The Impact of Language on Mathematical Learning

Implications From Research

BY RUTH POPE

"Teacher, I still don't get it." Bobby's plaintive tone pierced my heart. His statement really was a plea for help. As an idealistic first-year teacher, I was eager that each youngster in my classroom have positive experiences with math. Yet all of the methods I had tried seemed ineffective in helping Bobby understand the concepts I wanted him to learn. I wondered, "What am I doing wrong? What should I do differently?"

By talking with the principal and several colleagues about my dilemma, I discovered that sometimes even experienced teachers were unable to communicate concepts to certain students. Furthermore, these classroom veterans didn't know why the students weren't learning, either.

Since that time, research has shown that language skills and mathematics achievement are closely related[1] and that some of the most overlooked reasons for mathematics learning difficulties are language deficits in perception, processing, storage, retrieval, and/or expression.[2]

Language is the tool used to learn basic mathematical concepts, and the means by which concepts are "extended and sharpened," according to Andrews and Brabson.[3]

Therefore, teachers must ensure that students have adequate experiences at each stage of language development: inner, receptive, and expressive.[4] Then language can help bridge the gap between a child's procedural knowledge and his conceptual understanding.[5]

Mathematics is itself a language because symbols represent concepts. Also, mathematics includes semantics and syntax.[6] Sharma[7] points out that mathematics is a second language. Consequently, instructors must teach mathematics as one would teach a foreign language, i.e., provide for (1) assimilation and integration of nonverbal experiences, (2) association of symbols with the experiences, and (3) expression of abstract ideas.

Wiig and Semel[8] remind teachers that the language of mathematics is very specialized and "conceptually dense," has "limited redundancy," and gives "few contextual cues." They go on to say that a pupil must

understand the exact meaning of every word and concept and every expressed syntactic-semantic relationship must be understood. . . . Adjectives tend to carry more importance than in social language. Common words are used with a specific rather than a generalized meaning. Specific concepts that relate to size, number, space, time, and inclusion and exclusion . . . must be firmly established.

Recommendations from the National Council of Teachers of Mathematics[9] include communication as one of the major goals for all grades, K-12. Students need to "frequently and explicitly discuss relationships between concepts and symbols."[10] Small[11] says that teachers should talk, talk, talk about math, just as they hold conversations about other events in students' lives. She goes as far as to almost ban pencils and workbooks. Curcio[12] advocates using

a language-experience approach to teach elementary mathematics, while Gailey[13] encourages teachers to utilize trade books as a springboard for communicating mathematical ideas (Gailey's article offers a bibliography of specific titles).

Students who have difficulty learning mathematics may also have language delays or disabilities. Therefore, evaluation should include an assessment of their language skills. While remediation can help such children "learn to compensate for [their] disabilities,"[14] the teacher's role in remediation is crucial. The manner in which materials and language are used determines whether optimal learning occurs.[15] Fortunately, approaches that benefit special-needs students also are appropriate for nondisabled children. This means that the teacher does not have to plan entirely separate lessons for children with language disabilities.

"Learning numbers without consideration for the pre-symbolic aspects will result in rote learning of arithmetic facts."[16] Piaget has shown that visual-inspection forms the basis for the reasoning used in early quantitative thinking. Therefore, a child lacking visual-perceptual and/or visual-spatial abilities may be at risk in mathematics.[17] Math requires the student to discern general shapes and sizes, determine whether two amounts are the same or different, and notice details of alignment. Consequently, youngsters who have problems in identification, understanding, sequencing, or remembering what they see need help in interpretation.[18]

Introducing a new concept to a language-impaired child requires the use of concrete materials (usually repeatedly). The teacher must verbalize the information and show how to convert it into mathematical symbols (either verbal or written). This process helps develop a child's number sense, the inner language of arithmetic needed for quantitative thinking.[19]

Manipulatives should be presented in auditory, visual, tactile, and kinesthetic modes in order to capitalize on a student's learning strengths. However, Thornton and Wilmot[20] suggest in the beginning to use only one mode at a time to prevent sensory overload. These authors also emphasize that students should use manipulatives to check their work after recording each step. This helps ensure mastery and aids retention. "Only after concrete operations are clearly understood can mental perception and mental manipulation of symbols be expected."[21]

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Instructors must teach mathematics as one would teach a foreign language.

Should teachers begin remediation with two-dimensional or three-dimensional manipulatives? Johnson and Myklebust[22] found that two-dimensional shapes cut from large pieces of felt reduced confusion, while Kratochwill and Severson[23] found that children's learning rates increased with the use of three-dimensional shapes to begin remediation. Teachers should monitor students closely to determine which is best for each child. Because trial-and-error learning often is inadequate to develop concepts, teachers must explain and demonstrate how to use each manipulative.[24] Some specific ideas for working with students with disabilities in visual/spatial perception, processing, and/or recall are included in the box at the end of the article.

A youngster with a language disorder also needs extensive dialogue about the material he or she observes, manipulates, and classifies.[25] Teachers must help these children to encode their sensory perceptions by describing the attributes to be learned (e.g., color, texture, shape). These children also need to describe processes. They require "appropriate models of how language reflects experiences"[26] so that they can "store them in . . . memory, associate them with other experiences, and apply

them to tasks."[27] It is crucial for the student to verbalize what he or she is doing, since many language-disabled students "only internalize ideas when they *hear themselves speak*."[28]

Verbalizing also helps the child focus on relevant information and permits the teacher to monitor the child's thinking.[29] It allows a teacher to give immediate feedback and to ask questions that will help the pupil understand at a higher level of reasoning.[30]

Students who are encouraged to verbalize achieve at a higher level, says Bradley.[31] This may be done with a partner, a cooperative group, or by writing in a journal. Meaningful verbalization requires students to relate new information to what they already know, to integrate isolated facts, and to use prior knowledge in a new situation.[32] The child has mastered a concept when he or she can explain the ideas and strategies.[33] Additionally, verbalizing helps children learn self-questioning so that they can eventually plan, monitor, and evaluate their skills.[34]

Often a language-impaired child does not recognize that an idea may be expressed in more than one way. Working in small groups exposes students to the many ways the same idea may be expressed and to varying approaches to a problem. "Students can persuade one another by the logic of their arguments . . . and can discuss the merits of different proposed solutions."[35] This approach increases student achievement.[36] However, the teacher may need to point out that different words were used to communicate the same idea, and that different sequences to solutions may be equally correct.

The ability to identify, understand, sequence, and remember what one hears is called auditory perception.[37] Hearing is the "primary channel for language acquisition and interpersonal communication."[38] Consequently, an individual with poor auditory skills often has difficulty with mathematics. It is necessary for the teacher to structure the environment so that each pupil can hear and acquire words and concepts in meaningful settings. Johnson and Myklebust indicate that it is critical for the student to hear the spoken word at the exact time of the experience so that he or she can correctly associate the two. Some ideas for working with children with auditory perception, processing, and/or memory problems are included at the end of the article.

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Teachers should talk, talk, talk about math, just as they hold conversations about other events in students' lives.

Since vocabulary level seems to be more significant than syntax,[39] a great deal of mathematics practice will need to focus on vocabulary. Terms must be repeatedly defined, and students should be asked to state them in their own words. Many of the math definitions are not learned in out-of-school settings. For example, to "reduce a fraction" does not mean to decrease its value. Kutz[40] reminds instructors that "there may be a lag in students' ability to apply and use a term and their ability to define it in mathematically acceptable terms." Teachers must help students with auditory perception and processing deficits to understand the words and concepts necessary for successful arithmetic reasoning. Ideas for mathematical vocabulary development are given at the end of the article.

Lack of sequential skills affects learning such simple concepts as counting and basic computation. Sequencing problems may be visual or auditory. The box at the end of the article offers some specific ideas to help children improve their sequencing skills.

Finally, the teacher must review, test, and reteach. Through experimentation he or she can determine the amount of overlearning needed to ensure retention.

Since language disorders so strongly affect the learning of mathematics, every teacher must be aware of such disorders and use techniques that help each child compensate for his or her deficiencies. This means that every mathematics teacher must also be a language teacher!

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NOTES AND REFERENCES

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2. E. H. Wiig and E. M. Semel, *Language Assessment and Intervention for the Learning Disabled* (Columbus, Ohio: Merrill Publishing Co., 1980).

3. M. Andrews and C. Brabson, "Preparing the Language-Impaired Child for Classroom Mathematics: Suggestions for the Speech Pathologist," *Language, Speech, and Hearing Services in Schools* 8:1 (1977), p. 46.

4. *Inner language* is using words to think. Parents and teachers help children develop inner language by describing for youngsters what is happening as they interact together. *Receptive language* is language that a child understands, i.e., through listening and reading (those who can read sign language are also demonstrating receptive language skills). *Expressive language* refers to language produced by the child, either orally or in writing.

5. Bradley.

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8. Wiig and Semel, p. 403.

9. *Curriculum and Evaluation Standards for School Mathematics* (Reston, Va.: The National Council of Teachers of Mathematics, Inc., 1989).

10. Ibid., p. 78.

11. M. S. Small, "Do You Speak Math?" *Arithmetic Teacher* 33:5 (1990), pp. 26-28.

12. F. R. Curcio, "Mathematics as Communication: Using a Language-Experience Approach in the Elementary Grades," *Teaching and Learning Mathematics in the 1990s, 1990 Yearbook* (Reston, Va.: National Council of Teachers of Mathematics, 1990).

13. S. K. Gailey, "The Mathematics-Children's Literature Connection," *Arithmetic Teacher* 45:5 (1993), pp. 258-261.

14. Wiig and Semel, p. 11.

15. D. J. Johnson and H. R. Myklebust, *Learning Disabilities: Educational Principles and Practices* (New York: Grune and Stratton, 1967).

16. Ibid., p. 253.

17. Fleishner and Garnett; A. G. Tishler, *Cognitive Style in Students Evidencing Dyscalculia* (Presented to the Annual Meeting of the Mid-South Educational Research Association, November 11-13, 1981, Lexington, Ky.) (ERIC Document Reproduction Service No. ED 210 159, 1981).

18. R. J. Sovchik, *Teaching Mathematics to Children* (New York: Harper & Row, 1989).

19. Johnson and Myklebust.

20. C. A. Thornton and B. Wilmot, "Special Learners," *Arithmetic Teacher* 33:6 (1986), pp. 38-41.

21. Johnson and Myklebust, p. 253.

22. Ibid.

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25. Andrews and Brabson.

26. Ibid., p. 53.

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28. Thornton and Wilmot, p. 39.

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30. M. C. Sharma, "Levels of Knowing Mathematics," *Math Notebook* 6:1, 2 (1988), pp. 1-7.

31. Bradley.

32. K. Scheid, "Cognitive-Based Methods for Teaching Mathematics to Students With Learning Problems" (Columbus, Ohio: Information Center for Special Education Media and Materials. ERIC Document Reproduction Service No. ED 323 743 1989).

33. Sharma, 1988.

34. Scheid.

35. N. Davidson, "Small-Group Cooperative Learning in Mathematics," *Teaching and Learning Mathematics in the 1990s, 1990 Yearbook* (Reston, Va.: National Council of Teachers of Mathematics, 1990).

36. Bradley.

37. Sovchik.

38. Johnson and Myklebust, p. 67.

39. Wiig and Semel.

40. R. E. Kutz, *Teaching Elementary Mathematics* (Boston; Allyn and Bacon, 1991); "Learning Disabilities: A Report to the U.S. Congress" (Washington, D.C.: Interagency Committee on Learning Disabilities. ERIC Document Reproduction Service No. ED 294 358, 1987).

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