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ABSTRACT

This study sought to determine the effectiveness of self-instructional strategy training on the addition and subtraction problem-solving skills of four upper elementary-level learning-disabled students, and to evaluate maintenance and generalization of the trained skills. Each subject received individual criterion-based training in self-instructional strategies. Training emphasized the student's role as an active collaborator in the learning process, with responsibility for recruiting and applying strategies gradually placed upon the student. Strategies were explicitly and overtly modeled in context. Subjects' scores on one-step word problems in addition and subtraction significantly improved following training. All subjects showed that the skills were generalized across settings and were maintained 3-5 weeks after training. Subjects were more confident of their ability to complete the word problems following training, though they had overestimated their pre-training ability. The four students and their teacher evaluated the self-instructional strategy training positively. Inspection of students' papers collected when probes were administered provided concrete evidence of post-training use of the instructed problem-solving strategy. (JDD)

Self-Instructional Strategy Training: Improving the Mathematical Problem Solving Skills of Learning Disabled Students

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A significant number of learning disabled (LD) students evidence severe deficits in mathematical skills and abilities. However, arithmetic disabilities and interventions among LD children have received relatively little attention (Johnson, 1979). Of the available research, most work focuses on computational and application skills (Cawley & Vitello, 1972; Peterson, 1973). Further, instruction in basic operations often predominates; relatively little time is spent on higher order processes, such as problem solving.

Wallace and McLoughlin (1979) suggested that more emphasis should be placed on application and comprehension rather than rote memorization of facts. Bley and Thornton (1981) noted that LD students must become competent at computational and problem solving skills, but added that the latter is a more difficult skill for the LD student to acquire. They explained that this difficulty may be due to the prerequisite skills students must master: decision making, language proficiency, vocabulary usage, sequencing and patterning. A skill which gives students great difficulty in problem solving is translating the written problem into a mathematical sentence.

Similarly, Payne, Pollaway, Smith, and Payne (1981) discussed the importance of the development of mathematical reasoning skills and the fact that computational skills are necessary but not sufficient in meeting this goal. Peterson (1973) noted that teachers of handicapped learners are often tempted to move on to rote memorization of multiplication and division facts once addition and subtraction facts are mastered, even though the student may not know when or how to apply those addition and subtraction facts, particularly in problem solving.

Therefore, instruction in mathematical problem solving needs to be more adequately addressed in instructional research. Throughout math instruction, abstract thinking and problem solving must be encouraged. Cawley and Vitello (1972) noted that LD students often perform poorly in effective use of these cognitive processes. Thus, a self-instructional strategy training procedure was developed in this study to instruct LD students to understand and perform addition and subtraction word problems.

While not frequently applied in the area of mathematical problem solving, current research indicates that cognitive strategy training can be highly effective with problem learners across a variety of academic tasks (Pressley & Levin, in press; Reeve & Brown, 1985). The purpose of the present investigation was to determine the effectiveness of self-instructional strategy training on the addition and subtraction problem solving skills of learning disabled students. Maintenance and generalization of trained skills was also investigated. Further, both treatment validity and social validity were addressed; these are critical concerns in cognitive strategy training which are typically neglected (Harris, 1985). Treatment validity was evaluated by collecting evidence of self-instructions and strategy use during and after training. Interview data was collected to determine the social validity (or acceptability) of training among teachers and students.

Method

Subjects and Setting

Four LD students, three boys and one girl, from an upper elementary level self-contained classroom were selected to participate in the study. Their ages ranged from 11 years - two months to 11 years - nine months at the beginning of training. The elementary school was situated in a middle class suburb of Maryland near the District of Columbia. Due to the heterogeneity of school-identified LD populations and the problems of validity with this label (Shepard, Smith, & Vojia, 1983), the LD subjects in this study were identified according to the following criteria: identified by their local system as exhibiting a specific learning disability, an IQ score of 75 - 110 on the Weschler Intelligence Scale for Children-Revised (WISC-R), achievement at least two years below grade/age level in one or more academic areas, and absence of multiple handicaps or motor involvement. In addition, the students were identified by their teacher as having mathematical difficulties. Finally, each subject was tested on a reading vocabulary list of common words found in the word problem sets.

On the Weschler Intelligence Scale for Children-Revised (WISC-R) the subjects' full scale performance scores ranged from 77 - 82 with a mean of 79. Verbal scores on the WISC-R ranged from 77 to 87, while performance scores ranged from 77 to 82. The Woodcock Johnson Achievement Test grade scores in math and reading ranged, respectively, from 2.0 to 3.2 (mean 2.6) and 2.1

to 2.8 (mean 2.4). On the reading vocabulary pre-test, three subjects' percentage scores ranged from 80% to 95%, one subject scored 60%.

Tasks and Materials

The mathematical tasks chosen were one-step word problems in addition and subtraction. All of the problem sets used throughout the study for data collection contained 14 problems, seven addition and seven subtraction. Each problem set contained the same type of problems, with control procedures for vocabulary and the order of larger and smaller numbers. These problem types were modeled after a research study performed by Carpenter and Moser (1984). The order of the problems was randomly determined for each problem set. Each problem set was handwritten on a ditto sheet so that the subjects could write on the paper and so that this permanent record could be kept. Each subject had folders in which to keep their progress graphs, strategy steps, learned vocabulary and self-instruction statements.

General Procedures

Senior level preservice special education teachers served as instructors in the study. The subjects referred to these instructors as their "special math tutors." The instructors followed detailed lesson plans, and checked off steps as they were completed (lesson plans are available from the authors). Other materials in the trainers' notebooks included daily recording sheets to keep data and notes on the subjects' daily performance.

Self-Instructional Strategy Training Procedures

The self-instructional strategy training procedures followed in this investigation were previously validated (Graham & Harris, 1987; Harris & Graham, 1985), and developed in adherence with guidelines for designing and implementing cognitive-behavioral interventions (cf. Brown & Campione, 1986; Harris, 1982; Meichenbaum, 1977). Learner and task analyses were carefully conducted to allow subsequent selection of skills and strategies to be taught as well as tailoring of components and procedures to students' capabilities. Training emphasized the student's role as an active collaborator and interactive learning between teacher and students, with responsibility for recruiting and applying strategies gradually placed upon the student. Principles of interactional scaffolding and Socratic dialogue were incorporated; trainers were enthusiastic and responsive to each child. Strategies were explicitly and overtly modeled in context; the goal and significance of the strategies were also made clear.

Each subject received individual training two - three days a week; training sessions were approximately 35 minutes long. Training was criterion-based; subjects did not move to the next step in training until mastery of the preceding step was established. Four to five training sessions were required for the addition word problem solving strategy training, while five to seven sessions were required for the subtraction training. Training occurred in a small unused classroom. An outline of the training steps follows:

Step 1: **Pretraining.** In this step, the instructor assessed the current skill level of the students and their ability to read the word problems. The students had to be familiar with target vocabulary words which can cue the reader to the meaning of the problem. The instructor introduced common words that help tell the readers what the problem is asking them to do. After discussion, the students came up with examples of their own and practice problems were read to see if the students could pick out the important cue words.

Step 2: **Review current performance level.** The students reviewed their baseline data during this step. With the instructor they discussed the goals and the significance that training could have on their problem solving skills. The students were encouraged to talk about their strengths and weaknesses and make a commitment to improve their skills through self-instructional strategy training.

Step 3: **Describe the problem solving strategy.** The instructor described the 5-step strategy to be taught: 1) read the problem out loud, 2) look for important words and circle them, 3) draw pictures to help tell what's happening, 4) write down the math sentence, 5) write down the answer.

Step 4: **Model the problem solving strategy and self-instructions.** The instructor modeled the strategy while incorporating self-instructions to regulate effective use of the strategy. The instructor modeled the following types of self-instructions: 1) define the problem ("I have to work on the answer to this story problem"), 2) make a plan and get started ("How can I solve this problem, I have to look for important words"), 3) use the strategy ("I will follow the 5-step strategy"), 4) self-evaluate ("How am I doing? Does this make sense?"), 5) self-reinforce ("I did a nice job. I got it right!"). Next, the group discussed the self-instructions and their purposes. Students then generated and recorded self-instructions of each type above in their own words.

Step 5: **Mastery of the problem solving strategy.** The students memorized and practiced using the problem-solving strategy. They also began to use the self-instructional statements. The instructor provided feedback when necessary and made certain that the strategy and self-statements memorized retained the proper meaning when used by the students.

Step 6: **Controlled practice of strategy steps and self-instruction.** The students practiced using the self-instructions and strategy. A chart listing the five steps in the problem solving strategy and the students' list of self-instructions were initially available as prompts, then gradually withdrawn. Positive and corrective feedback was provided when necessary. The instructor encouraged the students to use covert speech once mastery of the strategy and self-statements was apparent.

Step 7: **Independent performance.** Students used the self-instructions and strategy procedures independently to solve word problems. Together the instructor and student recorded the progress being made; a daily graph was kept for number of correct answers. Problem sets were completed by the students until criterion for use was met (6 of 7 correct).

Step 8: **Generalization and maintenance components.** Throughout the training sessions, students were reminded to use the self-instructional strategy in their classrooms and were asked to share occurrences of doing so with their instructor. Students kept the folders with the written self-instructions, and strategies could be reviewed or referred to. They were encouraged to talk to their teachers about the training and were required to have their special education teacher initial their graphs during training. During the final lesson plans, the instructor led discussions on appropriate times to use the strategy.

Dependent Measures

Word problems. The subjects' abilities to solve mathematical word problems were measured in two ways for each problem set administered. First, the number of correctly written equations was recorded. Second, the number of problems for which both the equation and answer were written correctly was recorded. These measures were taken to ascertain the students' understanding of the word problem as well as her/his accuracy in solving the problem.

Reliability. Interobserver reliability data was collected by one scorer blind to the conditions of the study. Thirty-three percent of the permanent product data was rescored for both the number of correctly written equations, and the number of correct equations and answers. These results were compared to those of the instructors. The reliability formula calculated was the number of agreements divided by the total number of agreements and disagreements, multiplied by 100. Reliability for number of correct addition equations, number of correct addition equations and answers, number of correct subtraction equations, and number of correct subtraction equations and answers was, respectively, .98, .96, .99, and .96.

Self-efficacy measure. A procedure developed by Schunk (1982) was adapted to measure self efficacy, defined as a student's judgment of her/his ability to complete a task. This procedure required that the students read word problems and rate their ability to solve the problem. Each student was shown an index card with a word problem written on it, similar to the problems used in the study. The student was given 10 seconds to read the problem and then privately rated her/his ability to solve the problem according to the scale used in Schunk's studies in mathematics (Bandura & Schunk, 1981; Schunk, 1982). Perceived efficacy is rated on a 100-point scale, ranging in 10-unit intervals under the following headings: 10 - not sure; 40 - maybe, 70 - pretty sure, and 100 - real sure. Each subject completed several warm-up items unrelated to mathematics and then read a total of ten problems (five addition and five subtraction) and circled the rating on the provided sheet with the interval ranking scale.

Inteiviews. The subjects, the strategy instructors, and the classroom teacher were interviewed at the conclusion of the study to assess the practicality and social validity of self-instructional strategy training. General questions about the applicability and the results of the self-instructional procedure were asked. The questions asked were modeled after research completed by Harris (1986).

Experimental Design

A multiple-baseline-across-subjects-across-two-behaviors design was employed in this study. After establishing a stable baseline for Subject 1, self-instructional strategy training sessions began for solving addition problems; after post-training data on performance was collected, strategy training for solving subtraction problems was initiated. Subject 2 did not begin training until a stable trend was established for Subject 1. Subjects 3 and 4 followed in the same manner.

Baseline. During baseline the instructor met with the subject and assigned them to complete a math task sheet. Baseline data on Subjects 2, 3 and 4 were collected using multiple probes spread out over the baseline periods. This procedure has been suggested when subjects can be expected to exhibit boredom or fatigue from performing the same task repeatedly, and when extended baselines raise ethical issues. (Horner & Baer, 1978).

Training I. In Training I the lesson plans were designed to teach addition word problem solving. The self-instructional strategy training steps previously described were followed. Students were trained until they met the criteria of the lesson plans (six out of seven addition problems correct). After a student had met criterion on instructional steps 1-6 the student performed problem sheets independently. During independent practice the subjects graphed the number of correct addition problems they completed on their graphs.

Post-Training. No instruction was given during the Post-training stages. The subject met with the instructor to complete word problem worksheets similar to the sets given during baseline (but with different problems). The total number of correct addition and subtraction problems was recorded by the instructor.

Training II. The instructional sessions in Training II were designed to work on solving subtraction word problems. The essential difference between solving addition and subtraction story problems was recognizing the appropriate vocabulary cue words that indicated the meaning of the problem. Training II was conducted in the same manner as Training I.

Post-Training II. The same procedures from Post-training I were followed. The total number of correct addition and subtraction problems was recorded.

Follow-up probes: maintenance and generalization. Two weeks and approximately four weeks after training was completed, instructors met with the students to take maintenance data. To assess the subjects' generalization of the intervention, the LD classroom teacher incorporated the math task sheets into the students' regular seatwork activities. These probes were collected after Post-training II was completed.

Results

Baseline data indicated that all four subjects were unable to distinguish the need to add or subtract in word problems. Following addition word problem strategy training, the subjects performed significantly better on the addition word problems. However, two subjects simply added all 14 of the problems in the first post-training probes. The second portion of training, subtraction word problem strategy training, proved essential for the subjects to correctly solve both addition and subtraction word problems with meaningfully improved accuracy when compared to baseline. Subjects' scores typically increased from 0 to 2 (out of 7) problems correct in baseline to 5 to 7 (out of 7) problems correct at post-training for both addition and subtraction. (see Figure 1 and Figure 2) Figure 2 indicates that even when the subtraction and addition equations were correctly written, incorrect answers to the equations were occasionally determined. Thus, addition and subtraction facts and self-checking of answers needs continued emphasis.

Generalization and maintenance. On the generalization across settings measure all of the subjects scored well above their baseline scores and equally as well as their Post-Training II scores. Maintenance data was taken two and three weeks after Post-Training II for the first subject. These results show that this subject had maintained the skills taught. The remaining subjects were seen between four and five weeks after training at their homes during summer vacation. This data indicates that these subjects also evidenced maintenance of their skills. The exception was subtraction for Subject 2; however, during maintenance Subject 2 skipped a page with two problems on it, possibly accounting for the low subtraction score.

Further, some evidence of generalization across tasks was also found. Both Subjects 1 and 2 exhibited some improvement of the subtraction word problems following the addition word problem strategy training, before the subtraction word problem strategy training was initiated.

Self-Efficacy. The results of the self-efficacy measure indicated that each student perceived her/himself as somewhat more able to complete the word problems after the intervention process. It should be noted, however, that all the subjects initially rated their ability at 91%, 97%, 89%, and 64% (from Subject 1 to Subject 4). Following training the averages were 100%, 100%, 93%, and 79%, respectively. Therefore, the subjects were more confident in their ability following training, but this had initially been overestimated. This problem of overestimation and investigation of children's self-efficacy has been discussed by Graham and Harris (1988).

Interviews. Each subject evaluated the self-instructional strategy training positively. Each indicated that before training he/she was not very good at doing the problems, but had improved. The subjects specifically spoke positively about the advantages of learning the strategy steps and important words, and that they "paid attention." One boy verbalized that the trainer ". . . taught me to be quiet and concentrate. And I did better." Three of the subjects gave specific examples of when they could use their self-instructions other than during math time (during physical education, in social studies, in science).

The special education teacher was pleased with the results of training and the students' positive attitudes, and said she planned to continue the use of the strategy training the following school year. She also indicated that self-instructions were observed in the classroom during math seatwork, and that she believed there was an improvement in their concentration during seatwork. The trainers were enthusiastic about the training procedures and students' responses.

Validation of the intervention. Finally, inspection of students' papers collected when probes were administered provided concrete evidence of post-training use of the instructed word problem solving strategy. Students used self-instructions during training consistently and willingly. Thus, validation of instructional manipulations and mechanisms of change helped provide confirmation of mediating responses.

Discussion

The subjects' baselines in this study supported Bley and Thornton's (1981) contention that problem solving is an area of great difficulty for handicapped learners. Specifically, the LD subjects in this study had difficulty comprehending when it was necessary to add or to subtract.

Through the use of a self-instructional strategy training regimen, the LD students in this study improved their problem solving abilities on one-step addition and subtraction work problems. These improvements in performance were successfully generalized to the students' special education classroom, and two subjects evidenced an unexpected generalization from the addition training to the completion of the subtraction word problems. Maintenance was also evidenced. Finally, subjects' self-efficacy improved somewhat, although initial judgments indicated overestimation of word problem abilities.

Interviews with both the subjects and their teachers indicated a strong, positive response to the strategy training techniques employed in the study. The results of this study support and extend the use of cognitive strategy training interventions with mild to moderately handicapped learners.

Further observations made in the present study may be helpful in future research. Daily notes on the subjects' behaviors and reactions to the presented material were an important aid in analyzing the subjects' progress. The preliminary lessons taught during each training session involved the memorization of selected important words. By the end of the subtraction strategy training it was imperative that the subjects knew which words implied that addition or subtraction should occur. Having subjects circle these important words as they read them was an important factor, and allowed the instructors to evaluate the subjects' memorization of these words. However, it became evident that the subjects began to jump immediately to the important words in each problem, circled the words, and then wrote the equation. Thus, careful reading of the problem first needed to be stressed. This would become particularly important as word problem training progressed to the point where, in some cases, the same cue words can have different meanings (e.g., to add or to subtract) depending on their usage in the word problem.

Future research is also needed to determine the necessary and sufficient training steps/components in the self-instructional strategy training intervention (see Graham & Harris, 1988). For example, in the present investigation, the strategy step, to "draw pictures to tell what's happening" was designed to clarify the subjects' understanding of the word problem. Also, this was intended to provide a more concrete representation of the word problem. Daily records showed that this step was not used as consistently during independent practice. Future research might help to determine if more instruction on this step would enhance subject usage or if picture representation becomes unnecessary as students become more proficient.

References

Bandura, A., & Schunk, D.H. (1981). Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation, Journal of Personality and Social Psychology, 41, 585-598.

Bley, M.S., & Thornton, C.A. (1981). Teaching mathematics to the learning disabled. Rockville, Maryland: Aspen Systems Corporation.

Brown, A.L., Campione, J.C., & Day, J.D. (1981). Learning to learn: On training students to learn from texts. Educational Researcher, 10, 14-21.

Carpenter, T.P., & Moser, J.M. (1984). The acquisition of addition and subtraction concepts in grades one through three. Journal for Research in Mathematics Education, 15, 179-202.

Cawley, J.F., & Vitello, S.J. (1972). Model for arithmetic programming for handicapped children. Exceptional Children, 39, 101-110.

Graham, S., & Harris, K.R. (1987). Improving composition skills of inefficient learners with self-instructional strategy training. Topics in Language Disorders, 1, 66-77.

Graham, S., & Harris, K.R. (1988). A components analysis of cognitive strategy training: Effects on learning disabled students' compositions and self-efficacy. Manuscript submitted for publication.

Harris, K.R. (1982). Cognitive-behavior modification: Application with exceptional students. Focus on Exceptional Children, 15(2), 1-16.

Harris, K.R. (1985). Conceptual, methodological, and clinical issues in cognitive-behavioral assessment. Journal of Abnormal Child Psychology, 13, 373-390.

Harris, K.R. (1986). Self-monitoring of attentional behavior vs. self-monitoring of productivity: Effects on on-task behavior and academic response rate among learning disabled children. Journal of Applied Behavior Analysis, 19, 417-423.

Harris, K.R., & Graham, S. (1985). Improving learning disabled students' composition skills: Self-control strategy training. Learning Disability Quarterly, 8, 27-36.

Horner, R.D., & Baer, D.M. (1978). Multiple-probe technique: A variation of the multiple baseline. Journal of Applied Behavior Analysis, 11, (1), 189-196.

Johnson, S.W. (1979). Arithmetic and learning disabilities: Guidelines for identification and remediation. Boston: Allyn and Bacon, Inc.

Meichenbaum, D. (1977). Cognitive-behavior modification: An integrative approach. New York: Plenum Press.

Payne, J.S., Pollaway, E.A., Smith, Jr. J.E., & Payne, R.A. (1981). Strategies for teaching the mentally retarded 2nd Ed. Columbus, Ohio: Charles E. Merrill Publishing Co.

Peterson, C.L. (1973). Functional mathematics for the mentally retarded. Columbus, Ohio: Charles E. Merrill Publishing Co.

Pressley, M., & Levin, J.R. (in press). Elaborative learning strategies for the inefficient learner. n S.J. Ceci (Ed.), Handbook of cognitive, social, and neuropsychological aspects of learning disabilities, Hilldale, N.J.: Erlbaum.

Reeve, R.A., & Brown, A.L. (1985). Metacognition reconsidered: Implications for intervention research. Journal of Abnormal Child Psychology, 13, 343-356.

Schunk, D.C. (1982). Effects of effort attributional feedback on children's perceived self-efficacy and achievement. Journal of Educational Psychology, 74, 548-556.

Shepard, L.A., Smith, M.L., & Vojir, C.P. (1983). Characteristics of pupils identified as learning disabled. American Educational Research Journal, 20, 309-331.

Wallace, G., & McLoughlin, J.A. (1979). Learning disabilities: Concepts and characteristics. Columbia, Ohio: Merrill Publishing Company.

Figure 1

Number of Equations Correct
for Addition and Subtraction Problems

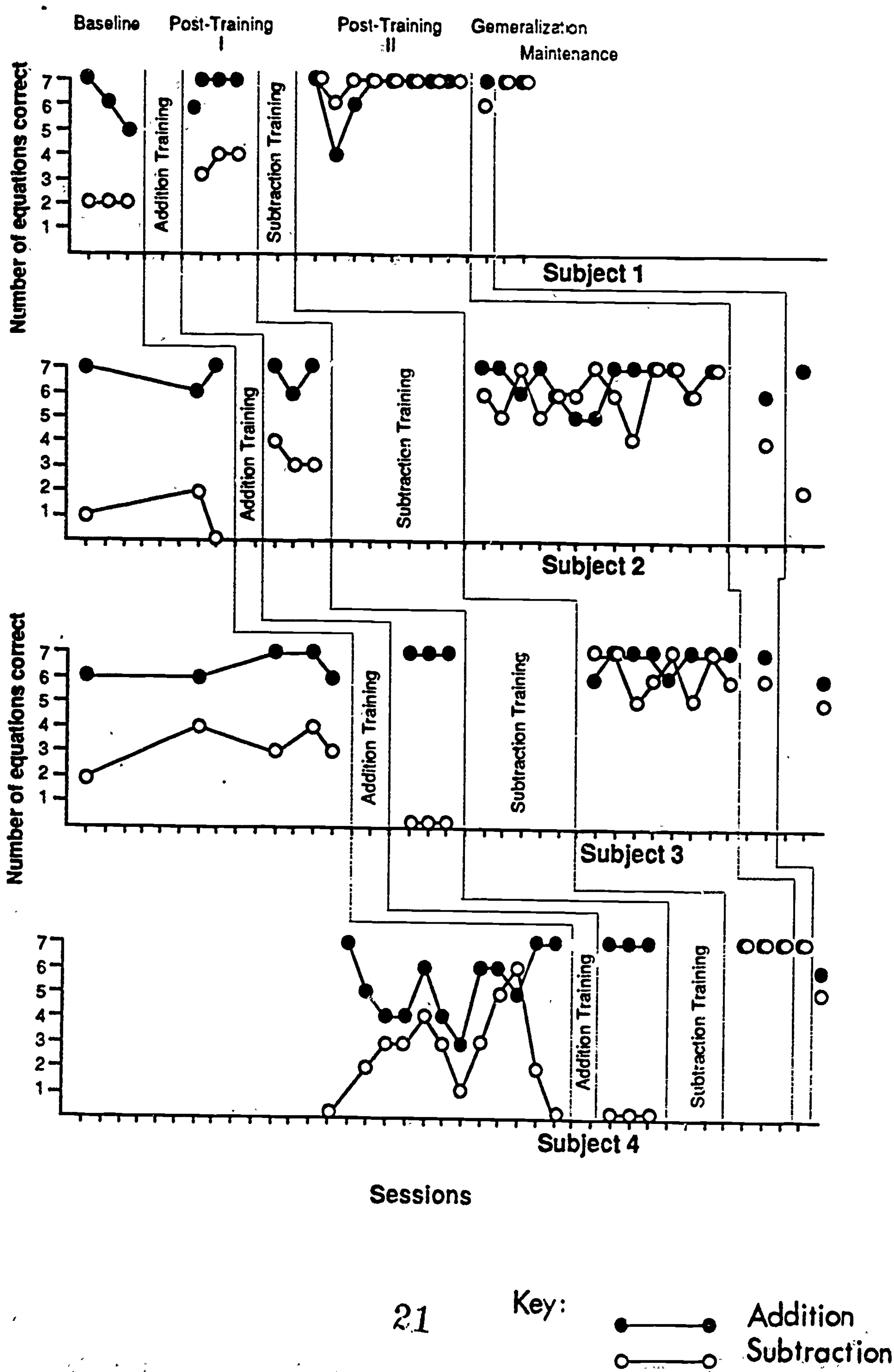
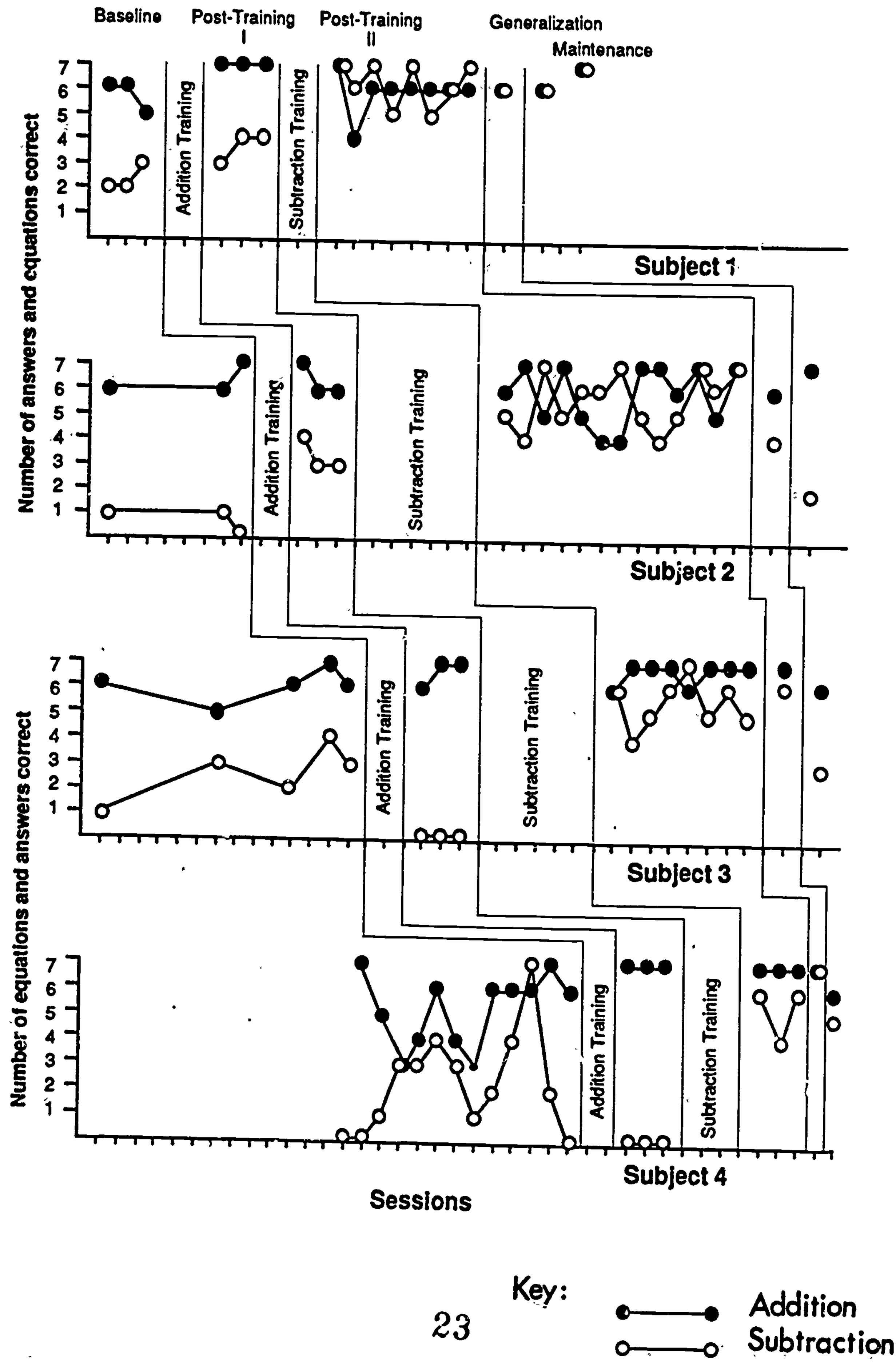

Baseline
Post-Training I
Post-Training II
Generalization
Maintenance
Addition Training
Subtraction Training
Number of equations correct
Subject 1
Subject 2
Subject 3
Subject 4
Sessions
Key:
Addition
Subtraction

Figure 2

Number of Equations and Answers Correct
for Addition and Subtraction Problems



Baseline
Post-Training I
Post-Training II
Generalization
Maintenance
Addition Training
Subtraction Training
Number of answers and equations correct
Subject 1
Subject 2
Number of equations and answers correct
Subject 3
Subject 4
Sessions
Key:
Addition
Subtraction