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ABSTRACT

This issue of the newsletter focuses on the teaching of mathematics to mildly handicapped students. The feature article reviews the theory of generalization and its application to specific practices in teaching arithmetic. A set of six-step guidelines is offered for the teacher to follow in ensuring that generalization of arithmetic skills takes place. The "count-by's" approach is described as a useful technique in teaching for generalization of basic multiplication facts. Additional sections of the newsletter review current books and journal articles that address mathematics instruction for learning disabled and other mildly handicapped students, as well as a 75-episode public television series designed to demonstrate everyday uses of mathematics for third through sixth graders. Two mathematics assessment instruments, the Sequential Assessment of Mathematics Inventories and the Test of Computational Processes, are briefly noted. In two concluding sections, the Vaughn System of Multiplication multimedia instructional program is described, and a published research study comparing sequential and concurrent elementary mathematics instruction is summarized. (JW)

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issues and happenings in the education of handicapped students

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GENERALIZATION IN ARITHMETIC

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Instruction in special education classrooms is often focused on remedial basic skills. Although critical, instruction in basic skill remediation alone is not enough. Students may reach the acquisition level in the resource room setting but are unable to use their skills in the regular classroom where different activities, books or worksheets are introduced. They must learn how to generalize these skills to settings and materials other than those in the special education classroom. The purpose of this article is to review the theory of generalization and relate it to specific practices in arithmetic.

There are essentially four types of generalization. **Maintenance** occurs when a skill is used accurately after instruction is withdrawn. For example, maintenance of a skill has taken place if a student continues to complete sums to 9 problems after instruction in the "add-on" approach has stopped. If such accurate performance continues over an extended period of time, **retention** has taken place. That is, if a student continues to add correctly in 6 months, he or she has retained the skill. **Response generalization** is indicated when a student learns a skill even though no specific instruction has taken place. For example, if a student has learned the "add-on" skill to complete sums to 9, and he or she used this skill to complete 2 digit addition, response generalization has occurred. Finally, **stimulus generalization** occurs when a student performs a certain task in a condition different from the condition in which the skill was learned. This may be demonstrated in the following example. When originally learning the "add-on" approach, the pupil needed to use his fingers; stimulus generalization is indicated if the student can mentally add-on without using his fingers. Instruction for generalization is extremely important in attempting to prepare special education students for regular classroom activities. Unfortunately, instruction often stops before skills can be generalized. In other words, teaching for generalization often does not occur.

Guidelines for Teaching for Generalization

Teaching for generalization is basically a six-step process. Initially, the teacher must **demonstrate** the specific skill to be learned. This provides the student with an accurate guideline to follow as he or she begins to **model** the behavior demonstrated by the teacher. Next, the student must be given numerous opportunities to **practice** the target behavior. As practice in the new skill continues, teachers must **monitor** not only accuracy of student performance, but also consider the rate at which students accurately complete the problems. While it is desirable for a student to complete 10 addition problems, it is of little practical value if it takes 30 minutes to do so. However, completing 10 problems in 2 minutes suggests that the student is well on his way to generalization.

As students approach appropriate levels of accuracy and speed, instruction should begin to focus on the **application** of the skill in a generalized setting. Instruction of new facts, in new books or using different types of worksheet activities facilitates the generalization of learned skills.

Before discussing the final step in the generalization process, a key factor should be introduced. Although it has not been mentioned during the description of the initial 5 steps, it is extremely important for the teacher to provide appropriate feedback throughout the teaching process. Teacher feedback provides direction and support for student performance. Feedback lets the students know if they are accurately completing a task, or provides them with guidelines as to how to continue to be successful. Teacher feedback is a critical component of teaching for generalization and should be provided throughout the instructional process.

The final step in teaching for generalization begins as the teacher starts to fade her participation in the process, focusing on student **self-monitoring** or verbal mediation. The student must be taught specific strategies that will allow the basic skill knowledge to be generalized to other settings.

Application to Arithmetic of Teaching for Generalization

The remainder of this article will focus on the direct application of the theory of teaching for generalization. A recent research project in arithmetic which I am conducting will serve as the guideline for this discussion.

Many mildly handicapped students have trouble just learning basic multiplication facts, much less learning to generalize these facts to other statistics. A technique called "count-by's" was used to try to teach for generalization of these multiplication facts. During the initial instructional

> This issue of the **PRISE reporter** focuses on the teaching of mathematics to mildly handicapped students. It includes suggestions for strategies, interventions, tips on instruction as well as materials, assessment and tests.

stage, the teacher demonstrated the count-by process for a student. The demonstration consisted of a "see-say" process. The teacher displayed a series of numbers (e.g., 3, 6, 9, 12, 15, 18, 21, 24, 27, 30) and said the numbers as quickly as possible. It was explained that counting-by a specific number (in this case "3") was just like doing repeated addition or multiplication. The teacher again demonstrated the count-by process. The student was asked to model the behavior demonstrated by the teacher, until mastery criteria had been reached.

While a valuable first step, it was determined that mastery of "see-say" activity was insufficient. Subsequently, a second teacher demonstration, a "think-say" phase, was introduced. The teacher "counted-by" the 3's *without* the visual stimulus and then asked the student to also complete the "think-say" activity. After mastery was achieved in the "think-say" phase (four 5 minute sessions in this case) probe sheets were provided to allow ample opportunity for practice. The probe sheets consisted of 60 specific multiplication facts with a constant (e.g., the 3's). As the student was completing the worksheet, feedback was provided as to correct responses as well as to how well the count-by technique was being used.

Initially, prompts such as "try your count-by's" were used by the teacher. The initial probes resulted in accurate work, but work that was still too slow. Repeated practice with the "think-say" phase and with the probe sheet resulted in mastery within 6 days (mastery was set at 70 correct productions per minute). After four days, the student no longer needed teacher input, but was able to self-monitor the use of the count-by process. The excitement of seeing these facts being mastered was wonderful, but the true test of the effectiveness of the count-by procedure is its usefulness with other multiplication facts.

To determine if the student was able to generalize for one response (e.g., the 3's) to another response (e.g., the 4's), the student was given a probe sheet with only 4's multiplication. The student was simply asked to complete the sheet as quickly as possible and to use the count-by technique whenever he had a problem. Again, the initial performance rate was low although the student accurately completed the problems.

The final judgment came from a review of the student's math worksheets in his regular classroom. Although he occasionally missed some multiplication problems, these rarely included errors with the 3's or 4's problems. His average scores increased from 70-75 to 90-95. The skill of "count-by's" had been proven to be an effective technique in teaching for generalization of basic multiplication facts

As the preceding example shows, teaching for generalization is critical to overall academic performance of special students. The format described above provides the basic structure, but individual implementation may be teacher specific. The "count-by's" approach is one technique that appears to be useful in teaching multiplication facts. There are certainly other techniques that may also be effective in teaching for generalization of arithmetic skill In implementing these skills, it appears to be sound instructional practice to consider the six-step process designed to ensure generalization.

John Beattie is an assistant professor in the Department of Curriculum and Instruction at the University of North Carolina at Charlotte. He received his Ph.D from the University of Florida. His current research concerns are in the area of arithmetic for mildly handicapped students as well as the study, social and communication skills of this population.

CURRENT CITATIONS

Cawley, John (Ed.) **Cognitive Strategies and Mathematics for the Learning Disabled.** Aspen Systems Corporation, 1600 Research Blvd., Rockville, MD 20850. 1985. 244p. $33.00. This book presents learning theories and educational implications of selected views from several contributors on cognitive functioning, mathematics, and the learning disabled. Cawley attempts to direct attention from the traditional emphasis on arithmetic computations instruction, wherein practice seems limited to rote learning via drill and practice, towards an emphasis on arithmetic tasks instruction to facilitate cognition skills which include but are not limited to reasoning, problem solving, thinking and information processing.

Issues of cognitive functions, mathematics and the learning disabled are reviewed in Chapter 1. Chapter 2 is procedural in that it details the process of classroom assessment of the mathematically learning disabled (MLD) student with teacher-constructed instruments, regardless of selected cognitive theory. Measurement terms as well as their application to classroom tests are explained. The easy-to-follow guidelines include the topics of item construction, scoring, and evaluation of the administered test. The remaining chapters provide a detailed discussion of selected cognitive theories as applied to MLD students. Theory content is presented in a format that is easily translated into test items by following the framework of Chapter 2. The final chapter is devoted to implications of cognitive strategies in the classroom. Suggestions for instructional activities representing accepted theories of learning are incorporated in a list of guidelines for mathematics instruction. These theories, guidelines and activities when integrated in an instructional program for MLD students may enable a teacher to circumvent some common problems LD students acquire in the attainment of skills and concepts in mathematics.

Lambie, Rosemary A. and Hutchens, Patricia W. **Adapting Elementary School Mathematics Instruction.** *Teaching Exceptional Children*, Spring, 1986, pp. 185-189. Ten of the most common difficulties of teaching mathematics to mainstreamed special needs learners in the elementary classroom are described in this clearly written "how to" article. Probable causes of these difficulties are presented and teacher adaptations and modifications to alleviate the problems are enumerated. The teacher adaptations are categorized into five areas: modifications of materials, instructions, assignments, consequences and environment. The authors stress encouragement and praise for small successes of the mainstreamed student as well as the consistent use of various combinations of adaptations to meet the unique needs of the individual learner.

Pellegrino, James W. and Goldman, Susan R. **Information Processing and Elementary Mathematics.** *Journal of Learning Disabilities*, 1987, 20(1), pp. 23-32, 57. An overview is presented of information processing analyses of knowledge and performance in three areas of the elementary mathematics curriculum. These areas include basic addition and subtraction facts, complex procedures such as multicolumn subtraction, and the solution of word problems. Theories of the knowledge associated with "expert" performance are presented. These theories emphasize the gradual acquisition of declarative knowledge facts (basic math facts), changes in procedural knowledge, and the shift from solution of problems by calculational methods to solution by direct retrieval of addition and subtraction facts. Less than expert performance is generally characterized as slow and prone to error, with errors often showing systematic patterns. Evidence suggests that in the three areas of math analyzed, learning disabled children do not suffer from conceptual deficits but rather from deficits in knowledge of basic facts. This impedes their performance in other tasks requiring this knowledge.

Pieper, Edward, & Deshler, Donald. **Intervention Considerations in Mathematics for the LD Adolescent.** *Focusing on Learning Problems in Mathematics*, Winter, 1985, 7(1), pp. 35-47. The growing trend of secondary schools to increase the amount and quality of mathematics and science instruction sparked the authors to consider the impact of a concentrated mathematics curriculum on the learning disabled adolescent.

Four major curriculum and instructional problems are discussed that precipitate failure among the learning disabled population in the area of mathematics at the secondary level. One of the major problems is the fixed curriculum which specifies which math skills are to be presented by the end of the year in regular content math classes. The demands of a fixed curriculum, coupled with the frequent use of symbolic presentations as an instructional style, promote failure among many LD adolescents. As learning disabled adolescents progress through the secondary grades, the disparity between skills needed and those mastered increases and the resource room cannot remediate this growing gap.

Pieper and Deshler offer seven interventions to alter instructional practices that are seen to be central to the issue of effective mathematics curriculum delivery to the LD adolescent. These interventions include: 1) individualizing instruction to insure success; 2) gearing instruction to stress meaning; 3) using word problems and real-life applications to insure skill mastery; 4) teaching learning strategies to facilitate independent learning; 5) using flow charts to teach rules and principles; 6) using rate measures and precision teaching to enhance fluency; 7) increasing the intensity of instruction.

The authors stress that as schools are turning more attention to math as a curricular area, it is important that commensurate attention be devoted to defining an appropriate curriculum for the learning disabled adolescent as well as discovering specific instructional practices that will maximize the mastery of the mathematics content area.

Thornton, Carol A., & Toohey, Margaret A. **Basic Math Facts: Guidelines for Teaching and Learning.** *Learning Disabilities Focus*, 1985, 1(1), pp. 44-57. Many LD students have difficulty mastering basic math facts because of a weakness in using organized strategies that make fact learning easier. Research suggests that fact learning can be improved by modifying the sequence of instruction and the presentation of learning tasks.

Ten guidelines are suggested in planning a basic fact program for LD students: 1) Review or reteach prerequisite learnings before students are required to use them. 2) Establish through on-going diagnosis and treatment which facts have been retained, which strategies were used and their efficiency, and what learning style was employed by the student. 3) Modify the sequence in which facts are presented. 4) Prior to drill, explicitly teach students strategies for working out fact answers. 5) Match learning activities and individual learning styles. 6) Control the pacing. 7) Help students discriminate when a strategy applies and to integrate new learnings. 8) Provide verbal prompts. 9) Help students build self-monitoring skills. 10) Make adequate provisions for overlearning, shifting the focus to long-term memory.

VIDEO

"Square One TV," developed by Children's Television Workshop (CTW) is a new PBS series of 75 half-hour episodes designed to spark the interest of third through sixth graders in math by demonstrating its everyday uses. While not developed specifically for special education students, it may be applicable to a special needs population.

This new program tries to take advantage of students' familiarity with television. Recurring elements include "Mathnet," a "Dragnet" spoof, complete with deadpan dialogue, in which Sgt. Kate Monday and Officer George Frankly use their mathematical knowledge to crack mysteries; and "But Who's Counting?" a numbers game in the "Wheel of Fortune" vein with host Monty Carlo and "the lovely Amber Jeanette," a wheel-spinning model. There are also music videos that introduce math concepts such as percentage and infinity or that simply extol math's usefulness.

"Square One TV" isn't meant to replace classroom teaching, but rather, to make students more receptive to thinking through problems. CTW encourages teachers to tape the episodes and use them whenever they supplement the regular curriculum. There are three year rights for taping the episodes; that is, there is an obligation to erase the tapes after three years.

TESTS

The **Sequential Assessment of Mathematics Inventories (SAMI)** is a standardized test inventory which evaluates a student's performance on mathematics content taught in the K-8 curriculum. The subtests are: Number Notation, Computation, Mathematical Language, Ordinality, Geometry, Measurement, Word Problems, and Mathematical Applications. Norm referenced and individually administered, **SAMI** enables the school psychologist or special educator to diagnose strengths and weaknesses and to decide placement of a student.

Reisman, Fredericka K. 1985. The Psychological Corporation, 555 Academic Court, San Antonio, TX 78204-0952. Components are. Examiner's Manual, Stimulus Manual in Easel Form, 12 Student Response Booklets and Teacher Record Forms. $49.00.

The Test of Computational Processes (TCP) measures the ability of students, grades 1 to 8, in math computation. It pinpoints fact and process errors in addition, subtraction, multiplication and division of whole numbers, fractions and decimals, and also includes some measurement facts and calculations. It compares the student's overall ability with that of his or her peers, identifies strengths and weaknesses in arithmetic computation, and evaluates and monitors progress. Criterion referenced with normative data, it may be administered individually or to groups, and is independent of reading level or vocabulary.

Kingston, Nelson D. 1985. DLM/Teaching Resources, P.O. Box 4000, One DLM Park, Allen, TX 75002. Examiner's Manual and 25, 8-page test booklets, $50.00. Additional sets of 25 booklets, $20.00.

INSTRUCTIONAL MATERIAL

The **Vaughn System of Multiplication** is a multimedia program which proposes the use of a memory technique for teaching one hundred basic multiplication facts from 0 x 0 to 9 x 9. Following eight years of field testing with nondisabled children it is currently being promoted as an alternative to more traditional drill and practice methods for learning to multiply.

The **Vaughn System** is designed to capitalize on the elementary school child's visual retention capacity. Specifically, it attempts to teach children how to remember answers to multiplication questions. All but twenty-eight multiplication facts are discerned through the application of four easy rules. 1) the "little" rule—always say the little number first, 2) the "zero" rule—zero times any number is zero; 3) the "one" rule—one times any number is that number; 4) the "two" rule—two times any number is the same as adding that number twice. A "secret" number code which changes numbers to letters, and twenty-eight funny pictures are employed to solve the twenty-eight remaining facts.

The **System** consists of six sound filmstrips, ten large flashcards, thirty consumable student workbooks, one software disc, and one teacher's guide. The producers suggest its use for teaching multiplication to children for the first time as well as for remediating learning disabled and nondisabled youngsters.

Dean Vaughn Learning Systems, Inc., Advanced Instructional Systems. 1985. $649.50. (RRC Code: 4c ADVINS 01 01).

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RESEARCH BRIEF

Study Compares Sequential and Concurrent Instruction

A persistent problem in elementary mathematics instruction is that students do not apply learned computational skills to solve verbally presented problems. Some researchers hold that insufficient instruction, rather than a student's cognitive processes, is responsible for failure to learn basic academic skills.

The purpose of this study was to compare the relative effectiveness of two variations of direct instruction for teaching elementary students to discriminate between addition and subtraction story problems. The hypothesis tested was whether sequential instruction in four problem types (simple action, classification, complex action, comparison) would result in higher posttest achievement than concurrent instruction.

Third grade students from six different classes were pretested and randomly assigned to either a sequential or a concurrent training group. A total of 144 story problems were used for board work and seat work. The same problems were used in the sequential and concurrent training. Students were engaged in nine instructional sessions of 15 minutes each. The first 3 days of training were the same in both groups, but beginning with the fourth day, procedures differed for the sequential and concurrent instructional conditions.

Results of the study demonstrated that training third grade students to solve examples of four basic types of verbal math problems in a sequence results in higher posttest scores than training students to solve an unsequenced (concurrent) mixture of the same problems. In addition, the teacher stated that using the sequenced presentation model provided an opportunity for repetition, was simpler and more efficient, and allowed for generalization of learned skills. The authors suggest that those using other teaching methods should consider the advantage of sequenced instruction in teaching students to solve verbal math problems.

Jones, E. D., Krouse, J. P., et al., **A Comparison of Concurrent and Sequential Instruction of Four Types of Verbal Math Problems.** *RASE,* 1985, 6(5), pp. 25-31.

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