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Using Language Arts to Promote Mathematics Learning

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Mathematics is a complex and compact symbol system, and unless meanings are attached to those symbols, mathematics becomes literally meaningless to children (National Council of Teachers of Mathematics [NCTM], 1989). Although caring teachers will wish to help students attach meaning to the many symbols of mathematics, the teacher's own facility with "5," "+," and "23" makes it difficult to remember that meanings are not conveyed by symbols alone. As Skemp (1982) said,

The problems which so many have with mathematics symbols (arises) partly from the laconic, condensed, and often implicit nature of the symbols themselves; but largely also from the absence or weakness of the deep mathematical schemas which give the symbols their meaning. Like a referred pain, the location of the trouble is not where it is experienced. The remedy likewise lies mainly elsewhere, namely in the building up of conceptual structures. (p. 286)

To a teacher who believes children acquire understanding through "paying attention" and "looking and listening carefully," repetition and additional practice sheets appear to be appropriate responses to student failure. Many psychologists and educators, however, assert that concepts cannot be directly transmitted from teacher to student, but must be built up by each individual learner (Burton, 1982; Frankenstein, 1983; Van de Walle, 1990). Those who believe this way generally suggest that this happens when children interact with objects, think about those interactions, and share their experiences and conclusions with others (Green, 1983; Pai, 1973; Piaget, 1953; Wirtz, 1977). Languageboth internal and externalis the tool that allows students to speak to themselves about what they have perceived about the world and to share those perceptions with others.

In lists of the language arts, fourspeaking, listening, reading and writingare typically mentioned; others such as drama, penmanship, and spelling are also added by various authors. While only the first four will be discussed in this paper, none should be overlooked as possible enhancers of mathematics learning (Cuevas, 1984; Johnson, 1983; Lipman, Sharp, & Oscanyon, 1980; Skypek, 1982). Providing students at any age with opportunities to converse, read, and write about mathematics will encourage the development of concepts.

Talking About Mathematics

When concept development is the desired goal, verbal interaction among peers is a tremendous facilitator (Skemp, 1971). It is unfortunate, therefore, that few children get the chance to verbalize mathematical understandings. Personal experience, years of observation, and reading the autobiographies of over 750 preservice teachers have convinced me that the typical mathematics lesson in elementary school is more often characterized by teacher presentations and independent silent work than by group discussions. Although this practice has a long history, teachers can design the physical and psychological environment of a classroom so that student interchange about mathematical situations and events is encouraged.

A conversation-inviting room might include movable furniture where groups can work comfortably together and materials that are easily accessible to students. In addition to these physical arrangements, it is important that both teachers and students acknowledge that errors and misinterpretations are a natural, even valuable, part of the learning process. The chance to share one's ideas and justify them to others helps develop a solid understanding of those ideas (Clark, Erway, & Beltzer, 1971; NCTM, 1991).

Listening: A basic skill

The complement of speaking is listening. This internal, personal and idiosyncratic activity forms the basis for understanding spoken material (Glachan & Light, 1982) and can be subdivided into hearing, attending, general listening and critical listening (Kean & Personke, 1976; Lundsteen, 1971). Hearing is the reception of audible sensory stimulus; attending refers to the individual's ability or desire to receive and process the incoming information. Both of these functions suggest that the classroom should be arranged so the students can hear the teacher and their fellow students, that the students are affectively ready to receive academic information, and that all prerequisites for the new material have been met.

Listening has also been conceptualized as consisting of perceiving, ideating and presenting ideas (Smith, Goodman & Meredith, 1976). This schema is an even more convenient way to describe the role of listening in mathematics learning. In the perceiving phase, students confront a situation, often in the form of a question, and muse about its relation to what they already know. In the ideating phase, students confront a situation, often in the form of a question, and muse about its relation to what they already know. In the final stage, presentation, learners ready their solutions for oral or written communication and analyze their products. These stages parallel the well-known stages for solving a problem: understand it, devise a plan, carry out the plan, look back (Polya, 1945). Good listeners also direct their attention to the speaker, think carefully about the message, and prepare an appropriate response. In the learning of mathematics, such established behaviors cannot help but be beneficial.

Believing that listening is a skill that can be developed, many teachers have devoted space in their classrooms to areas where students can don headphones and use materials that require little teacher direction. Although fiction and poetry can obviously be the content of a listening center, it may be less obvious that such a center can contain mathematical material. Teachers might record an entertaining story that requires the solution of a mathematical problem, a recent lesson for students who were absent, or even a set of directions that requires a written response from the students. Tapes might also be made for timed number facts drills and tests.

Reading and knowing

Reading is like listening with the eyes. It requires analysis and the generation of meaning from a symbol system and involves two types of comprehension: literal, including word meanings, sentence meanings, and getting the main idea; and inferential, including drawing conclusions, making judgments, and using symbolic language (Hillerich, 1977). Both types have their analog in learning mathematics.

At the most basic level, students must comprehend the words and sentences they are reading if they are to understand the story being told or the information being transmitted. So it is with mathematics. Students need to understand "words" such as 5, +, 23, = and "sentences" such as $6 < 7$, $3 + 2 = 5$ as well as the contexts in which these are used. Activities from reading instruction such as discussion of new symbols and groups of symbols, relating the symbols to personal experience, and concentration-type games have a place in mathematics instruction when vocabulary development is an objective (Lapp & Flood, 1978).

Two classes of words used in teaching mathematics can cause special problems for young as well as older learners: (a) those whose mathematical meanings differ from their meanings in everyday life and (b) those that are homonyms. Examples of the first category are words such as plane, multiply, set, and carry. Examples of the second category are eight, whole, pi, and some. These words must be taught with special care, perhaps using crossword puzzles and word searches.

Even more crucial to success in mathematics is the ability to go beyond "word calling" to answering questions concerning the meaning of the material on the page. In mathematics, this ability is most apparent when word problems are encountered. Teachers will unfortunately be able to supply their own examples of students who can read the problem, are capable of doing the required computation, but ask, "Do I add, subtract, multiply, or divide here?" the use of cue words as the sole criteria for selecting the operation is at best a sometimes successful strategy, as those who encounter problems dealing with the question "Who has more?" can attest. What is needed is the ability to understand the structure of the presented situation and to translate that structure into numerals and operational indicators. This is a high-level cognitive task indeed. It requires not only a complete understanding of the various models for the operators (Knifong & Burton, 1985) but also a high level of inferential comprehension.

Using the second "R"

Writing is another useful tool for the learner of mathematics because "we find out what we think when we write" (Smith, 1982, p. 35). Expressing ideas explicitly helps students to reflect on the schemas they have constructed and to develop intellectual skills that allow them to approach any discipline intelligently. In the process of writing, they come to know what questions to ask, where to discover the answers to those questions, and, finally, how to develop and organize their ideas about the subject (Davidson & Pearce, 1988).

Certain conditions foster written expression. Daniels (1985) and Atwell (1987) suggest that acceptance, private evaluation, freedom of choice, and sharing are all important in fostering written expression and that an arresting stimulus or a personally meaningful experience will motivate students to do the kind of writing teachers say they want to read. Such situations in mathematics can be planned or utilized as they occur naturally in the classroom. When students spontaneously write, their creativity should be shared with the class and accorded the recognition it deserves.

A potent way to squelch novice authors is to place premature stress on grammatical conventions. Although such rules are certainly necessary when writing is to be shared formally, initial emphasis should be on formulating a consistent point of view and expressing it clearly and coherently (Maimon, Belcher, Hearn, Nodine, & O'Connor, 1981).

Ungraded informal writing such as journals (Fulwiler, 1987); Nahrgang & Petersen, 1986) are also valuable. This type of writing can easily become a part of a class at any level (Burton, 1985; Geeslin, 1977). A form of writing that can be used in journals is free-writing, writing as rapidly as possible without regard for grammatical conventions or planning what will be said next. To begin a lesson, the teacher might ask the students to free-write for 3 or 4 minutes about the lesson topic. Such focusing of attention increases the probability that students will be active participants in the lesson. The use of this technique after a presentation will help students and teachers become aware of what was clearly understood, what was partially understood, and what was missed altogether. Journals read by the teacher give him or her a chance to individualize instruction in a very personal way. A note of caution follows: since free-writing often includes private thoughts, students should be allowed to delete any portions they prefer that the teacher not see. Requiring that a few minutes of free-writing follow each day's lesson will encourage each student to reflect on that lesson; a notebook full of these meditations will provide a personal review guide.

Language Arts Suggestions for Mathematics Trouble Spots

Missing Addends

Preservice teachers are usually astounded when a student who can easily give the answers to number facts such as 2 + 3 = ? and 4 + 1 = ? fills in the blanks in 2 + _ = 5 and 4 + _ = 5 with 7 and 9, respectively. Seasoned teachers, however, do not assume that students automatically form the connections within the addition families. They know, however, that communication between students will aid in the acquisition of this, as well as other, mathematical ideas (NCTM, 1989).

Baratta-Lorton (1978) developed materials designed to facilitate conversation about mathematical topics. Her book, *Workjobs II*, includes directions for 20 easily-constructed manipulative sets. Through the use of inexpensive and colorful materials, students come to understand mathematical symbols and operations by first manipulating materials and discussing the manipulation with teachers and fellow students, then matching printed symbols to representations of operations, and lastly, recording the operations using numerals. Students are invited to tell stories that can be described with number phrases, such as 3 + 2, 2 + 3, 5 - 3, and 5 - 2, and match cards bearing these number phrases to situations they have constructed. It is a fairly easy step to ask them to tell a story involving the number sentence 2 + _ = 5. Here is an example:

Five ghosts are coming to the party. Only two have arrived. How many are still to come?

Using lima beans decorated with ghost faces (see Figure 1), first graders can display the known quantity and then just "count up" to find the missing addend. As the students pose and solve other problems of this type, teachers can record the students' stories on tape or write them out on chart paper. This will preserve the lesson for use as listening or reading material at another time, thus extending the lesson even further. Children also like to draw scenes from a story and dictate the plot to an adult scribe.

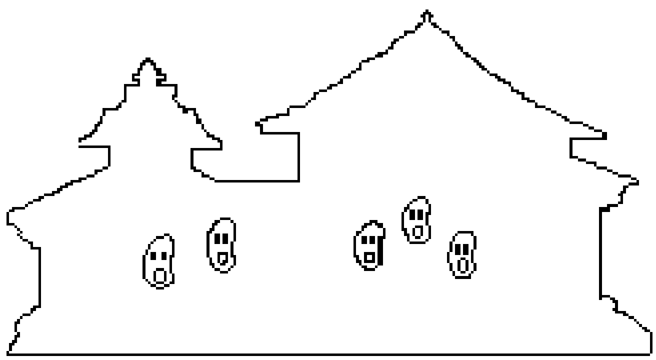

Figure 1: Halloween Kit adapted from *Workjobs II* (Baratta-Lorton, 1978) showing 3 + 2.

Learning the Algorithms

When students manipulate numerals and operator signs that have no external referents, they are left with "empty symbols, handles without anything attached, labels without contents" (Skemp, 1982, p. 286). Understanding will be fostered, however, if students discuss with a partner what they are doing and keep records of what they do with the "stuff" (Wirtz, 1977). In the study of algorithms, this procedure will also encourage retention and transfer. When the teacher provides students with bundled coffee stirrers, beansticks, or proportional rods along with standard exercises and encourages students to use the materials to model the algorithms, reasons behind the steps of the algorithms are clarified. Some of the finest examples of teaching algorithms with base ten materials are in *Drill and Practice at the Problem-Solving Level* (Wirtz, 1974). An introduction to addition and subtraction with or without regrouping, for example, guides students through the process of finding sums and differences by having them exchange beansticks for single beans, record with numerals as they go, and talk about what they are doing at each step. (See Figure 2.) A student who has had the benefit of such thoughtful instruction is less likely to make that most common of errors, subtracting "upside down." The benefit of such carefully designed teaching is the ease with which students can use what they have learned about two-digit subtraction when they later encounter three-digit subtraction or, even later, computation with decimals.

Another way of incorporating the language arts into learning algorithms is to ask small groups to write out the steps for the algorithms in their own words. This is both a good way to promote conversation about a little discussed topic and a valid and reliable assessment tool.

Learning the Number Facts

Despite what some older persons would have us believe, the great grandparents, grandparents, and parents of today's students also had trouble learning "the tables" (Brownell & Chazal, 1935). Since the early days of the present century, mathematics educators and psychologists have studied ways to promote mastery of this material. Their research suggests that drill should follow developmental experiences, that massed practice is less efficient than spaced practice, that the helpful features of the number systemcommutativity, associativity, and identity elementsshould be used to help lighten the memory load (Burton & Knifong, 1982) and that accessing several modalities facilitates the learning. Language can play a starring role in the drill and practice necessary for ease in attainment and maintenance of proficiency in the basic facts.

Ten sticks

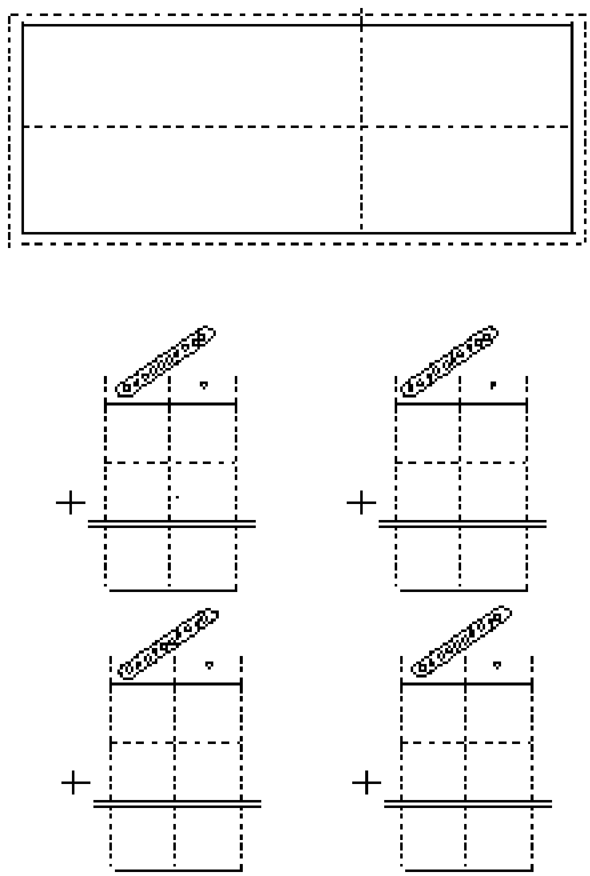

Figure 2: Worksheet adapted from *Drill and practice at the problem-solving level* (Wirtz, 1974).

One way to use language to promote proficiency in the basic facts is the easily constructed game "Who Has?" This activity combines careful listening with mental computation, and the idea is adaptable to any content which can be tested by matching. A sample version for four students is shown in Figure 3 although the game is best played by the whole class. First, the teacher writes enough statements on file cards so that everyone can have one. Taking any card, the teacher distributes the remaining cards, then reads the reserved card. The student holding the answer to the question on the teacher's card reads his or her whole card. Play continues until the teacher's statement is again called for. When the children are familiar with the game, the teacher may choose a child to begin and end play. "Who Has?" can be made either more or less difficult than this sample by varying the operations or numerals used. While the game is in progress, both speaking and listening skills are utilized. Children can also practice both computation and handwriting skills by generating additional sets on different colored card stock so the materials can be separated easily for later use. Other activities that help students learn the basic facts include playing board games where "chance" cards need to be read, having "fact scavenger hunts" with items such as "find 2 + 3 buttons on a shirt," and scanning the newspaper to make a collage of number sentences.

I have 9. Who has that times 8?

I have 72. Who has that plus 14?

I have 86. Who has that divided by 2?

I have 43. Who has that minus 7?

I have 36. Who has that divided by 4?

Figure 3: Sample set of "Who Has?" statements.

Problem Solving

Mathematics educators view problem solving as of primary importance in the mathematics instruction of students (NCTM, 1989). Widespread concern with the difficulties students have traditionally had, and continue to have, with word problems has generated copious research and numerous teacher inservice programs on this topic. Among the necessary prerequisites for solving word problems are the ability to comprehend printed problems, to distinguish important from unimportant information (Suydam, 1982), and to determine which operations to employ. Teaching complete meanings for the operators will help assure the last-mentioned prerequisite (Knifong & Burton, 1985); the other two are specific language arts abilities.

One way of using the language arts to help students become more capable problem solvers is to suggest they paraphrase given problems or act them out with people, puppets, or appropriate manipulative objects. Another is to provide students with a variety of number sentences to match with printed word problems. One step further, students might generate word problems for given number phrases such as $12 \div 4$ or 1/2 of 8 and read them to their classmates. By trading the problems they have written, students get further practice in both reading and solving word problems.

Parting Words

Elementary teachers who are comfortable teaching and using the language arts will be happy to know that these subjects will help their students reach important mathematical goals. Understanding happens when students are encouraged to interact verbally and in print with both their peers and interested adults and to record and read about their experiences with number and measurement. Teachers who find a place for students speaking, listening, reading, and writing in mathematics lessons will go far towards ensuring that their students enjoyably, efficiently, and effectively acquire the facts, concepts, and skills that are the goals of mathematics instruction.

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