Language and Mathematics: A Natural Connection for Achieving Literacy.

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Time for a change

Regie Routman, in Transitions (1988), stated that "our schools are turning out functional literates, children who can read and write in school, but who do not necessarily read and write in other contexts. These students may do reasonably well at word calling, but they have no real understanding of what the words convey. It is time for a change" (p. 15).

With the substitution of only a few words and phrases, this assessment of the status of reading education could also be used to describe the situation that faces mathematics education. According to recent assessments of educational progress in mathematics, the majority of students can do basic computation reasonably well. However, when children are called upon to do higher order thinking in mathematics, or to apply mathematical concepts away from the classroom, results show that most are neither numerate nor functional in these areas of mathematical thinking (e.g., Dossey, Mullis, Lindquist, and Chambers, 1988).

Yet the connection between language and mathematics involves much more than similar failings in traditional teaching methodologies. More importantly, the language

mathematics connection offers positive new ways of thinking about mathematics education. Concepts such as active literacy and the natural learning environment have proved to be powerful tools in changing attitudes and practice in the field of language arts. Properly understood and adapted, the same concepts can work just as powerfully for us, and for our students, in mathematics.

What is active literacy?

Garth Boomer (1985) defines active literacy as a process that enables learners to go much deeper than the coding and encoding of written symbols. Such learners have experienced language not as a set of isolated skills, but as meaningful, purposeful, and inseparable from real life. Active literacy in reading and writing can find its parallel in a model of active mathematical literacy. For learners to achieve active mathematical literacy, they must go beyond the basic computational skills that have served both to define and to limit mathematics during recent decades (Monroe and McMain, 1994).

Learners who are to achieve active mathematical literacy must solve meaningful problems relating to many real-world contexts. Only by doing so can they develop an understanding of their world that is enhanced by mathematics, instead of coming to believe that mathematics — "doing sums" in school — has nothing to do with the real world. "No longer can society afford to view mathematics as a subject ... solely composed of arithmetic skills. Students must come to see it as a way of thinking, communicating, and solving problems" (Dossey et al., 1988, p. 13).

Natural learning environments

The natural learning environment is a useful model when thinking about how best to promote active literacy in

both language and mathematics.   For those who are newcomers to this idea, it is important to recognize that such an environment is less a matter of the physical features of a classroom than a set of beliefs that permeate every aspect of a child's classroom experiences.   There will be outward differences for every teacher and every class.   However, all natural learning environments reflect a commitment to the basic premise that the natural motivation of the child is of prime importance in structuring learning experiences.

This does not mean that learning experiences are haphazard.   In fact, teachers who are committed to creating a natural learning environment plan learning experiences with particular care, drawing on their insight into both the content to be learned and the needs and interests of the children who are doing the learning.

As a teacher educator in reading and mathematics, I have been particularly interested in identifying the principles that underpin natural learning environments and the success that they foster.   There are five principles that stand out as being supported both by research and by the experience of practicing teachers, and it is striking that they all reinforce the importance of the language-mathematics connection.   These principles, I believe, are among the most important guidelines that we can give to teachers of mathematics today.

Children come to school with a great deal of knowledge of both language and mathematics. In reality, children's language and mathematics are virtually inseparable; mathematics is embedded in the language they use naturally.   For example, when asked "How old are you?" the child responds with a number name (e.g., five) and perhaps a concrete representation of the number (five fingers raised).   Such directions as "Move to the center of the circle" or "Place your book on

the table" reflect our expectations as teachers that children have well-developed spatial awareness when they enter our kindergarten classrooms. Even mathematical problem solving is not new to young children. Research by James Moser and Thomas Carpenter (1982) indicates that children entering school already have successful strategies for solving problems involving addition and subtraction, as long as those problems occur in a natural language context.

When mathematical concepts are segregated from the language contexts in which they naturally occur, learning difficulties are likely to result. Language not only provides the labels with which to access and describe concepts, but also the fabric to be used in constructing networks of ideas and meaningful relationships between one concept and another. When we separate mathematics from its language context, we also miss valuable opportunities to use the child's language as a tool for evaluating progress and diagnosing strengths and needs (Cambourne and Turbill, 1990).

Students clarify their thinking and construct personal meaning when they verbalize what they learn. Students use their natural ability to create meaning through the use of language in numerous ways: working with manipulatives; solving open-ended problems; working cooperatively on a group project; explaining a strategy in writing or orally to a peer; or responding to questions posed by the teacher that call for divergent reasoning. In these ways, students are using their natural ability to create meaning through the use of language. The natural learning environment is essential in fostering such interaction.

The cognitive abilities necessary to learn both languages and mathematics are developmentally acquired. Ample research evidence tells us that these abilities can be nurtured,

but they cannot be forced — the child must be developmentally ready. The noted Swiss psychologist, Jean Piaget, developed a theory which identifies and explains the stages through which children proceed as they develop physical and logico-mathematical knowledge (Piaget and Inhelder, 1969). In helping us understand the thought processes of children, Piaget also provided the rationale for developing learning environments in which children construct their own knowledge from the inside, through mental activity and in interaction with the environment (Kamii, 1982). This constructivist approach assumes that children naturally construct knowledge as an interrelated whole and that they need only be limited by the constraints of their current developmental level.

The necessity for an environment that nurtures child development cannot be overemphasized. There exists within each child the potential for literacy in both language and mathematics. Given an appropriate environment, each child can be successful at his or her own level of development. Children listen, speak, draw, read and write in a variety of modes to develop active literacy in language. In just the same way, they need to use a variety of ways of communicating as they develop active mathematical literacy. According to the National Council of Teachers of Mathematics (1989):

> ... *the study of mathematics should include numerous opportunities for communication so that students can: relate physical materials, pictures, and diagrams to mathematical ideas; reflect on and clarify their thinking about mathematical ideas and situations; relate their every day language to mathematical language and symbols; realize that representing, discussing, reading, writing, and listening to mathematics are a vital part of learning and using mathematics. (p. 26)*

These forms of communication are most likely to occur in situations that encourage cooperation and the use of a variety of materials within a context of meaningful, purposeful learning. There is little room for rote memorization in this environment; students are busy developing concepts through active exploration with language and materials.

Language and mathematics are best learned not as isolated fragments of knowledge in artificially contrived situations, but as tools for the active construction of meaning. Frank Smith (1988) developed the metaphor of "the literacy club" to describe the community of language users to which children are admitted early in their lives and supported by more experienced language users as they engage in meaningful activities. The same metaphor serves equally well to describe the context within which mathematical literacy develops. As current views on the development of mathematical thinking emphasize, "children do not learn an abstract system of mathematics first and then attempt to apply it to various situations; instead, they learn ... mathematics as they use mathematics ..." (Jongsma, 1991, p. 442).

Just as reading cannot be defined as filling in the blanks on a workbook page, mathematics cannot be defined as finding answers to a set of computational exercises. Although computation has an essential role to play in mathematics, instruction must focus on problem solving, reasoning, and meaningful communication, not on narrowly defined skills practiced in isolation. Children achieve growth in active mathematical literacy through participation in meaningful mathematical activities. In this way children are welcomed to "the mathematical literacy club," in which they expect to — and are expected to — learn mathematics through meaningful interaction with other people.

The strategies that allow children to develop active literacy in language and in mathematics are those that will help them construct meaning. Please note that I have deliberately used the term strategies, not skills. Don Holdaway explains the difference between the two terms in the following excerpt from his now classic work, *The Foundations of Literacy* (1979):

> *The major difference between a "skill" and a "strategy" is the coordinating control of a human mind operating in purposeful, predictive, and self-corrective ways. The major difference, then, between "skills teaching" and "strategy teaching" concerns the presence or absence of self-direction on the part of the learner. In skills teaching the teacher tells the learner what to do and then "corrects" or "marks" the response. In strategy teaching the teacher induces the learner to behave in an appropriate way and encourages the learner to confirm or correct his [sic] own responses — the teacher does not usurp the control which is crucial to mastering a strategy. (p. 136)*

Because students must continually develop, refine, and monitor strategies in order to be able to construct their own meaning, the development and application of strategies cannot be left to chance:

> *When making instructional decisions, we capitalize on the students' needs and interests. We try to strike a balance between following their lead and engaging them in projects which encourage them to explore a diverse range of strategies while learning specific mathematical concepts. (Jongsma, 1991, p. 443)*

Such an environment requires planning. It requires careful planning and guidance to ensure that children not only develop a repertoire of strategies but acquire flexibility in

using them. It is this kind of environment that gives the children the ability and the confidence to apply these strategies in other content areas and in real-life situations. For example, when children have opportunities to study and apply mathematics through children's literature, their language and mathematics learning becomes an integrated whole.

It can be done

We know that almost all students enter school with a real desire and expectation for learning. They want to read and write, and they want to do mathematics. This eagerness quickly dissipates if we provide tasks that children do not see as meaningful or purposeful. There is ample evidence to suggest that active literacy in language and mathematics is not being achieved through traditional means. On the other hand, natural learning environments are proving to be successful in this area. Widely implemented in Australia and New Zealand and rapidly spreading to other nations, this approach recognizes that the natural motivation of the child is of prime consideration in structuring learning experiences.

It is easy to assume that natural learning environments can be replicated from classroom to classroom. To be effective, the classroom environment must be responsive to the needs and interests of the children in that particular classroom. In addition, the organization and methods we choose to use should reflect our own teaching personalities. Therefore, there is — and should be — no one model for successful implementation.

Changing from traditional teacher-centered methodology and organization to the implementation of a natural learning environment may require considerable reorientation in the ways we think about teaching and learning. Although teachers hold differing philosophies regarding how children

best develop active literacy in language, most of us agree that we should not be bound to a rigidly structured teaching program. Rather, we should plan and implement language development activities based on our knowledge of what children already know and what they need to know.

Similarly, we should plan experiences that communicate the structure and conceptual underpinnings of mathematics, not discrete sets of isolated skills. For example, students should be encouraged to rely on their knowledge of tens and hundreds to understand the concept of thousands. When they learn mathematics in this manner, they are developing strategies for "... building bridges between the new and the known" (Pearson and Johnson, 1978, p. 24). Thus students will construct the network of ideas necessary to develop a working knowledge of the content.

At the same time, we must also be careful not to impose artificial constraints when making curriculum decisions, many of which are determined more by tradition than by research. For instance, why should we wait to ask children to solve word problems using addition and subtraction until they have mastered the basic facts? We know that most children already have considerable facility in using addition and subtraction processes in their everyday problems — problems that occur within a natural language context — before they enter school.

Recent research conducted in language development indicates that it is both desirable and appropriate to accept and reinforce children's efforts in learning language, not just correct responses. Approximation, one of seven natural language learning conditions identified by Cambourne (in Butler and Turbill, 1984, pp. 5-9), is the phase of trial and error we go through in mastering any new skill. If our attempts are met

with encouragement and constructive feedback, we are more likely to persevere and refine our approximations until competence is attained. For example, young children learn to speak by approximating the forms of speech they hear in their environment. Their efforts are met with the encouragement and constructive feedback necessary for them to gain considerable competence in speaking during their early years.

The need for accepting and encouraging approximation in learning mathematics is equally important. For too long we have allowed our teaching methods to be dominated by the tyranny of the right answer, the demand for one, and only one, correct response. (And frequently we have accepted only one correct way of arriving at that response!) When children are encouraged to make approximations, they are developing powerful skills in such areas of mathematics as reasoning, number sense, and estimation. In addition, they will eventually discover the utility of approximations in the mathematics of everyday life. (Think about how infrequently we, as adults, require an exact answer to a complex mathematical problem. When we need an exact answer, and it requires computation, we would probably use a calculator. But even then we would use approximation strategies to check if the answer is reasonable.)

Fortunately, the educational climate is such that we can make needed changes more readily than in the past. Many school systems are responding positively to the challenges of the reform movement of the 1980s by encouraging teachers to examine the other options for classroom organization and curriculum development and implementation. The growing body of research on the development of literacy in both language and mathematics provides helpful direction. We no longer have to create all the instructional materials we need; published materials and manipulatives are available to aid us

in establishing a natural learning environment. Inservice models and mentorship programs that focus on teachers sharing with other teachers should help to provide support and to alleviate some of the management concerns. Discipline and classroom management models that encourage group planning and discussion can be especially helpful (e.g., Glasser, 1985).

Traditional assessments, artifacts of decades of skills-based instruction, remain one of our major obstacles in developing natural learning environments. For many years, achievement testing has driven the curriculum, determining to a large extent not only what, but how, language and mathematics have been taught. Although assessment may continue to drive the curriculum, major changes are forthcoming in the types of assessment tasks to be administered to students. Performance-based, authentic assessments — assessments that measure what students can really do when encountering real-world problems — offer us hope as we guide the development of the curriculum in more meaningful directions. Natural assessments such as folios, checklists, and anecdotal records have become widely accepted for monitoring student development in language. We can make similar use of natural assessments in mathematics.

Somewhere, early in their school experience, too many students lose the wonder and excitement that they bring with them when they enter the doors of school. And far too many students exit their formal school experience with neither the capability nor the desire for active literacy. The model of the natural learning environment offers us hope and practical guidance for helping our students achieve active literacy — in language and in mathematics.

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