

**INSTITUTE
FOR
RESEARCH
IN
LEARNING
DISABILITIES** 
The University of Kansas
Lawrence, Kansas, 66045
Emphasis on Adolescents and Young Adults

A COMPARISON OF
VERBAL PROBLEM-SOLVING IN ARITHMETIC
OF LEARNING DISABLED AND NON-LEARNING DISABLED
SEVENTH GRADE MALES

Wanda M. Lee and Floyd G. Hudson

Research Report No. 43

April, 1981

The University of Kansas Institute for Research in Learning Disabilities is supported by a contract (#300-77-0494) with the Bureau of Education for the Handicapped, Department of Health, Education, and Welfare, U. S. Office of Education, through Title VI-G of Public Law 91-230. The University of Kansas Institute, a joint research effort involving the Department of Special Education and the Bureau of Child Research, has specified the learning disabled adolescent and young adult as the target population. The major responsibility of the Institute is to develop effective means of identifying learning disabled populations at the secondary level and to construct interventions that will have an effect upon school performance and life adjustment. Many areas of research have been designed to study the problems of LD adolescents and young adults in both school and non-school settings (e.g., employment, juvenile justice, military, etc.)

Director: Donald D. Deshler

Research Coordinator: Jean B. Schumaker

Institute for Research in Learning Disabilities
The University of Kansas
313 Carruth-O'Leary Hall
Lawrence, Kansas 66045

*
*
* The preparation of this document was supported by a government
* contract. The views expressed here are those of the Institute,
* and do not necessarily reflect official positions of the Bureau
* of Education for the Handicapped, DHEW, USOE.
*
*

COOPERATING AGENCIES

Were it not for the cooperation of many agencies in the public and private sector, the research efforts of The University of Kansas Institute for Research in Learning Disabilities could not be conducted. The Institute has maintained an on-going dialogue with participating school districts and agencies to give focus to the research questions and issues that we address as an Institute. We see this dialogue as a means of reducing the gap between research and practice. This communication also allows us to design procedures that: (a) protect the LD adolescent or young adult, (b) disrupt the on-going program as little as possible, and (c) provide appropriate research data.

The majority of our research to this time has been conducted in public school settings in both Kansas and Missouri. School districts in Kansas which have or currently are participating in various studies include: Unified School District USD 384, Blue Valley; USD 500, Kansas City, Kansas; USD 469, Lansing; USD 497, Lawrence; USD 453, Leavenworth; USD 233, Olathe; USD 305, Salina; USD 450, Shawnee Heights; USD 512, Shawnee Mission; USD 464, Tonganoxie; USD 202, Turner; and USD 501, Topeka. Studies are also being conducted in several school districts in Missouri, including Center School District, Kansas City, Missouri; the New School for Human Education, Kansas City, Missouri; the Kansas City, Missouri School District; the Raytown, Missouri School District; and the School District of St. Joseph, St. Joseph, Missouri. Other participating districts include: Delta County, Colorado School District; Montrose County, Colorado School District; Elkhart Community Schools, Elkhart, Indiana; and Beaverton School District, Beaverton, Oregon. Many Child Service Demonstration Centers throughout the country have also contributed to our efforts.

Agencies currently participating in research in the juvenile justice system are the Overland Park, Kansas Youth Diversion Project, and the Douglas, Johnson, Leavenworth, and Sedgwick County, Kansas Juvenile Courts. Other agencies which have participated in out-of-school studies are: Penn House and Achievement Place of Lawrence, Kansas; Kansas State Industrial Reformatory, Hutchinson, Kansas; the U. S. Military; and Job Corps. Numerous employers in the public and private sector have also aided us with studies in employment.

While the agencies mentioned above allowed us to contact individuals and support our efforts, the cooperation of those individuals--LD adolescents and young adults; parents; professionals in education, the criminal justice system, the business community, and the military--have provided the valuable data for our research. This information will assist us in our research endeavors that have the potential of yielding greatest payoff for interventions with the LD adolescent and young adult.

Abstract

This study was conducted to determine if differences existed between a group of LD and a group of NLD students in their ability to solve verbal arithmetic problems. The sample consisted of 20 LD and 20 NLD seventh-grade males who were asked individually to read orally and to solve one sample problem and six verbal problems at two levels of difficulty taken from a seventh-grade textbook. Analysis of data sheets, subjects' papers and cassette recordings of the sessions revealed quantitative as well as qualitative differences between the two groups. LD subjects obtained lower mean problem-solving scores and made significantly more errors than did NLD subjects in both arithmetic and oral reading. Qualitative differences primarily stemmed from generalizations from analysis of error patterns, i.e., LD students were more likely to commit errors in the reasoning and miscellaneous categories. Overall, reading achievement proved to be more influential in the subjects' problem-solving skills than did IQ.

A COMPARISON OF VERBAL PROBLEM-SOLVING IN ARITHMETIC
OF LEARNING DISABLED AND NON-LEARNING DISABLED SEVENTH GRADE MALES

The ability to correctly apply mathematical skills to problem-solving in real life is considered a major goal of math instruction. Hence, teachers and researchers in the field of mathematics have been concerned for some time with the difficulties many students encounter in the area of verbal problem-solving. While numerous studies have focused on the arithmetic problem-solving skills of nonhandicapped students over the years, only recently have investigators attended to similar difficulties among the handicapped. Thus, studies specific to learning disabled (LD) students' verbal problem-solving skills are virtually nonexistent.

Given the paucity of research on verbal problem-solving in the LD population and the more extensive research on nonhandicapped students, the question remains as to whether or not the two groups experience similar difficulties in this area. If differences exist, are these qualitative (due to strategies employed and/or type of errors made) or quantitative (strategies and error patterns are similar, yet LD students make more mistakes and make these more consistently than their nonhandicapped peers).

To date, no generally successful method of teaching verbal problem-solving skills to either handicapped or nonhandicapped students has been developed. Clearly, if commonalities in math disabilities exist between the two groups, developers of curriculum and remedial procedures should aim at making such methods and materials appropriate for both populations.

Purpose of the Study

The present study was designed to investigate the nature of verbal problem-solving difficulties among a group of LD students and among a group of

non-learning disabled (NLD) students to determine if such difficulties were similar across both groups.

The following research questions were examined:

1. Is there a significant difference in the application of logical problem-solving strategies between the group identified as learning disabled and the group identified as non-learning disabled as reflected in problem-solving scores?
2. Is there a significant difference between the problem-solving strategy applied to easier and harder problems by the learning disabled group and non-learning disabled group?
3. Is there a significant interaction effect between group membership and level of item difficulty?
4. Is there a significant difference between the learning disabled group and the non-learning disabled group in the number of errors in each category (reasoning, fundamentals, miscellaneous)?
5. Is there a significant difference between the learning disabled group and non-learning disabled group in number of errors on easier and harder items for each of the error categories (reasoning, fundamentals, miscellaneous)?
6. Is there a significant interaction effect between group membership and level of item difficulty for each of the error categories (reasoning, fundamentals, miscellaneous)?
7. How capable are students from each group of monitoring their own performance? That is, how accurately can the students from each group assess the correctness or incorrectness of their answers to the verbal arithmetic problems?
8. Does the percentage of oral reading errors involving omissions, substitutions, repetitions and mispronunciations of words indicate that the reading level for the verbal arithmetic problems is at frustration level for any of the subjects?

Relationship Between Learner Characteristics
and Verbal Arithmetic Problem-Solving

Within the literature related to verbal problem-solving, a major area of interest has been the relationship between reading achievement and ability to solve verbal arithmetic problems (Coffing, 1941; Hansen, 1944, Johnson, 1949). In general, investigators have found that while reading ability is necessary for verbal problem-solving in arithmetic, it does not by itself explain many

students' difficulties in this area (Hollander, 1973; Smith, 1971). Other writers (Dolgin, 1977; Earp, 1970; Henney, 1971; McCallister, 1930; Treacy, 1944) have stated the need for reading instruction specific to verbal problem-solving in math (i.e., knowledge of formulas, vocabulary, symbols, and abbreviations). Studies of the effects of direct study of quantitative vocabulary (Johnson, 1944; Vanderlinde, 1964) showed that the experimental groups achieved greater gains than did the control groups.

Level of Difficulty

While the majority of published research has centered on defining learner characteristics which relate to verbal problem-solving skills, certain researchers have examined the characteristics of verbal problems themselves that may influence difficulty level. Based on their findings (Burns & Yonally, 1964; Loftus & Suppes, 1972; Suppes, Loftus, & Jerman, 1969), it appears that sequence and number of arithmetical operations required as well as the language structure of the problem statement are contributing factors.

Problem-Solving Strategies

Results of several studies in which students were asked to explain the methods used to obtain a solution to a verbal arithmetic problem have failed to demonstrate that specific problem-solving strategies lead to a successful solution (Buswell & Kersh, 1956; Hollander, 1973; Sanders, 1972). Intelligence, creative thinking, and the abilities to think abstractly and to reason logically are the most frequently mentioned assets.

Teaching Methods

A review of the attempts made over the past 50 years (Clark & Vincent, 1925; Faulk & Landry, 1961; McLatchy, 1941; Stevenson, 1925) to develop teaching techniques to improve students' problem-solving skills reveals that no "best" technique has been identified (Riedesel, 1969). However, the

following commonalities among the studies have implications for classroom instruction: (a) training students to employ formal or systematic analysis of the problem through answering a series of prescribed questions does not by itself produce superior results but may be helpful as a basis for daily lessons, (b) training in computation skills alone "has little, if any measurable effect upon reasoning and problem-solving" (p. 54), (c) a single day's lesson should contain a variety of computational operations, and (d) mathematical sentences and drawings or diagrams may be helpful in problem-solving.

Spitzer and Flournoy (1956) best summarized the inconsistent opinions among writers and researchers after reviewing the approaches to problem-solving advocated by five fifth-grade arithmetic textbooks when they stated the following conclusions: (a) the typical textbook program must be supplemented by experiences and techniques not included in that text, and (b) a need exists for studies to determine to what extent various proposed problem-solving improvement procedures actually promote skill in problem-solving.

Verbal Arithmetic Problem-Solving: Handicapped Population

The verbal problem-solving abilities of two categories of handicapped children will be discussed, the mentally retarded and those identified as learning disabled.

Research concerning mentally retarded students has shown that the abilities of this group to solve verbal arithmetic problems are influenced both by characteristics of the subjects themselves and by characteristics of the statement of the verbal problem. Characteristics of the mentally retarded subjects that have been reported to influence verbal problem-solving ability are level of language skills, reasoning ability, and tendency toward rote computation. Characteristics of the verbal arithmetic problem found to influence

difficulty level for mentally retarded subjects are: choice of super-ordinate or iso-ordinate labeling of sets, use of existential quantification, use of numerals or numerical names, presence of extraneous information, and use of visual aids.

The few available studies on verbal problem-solving among LD students suggest that their computational abilities are similar to those of mentally retarded students when mental age is equated (Lepore, 1974). Memory problems associated with LD students implicate organization and retrieval problems (Goodstein & Sedlak, 1973). In terms of programming, difficulties of LD students are similar to those of educable mentally retarded students even though in chronological age the learning disabled students may be at different levels of curriculum planning. However, such limited data are available describing the nature of arithmetic disabilities in mentally retarded and learning disabled students that this area requires more extensive research.

Method

The first purpose of the present study was to determine what strategies were employed by LD and NLD students in the solution of a set of verbal problems at two levels of difficulty. Using the subjects' explanations of how they worked each problem, their logical problem-solving strategy on each problem was assigned zero, one, two or three points, reflecting the extent to which the student was capable of applying a logical strategy. Level of item difficulty was classified as easier for problems requiring at least two operations and harder for problems requiring at least three operations (Loftus & Suppes, 1972). All subjects were requested to solve the same sets of verbal problems.

As a second purpose of the present study, analysis of error patterns was made on all subjects' responses using the categories of errors (reasoning,

fundamentals, miscellaneous) adapted from the listing published by John (1930). Errors were analyzed in relation to group membership (LD and NLD) and in relation to the sets of easier and harder problems.

A third purpose of the study was to compare the ability of members of each group to monitor their own performance, i.e., to judge whether the answer obtained for each problem was correct or incorrect.

The fourth purpose of the study was to informally assess the level of reading difficulty of the arithmetic problems on the basis of each subjects' oral reading skills to determine if the number of oral reading errors exhibited placed the problems at the student's frustration level (Betts, 1954).

Subjects

The forty male subjects (20 LD and 20 NLD) were selected from junior high schools in a large middle to upper-middle class suburban school district. District criteria for identification of learning disabilities include average intelligence, scatter of subtest scores on individualized intelligence tests, and at least a two-year deficit in two or more basic subject areas. Only LD students demonstrating math deficits were included in the study. Age range of LD group was 12 years, 10 months to 14 years, 6 months.

The twenty NLD subjects were randomly selected from males having at least a C average and who had not previously been referred for special services. The age range of the NLD group was 12 years, 7 months to 14 years, 3 months.

IQ scores from either WISC-R (Wechsler, 1974) or the Cognitive Abilities Test (Thorndike & Hagen, 1974) ranged from 83 to 111 (\bar{X} = 96) for the LD group; for NLD subjects, IQ scores fell between 93 and 130 with a mean of 114.

In terms of achievement, subjects were classified as being at grade level, below grade level, or above grade level at the time of the most recent testing. Table 1 illustrates the test data gathered from subjects' cumulative folders.

Insert Table 1 about here

Instrumentation

The verbal problems used in this study resulted from a review of seventh-grade mathematics textbooks and from consultation with district math specialists. A total of 23 problems selected from the Heath Mathematics Series were reviewed by math supervisors in the school district. Any problem judged to be nonrepresentative of seventh-grade mathematics was eliminated. The final selection of seven verbal problems, including one sample problem, was based on the following criteria (Burns & Yonally, 1964; Loftus & Suppes, 1972): (a) the problems were written in simple declarative form, (b) the problems contained approximately an equal number of words, (c) the problems did not require conversion of units, (d) numerical data were presented in the order in which they were most likely to be used in solving the problem, and (e) three problems required at least two operations, while another three required at least three operations. Each problem was presented on a 12.5 X 20 cm card reproduced verbatim from the textbook.

Procedure

Each subject was seen individually by the experimenter during school hours. After presentation of the sample problem as a training procedure, the six problems were given one at a time to the subject who read a problem silently and then orally. The oral reading was recorded on cassette tape for later scoring to determine the percentage of oral reading errors, i.e., omissions, substitutions, repetitions, and mispronunciations (Betts, 1954).

Questioning of the Subject's Strategy

When the student indicated that he had finished working a problem, the investigator asked the series of unstructured and structured questions described below.

Unstructured questions. Unstructured questions were phrased in a manner to elicit the subject's problem solving procedures:

1. Tell me in your own words exactly how you solved the problem.
2. Why did you do it that way?
3. Do you think your answer is right or wrong?

Whenever the investigator was uncertain of the problem-solving strategy employed or when the subject's response was incomplete, the investigator probed with the statements, "Explain what you mean," or "Tell me more about that."

Structured questions. Structured questions attempted to elicit the subject's comprehension of information contained within the problem (Hollander, 1973).

1. What information were you given in the problem?
2. What were you asked to find?
3. Your answer is (a number). What does it mean? Is it peanuts, dollars, or what?

The last question was omitted whenever the subject had previously indicated that he understood what the number represented.

Scoring

Following the sessions, data sheets with pertinent information, the papers on which subjects had recorded their written work, and cassette recordings of the sessions were analyzed. The problem-solving strategy used on each problem was scored according to the following criteria:

Three points were awarded for correct solution of a verbal problem. The assumption was that the subject had employed a logical problem-solving strategy in that he comprehended the information provided and what was asked in the statement of the problem, possessed the preinformation necessary (Manheim, 1961), selected the appropriate operations, and completed the required computation correctly.

Two points were awarded for each problem in which the subject did not achieve the correct solution due to computational errors but demonstrated comprehension of the problem by correctly answering structured questions 1 and 2, and by selecting appropriate operations for solution of the problem.

One point was awarded for each problem in which the subject selected incorrect operations and thus did not achieve a correct solution but did demonstrate a minimal comprehension of the problem by correctly answering structured questions 1 and 2.

One point was awarded for any problem on which the subject refused to attempt a solution but on which he correctly answered structured questions 1 and 2.

Zero points were awarded when the subject did not obtain a correct solution and did not answer structured questions 1 and 2 correctly even though he might have employed the appropriate operations. The assumption was that without meeting these two criteria, his correct choice of operations was the result of rote learning or responding to certain cue words (altogether, how many are left, how much change, etc.) without adequate understanding of the problem.

Errors on any problem were analyzed and placed in the categories of reasoning, fundamentals and miscellaneous utilizing criteria developed by John (1930). The accuracy with which subjects monitored their own performance was assessed through each subject's responses to unstructured question 3. The subject was considered as having monitored correctly if he rated

his answer to that particular problem as "right" when it was correct or as "wrong" when indeed it was incorrect. Thus, the percentage of times in which subjects correctly monitored their performance consisted of the number of times monitored correctly in proportion to the number of times they answered unstructured question 3 since those problems which a subject did not attempt were omitted from consideration.

In determining whether the verbal problem overall might be at a level of reading difficulty considered frustration level for any one particular subject (Betts, 1954), the total number of oral reading errors (omissions, substitutions, repetitions, mispronunciations) made during the oral reading of all problems was considered in proportion to the total number of words comprising the six experimental problems.

Hypotheses

The following hypotheses were stated to evaluate each group's performance on the dependent variables of logical problem-solving score, types of errors, and ability to monitor correctness of response.

- Hypothesis 1. There is no significant difference between the learning disabled and non-learning disabled groups in total score for arithmetic verbal problem-solving.
- Hypothesis 2. There is no significant difference between two levels of verbal problem difficulty for the learning disabled and non-learning disabled groups.
- Hypothesis 3. There is no significant difference in problem-solving for the learning disabled and non-learning disabled groups under the two different levels of difficulty. That is, both groups will be equally influenced by each level of difficulty.
- Hypothesis 4. There is no significant difference between the learning disabled and non-learning disabled groups in number of errors for any of the three error categories: reasoning, fundamentals, miscellaneous.
- Hypothesis 5. There is no significant difference between two levels of verbal problem difficulty for either the learning disabled or non-learning disabled groups for any of the three error categories: reasoning, fundamentals, miscellaneous.

Hypothesis 6. There is no significant difference in error scores for all types of errors for the learning disabled and non-learning disabled groups under the two levels of difficulty. That is, for each error category (reasoning, fundamentals, miscellaneous) both groups will be equally influenced by each level of difficulty.

Hypothesis 7. There is no significant difference between the learning disabled and non-learning disabled groups in their ability to monitor the correctness of their answers to the verbal problems at either level of difficulty.

Research Design

Group membership (LD and NLD) and level of item difficulty (easier and harder) comprised the two independent variables. Four dependent variables were collected and analyzed: (a) adjusted mean problem-solving scores, (b) types of errors in problem-solving, (c) accuracy of monitoring answers to verbal problems, and (d) percent of oral reading errors on the verbal problems themselves.

A two by two factorial analysis of covariance design with repeated measures across one factor was used to analyze the first dependent variable. The two covariates used in analyzing the first dependent variable, that of adjusted mean problem-solving scores, were IQ scores and reading achievement.

A two by two factorial analysis of variance design with repeated measures was employed for each of the three types of errors (reasoning, fundamentals, miscellaneous) to analyze the second dependent variable. The computer program used for analysis of covariance and analysis of variance was BMDP2V (Dixon, 1977). A Chi Square analysis was employed to analyze the third dependent variable.

The .05 probability level was used with all hypotheses pertaining to the first two dependent variables, while the .01 probability level was used with the Chi Square analysis in determining significance on the third dependent variable.

Finally, results of the analysis of the fourth dependent variable, percentage of oral reading errors made by subjects in each group, were presented descriptively rather than statistically.

Data Analysis and Discussion

Problem-Solving

Results of the analysis of the problem-solving strategies using IQ as a covariate indicated that the NLD group had significantly higher problem-solving scores than did the LD group (see Table 2). Both groups scored significantly higher on the harder problems possibly due to the fact that two of the easier problems required division with a remainder in the solution which may have confused subjects. In summary, Hypothesis 1 and 2 were rejected.

Insert Table 2 about here

Since the observed differences between the problem-solving skills of the two groups may have been influenced by reading skills, the data were reanalyzed using reading achievement as a second covariate (see Table 3). Using the two covariates of IQ and reading achievement, the problem-solving scores of the LD and NLD groups did not differ significantly. When both IQ and reading achievement were used as covariates, only Hypothesis 2 was rejected.

Insert Table 3 about here

Error Patterns

Analysis of errors of reasoning showed that NLD subjects performed significantly better in this area than did the LD subjects (see Table 4). As illustrated in Table 5, further analysis indicated nearly equal ability of the

two groups to correctly calculate an answer once the mathematical process had been selected (fundamentals category). Finally, an investigation of miscellaneous errors revealed that LD subjects made significantly more errors in this category than did their NLD peers (see Table 6).

Insert Tables 4, 5, and 6 about here

In summary, three hypotheses (4, 5, and 6) for each error category were tested using F tests. As applied to errors of reasoning and errors in fundamentals, only Hypothesis 5 was rejected. However, all three hypotheses concerning miscellaneous errors were rejected. The LD subjects made significantly more errors in this category, particularly due to their failure to appreciate the absurdity of an impossible answer.

In reviewing the mean number of errors in each category (reasoning, fundamentals and miscellaneous), it was found that the LD subjects made significantly more errors in the categories of reasoning and miscellaneous errors. LD subjects encountered more difficulties than their NLD peers in selecting the relevant information given in the verbal problems and in determining the correct and most efficient process for obtaining the solution. The LD subjects also encountered greater difficulty in assessing the correctness of their responses and were frequently unable to determine that an obtained solution was absurd in terms of information presented in the problem itself. In addition, LD subjects were more likely to estimate an answer without calculation. LD subjects more often refused to even attempt certain problems than did their NLD peers.

Monitoring Correctness of Response

The NLD group was significantly better at monitoring their own responses,

i.e., knowing whether the solution obtained for each of the verbal problems was correct or incorrect. This is further evidence of results of the category of miscellaneous errors indicating that LD subjects were less likely than NLD subjects to detect that the solution obtained for a problem was impossible in terms of the information stated in the problem.

Oral Reading Errors

Any subject whose oral reading was scored 90% or less was considered to be reading at frustration level. That is, the subject was unable to comprehend the printed symbols to a reasonable degree and the reading requirements of the verbal arithmetic problems were too difficult for either independent reading or for reading instruction. Reading assessment conducted as subjects read each verbal problem aloud revealed that the problems constituted a frustration level for 30% of the LD group, but not for any member of the NLD group. For 60% of the LD and 40% of the NLD subjects, the reading requirements were at the instructional level, whereas they represented an independent level for 60% of the NLD and for only 10% of the LD group.

Conclusions

The present study was concerned with assessing the differences between learning disabled and non-learning disabled subjects in the solution of verbal arithmetic problems. Differences were noted in the application of problem-solving skills, in errors of reasoning and miscellaneous errors, in ability to monitor correctness of response and in number of oral reading errors. The groups were similar in errors in fundamentals, notably errors in computation. However, at this time not enough research is available to make a definitive statement regarding verbal problem-solving in arithmetic and computation of LD subjects as compared with nonhandicapped students and with other handicapped groups.

Results of the present study clearly show the differences in LD and NLD students' ability to solve verbal arithmetic problems to be both qualitative (due to strategies and/or type of error) and quantitative (LD students make more mistakes and make them more consistently). Quantitatively, LD subjects obtained a lower mean problem-solving score and made significantly more errors than did NLD subjects. The groups also differed quantitatively in the number of oral reading errors, again favoring the NLD group. In this study reading achievement proved to be more influential in subjects' problem-solving than IQ.

Qualitatively, LD students were more likely than NLD subjects to commit errors of reasoning and to make miscellaneous errors. In addition, they more often: (a) failed to realize that an obtained solution was absurd in view of the information presented, (b) estimated an answer without calculation, and (c) failed to make even an attempt to solve a problem (all miscellaneous errors). Finally, LD subjects had greater difficulty than their NLD peers monitoring their own performance. Similarities between the two groups were found in the category of errors in fundamentals and in the mean problem-solving scores for each group on the easier and harder levels of difficulty.

Based on the results of the present study, the following areas need to be addressed when designing programs for improving LD students' verbal arithmetic problem-solving: reading skills specific to the verbal arithmetic problems, determination of the correct process or processes to be used, making an estimate of the answer, and calculating the answer.

In view of the results of the present study, it is clear that more emphasis should be placed on the reading and reasoning aspects of the verbal arithmetic problems than on practice in computation skills with this age student. This is particularly true in view of the ready access most students have to hand calculators. However, the learning disabled student must know which numbers to enter and in what order to enter the numbers to obtain the correct solution.

References

- Betts, E. Foundations of reading instruction. New York: American Book, 1954.
- Burns, P. C., & Yonally, J. L. Does the order of presentation of numerical data in multi-steps affect their difficulty? School Science and Mathematics, 1964, 64, 267-270.
- Buswell, G. T., & Kersh, B. Y. Patterns of thinking in solving problems. Berkeley: University of California Press, 1956.
- Clark, J. R., & Vincent, E. L. A comparison of two methods of arithmetic problem analysis. The Mathematics Teacher, 1925, 18, 226-233.
- Coffing, E. A. The relationship between silent reading ability and arithmetical ability. School Science and Mathematics, 1941, 41, 10-14.
- Dixon, W. BMD biomedical computer programs. Los Angeles: University of California Press, 1977.
- Dolgin, A. B. Improvement of mathematical learning through reading instruction. High School Journal, 1977, 61, 59-69.
- Earp, N. W. Procedures for teaching reading in mathematics. The Arithmetic Teacher, 1970, 17, 575-579.
- Faulk, C. J., & Landry, T. R. An approach to problem solving. The Arithmetic Teacher, 1961, 8, 157-160.
- Goodstein, H. A., & Sedlak, R. A. The role of memory in the verbal problem solving of average, educable mentally retarded, and learning disability children. Unpublished manuscript, University of Connecticut, 1973.
- Hansen, C. Factors associated with successful achievement in problem solving in sixth grade arithmetic. Journal of Educational Research, 1944, 38, 111-118.
- Henney, M. Improving mathematics verbal problem-solving ability through reading instruction. The Arithmetic Teacher, 1971, 18, 223-229.
- Hollander, S. K. Strategies of selected sixth-graders reading and working verbal arithmetic problems. (Doctoral dissertation, Hofstra University, 1973). Dissertation Abstracts International, 1973, 34, 6258A. (University Microfilms No. 74-07896).
- John, L. Difficulties in solving problems in arithmetic. Elementary School Journal, 1930, 31, 202-215.
- Johnson, H. C. The effect of instruction in mathematical vocabulary upon problem solving in arithmetic. Journal of Educational Research, 1944, 38, 97-110.

- Johnson, J. T. On the nature of problem solving in arithmetic. Journal of Educational Research, 1949, 43, 110-115.
- Lepore, A. A comparison of computational errors between educable mentally handicapped and learning disability children. Unpublished manuscript, University of Connecticut, 1974.
- Loftus, E. F., & Suppes, P. Structural variables that determine problem-solving difficulty in computer-assisted instruction. Journal of Educational Psychology, 1972, 63, 531-542.
- McCallister, J. M. Reading difficulties in studying content subjects. Elementary School Journal, 1930, 31, 191-201.
- McLatchy, J. H. Variety in problem solving. Education, 1941, 61, 453-457.
- Manheim, J. Word problems or problems with words. The Mathematics Teacher, 1961, 54, 234-238.
- Riedesel, C. A. Problem solving: Some suggestions from research. The Arithmetic Teacher, 1969, 16, 54-58.
- Sanders, V. A. Arithmetic problem-solving strategies of fourth-grade children. (Doctoral dissertation, Wayne State University, 1972). Dissertation Abstracts International, 1972, 33, 5983A. (University Microfilms No. 73-12590).
- Smith, F. The readability of sixth grade word problems. School Science and Mathematics, 1971, 71, 559-562.
- Spitzer, H. F., & Flournoy, F. Developing facility in solving verbal problems. The Arithmetic Teacher, 1956, 3, 177-182.
- Stevenson, P. R. Difficulties in problem solving. Journal of Educational Research, 1925, 11, 95-103.
- Suppes, P., Loftus, E. F., & Jeman, M. Problem solving on a computer-based teletype. Educational Studies in Mathematics, 1969, 2, 1-15.
- Thorndike, R. L., & Hagen, E. Technical manual for the Cognitive Abilities Test. Boston: Houghton Mifflin, 1974.
- Treacy, J. P. The relationship of reading skills to the ability to solve arithmetic problems. Journal of Educational Research, 1944, 38, 86-96.
- Vanderlinde, L. F. Does the study of quantitative vocabulary improve problem solving? Elementary School Journal, 1964, 65, 143-152.
- Wechsler, D. Manual for the Wechsler Intelligence Scale for Children - Revised. New York: The Psychological Corporation, 1974.

TABLE 1
 Summary of Test Data
 from Subjects' Cumulative Files

Type of Test Data	Learning Disabled Group	Non-Learning Disabled Group
Mean IQ	96	114
Reading Achievement:		
Subjects scoring above grade level	1	18
Subjects scoring at grade level	4	2
Subjects scoring below grade level	15	0
Mathematics Achievement:		
Subjects scoring above grade level	1	17
Subjects scoring at grade level	3	1
Subjects scoring below grade level	16	2

TABLE 2
 Analysis of Covariance for Problem Solving Scores
 Using IQ as Covariate

SOURCE	SS	df	MS	F
Group: Learning Disabled/Non-learning Disabled	16.130	1	16.130	6.174**
IQ (first covariate)	27.076	1	27.076	10.363**
Error	96.674	37	2.613	
Item Difficulty: Easier/Harder	24.200	1	24.200	21.714***
Item Difficulty x Group	2.450	1	2.450	2.198
Error	42.350	38	1.115	

**p < .01

***p < .001

TABLE 3

Analysis of Covariance for Problem Solving Scores
Using IQ and Reading Achievement as Covariates

SOURCE	SS	df	MS	F
Group: Learning Disabled/Non-Learning Disabled	1.294	1	1.294	0.507
IQ (first Covariate)	4.764	1	4.764	1.866
Reading Achievement (second covariate)	21.277	1	21.277	8.334**
All Covariates	31.840	2	15.920	6.236**
Error	91.910	36	2.553	
Item Difficulty: Easier/Harder	24.200	1	24.200	21.714***
Item Difficulty x Group	2.450	1	2.450	2.198
Error	42.350	38	1.115	

**p < .01

***p < .001

TABLE 4
Analysis of Variance for Errors of Reasoning

SOURCE	SS	df	MS	<u>F</u>
Group: Learning Disabled/Non-learning Disabled	122.513	1	122.513	15.945***
Error	291.975	38	7.684	
Item Difficulty: Easier/Harder	0.313	1	0.313	0.135
Item Difficulty x Group	0.113	1	0.113	0.049
Error	88.075	38	2.318	

***p < .001

TABLE 5
Analysis of Variance for Errors in Fundamentals

Group	SS	df	MS	<u>F</u>
Group: Learning Disabled/Non-learning Disabled	3.200	1	3.200	3.800 ¹
Error	32.000	38	0.842	
Item Difficulty: Easier/Harder	11.250	1	11.250	24.711***
Item Difficulty x Group	0.450	1	0.450	0.988
Error	17.300	38	0.455	

¹Probability F exceeded 0.059

***p < .001

TABLE 6
Analysis of Variance for Miscellaneous Errors

GROUP	SS	df	MS	<u>F</u>
Group: Learning Disabled/Non-learning Disabled	20.000	1	20.000	38.875***
Error	19.550	38	0.515	
Item Difficulty: Easier/Harder	16.200	1	16.200	52.392***
Item Difficulty x Group	4.050	1	4.050	13.098***
Error	11.750	38	0.309	

***p < .001
