phrase.

At the primary level:

a) $8 + 45$

b) $25 - 20$

c) $63 \div 7$

At the middle and high school levels:

a) $7(x+9)$ b) $\frac{1}{2}y^2 - 2$

Summary

Math is part of the everyday world around us; it is not something that comes out of a book. As students work math problems pertinent to their lives and simultaneously translate the working of their problem into mathematical language, they will come to understand that the content of their math books has meaning for them. However, they must also be able to read the special language of mathematics found in the text. This requires that they be made aware that there are five language forms with which they must deal. They must then be taught how to deal with them. The math teacher must recognize that he or she is the professional best qualified to help the student acquire this knowledge and often the only person available to do so.

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