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ABSTRACT

The purpose of this study was to determine if selected mental, mathematical, reading, and personality assessments of sixth-grade pupils could predict high achievers in mathematical verbal problem solving. The subjects were 112 sixth graders, 56 classified as high achievers in mathematical verbal problem solving and 56 classified as low achievers according to criterion verbal problem solving scores available in cumulative school records. Thirty-eight mental, mathematical, reading, and personality scores for each pupil were analyzed, and four combinations of assessments resulted: (1) the correlation battery operated with 70 percent accuracy in placing high achievers into the high group and with 66 percent accuracy in placing low achievers into the low group, (2) the "t" test battery placed high achievers into the high classification with 70 percent accuracy and low achievers into the low classification with 68 percent accuracy, (3) the short factor analysis battery placed high achievers into the correct classification with 93 percent accuracy and low achievers with 91 percent accuracy, and (4) the long factor analysis battery placed 95 percent of the high achievers and 93 percent of the low achievers into correct classifications. The major conclusion was that total intelligence is the main individual contributor to high achievement in verbal problem solving ability. (Author/WR)

AN INVESTIGATION OF SELECTED MENTAL, MATHEMATICAL, READING, AND PERSONALITY ASSESSMENTS AS PREDICTORS OF HIGH ACHIEVERS IN SIXTH GRADE MATHEMATICAL VERBAL PROBLEM SOLVING

A Dissertation

Submitted to the Faculty of the Graduate School of
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Doctor of Education

by
Carolyn Flanagan Talton
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NORTHWESTERN STATE UNIVERSITY OF LOUISIANA

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A Dissertation
Presented to
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Approved:

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Major Professor

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Dean, Graduate School

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DEDICATED

TO MY HUSBAND
BILLY JACK

Whose understanding, assistance, and sacrifices along with his love and devotion have given encouragement to the writer

and

to my children

Tanya Carol
Billy Jack, Jr.

whose patient concern and affection have been a source of inspiration to the writer

and

to my parents

Mr. and Mrs. William Earl Flanagan

whose continued faith in my ability have been a source of strength to the writer.

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C.F.T.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The Problem: The purpose of this investigation was to determine if selected mental, mathematical, reading, and personality assessments of sixth grade pupils could predict high achievers in mathematical verbal problem solving. The resulting assessments would then offer direction in elementary mathematics classrooms to enable more pupils to be high achievers in mathematical verbal problem solving.

Subjects for this study were an incidental sample of 112 sixth grade pupils, 56 classified as high achievers in mathematical verbal problem solving and 56 classified as low achievers according to criterion verbal problem solving scores available in cumulative school records.

The Method: Thirty-eight mental, mathematical, reading, and personality scores for each pupil were analyzed by the statistical techniques of correlation, analysis of variance, and factor analysis to determine combinations of assessments capable of identifying high and low achievers in mathematical verbal problem solving when computed in discriminant analyses.

The Findings: Four combinations of assessments resulted from the statistical analyses of the scores in this investigation. The first combination, The Correlation Battery, operated with 70 percent accuracy in placing high

achievers into the high group and with 66 percent accuracy in placing low achievers into the low group. The battery consisted of: (1) Total Intelligence; (2) Verbal Intelligence; (3) What Process Must You Use? (4) Non-Verbal Intelligence; (5) Total Reading; (6) Reference Skills in Reading; (7) Arithmetic Concepts; (8) Reading Vocabulary; (9) Solving Problems with No Numbers; (10) Following Directions in Reading; and (11) Arithmetic Computation.

The second battery, The t Test Battery, placed high achievers into the high classification with 70 percent accuracy and low achievers into the low classification with 68 percent accuracy. The assessments in this battery were: (1) What Process Must You Use? (2) Total Intelligence; (3) Total Reading; (4) Verbal Intelligence; (5) Non-Verbal Intelligence; (6) Reference Skills in Reading; (7) Reading Vocabulary; (8) Interpretation Skills in Reading; (9) Arithmetic Concepts; (10) Solving Problems with No Numbers; and (11) What is Given in the Problem?

Factor analysis resulted in the formation of the third and fourth batteries. The Short Factor Analysis Battery placed high achievers into the correct classification with 93 percent accuracy and low achievers with 91 percent accuracy. Assessments in this battery were: (1) Total Intelligence; (2) Total Social Adjustment; (3) Fluency; (4) Withdrawal Tendencies; (5) What is Asked in the Problem? (6) Mathematical Vocabulary; (7) Family Relations; and (8) Level of Intellectual Development.

The Long Factor Analysis Battery contained the 8 assessments of the short battery with 3 additional assessments: (1) Total Reading; (2) Flexibility; and (3) Originality. The most accurate separation of the groups was obtained using the long battery; 95 percent of the high achievers and 93 percent of the low achievers were placed into the classifications as determined by the criterion verbal problem solving score.

Conclusions and Recommendations: 1. Total Intelligence is the greatest individual contributor to high achievement in verbal problem solving. 2. Activities stressing the following reading skills should improve the ability to solve verbal problems in mathematics: selecting main ideas, making inferences, constructing sequences, following directions of simple and complex choices, and reading maps and graphs. 3. Opportunities should be provided for children to determine the question to be answered in a verbal problem, select specific facts necessary to the solution, and choose the appropriate process for solution of the problem. 4. Children should have experience with verbal problems which contain unnecessary data, insufficient data, and no numbers. 5. The level of intellectual development achieved by a pupil determines the ability to think abstractly and form mental operations for the solution of mathematical verbal problems.

CHAPTER I

INTRODUCTION

Solving verbal problems in mathematics has been recognized as a difficult task for children and research has failed to specify why this is true. Past research has centered on comparing methods for solving verbal problems and identifying the types of errors children make while solving verbal problems. While these are important areas to consider, more research was necessary to determine the nature of the skills and abilities which are required for solving verbal problems. Simply identifying the abilities which contribute to success is not enough. Some method of looking at these skills and abilities in combination as well as in isolation could conceivably help classroom teachers provide instruction based on deficiencies in these abilities.

Foran (1934) recognized the possibility of investigating abilities in combination when he stated:

> Each school subject undoubtedly involves many abilities of which some are important and others of small significance alone but important in the aggregate. The analysis of learning activities is an indispensible aid to the determination of methods of teaching such activities, for the way in which any learning occurs dictates the way in which the material should be presented (Foran, 1934, p. 188).

This study analyzed selected skills and abilities individually and in combination to determine their effectiveness in solving verbal problems. Discriminant analysis was employed to determine which abilities differentiate between high and low achievers in mathematical verbal problem solving.

THE PROBLEM

Statement of the Problem

The purpose of this study was to identify mental, mathematical, reading, and personality assessments of sixth grade pupils which could predict high achievers in mathematical verbal problem solving. These assessments could then be emphasized as areas of concentration in elementary classrooms to improve verbal problem solving ability. Answers were sought to the following questions:

1. What is the relationship between the selected mental, mathematical, reading, and personality assessments and verbal problem solving in mathematics?

2. What percent of the common variance in a verbal problem solving situation in mathematics can be accounted for by the individual mental, mathematical, reading, and personality assessments?

3. Can a combination of mental, mathematical, reading, and personality assessments predict the high and low achiever in mathematical verbal problem solving?

Limitations of the Study

One hundred twelve pupils were selected from the sixth grades of elementary schools in Natchitoches, Louisiana. Schools involved in the investigation were the two Northwestern State University Laboratory Schools, North

Natchitoches Elementary School, Parks Elementary School, and Weaver Elementary School.

DEFINITIONS OF TERMS

Mathematical Verbal Problem. A verbal problem in mathematics refers to a written or printed word description of a quantitative situation about which a question is raised.

High Achiever in Verbal Problem Solving. A high achiever in verbal problem solving is a sixth grade student who scored in the upper 27 percent of achievement on the verbal problem solving criterion test.

Low Achiever in Verbal Problem Solving. A low achiever in verbal problem solving is a sixth grade student who scored in the lower 27 percent of achievement on the verbal problem solving criterion test.

Mental Assessments. Mental assessments include measures of the following: level of intellectual development; verbal intelligence; non-verbal intelligence; total intelligence; and creativity.

Mathematical Assessments. Mathematical assessments include measures of the following: arithmetic computation; arithmetic concepts; knowledge of basic facts; ability to solve problems containing unnecessary data; ability to solve problems containing insufficient data; ability to solve problems containing no numerals; mathematical vocabulary; and ability to identify the steps of formal analysis.

Reading Assessments. Reading assessments include measures of the following: total vocabulary; following directions; reference skills; interpretations; and total reading.

Personality Assessments. Personality assessments include measures of the following: self reliance; personal worth; personal freedom; feeling of belonging; withdrawal tendencies; nervous symptoms; total personal adjustment; social significance; social skills; anti-social tendencies; family relations; social relations; community relations; total social adjustment; and total adjustment.

Formal Analysis. Formal analysis is defined in this investigation as a three-step procedure for solving verbal problems. The steps are: (1) What is asked in the problem? (2) What facts are given in the problem? and (3) What process must you use?

IMPORTANCE OF THE STUDY

Most areas of mathematics instruction culminate in application and solving verbal problems; therefore, guidance in this area should be the most interesting and challenging aspect of mathematics teaching. Continuous research is needed to resolve the specific verbal problem solving difficulties that students face.

Research completed in verbal problem solving can be grouped under three headings: (1) investigations of verbal problem solving procedures; (2) analytical studies of verbal problem solving skills; and (3) characteristics of children indicative of verbal problem solving ability.

The statement made by Spitzer in 1956 regarding comparisons of verbal problem solving procedures is generally in agreement with most research in this area.

> There are many widely differing practices for improving problem solving ability. The divergence is probably not due to faith in the value of divergence but to the search for better procedures. None of the procedures have produced the results teachers desire, so, the search for new and different procedures continues. In view of the rather long time that instructors have been concerned with problem solving, it is doubtful whether any one entirely new procedure of merit will turn up (Spitzer, 1956, p. 177).

Analytical studies identifying abilities necessary for verbal problem solving have attempted to distinguish between high and low achievers in verbal problem solving. Researchers arbitrarily select skills and abilities thought to influence high achievement and then test for differences between two groups of subjects using these abilities as criteria. As a result, findings conflict from study to study concerning the abilities essential to success. The findings of Engelhart (1932) are typical of many investigations using an analytical approach in research.

1. Intelligence accounts for 25.69 percent of the variance in verbal problem solving.
2. Computation ability accounts for 42.05 percent of the variance in verbal problem solving.
3. Reading ability accounts for 1.33 percent of the variation in verbal problem solving.
4. Unknown causes are responsible for a remaining 33.59 percent of the variation in verbal problem solving (Engelhart, 1932, p. 29).

Engelhart challenged future researchers to identify the unknown factors responsible for the large amount of variance not identified in his investigation.

Studies relating to characteristics of children indicative of verbal problem solving ability usually recognize the importance of intelligence. This area has been challenged by Getzels and Jackson (1962) in defense of other traits such as creativity, perseverance, and critical thinking. Studies of intellectually gifted children have resulted in these observations:

> The very fact that some high IQ students do poorly in school and some lower IQ students do well indicated that intelligence, as conventionally assessed, is not the only quality making for educational success. Indeed, the intelligence test rarely accounts for more than a quarter of the variance in such critical factors as school achievement and academic performance (Getzels & Jackson, 1962, p. 3).

This investigation has been an attempt to identify those skills and abilities necessary for attaining high achievement in sixth grade verbal problem solving.

CHAPTER II

REVIEW OF RELATED LITERATURE

Research to evaluate previous studies and suggest areas needing attention has been reviewed and is presented in this chapter. The review is presented in the following order: (1) Investigations of verbal problem solving procedures; (2) Analytical studies of verbal problem solving skills; and (3) Characteristics of children indicative of verbal problem solving ability.

INVESTIGATIONS OF VERBAL PROBLEM SOLVING PROCEDURES

Much research has been conducted to find which verbal problem solving procedure is superior among the many available to the teacher. The findings of research have been conflicting, and at the present, a step-by-step procedure for solving problems has not been identified that is satisfactory for teaching to students.

The most widely used procedure offered by mathematics texts is having pupils work verbal problems without specific suggestions or directions. Another procedure most texts suggest is specific steps for pupils to follow. Neither the broad procedure of "just solve problems" nor the many specific problem solving procedures have produced the results teachers desire. Therefore, the search for new procedures continues (Spitzer & Flournoy, 1956, p. 117).

In 1926, a two-year study was begun in an effort to determine why educating children to solve verbal mathematics problems was one of the teacher's hardest and most discouraging tasks. The investigation conducted by Washburne and Osborne (1926) was initiated by the Committee of Seven of Illinois (see Appendix A). The subjects for this investigation ranged in number from 300 to more than 1,000 in grades three, four, five, six, and seven.

The investigation was primarily concerned with answering, "Is there any relation between an ability to solve problems and an ability to make some such formal analyses?" An analysis of all tests in each grade revealed that in every case there was little or no relation between an ability to solve problems and take any of the steps of problem analysis. The conclusion was reached that an ability to make the type of formal analysis frequently taught in school had practically no relationship with an ability to solve problems.

In an effort to verify this finding, numerous investigations were arranged which compared one group of children who received only practice in verbal problem solving with another group of children who received special training in formal analysis. The results were the same; those who had not been taught formal analysis did as well as if not better than those who had been trained in analysis.

In the second year of this experiment by Washburne and Osborne, the question of the importance of formal problem analysis was further investigated because of contrary findings in investigations conducted the previous year. The Committee of Seven confined the work to an intensive study of the results and relative merits of three methods of training children to solve problems. In the study, 763 children were selected as subjects and were exposed to such methods as: (1) working large numbers of problems as practice; (2) analyzing problems; and (3) seeing analogies or similarities between written problems and oral problems. The steps in the formal analysis were: (1) read the problem carefully; (2) determine what is to be found; (3) determine what elements in the problem will help find the answer; (4) decide what process to use; (5) estimate roughly the results; and (6) solve the problem.

The general conclusion drawn by Washburne and Osborne was:

> Children who are taught no special technique of solving problems, and simply solve many problems surpass those students who spend time learning a method of solving problems. All treatment groups made progress, indicating that concentrated attention on solving verbal problems by any method brings a rich reward (Washburne & Osborne, 1926, p. 301).

The conclusions reached by Washburne and Osburne following completion of the two-year study were:

1. No relation was found to exist between ability to make formal analysis of problems and ability to solve problems.

2. Giving many problems without any special technique of analysis or seeing analogies appears to be the most effective method of all (Washburne & Osborne, 1926, pp. 303-304).

In a 1929 survey of mathematics textbooks, Hanna found problem analysis used in 14 of 20 textbooks examined and in 12 of 16 professional books examined (Hanna, 1929, p. 51). As a result of this survey, Hanna in 1930 conducted an experiment which involved the comparison of three methods for teaching verbal problem solving. The methods investigated were: (1) dependencies, diagramming the thought processes involved in verbal problem solving; (2) four steps of problem analysis; and (3) individual, involving no formal method.

The subjects for Hanna's investigation were 225 pupils in the fourth grade and 252 in the seventh grade who were equated on intelligence and arithmetic reasoning achievement. Subjects practiced the method assigned for approximately 10 hours in a six weeks period. At the end of the six weeks training period, the subjects were tested to determine which, if any, of the three methods had been superior.

Children in the fourth grade, regardless of arithmetic reasoning ability, made the greatest gain with the dependencies method. Considering the pupils with superior reasoning ability at the fourth grade, there was no clear evidence of superiority of any one method. Considering those in the average reasoning ability group of the fourth grade, the greatest gain was made by the group using the dependencies method, but there was no positive or statistical evidence of superiority. Considering those with inferior reasoning ability, the results were positive in favor of the dependencies over both the formal analysis and individual methods.

Pupils of the seventh grade, regardless of ability grouping, made the greatest gain with the individual and dependencies methods. When considering the pupils of superior reasoning ability, the results were positive in favor of the dependencies and individual methods over the conventional formula. The subjects in the average and inferior reasoning ability groups made the greatest gains by using the individual method (Hanna, 1930, p. 448).

There were significant differences in favor of the dependencies and individual methods when the superior pupils were considered, regardless of grade level. For the combined average ability groups of both grades, the differences were not statistically significant. For pupils of inferior arithmetic ability, the dependencies method was superior to either the formal analysis or the individual method (Hanna, 1930, pp. 449-450).

In conclusion, Hanna stated that problem analysis resulted in the least mean score gain. A significant difference was noted in favor of the dependencies and individual methods, with no difference between the two methods (Hanna, 1930, pp. 442-450).

Two groups of fourth, fifth, and sixth grade pupils were administered two verbal problem solving tests by Burch (1953) to investigate the effectiveness of formal analysis. The investigation was made in an effort to determine if the lock-step procedure of formal analysis was an aid in solving mathematical verbal problems. One group, consisting of 165 pupils, was given an analysis test of four questions for each verbal problem: (1) What does the problem tell you? (2) What must you find? (3) What must you do? and (4) Which answer is closest to the right answer? Scores were given for correct steps and correct final answers. Two weeks later, the group was given another verbal problems test in which formal analysis was not required.

The second group consisted of 140 pupils at grade levels four, five, and six, were administered the same tests, in reverse order. Results were examined to determine superiority of the analytic test or the non-analytic test. Answers consistently revealed differences in favor of mean scores on the non-analytic test. In conclusion, Burch stated:

1. Pupils involved in the study scored higher on the test which did not require formal analysis.

2. Correctly responding to each step of formal analysis was more difficult than solving the problem.

3. Oral interviews revealed that pupils do not use the formal analysis procedure unless required to do so (Burch, 1953, pp. 44-47).

Based on the findings of the investigation, Burch further concluded that much time now devoted to teaching formal analysis might well be better spent in guiding pupils to think more carefully about the sizes and relationships of quantities described in each verbal problem (Burch, 1953, pp. 44-47).

In a survey of five arithmetic textbooks, Spitzer and Flournoy (1956) identified 17 special techniques for improving verbal problem solving. The techniques identified were: (1) problem analysis; (2) writing original problems; (3) designating the process for solution; (4) stating the hidden question; (5) studying problems without numbers; (6) two-step problems with the two questions written; (7) rewriting a two-step problem with two questions written as a problem with one written question; (8) a written general reminder that problems on the page have two or more steps; (9) supplying the missing question; (10) supplying the missing facts; (11) working problems without paper and pencil; (12) estimating answers; (13) diagrams drawn for the pupil to use in solving; (14) directions to draw a picture if needed; (15) telling aloud how you thought in solving; (16) solving by more than one written method; and (17) completing a statement of rule and making up a simple problem to illustrate it. None of the 17 specific procedures was recommended by all five arithmetic textbooks surveyed. This finding emphasizes the disagreement concerning a superior procedure for solving verbal arithmetic problems (Spitzer & Flournoy, 1956, pp. 177-182).

In a recent study, Chase (1962) stated that the problem analysis method was inferior in identifying successful and unsuccessful verbal problem solvers at the sixth grade level. The "good" problem solvers consisted of those subjects who scored in the highest one-third of 151 pupils on a criterion verbal problem solving test and the "poor" problem solvers were subjects who scored in the lowest one-third on the same criterion test.

Both groups were given a Problem Analysis Test in which the following questions were asked: (1) What should I find? (2) What should I do to get the answer? and (3) The answer would be about _____. In addition to the analysis test, subjects were given a computations and fundamental knowledge test in an effort to determine which skills would identify the good problem solvers. The following conclusions were reached by Chase:

1. No step in the formal analysis test distinguished between good and poor problem solvers.

2. The mean computation score for the good problem solvers was 12.14 and for the poor problem solvers, 7.00, significant at the .01 level of confidence.

3. A significant difference at the .05 level of confidence was found for the mean fundamental knowledge score of the good problem solvers and poor problem solvers, in favor of the successful group (Chase, 1961, p. 285).

An investigation conducted in 1922 revealed the superiority of the formal analysis method of solving verbal problems in mathematics. Four experimental classes solved problems using the following procedure: (1) state the problem; (2) determine the data given; (3) determine data required; (4) determine processes necessary to reach a solution; (5) estimate the answer; (6) find the answer; and (7) check the results.

The four experimental classes used the question method for six weeks while two control classes worked problems by any method desired for the same period. Using the Stone Reasoning Test as a measure of growth in verbal problem solving ability, the following conclusions were stated:

1. Pupils enrolled in the four experimental classes made an improvement in speed of 75.2 percent; 53.3 percent made an improvement in accuracy; and 47.6 percent improved in both speed and accuracy.

2. During the same period, 61.3 percent of the pupils enrolled in the control classes showed an improvement in speed; 50.0 percent improved in accuracy; and 32.3 percent improved in both speed and accuracy.

3. The experimental group showed a superiority over the control group of 13.9 percent in speed, 3.3 percent in accuracy, and 15.3 percent in speed and accuracy combined (Newcomb, 1922, pp. 187-189).

Superiority of the formal analysis method was also indicated in a 1924 study by Stevenson. The study was conducted to develop remedial programs for students experiencing difficulty in solving verbal problems in mathematics.

The instruction covered a period of 12 weeks and involved 1,014 pupils. The first three weeks of the twelve-week experiment, pupils were taught to read and analyze the problems by finding: (1) What facts were given in the problem? (2) What question was asked? (3) What process or different processes should be used in solving the problem? and (4) What is the answer in round numbers? The fourth, fifth, and sixth weeks of the experiment, pupils worked a large variety of problems containing data from actual life situations. During the seventh, eighth, and ninth weeks, pupils solved problems without numbers. The tenth, eleventh, and twelfth weeks of the investigation, pupils studied difficult words in verbal problems. The Buckingham Scale was administered to all pupils in grades five, six, and seven to determine the effectiveness of the remedial program. An examination of the pre- and post-test scores revealed that grade six profited most by the instruction, showing a growth of 10.0 points. According to the norms of the test, a gain of 5 points was equivalent to the growth made in a semester; therefore, the sixth grade classes made a year's improvement in the twelve week remedial period.

To determine the effects of the remedial program on intelligence, the sixth grade pupils were divided into three groups according to these ranges: 110 and above, bright; 90 to 109.9, average; and 90 or less, dull. The criterion test revealed that the bright group gained 2.63

points, the average group gained 6.9 points, and the dull group gained 8.75 points. The conclusion was reached that the type of remedial instruction outlined in the research was of most benefit to the dull group (Stevenson, 1924, p. 170).

The importance of drill and problem analysis as an aid in verbal problem solving was investigated in 1932 by Mitchell who recommended that arithmetic textbooks be supplemented with detailed analytical questions (Mitchell, 1932, pp. 464-466).

The purpose of a study conducted by Lerch (1966) was to compare the growth in problem solving ability of 28 fifth grade pupils who studied a structured equation approach to verbal problem solving, with 17 fifth grade pupils who studied a traditional formal analysis approach to verbal problem solving. The structured equation approach involved a subject recognizing the total quantitative situation and writing a number sentence to describe the situation. The control class was instructed by the traditional method of lock-step formal analysis. Subjects in this investigation were scored on: (1) programming, determining the procedure for solving the problem; and (2) processing, computing the answer. The post-test score, following five months of instruction with the respective procedures, revealed a mean growth score in programming of 4.21 for the experimental group and a mean growth score of 1.88 for the control group which created a difference significant at the .05 level of confidence.

In the skill of processing, the experimental group had a mean growth score of 3.50 as compared to a mean growth score of 3.94 for the control group. This difference was not significant indicating that pupils who studied a structured equation approach to verbal problem solving did not gain more in processing ability than did pupils who studied a traditional approach to verbal problem solving (Lerch, 1966, p. 245).

Comparing various types of verbal problems has been the approach used by some researchers to obtain more knowledge concerning the skills needed for success in solving problems. Mitchell (1929) investigated the difficulty of problems having no numbers. A test containing 15 quantitative problems without numerical values was administered to 60 seventh grade and 70 eighth grade pupils. No statistical analysis was reported; however, the mean score differences between the two types of problems were large. Mitchell reported that verbal problems with definitely expressed numerical quantities seemed more readily understood and solved than problems of a general nature without numerical values (Mitchell, 1929, pp. 594-596).

Two hypotheses were investigated by Babcock (1954) in an investigation of verbal problem solving abilities of seventh, eighth, and ninth grade subjects: (1) There are characteristic differences in the methods employed by good and poor students in solving verbal problems in arithmetic. and (2) There is significant growth in the ability to solve verbal problems from each of these grades to the next. The hypotheses were tested with respect to three types of problems: (1) proper amounts of information; (2) irrelevant data; and (3) insufficient data.

Subjects for this study were 100 students at each grade level, seven, eight, and nine, paired on intelligence. Subjects were compared on the number of correct responses made when working the three types of verbal problems under investigation. The following conclusions were reached regarding student responses at the three grade levels:

1. Great individual differences were manifested in the verbal problem solving patterns of all pupils when solving the three types of problems.

2. There was an increase in the mean numbers of problems correct for each test from the seventh through the ninth grade except in the case of problems having insufficient data. Here, the seventh grade pupils scored slightly higher than the eighth grade pupils.

3. A significant difference at the .05 level of confidence in favor of the ninth grade pupils was found to exist between the ninth and seventh grade when working problems containing irrelevant data as well as those containing insufficient data.

4. None of the three grades demonstrated significant superiority solving problems with insufficient data.

5. Problems with irrelevant data were found to correlate consistently higher with intelligence, reading, and arithmetic in grades eight and nine than either of the other two types of problems (Babcock, 1954, pp. 195-197).

At the conclusion of the investigation, Babcock accepted the first hypothesis, "There are characteristic differences in the methods employed by good and poor students in solving verbal problems in grades seven, eight, and nine." The second hypothesis, "There is significant growth in the ability to solve verbal problems from each grade to the next," was rejected (Babcock, 1954, p. 197).

Successful and unsuccessful problem solvers were compared on six types of problems in a study conducted by Beldin (1960). Two hundred twenty-four pupils at the sixth grade level were tested on intelligence as measured by the California Short Form Mental Maturity Test and on reading grade equivalent as measured by the Iowa Test of Basic Skills. An analysis group consisting of 43 boys and 48 girls was drawn from the original sample based on the following criteria: (1) intelligence level between 105 and 125; and (2) reading grade equivalent of 6.0 or above.

The problem solving grade equivalent score on the Iowa Test of Basic Skills was used as the selection criterion for successful and unsuccessful verbal problem solvers. Those who achieved in the upper 27 percent of the total distribution of scores were designated as "successful" verbal problem solvers and those who scored in the lower 27 percent of the total distribution of scores were designated as "unsuccessful" verbal problem solvers. Each group contained 25 subjects.

The six types of verbal problem skills compared were: (1) designating the process for solving a problem; (2) noting the presence of unnecessary data; (3) solving problems with no numbers; (4) selecting problems to fit a given example; (5) noting the absence of essential data; and (6) selecting the missing question. The mean scores obtained by the two groups of subjects were compared by a *t* test, and the following results were obtained:

1. Designating the process yielded a mean score for the successful group of 8.16 and for the unsuccessful, 8.24. This difference was not significant.

2. Noting presence of unnecessary data yielded a mean score for the successful group of 8.04 and for the unsuccessful, 6.72. This difference was significant in favor of the successful group at the .01 level of confidence.

3. Solving problems with no numbers yielded a mean score for the successful group of 7.84 and for the unsuccessful, 6.96. This difference was significant in favor of the successful group at the .05 level of confidence.

4. Selecting problems to fit a given example yielded a mean score for the successful group of 9.32 and for the unsuccessful group, 8.60. This difference was significant in favor of the successful group at the .05 level of confidence.

5. Noting absence of essential data yielded a mean score for the successful group of 8.85 and for the unsuccessful, 7.84. This was not a significant difference.

6. Selecting the missing question yielded a mean score for the successful group of 8.52 and for the unsuccessful, 7.00. This difference was significant in favor of the successful group at the .01 level of confidence.

7. When all tests were combined, the successful group obtained a mean score of 50.72 and the unsuccessful group, 45.36. This difference was significant in favor of the successful group at the .001 level of confidence (Beldin, 1960, pp. 70-72).

Comparisons were also made between the scores of boys and girls, but test results revealed no significant differences.

Based on the mean scores of the two groups of verbal problem solvers after comparisons of these scores with a *t* test, Beldin stated the following conclusions:

1. "Designating the process for solving a problem" is a verbal arithmetic skill that does not differentiate between the successful and unsuccessful verbal problem solvers in this study.

2. "Noting the presence of unnecessary data" is a skill that clearly differentiates between successful and unsuccessful verbal problem solvers.

3. "Solving problems with no numbers" is a test that differentiates between the successful and unsuccessful verbal problem solvers.

4. "Selecting problems to fit a given example" is defined as a questionable skill for differentiating between successful and unsuccessful verbal problem solvers.

5. "Noting absence of essential data" is a skill that clearly differentiates between successful and unsuccessful verbal problem solvers.

6. "Selecting the missing question" is a questionable skill for differentiating between the two verbal problem solver groups under consideration.

7. The combined tests of verbal arithmetic problem solving skills is a somewhat questionable means of differentiating successful from unsuccessful verbal problem solvers (Beldin, 1960, pp. 72-74).

Beldin made the recommendation that differentiation of successful and unsuccessful verbal problem solvers be further investigated and that a factor analysis of selected skills could further isolate areas of importance in verbal problem solving in arithmetic (Beldin, 1960, p. 81).

James (1967) compared the performance of 333 sixth grade pupils on three types of problem situations: (1) verbally stated arithmetic problems with relevant data only; (2) verbally stated problems revised to include irrelevant data; and (3) computations for non-verbal exercises with appropriate processes indicated. The subjects were divided into 16 sub-groups in the following way: (1) four sub-groups based on high to low performance on a standardized mathematics achievement test; (2) four sub-groups based or high to low performance on a standardized reading achievement test; (3) four sub-groups based on high to low performance on the quantitative section of an intelligence test; and (4) four sub-groups based on high to low performance on the verbal section of an intelligence test. The purpose of the study was to determine whether or not the pupils comprising the total population and the various sub-groups showed a significant difference in performance in the above three arithmetic tasks.

The following findings were true for the total population and each of the sixteen sub-groups which were studied:

1. The children had more difficulty in dealing with verbal arithmetic problems if the problem statements included data not needed for solving the problem than when such data were omitted.

2. They were clearly more competent in routine computation than in solving typical textbook verbal problems in which all data given were relevant to the solution.

3. They experienced much less difficulty in working with computational examples than in solving verbal problems that included data not needed for the solution of the problem.

4. The children had the least difficulty in working with typical computational examples and seemed to be the least successful in solving verbal problems when the solutions required separation of relevant from irrelevant data (James, 1967, p. 2030-B).

Hagelburg (1957) investigated special training procedures for improving the verbal problem solving ability of sixth grade pupils in a manner similar to Beldin. Eleven classes of sixth grade pupils received the following special practices with verbal problems: (1) problems with no numbers; (2) writing number questions for the problems; (3) identifying extra data in the problems; and (4) identifying insufficient data in problems. Nine control classes of sixth grade pupils received only the regular classroom instruction in verbal problem solving. Achievement after 24 special practices was measured by the Iowa Test of Basic Skills and these conclusions were reported:

1. Significant differences were revealed in favor of the experimental procedure beyond the .01 level of confidence.

2. Teachers' comments about pupils' reactions to the lessons indicate there is considerable merit in their use for motivation (Hagelburg, 1957, p. 2878).

Selecting the correct process has been used as an experimental variable in several studies. Greene (1925) investigated the value of drill in selecting the correct arithmetical processes with a group of 62 experimental and 30 control subjects in the sixth grade. Both groups practiced solving verbal problems for ten minutes a day, eight days, with the experimental group emphasizing recognizing and selecting processes.

Greene stated that the groups were not equivalent in arithmetic reasoning ability prior to the investigation; therefore, when the Monroe Standard Reasoning Test was administered following eight days of instruction, the results were corrected proportionally for lack of equivalency. Differences favored the experimental group but no statistical difference was reported (Greene, 1925, pp. 33-40).

Another study in support of teaching the selection of correct processes for verbal problem solving was reported by Lutes (1925). An experiment was conducted in the sixth grades of twelve elementary schools with 256 selected pupils. Pupils were taught by one of three methods: (1) computation; (2) choosing the correct process; and (3) choosing the correct solutions needed. Three levels of intellectual ability were determined by the National Intelligence Test: above 110; 90 to 110; and under 90. The Stanford Achievement Test provided a score in verbal problem solving prior to the experimental period and an equivalent form provided the post-test scores. The group receiving practice in computational skills attained the greatest gain, 10.0 months. The control group, receiving instruction from the adopted text, attained a growth of 7.4 months. The group estimating the solution attained a growth of 5.4 months and the group instructed in selecting the correct process attained a growth increase of 5.1 months.

In conclusion, Lutes stated:

1. All pupils of normal intelligence can profit from instruction in problem solving.

2. Improvement in computational accuracy increases ability to solve verbal problems greater than choosing the solutions or processes (Lutes, 1925, pp. 18-37).

Washburne approached the solution to verbal problems in a unique manner. At the second, fourth, sixth, and seventh grades, 1,184 pupils were grouped into problem solving ability levels. Each grade was divided into four sections: highest quarter, second quarter, third quarter, and lowest quarter. Each quarter was divided into an experimental group and a control group. The experimental groups were taught a number process through the use of verbal problems and constant application to problems for a period of six weeks. The control groups were taught the same number process for four weeks without application to concrete situations. When the mechanics were mastered, the control group concentrated on problem solving for two weeks. After six weeks, both groups were given a test in the newly-learned process and a test in the mechanics of the process. Tests were scored for both the selection of the correct process and the accuracy of the response. The differences between the groups were no greater at the conclusion of the experiment and Washburne subsequently reported:

> There is no important difference between the results f teaching processes or application. Children learn th the mechanics and problem solving equally well ither way (Washburne, 1927, pp. 758-767).

Computation ability proved to be essential to success in a study conducted by Lerch (1966). Subjects were compared on growth in problem solving ability following instruction by either a structured equation approach or an analytical approach. This growth was measured by improvement of programming, arriving at a mathematical statement for solving a verbal problem and by improvement of processing, computing and labeling answers. The group instructed by the structured equation approach attained a growth of 4.21 months on the programming aspect while attaining a growth of 3.50 months in processing. Some pupils programmed problems correctly and made mistakes in processing while very few pupils programmed incorrectly and processed correctly. Lerch made the observation that computational skil'~ continued to be of major importance in problem solving (Lerch, 1966, pp. 245-246).

Estimating answers has been investigated as a factor in verbal problem solving as evidenced by Dickey's study in 1934 involving 198 sixth grade pupils. An experimental group received special emphasis in estimating the answers to verbal problems in arithmetic before solving the problems, while a control group solved problems by the normal classroom procedure. Pupils worked on verbal problems for 15 minutes, 50 consecutive school days. To compare gains according to intellectual ability, scores were obtained from performance on the Stanford Achievement Test.

The experimental and control groups were divided into superior and inferior ability pupils to determine the effects of intelligence on estimation. The "superior" group was composed of pupils who scored above the mean intelligence score of 100 and above the mean arithmetic score of 76. Twenty-eight pupils met the criteria from the experimental group and 28 pupils from the control group resulting in a total of 48 pupils who were considered superior. "Inferior" pupils were those who scored below both the mean intelligence and arithmetic scores. Twenty-four pupils were selected from the experimental and control groups resulting in a total of 48 pupils who were considered inferior. Results of the post-test score in arithmetic problem solving revealed no significant differences between the experimental and control groups when pupils were grouped as superior and inferior as verbal problem solvers. As a result of the special emphasis on problem solving, both the experimental and control groups attained approximately one year's growth in problem solving ability. In conclusion, Dickey stated:

> There is no superiority of one group over the other, and the gains made were approximately equal to a gain of one year. The similarity of results of the study of ability in solving problems and of the comparison of ability in estimating answers indicates that practice in estimating is probably of no especial value.
>
> The evidence from this study seemed to indicate that practice in estimating answers to arithmetic problems was of no more value to sixth grade pupils than traditional practice in the solution of problems (Dickey, 1934, pp. 29-31).

The value of estimating answers has more recently been studied by Faulk (1961) in an eleven parish study. An experimental group received instruction in vocabulary, verbalizing problem situations, diagramming problems, estimating answers, and writing solutions. A control group received regular classroom instruction. The 74 pairs of students were equated on intelligence as measured by the California Test of Mental Maturity and on arithmetic reasoning as measured by the California Arithmetic Reasoning Test. Within each treatment group, students were ranked according to upper, middle, and lower thirds of intelligence and reasoning ability.

Following an 18 week instructional period, the experimental group made the following gains in verbal problem solving ability: (1) the upper group, .7 of a year; (2) the middle group, .9 of a year; and (3) the lower group, .8 of a year. The control group made the following gains in verbal problem solving ability: (1) the upper group, .5 of a year; (2) the middle group, .6 of a year; and (3) the lower group, .7 of a year. For all 74 pairs of students, the mean gains of the experimental group were .8 of a year and the control group, .6 of a year.

Faulk reached the following conclusions based on the data gathered:

1. The experimental procedure was effective, as all groups made gains of .7 or more years growth in the four-month study.

2. The control procedure was also effective. Every ability group made gains of at least .5 of a year.

3. Mean gains for the total experimental groups over the gains of the total control groups were significant at the .10 level of confidence.

4. Further experimentation is needed to determine whether the experimental procedures used in this study are consistently superior to the procedures used with the control group.

5. Further experimentation is needed in the area of learning problem solving (Faulk, 1961, pp. 122-123).

The study of arithmetical vocabulary has been compared by several investigators as a factor in verbal problem solving success. An analysis of arithmetic textbook vocabularies was made by Brooks, in 1925, with an analysis of arithmetical terms in five series of texts for grades three to eight. In five third grade texts, 429 different arithmetical terms were noted and of these, 117 occurred in one book, 76 in two books, 70 in three books, 56 in four books, and 110 in all five books. Results of this study indicated that textbooks present unnecessary difficulties for children by the selection of technical terms which are uncommon and appear infrequently (Brooks, 1926).

The growth of arithmetical vocabulary was studied by means of individual tests given to 240 children, 40 from each of the first six grades by Buswell and John (1931). Group tests were devised and administered to determine the words known to pupils at various grade levels.

To refute the assumption that arithmetical terms may be learned in connection with other school subjects, Buswell and John compared the test developed for the study with two accepted vocabulary lests, Thorndike's The Teacher's Word Book and Horn's A Basic Writing Vocabulary. The researchers revealed that 24 percent of the terms were not included in Thorndike's list and 28 percent were not in Horn's list. As a result of this study, Buswell and John stated:

> It is evident that a considerable number of arithmetical terms are not likely to be encountered by the pupil in his work in reading and spelling. Since there are the two subjects in which new words are generally presented, it is doubtful whether the pupils will learn many of the technical terms in arithmetic unless they are taught in the arithmetic class or developed in the arithmetic textbook. If technical terms are to be taught, the obligation rests mainly on the subject of arithmetic. The teacher of arithmetic cannot assume that the words will be learned in other classes (Buswell and John, 1931, p. 100).

A study in 1933 was conducted by Kramer who investigated the effect of four factors upon sixth grade children's success in solving verbal arithmetic problems. The factors chosen for investigation were: (1) sentence form of the problem, interrogative or declarative; (2) vocabulary of the problem, unfamiliar or familiar; (3) style of the problem, brief or detailed; and (4) problem situation, uninteresting or interesting. Kramer developed 120 verbal problems involving all possible combinations of sentence form, vocabulary, style, and situation. These problems were arranged in eight tests and administered to all subjects in eight consecutive school days. The subjects were 237 pupils selected as representative of sixth grade pupils.

The Illinois Intelligence Examination provided the following information concerning ability levels: (1) 62 pupils were in the intelligence range of 90 or less; (2) 95 pupils were in the intelligence range of 90 to 110; and (3) 80 pupils were in the intelligence range of 110 and above. The outcomes of this experiment were recorded in the percent right for each subject. With the four factors of sentence form, vocabulary, problem solving, and problem situation manipulated, Kramer reached the following conclusions:

> 1. The difference in success with the uninteresting and the interesting sections of the test material proved negligible.
>
> 2. There is probably no one best pattern for the statement of the arithmetic problem.
>
> 3. A better percentage was earned using problems employing brief, concise statements.
>
> 4. The percentage gains with all three intelligence levels remained over 6 percent for problems written in familiar vocabulary (Kramer, 1933, pp. 88-89).

After stating the above conclusions based on the findings, Kramer further concluded:

> 1. The outcome of this study would suggest further careful investigation before the school places too great reliance upon interesting content or attractive style to aid reasoning power in verbal problem solving.
>
> 2. Children responded to clues rather than to facts and requirements of the problem. They appear to do little intelligent estimating or reflective thinking.

3. There is genuine need for reliable vocabulary studies measuring both the difficulty and utility of vocabulary for older children (Kramer, 1933, pp. 89-90).

The purpose of a study directed by Dresher (1934) was to determine the effects of extensive, specific vocabulary training for subjects in junior high school mathematics. Five hundred pupils participated in the experiment with 250 pupils assigned to both the experimental and control groups. The experimental group was provided with special training in vocabulary by giving special attention to words in the text and a selected list of technical words with accompanying definitions.

After a semester of vocabulary instruction, tests in arithmetical vocabulary and verbal problem solving were given to both the experimental and control groups. The gain made by the experimental group in knowledge of arithmetic vocabulary was 12.5 points and the gain made by the control group was 9.0 points. The gain made by the experimental group in verbal problem solving ability was 2.5 points while the control group lost 10.4 points. No mention was made of the statistical significance of these differences. In conclusion to the investigation, Dresher stated:

> Apparently vocabulary training does help the pupils to understand and work concrete problems. Pupils cannot work problems if they cannot read and understand them; they cannot understand the explanation of problems if they do not understand the terminology used. The failure to know a word is evidence of failure to comprehend the idea represented by this word (Dresher, 1934, p. 203).

Johnson (1944) also investigated the effects of an arithmetical vocabulary study upon the solution of verbal problems. From an original sample of 898 seventh grade pupils, an experimental group consisting of 316 pupils and a control group consisting of 282 pupils was equated on such parameters as chronological age, mental age, selected arithmetic abilities, reading ability, and knowledge of arithmetic vocabulary. For 14 weeks, five to eight minutes per class period were devoted to special arithmetical vocabulary exercises in the experimental group. The control group received no special emphasis in arithmetical vocabulary other than the information normally included in the adopted arithmetic textbook.

Tests in vocabulary and verbal problem solving ability revealed growth for both the experimental and control groups. Findings indicated that the experimental group achieved significantly greater gains than did the control group in both arithmetic vocabulary and verbal problem solving ability and that this superiority was maintained for pupils of all levels of mental ability. From these findings, Johnson listed the following conclusions:

1. The use of instructional materials in mathematical vocabulary leads to significant growth in the knowledge of the specific terms included in these materials, as well as in the solution of numerical problems involving use of these terms.
2. The value of instructional materials is independent of the class in which they are used. A teacher using such materials can bring about greater growth in vocabulary and problem solving than if the materials were not used.

3. Instructional materials should be used regularly and systematically as an integral part of the classroom procedure (Johnson, 1944, pp. 108-109).

The importance and effect of vocabulary development on verbal problem solving was included in a study previously reviewed by Faulk (1961). A study of technical arithmetical terms was included in the instructional program provided for the experimental group. As the experimental group made gains significant at the .10 level of confidence, the influence of vocabulary instruction was recognized as useful. There is, at present, no way of determining the importance of vocabulary study alone based on Faulk's research as this skill was part of the whole experimental method (Faulk, 1961, pp. 122-123).

For many years, educators have opined that the reason children cannot solve verbal problems in arithmetic was based on an inability to read. However, research has indicated this is only partly true as there are many good readers who are poor verbal problem solvers.

The importance of reading improvement to verbal problem solving ability was recognized early, as evidenced by a study in 1922 (Newcomb, 1922). Four experimental groups receiving special emphasis in reading verbal problems were compared with two control groups which received only traditional instruction in verbal problems. The groups ranged in size from 14 to 36 pupils and the subjects were selected from the seventh and eighth grades. Subjects were equivalent in arithmetic reasoning ability as determined by scores on the Stone Reasoning Test. For a period of 20 days, the experimental groups were taught one problem by using general directions in reading while control subjects worked the same problem without the assistance of reading instructions. Following the 20 day instructional period, the Stone Reasoning Test was again administered to all subjects and results revealed a significant gain in speed of solving problems and a slight, insignificant, gain in accuracy in favor of the experimental groups (Newcomb, 1922, pp. 183-189).

Treacy (1944) investigated the importance of 15 reading skills in relation to verbal problem solving. The criterion for verbal problem solving ability was the average performance on two standardized tests. Of the 244 pupils in the seventh grade of two junior high schools, the 80 having the highest combined verbal problem solving scores were designated as "good achievers" and the 80 having the lowest combined verbal problem solving scores were designated as "poor achievers." Scores for the good and poor achievers were compared by a *t* test on each of 15 reading skills. Scores were equated for intelligence using the Johnson-Neyman technique of statistical analysis and the following results were reported:

1. Good achievers were found superior at the .01 confidence level in Quantitative Relationships, Perception of Relationships, Vocabulary in Context, and Integration of Dispersed Ideas.

2. It is extremely unlikely that ability to solve problems in each of the content areas will have the same speed or comprehension requirements.

3. Reading includes the ability to adjust approach and rate to the reader's purpose and nature of the material (Husbands & Shores, 1950, pp. 455-457).

Recognizing that any relationship between reading achievement and arithmetic achievement might be attributable to intelligence, Fay (1950) controlled for chronological and mental age when working with good and poor readers. Data were collected for 384 sixth grade pupils in three areas: (1) mental ability, Stanford-Binet Intelligence Test; (2) reading ability, Gates Basic Reading Tests, Stanford Achievement Test, Iowa Every-Pupil Tests of Basic Skills; and (3) subject-matter achievement, Stanford Achievement Test. A frequency distribution was plotted for each of the 15 reading skills included in the study. The top one-third, 90 pupils, were classified as superior readers and the bottom one-third, 90 pupils, were classified as inferior readers. The resultant scores for the two groups of pupils were compared in the areas of arithmetic, social studies, and science achievement with mental and chronological age controlled by the Johnson-Neyman statistical technique. The null hypothesis was that there would be no difference in subject matter achievement between superior and inferior readers (Fay, 1950, pp. 541-544). When the two groups of subjects were compared on the subject matter achievement, the following finding in relation to arithmetic was cited:

1. Superior readers were found to achieve no better in arithmetic than did inferior readers (Fay, 1950, p. 544).

Balow investigated the null hypothesis, "There are no significant differences in problem solving ability associated with general reading ability, computation ability, or an interaction of these factors, when intelligence is controlled (Balow, 1964, p. 20)." To test this hypothesis, Balow evaluated 1,400 sixth grade students using the Stanford Achievement Tests for reading and arithmetic and the California Short Form Test of Mental Maturity for intelligence. A two-way factorial design was employed for analysis of the data. Subjects were grouped according to four levels of reading grade equivalent: (1) 7.0 to 11.5; (2) 6.0 to 6.9; (3) 5.1 to 5.9; and (4) 1.0 to 5.0. Subjects were further grouped according to four levels of arithmetic computation based on the same grade level divisions. Twenty-three subjects were randomly selected and placed into one of the 16 resulting cells which corresponded to the subjects' computational and reading abilities. Scores for the 468 pupils were controlled for intelligence through utilization of an analysis of covariance.

The findings of Balow's investigation are in direct opposition with those of Fay (1950). When intelligence was controlled, there was a significant difference associated with computational ability as the subjects in the higher levels of computation produced higher scores in problem solving. When intelligence was controlled, there was a significant difference associated with reading ability as the subjects in the higher levels of reading produced higher problem solving scores. The data indicated that computation was a much more important factor in problem solving than was reading ability.

Analysis of variance and interaction yielded the following data:

> 1. General reading ability does have an effect on problem solving ability.
>
> 2. When intelligence is not controlled, much of the apparent relationship between reading and problem solving ability is the result of the high correlation of each factor with intelligence.
>
> 3. Computation ability does have a significant effect upon problem solving ability. With the effects of intelligence controlled, scores on reasoning appear to bear a closer relationship to computation than to reading ability.
>
> 4. The lack of significant interaction suggests that for a given level of computation ability, problem solving increases as reading ability increases, and for any given level of reading ability, problem solving increases as computation ability increases.
>
> 5. The findings point out the importance of considering children's reading ability as well as computation ability when teaching problem solving skills. Both of these factors are important to the child if he is to deal adequately with verbal problems in school work (Balow, 1964, pp. 21-22).

There is an accumulation of evidence which indicates that the reading of verbal problems requires some specific reading skills as well as an acquaintance with the vocabulary employed in verbal problem statements. The question of the nature of the reading instruction that should be given has received only limited attention and further research is needed before any conclusion can be stated (Wilson, 1941, p. 54).

ANALYTICAL STUDIES OF VERBAL PROBLEM SOLVING SKILLS

The analytical studies include factor analyses, analyses of variance, and correlation procedures.

Factor Analysis

Companion studies were conducted by McTaggart and Emm in which 21 verbal problem solving abilities of 581 fifth grade pupils in a Catholic diocese were investigated (McTaggart, 1959), (Emm, 1959). McTaggart studied the test results of 308 girls in the sample and Emm, 273 boys. Both investigations were conducted to examine the factor patterns of performance in arithmetic problem solving and to compare resulting factor patterns of boys with girls in the same fifth grade population.

Tests on which factor analyses were computed were: (1) SRA Verbal Meaning; (2) SRA Space; (3) SRA Reasoning; (4) SRA Perception; (5) SRA Number; (6) Stanford Reasoning; (7) Stanford Computation; (8) Brownell Quantitative; (9) Steps in Process; (10) Problem Analysis; (11) Reading to Note Numerical Detail; (12) Reading to Note Irrelevant Detail; (13) Inferences; (14) Analogies; (15) Estimation; (16) Arithmetic Vocabulary; (17) Computation; (18) Brownell Problem

Solving; (19) Young Catholic Messenger Reading; (20) Young Catholic Messenger Vocabulary; and (21) Computation II.

Results of McTaggart's investigation of 308 girls were:

1. Factor A is a verbal factor calling for both general and specific skills in reading comprehension and vocabulary meaning.

2. Factor B is an arithmetic factor involving ability to perform fundamental operations in arithmetic as well as demonstrate understandings of number relationships.

3. Factor C is an approach to problem solving factor involving an ability to compare and organize data prior to the solution of a problem presented in verbal, arithmetical, or spatial form (McTaggart, 1959, p. 21).

Results of Emm's investigation of 273 boys were:

1. Factor A is a verbal-cognitive factor which is interpreted as: (1) verbal, meaning a knowledge of words; and (2) cognitive, meaning the interpretation and appreciation of verbal relationships.

2. Factor B is an arithmetic factor which is defined as an ability involving computational skills.

3. Factor C is a spatial factor which is an ability to visualize objects and symbols in more than one dimension (Emm, 1959, p. 43).

Conclusions based on the comparison of girls' and boys' factor arrangements were reached by McTaggart and Emm. The conclusions were:

1. Factor A is not structured the same for both sexes. It is a verbal factor for both, but the girls' factor is much clearer.

2. Factor B is an arithmetical factor, different in structure for both groups. The girls have a very clear factor with loadings from those tests which involve computation of the four fundamental processes. This factor for boys includes not only the computation tests but those of problem solving as well.

3. Factor C for boys is clearly a spatial factor, but for the girls, it is a reasoning or verbal-cognitive factor.

4. The fifth grade girls tend to be superior to boys in reading comprehension. Girls' verbal factor was much more clearly defined than that of the boys. Contrarily, the boys' number factor seems to point out that they use a mathematical reasoning or "method" in solving problems that girls do not have (Emm, 1959, pp. 41-43).

In a study to compare the factor patterns of boys with girls at the seventh grade, Donohue collected data from 17 tests given to 200 boys. The data were compared with scores of 200 girls who were entering the seventh grade and whose scores had been collected by another author. The 17 tests on which comparisons were made were: (1) Kuhlman-Anderson Intelligence; (2) Stanford Reasoning; (3) Stanford Computation; (4) Brownell Quantitative Understandings; (5) Steps in Process; (6) Problem Analysis; (7) Reading to Note Numerical Detail; (8) Reading to Note Irrelevant Detail; (9) Inference; (10) Analogies; (11) Estimation; (12) Arithmetic Vocabulary; (13) Computation; (14) Brownell Problem Solving; (15) Attitude Scale; (16) Young Catholic Messenger Reading; and (17) Young Catholic Messenger Vocabulary.

The Thurston Centroid Method of factor analysis revealed three factors from the 17 test scores. From this factor analysis, the following conclusions were supported:

1. Attitude Scale had practically no variance in common with the rest of the items and was not retained in further analyses.

2. There was much common variance between each test and every other test in the 17 items.

3. Factor A was a verbal factor involving the understandings of verbal symbols and word relationships.

4. Factor B was an arithmetic factor involving the ability to perform the fundamental operations in arithmetic.

5. The common variance between the factors was explained in terms of a "general" factor (Donohue, 1957, pp. 25-26).

Comparing these results for boys with the data from a study of seventh grade girls from the same population, these further conclusions were deducted:

1. Factor A shows a structural difference in the factor for the girls reflecting variance in symbolic fluency.

2. Factors B and C are basically similar in structure for both sexes.

3. In both groups, a general factor accounts for the correlations between the primary factors (Donohue, 1957, pp. 25-26).

Analysis of Variance Studies

Recognizing that research evidence was inconclusive concerning the skills and abilities most important in the solution of verbal arithmetic problems, Hansen (1943) conducted an investigation in which abilities of superior and inferior achievers were compared. Tests in verbal problem solving were administered to 681 sixth grade pupils. The upper 27 percent, 184 pupils, were designated "superior" achievers and the lower 27 percent, 184 pupils, were designated "inferior" achievers. The two groups were matched statistically on mental and chronological age by the Johnson-Neyman technique.

The superior and inferior achievers were compared on the 27 ability tests by means of a t test of significance and the following results were reported:

1. Superior achievers scored significantly greater on all tests except four: Comprehension Reading to Predict Outcomes; Speed Reading to Note Details; and Comprehension Reading to Note Details.

2. Significant differences were found to exist in favor of the superior achievers in the following areas at the .01 percent level of confidence: Fundamental Operations; Estimating Answers to Examples; Ability to Solve Problems; Thinking Abstractly with Numbers; Estimating Answers to Problems; Problem Analysis; Number Series; Quantitative Relationships; Finding Keys to Problems; Arithmetic Vocabulary; General Reasoning Ability; Noting Differences; Noting Likenesses; Non-Language Factors; Analogies; Delayed Memory Span; Memory; Spacial Imagery; Inference; General Language Ability; Reading Graphs, Charts, and Tables; and Speed Reading to Predict Outcomes.

3. Significant differences were found to exist in favor of the superior achievers in the following areas at the .05 percent level of confidence: Spacial Relationships and General Vocabulary (Hansen, 1943, pp. 113-115).

Based on the scores of the reading tests, Hansen made the observation that,

> Beyond the mastery of fundamental reading skills and basic vocabulary, it may be more profitable to devote instructional time allotted to the teaching of verbal problem solving in arithmetic to abilities bearing more directly on arithmetic reasoning (Hansen, 1943, p. 115).

Treacy's study in 1944 to determine the relationship of certain reading skills to the ability to solve verbal problems in arithmetic was an attempt to answer two general questions: Is general reading level significantly related to ability to solve problems in arithmetic? and, Are certain specific reading skills significantly related to an ability to solve problems in arithmetic?

The criterion for ability in problem solving was the average performance on two standardized tests which were given to 244 pupils in the seventh grade. Eighty pupils having the highest combined T score on these tests were designated as "good achievers" and the 80 pupils having the lowest combined T score were designated as "poor achievers." These two groups were compared on 15 reading skills by means of the _t_ test of significance with mental and chronological age statistically controlled. The reported findings were:

1. Good achievers were found to be better than poor achievers at the .01 level of significance in Quantitative Relationships, Perception of Relationships, Vocabulary in Context, and Integration of Dispersed Ideas.

2. Good achievers were found to be better than poor achievers at the .05 percent level of significance in Arithmetic Vocabulary, Vocabulary (Isolated Words), Retention of Clearly Stated Details, Drawing of Inference from Context, and Reading Level.

3. No significant differences were found between good and poor achievers in the Prediction of Outcomes, Understandings of Precise Directions, Rate of Comprehension, General Information, Grasp of Central Thought, and Interpretation of Content (Treacy, 1944, pp. 91-92).

The purpose of companion studies conducted by Kleibhan and Engelhard (1955) was to determine how groups of sixth grade boys and girls designated as high and low achievers in verbal problem solving differed in regard to certain abilities. The tests on which the boys and girls were compared were: (1) Quantitative Understanding; (2) Problem Analysis; (3) Steps in Process; (4) Computation; (5) Problem Solving; (6) Fundamentals; (7) Estimation; (8) Analogies; (9) Inference; (10) General Reading; (11) General Vocabulary; (12) Reading, Numerical Detail and Irrelevant Detail; (13) Arithmetic Vocabulary; and (14) Attitude Toward Arithmetic.

High achievers were defined as pupils whose grade equivalents on the Stanford Arithmetic Reasoning Test were four months or more above the subject's mental age score. Low achievers were pupils whose grade equivalent on reasoning was four months or more below the mental age score. From an original sample of 479 boys, two experimental groups numbering 112 each were selected on the basis of matching mental ages in the high and low problem solving achiever groupings. The average intelligence score of the high achievers was 103.4 and of the low achievers, 101.5. Kliebhan stated that the similarity in intelligence of the two groups was testimony to the fact that intelligence was not the lone determiner of verbal problem solving and reasoning ability.

Comparison between these two groups of boys matched on mental age indicated that high achieving boys surpassed the low achieving boys at the .01 percent level of significance on all tests except Attitude Toward Arithmetic. While the mean attitude score of the high achievers, 7.51, was slightly more favorable than the mean attitude score of the low achievers, 7.17, the difference was not significant. The tests having the largest differences in comparison of the two matched groups were arithmetical (Kleibhan, 1955, pp. 27-28). This finding corroborated that of Hansen (1943), that arithmetical factor and mental factors are more closely associated with superior achievement of boys and girls in problem solving than are reading factors.

In conclusion, Kliebhan made the following statements:

> 1. In comparison of two groups of high and low achieving boys matched on mental age, high achievers are significantly superior to low achievers on all tests at the .01 level of confidence except Attitude Toward Arithmetic.
>
> 2. In all tests, low achieving boys are inferior to high achieving boys, a fact which demonstrates that sixth grade boys who are doing poorly in arithmetic problem solving also tend to be weaker in other arithmetical abilities and skills. While the findings are not submitted as proof of causal relationships, it is suggested that boys are poor in arithmetic problem solving because they lack competence in these other skills (Kliebhan, 1955, pp. 44-46).

High achievers in Engelhard's (1955) study were defined as pupils whose grade equivalents on the Stanford Arithmetic Reasoning Test were four months or more above mental age scores. Low achievers were pupils whose grade equivalents in reasoning were four months or more below mental age scores. From the original sample of 496 girls, 81 matched pairs in intelligence were divided into high and low achievers. The mean intelligence score of the high achievers was 106.50 and the mean score of the low achievers, 105.52. When the two groups were compared on the same tests used in Kliebhan's study, the high achieving girls scored significantly higher than the low achieving girls at the .01 percent level of confidence. The data indicated that the most significant single ability between these groups was Steps in Process.

The ultimate objective of the studies of Kliebhan and Engelhard was to compare the performances of fifth grade boys and girls. The data from these comparisons justif ·d the following conclusions with regard to six differences in arithmetic verbal problem solving ability:

1. When no distinction is made as to the mental ability of boys and girls, girls differ from boys by:

   (a) higher mental age but lower chronological age.

   (b) superior achievement on Analogies, Steps in Process, Computation, and reading factors.

   (c) more favorable scores on Attitude Toward Arithmetic.

2. Boys exhibit superior ability to estimate answers to verbal arithmetic problems and a better understanding of quantitative concepts, principles, and relationships.

3. When the sexes are equated in mental age, boys are distinguished from girls by superior achievement in tests of Estimation, Quantitative Understanding, and Problem Solving.

4. Girls who are successful in arithmetic problem solving exhibit a more favorable attitude toward arithmetic than do equally successful boys. Girls who are less successful do not have a more favorable attitude toward arithmetic than boys. No other differences favor the girls (Engelhard, 1 55, r 57-58).

Correlation Studies

An early correlational study by Stevens (1932) was undertaken to obtain statistical evidence supplementing common sense judgment in verbal problem solving instruction. Reasoning ability scores were obtained for 3,089 pupils in grades four through seven in five communities. These scores were correlated with scores in the areas of: (1) ability in silent reading; (2) power in fundamental operations of arithmetic; (3) power in solving reasoning problems in arithmetic; and (4) general intelligence.

The area correlating highest was that of fundamental operations. Stevens stated that further experimentation was needed before a conclusion could be drawn that the teaching of verbal problem solving in arithmetic rests on a sound scientific basis (Stevens, 1932, p. 260).

In the same year, Engelhart (1932) conducted an investigation of the verbal problem solving skills of 568 fifth grade pupils. The purpose of the study was to determine the relative contributions of intelligence, computation ability, and reading ability to arithmetical verbal problem solving ability. Analysis of the data revealed:

1. Intelligence accounts for 25.69 percent of the variance in verbal problem solving.
2. Computation ability accounts for 42.05 percent of the variance in verbal problem solving.
3. Reading ability accounts for 1.33 percent of the variation in verbal problem solving.
4. Unknown causes are responsible for a remaining 33.59 percent of the variation in verbal problem solving (Engelhart, 1932, p. 29).

Erickson noted low correlation between general intelligence, as measured by the Iowa Test of Basic Skills, the Otis Quick Scoring Mental Ability Test, and the Iowa Silent Reading Test. For the group as a whole, there was a correlation coefficient of .72 between intelligence and arithmetic achievement. When groups were divided according to arithmetic achievement, the upper 27 percent had a correlation coefficient of .39 between intelligence and arithmetic achievement. The middle 46 percent had a correlation coefficient of .46 and the lower 27 percent, .40. The lower correlations which resulted from dividing the groups into three achievement levels would seem to indicate that factors other than intelligence were involved (Erickson, 1958, pp. 287-291).

Multiple correlation was utilized by Chase (1960) to identify abilities primarily related to success in solving verbal problems in arithmetic. The data for this study were collected from 119 sixth grade children whose mean chronological age was 11.5 years. Fifteen tests computed in multiple correlation with the criterion test of problem solving were: (1) Primary Mental Abilities Verbal; (2) Primary Mental Abilities Reasoning; (3) Primary Mental Abilities Space; (4) Primary Mental Abilities Perceptual Speed; (5) Primary Mental Abilities Number; (6) Computation; (7) Fundamental Knowledge in Arithmetic; (8) Arithmetic Vocabulary; (9) Problem Analysis A, what does the problem ask you to do? (10) Problem Analysis B, what arithmetic process should be used? (11) Problem Analysis C, estimating answers; (12) Reading for General Significance; (13) Predicting Outcomes; (14) Understanding Directions; and (15) Reading to Note Details.

Three of the tests were identified by multiple correlation as useful predictors of problem solving ability. These tests and the variances associated with each were: (1) Computation, 32.33 percent; (2) Reading to Note Details, 15.93 percent; and (3) Fundamental Knowledge of Arithmetic, 13.68 percent.

From the results obtained by the multiple correlation statistic, these conclusions were stated by Chase:

> 1. The number of skills primarily associated with the ability to solve verbal problems in arithmetic are relatively few.
>
> 2. The variables which seem to be secondarily related to problem solving ability in that they are closely associated with primary variables are intelligence, knowledge of generalizations, and ability to apply reading skills to a variety of purposes.

3. The variables which are primarily associated with performance in solving problems, and many of the abilities which are associated with these variables are skills which are taught in the elementary school. Greater emphasis on these skills may result in a significant increase in problem solving ability (Chase, 1960, p. 14).

CHARACTERISTICS OF CHILDREN INDICATIVE OF VERBAL PROBLEM SOLVING ABILITY

The very fact that some highly intelligent students do poorly in school and some students lower in intelligence do well is an indicator that intelligence, as conventionally assessed, is not the only characteristic of children responsible for educational success. Indeed, the intelligence test rarely accounts for more than a quarter of the variance in such crucial factors as school achievement and academic performance (Getzels & Jackson, 1962, p. 3).

This section includes studies relating to the level of intellectual development and reasoning, personality, and creativity.

Level of Intellectual Development

Piaget identified stages in the intellectual development of children with accompanying implications for arithmetic instruction. Copeland (1970) interpreted these stages and stated these implications for teachers:

1. The ability to think logically develops gradually during the time the child is in elementary school. It is developmental and even the best teaching methods must take the stages of development into account (Copeland, 1970, p. 120).

2. The primary grade child should probably not be given problems requiring a logical process of analysis (Copeland, 1970, p. 122).

3. Children in the elementary school are not ready to work at the abstract level with formal logic and proofs. Arithmetic for them should be exploration and discovery (Copeland, 1970, p. 145).

4. Confronting most children of eleven or twelve with formal logic may mean confronting them with something they cannot do (Copeland, 1970, p. 146).

Personality Characteristics

In an effort to determine the relationship between certain factors of personality and success in arithmetic achievement, Kuykendall (1956) administered the California Test of Personality, Pintner's Aspects of Personality, and Washburne Social Adjustment Inventory to 185 pupils selected randomly from the seventh grade. The Stanford Achievement Test and California Short Form Test of Mental Maturity Tests were also administered to the sample of pupils. Based on the results of arithmetic achievement, the upper 27 percent, 50 pupils, and the lower 27 percent, 50 pupils, were selected for study. Using intelligence as a covariant, the pupils' scores in arithmetic achievement were correlated with scores on the three personality inventories. The correlation coefficients with mental age partialled out resulted in significant relations at the .01 percent level for Personal Adjustment, Social Adjustment, and Total Adjustment from the California Test and for the total on the Washburne Social Adjustment Inventory.

The following coefficients were obtained as a result of correlating arithmetic scores with personality scores: (1) Personal Adjustment and achievement in arithmetic, .132; (2) Social Adjustment and arithmetic achievement, .191; and (3) Total Adjustment and arithmetic achievement, .134. None of the scores from Pintner's Aspects of Personality were significant above the .10 level of confidence. The total score of the Washburne Social Adjustment Inventory was correlated with achievement in arithmetic with a resulting coefficient of .212.

Attempts in this study to isolate particular factors of greatest relationship of adjustment to arithmetic achieve achievement met with little success. In conclusion, Kuykendall stated:

1. The correlation coefficient between mental age and arithmetic achievement was found to be .65.

2. The correlation coefficient with mental age partialled out showed a relationship significant at the .01 level of confidence for Personal Adjustment, Social Adjustment, and Total Adjustment on the California Test of Personality, and for the total score of the Washburne Social Adjustment Inventory.

3. Neither Personal Adjustment nor Social Adjustment as delineated by the study seem to be favored.

4. The attempt to isolate specific factors of adjustment that showed greatest relationship to achievement was not successful (Kuykendall, 1956, p. 71).

Plank became interested in the personality structures of children in 1950 while conducting an investigation of the learning process. In an effort to learn how personality affects achievement, Plank studied 20 children from kindergarten to the sixth grade. The subjects were divided into three groups for observation: (1) children having no formal instructions in arithmetic; (2) children having special ability in arithmetic; and (3) children having special difficulty in arithmetic. Groups one and two were of secure socio-economic backgrounds and group three was from varying insecure backgrounds. Throughout the observational period, subjects worked with Montessori materials. Using data concerning intelligence and family backgrounds available from the school files, Plank reported the following observations:

1. Achievement in arithmetic seemed to be more strongly related to problems of personal adjustment than to either intelligence or school experience.

2. Over-protection on part of elderly parents seemed to play an important role in some of the adjustment difficulties.

3. Rigid demands of high expectations for achievement tended to create a rigid attitude that may sometimes result in defeatism.

4. A definite discrepancy between scores in reasoning and computation was shown by insecure children.

5. The personality of the teacher played an important part in bringing about self-acceptance in insecure children (Plank, 1950, pp. 252-263).

The purpose of a study conducted by Cleveland and Bosworth (1967) was to discover whether there were statistically significant differences between certain psychological and sociological characteristics of the top quarter arithmetic achievers and the bottom quarter arithmetic achievers at the sixth grade level. These characteristics were measured by the California Test of Personality and the Dutton Arithmetic Attitude Scale and results were examined at three intelligence levels in relation to three aspects of arithmetic learning: skills; concepts; and problem solving. The population selected for this study included 282 sixth grade pupils selected from three lower socio-economic areas and three upper socio-economic areas. Pupils were grouped into three categories of intellectual ability: (1) 75 to 89; (2) 90 to 110; and (3) 111 to 125. Within each intellectual group, pupils were classified into high achievers and low achievers by selecting the top and bottom 25 percent in each arithmetic area: fundamentals; concepts; and problem solving. All groups were identified by sex and socio-economic level. When scores were received for all subjects on the California Test of Personality and Duttom Arithmetic Attitude Scale, an F-test analysis of variance was used to determine whether significant differences existed at the .05 level of confidence. Cleveland and Bosworth reported that:

1. There were no differences between the sexes in any aspect of arithmetic achievement. There were marked differences in achievement level between high and low socio-economic level schools.

2. Pronounced differences occurred in the 90 to 110 intelligence range between high achievers on the following tests: Total Adjustment, Personal Adjustment, Social Adjustment, Sense of Personal Worth, Freedom from Withdrawing Tendencies, Freedom from Anti-Social Tendencies, School Relations, Community Relations, and Sense of Personal Freedom.

3. High achieving girls in the middle and upper intelligence groups were superior to high achieving boys in Social Adjustment whereas high achieving boys in the lowest intelligence group were superior to girls in the following: Feeling of Belonging, Freedom from Withdrawing Tendencies, and Freedom from Nervous Symptoms.

4. Achievers in the higher social class schools attained higher ratings on Self-Reliance, Social Standards, Social Skills, and School Relations. These differences were most pronounced in the 90 to 110 intelligence range.

5. Positive attitudes toward arithmetic are correlated with achievement in fundamentals among children in the two lower intelligence ranges and lower socio-economic children who achieve in the areas of concepts and problem solving also have positive attitudes toward arithmetic (Cleveland & Bosworth, 1967, p. 385).

In summary, Cleveland and Bosworth stated that there seemed to be a positive correlation between arithmetic achievement and a psychologically healthy personality. The higher achievers of both sexes and from both socio-economic levels of school environment attained higher scores in the areas of Personal Adjustment, Social Adjustment, and Total Adjustment; however, scores on the attitude scale were not useful as predictors of successful achievement in arithmetic. The study revealed few differences between the sexes in achievement or personality. In relation to the influence of environment on personality, there was a tendency for high achievers in higher social class schools to have better social adjustment than low achievers, whereas in lower social class schools, the reverse tended to be true. As a final implication for education, Cleveland

and Bosworth suggested that more attention to personality factors in the school environment might improve arithmetic achievement (Cleveland & Bosworth, 1967, p. 386).

Bodwin conducted a study in 1957 to investigate the relationship between an immature self concept and educational disabilities in reading and arithmetic at the third and sixth grade levels. The research group consisted of 300 subjects, 100 with a reading disability, 100 with an arithmetic disability, and 100 with no educational disability. Self concept was measured by the Draw-a-Person Test and correlated with arithmetic and reading scores. Based on the findings of this study, Bodwin reported these conclusions related to arithmetic:

> 1. A positive and very significant relationship existed between self concept and arithmetic disability. The correlation coefficients obtained were .78 for third grade and .68 for sixth grade, both significant at the .01 level of confidence.
>
> 2. The relationship between an immature self concept and reading and arithmetic disabilities was greater at the third grade level than the sixth. This indicated the presence of age differences in these relationships (Bodwin, 1957, p. 1646).

Creativity

The relationship of creativity and verbal problem solving was analyzed by Doren (1967) in a book forworded by E. Paul Torrance. Doren made the statement that mathematical problem solving should be the nucleus of any curriculum in which there is a promotion of creativity in students and teachers (Doren, 1967, p. 115).

The difference between a classroom program in which creativity is promoted and one that inhibits creativity will be in the method by which problem solving has been presented. Doren further related that formal analysis taught by many teachers becomes a mental strait jacket. The suggestion was made that if creative verbal problem solving was to develop, children must be encouraged to develop flexible thinking (Doren, 1967, p. 117).

Hallman expressed the belief that creativity could and should be taught by stating:

> It (creativity) can be taught because the process of being creative is the process of developing one's self as a personality; it is the process of unfettering the chains of habit, routine, and repression. It is the process of shaping one's surroundings, or relating one's self productively to others; it is the process of identifying one's self and defining one's own existence. This is the central problem of creativity; it is also the central problem of education (Hall, 1964, p. 23).

SUMMARY OF RELATED LITERATURE

The preeminence of verbal problem solving ability as the ultimate goal of mathematics instruction in elementary classrooms has long been recognized by educators, but research has failed to consistently identify those variables that might predict success for children. The area of verbal problem solving has not been investigated systematically and few studies have built upon previous research findings.

For more than 40 years, researchers have compared one procedure of verbal problem solving with another in an attempt to discover the one "best" method for all children. This procedure has met with little success as the same conclusion has been realized by most; there is no best method; the value of any method depends upon the skills of the teacher using it.

Other researchers have selected abilities thought to be useful in solving verbal arithmetic problems and by means of correlation, analysis of variance, or factor analysis, have attempted to identify those abilities without which success could not be realized. Some skills and abilities have been identified as contributing to high achievement in verbal problem solving, but research findings are conflicting.

Another approach by researchers has been an attempt to identify specific characteristics of children which might enable them to be high achievers in verbal problem solving. Research in this area is limited though the available findings are encouraging as certain traits have been identified which would enable children to be more successful in verbal problem solving achievement. Researchers have stated that this area should be investigated more extensively to identify the characteristics of children which enable them to use their abilities more effectively in solving verbal problems in mathematics.

CHAPTER III

RESEARCH PROCEDURES

The research procedures employed in this investigation are described in this chapter. The selection of subjects, selection of experimental variables, administration of test items, tester competency, statistical procedures, statistical tools used in the investigation, and procedures for data analysis are herein presented.

SELECTION OF SUBJECTS

The subjects for this study were an incidental sample of 112 sixth grade students selected from the total sixth grade population of 259 in the city schools of Natchitoches, Louisiana. Cumulative records were examined and the "Arithmetic Applications" score of the Stanford Achievement Test recorded as the criterion for high and low achievement. The 56 high achieving students were those who scored in the upper 27 percent of verbal problem solving achievement and the 56 low achieving students were those who scored in the lower 27 percent of verbal problem solving achievement. Students for whom the Arithmetic Applications score was not available in the cumulative records were not considered as subjects for this investigation.

SELECTION OF EXPERIMENTAL VARIABLES

The purpose of this investigation was to select mental, mathematical, reading, and personality assessments that effectively differentiate between high and low achievers in verbal problem solving in mathematics. The tests used to accomplish the purpose of this investigation were:

Mental Assessments	Tests Used
1. Level of Intellectual Development	Piaget's Pendulum Problem
2. Verbal Intelligence	California Short Form Tests of Mental Maturity
3. Non-Verbal Intelligence	
4. Total Intelligence	
Creativity	Torrance Tests of Creative Thinking, Test 3, Figural
5. Fluency	
6. Flexibility	
7. Originality	
8. Elaboration	

Mathematical Assessments

9. Arithmetic Computation	Stanford Achievement, Test 5
10. Arithmetic Concepts	Stanford Achievement, Test 6
11. Knowledge of Basic Facts	Adston Diagnostic Test
12. Problems with Unnecessary Data	Dr. Horace Otis Beldin's Test
13. Problems Without Numbers	Dr. Horace Otis Beldin's Test
14. Problems with Insufficient Data	Dr. Horace Otis Beldin's Test
15. Mathematical Vocabulary	Constructed Test
Steps in Formal Analysis	Constructed Test
16. What is asked in the problem?	
17. What facts are given in the problem?	
18. What process will you use to find the answer?	

Reading Assessments

19. Total Vocabulary	California Reading Test
20. Following Directions	
21. Reference Skills	
22. Interpretations	
23. Total Reading	

Personality Assessments

California Test of Personality

24. Self-Reliance
25. Personal Worth
26. Personal Freedom
27. Feeling of Belonging
28. Withdrawal Tendencies
29. Nervous Symptoms
30. Total Personal Adjustment
31. Social Significance
32. Social Skills
33. Anti-Social Tendencies
34. Family Relations
35. Social Relations
36. Community Relations
37. Total Social Adjustment
38. Total Adjustment

An explanation of each test along with validity and reliability coefficients are provided in Appendices B through N.

ADMINISTRATION OF TEST ITEMS

Permission to conduct the investigation in Natchitoches Parish was granted by the Superintendent on September 12, 1972 (see Appendix P). The investigator with the aid of senior and graduate students administered the experimental variables to both the high and low achieving students during the two weeks of November 1, 1972, through November 14, 1972. In an effort to control extraneous variables, each tester administered the same test to all children at the same time of day in each of the schools. High and low achieving students were tested together in a vacant classroom or in the school library.

Testing schedules were arranged in cooperation with the principals and sixth grade teachers at each of the schools. The number of tests to be given each day were grouped together and arranged in a schedule for administration as follows:

Test Notation	Name of Tests
I	Piaget's Pendulum Problem
II	Torrance Creativity Test
III	California Short Form Test of Mental Maturity
IV	Arithmetic Computation and Concepts, Stanford Achievement Tests
V	Adston Diagnostic Test
VI	Problems with Unnecessary Data Problems without Numbers
VII	Problems with Insufficient Data Mathematical Vocabulary
VIII	Formal Analysis
IX	California Reading Test
X	California Test of Personality

Testing Sequence at the Five Schools

Testing Date	1	2	3	4	5
November 1	I	II	III	IV	V
November 2	II	III	IV	V	VI
November 3	III	IV	V	VI	VII
November 6	IV	V	VI	VII	VIII
November 7	V	VI	VII	VIII	IX
November 8	VI	VII	VIII	IX	X
November 9	VII	VIII	IX	X	I
November 10	VIII	IX	X	I	II
November 13	IX	X	I	II	III
November 14	X	I	II	III	IV

TESTER COMPETENCY

The test variables utilized in this investigation were administered by the researcher, graduate students, and senior students at Northwestern State University. All testers received instruction in the proper testing techniques according to test manuals and practiced until fully acquainted with the tests. Each tester selected a sixth grade student not eligible for the investigation and administered the designated tests for practice. The investigator supervised each practice session to ascertain that standardized instruction procedures were being carefully followed.

STATISTICAL PROCEDURES

To answer the questions posed in the statement of the problem, the following statistical applications were made in the analyses of the data for this investigation.

1. What is the relationship between the selected mental, mathematical, reading, and personality assessments and verbal problem solving in mathematics?

The Pearson product moment correlation coefficient was computed between the original 38 selected mental, mathematical, reading, and personality assessments and verbal problem solving to provide an indication of the relative importance of each variable individually. The use of this tool was included to determine the relationship between each variable separately and verbal problem solving.

2. What percent of the common variance in a verbal problem solving situation in mathematics can be accounted for by the individual mental, mathematical, reading, and personality assessments?

The computed Pearson product moment correlation coefficients were squared to determine how accurately the 38 assessments approximate 100 percent of the variance in a verbal problem solving situation. The difference between the actual contribution of the assessments and 100 percent is error variance, or variance due to skills of verbal problem solving not identified in this investigation.

3. Can a combination of mental, mathematical, reading, and personality assessments predict the high and low achiever in mathematical verbal problem solving?

Factor analysis, intercorrelations, and mean differences were computed on the 38 assessments in this investigation to select a combination of variables most suitable for a discriminant analysis of sixth grade verbal problem solvers. The factor analysis technique reduced the original 38 variables to a lesser number representative of the entire 38 tests. The discriminant analyses were computed with the reduced number of variables to determine the accuracy of the variables in placirg subjects into the high and low achiever classifications.

STATISTICAL TOOLS USED IN THE INVESTIGATION

Factor Analysis

Factor analysis is a method of analyzing a set of observations from a given sample to determine whether the variations in the scores can be accounted for adequately by a number of basic categories, or factors. The factors revealed were smaller than the number of variables with w[illegible] [illegible]vestigation was started. Thus, data obtained wi[illegible] [illegible] number of variables may be explained in terms of a smaller number of reference variables. A basic assumption of factor analysis is that a battery of intercorrel[illegible] variables have common factors running through and that the scores of an individual can be represented more economically in terms of these reference variables (Fruchter, 1968, pp. 1, 44).

Discriminant Analysis

The discriminant analysis statistic serves two purposes: (1) determining a combination of variables that best differentiates between defined groups; and (2) classifying individuals in terms of their similarity to the groups. Discriminant analysis establishes a combination of variables which maximize differences between groups to accomplish the two above purposes (Brown, 1970, pp. 218-220).

The first purpose of the discriminant analysis was of importance in this study; that is, determining a combination of variables that differentiated between high and low achievers in verbal problem solving. The variables found useful in correctly separating the groups are skills recognized as valuable to a child when solving verbal problems in mathematics.

Pearson Product Moment Correlation Coefficient

The Pearson product moment correlation coefficient is used to express the degree of relationship between two variables expressed in standard scores (Nunnally, 1967, pp. 109-113).

The formula utilized in this investigation converted raw scores into standard scores in the process of computation. The formula for the computation is given below: (Ferguson, 1966, p. 111).

$$r = \frac{N\Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{NX^2 - (\Sigma X)^2 \quad NY^2 - (\Sigma Y)^2}}$$

PROCEDURES FOR DATA ANALYSIS

When the data were complete, scores were transferred to a Fortran coding form for preparation of key-punched computer cards. The data were then analyzed by the Computer Center of Louisiana Polytechnic University, Ruston, Louisiana.

All 38 scores for each individual were computed in a Pearson product moment correlation coefficient. This coefficient of correlation was then squared to determine the variance each variable contributed to verbal problem solving.

Factor analysis reduced the 38 scores of each subject into a lesser number of representative scores providing a more appropriate number for use in the discriminant analysis. The discriminant analysis statistic determined the effectiveness of the selected variables in differentiating between high and low achievers in verbal problem solving.

CHAPTER IV

ANALYSIS OF THE DATA

The purpose of this investigation was to determine if selected mental, mathematical, reading, and personality assessments of sixth grade pupils could distinguish between high and low achievers in mathematical verbal problem solving. These assessments could then be emphasized in elementary classrooms to enable more pupils to be high achievers in mathematical verbal problem solving.

Seventy pupils were classified as high achievers and 70 as low achievers using the verbal problem solving score available in cumulative records as the criterion for classification. Fifteen tests were administered yielding 38 scores for each pupil. Complete scores were obtained for 112 pupils representing 80 percent of the original 140-pupil population. Four batteries of assessments were identified and employed in discriminant analyses to determine the predictive value of the selected assessments in discriminating the high achiever in mathematical verbal problem solving from those classified as low achievers.

PRESENTATION OF RESULTS

The purpose of this investigation was accomplished by identifying four test batteries capable of discriminating between high and low achievers in mathematical verbal problem solving. Results of this investigation are presented in the following manner:

1. Relationship between mathematical verbal problem solving and the selected assessments.

2. Common variance in mathematical verbal problem solving accounted for by the individual assessments.

3. Selection of predictor assessments for the four discriminant analysis test batteries.

    A. Rank order of the highest 11 correlation coefficients between mathematical verbal problem solving and the selected assessments.

    B. Rank order of the largest 11 significant t values separating the high and low achievers in mathematical verbal problem solving.

    C. Factor analysis of all 38 predictor assessments with resulting factors.

4. Summary of four discriminant analyses of high and low achievers in mathematical verbal problem solving.

RELATIONSHIP BETWEEN MATHEMATICAL VERBAL PROBLEM SOLVING AND THE SELECTED ASSESSMENTS

The first question posed in this investigation was:

What is the relationship between the selected mental, mathematical, reading, and personality assessments and verbal problem solving in mathematics?

Pearson product moment correlation coefficients were computed between the 38 selected mental, mathematical, reading, and personality assessments and mathematical verbal problem solving scores to provide an indication of the relationship of each assessment individually with verbal problem solving (see Table 1 for assessments). Table 2 presents the correlation coefficients in rank order.

Table 1

Summary of the 38 Mental, Mathematical, Reading, and Personality Assessments Tested

Mental Assessments

1. Level of Intellectual Development
2. Verbal Intelligence
3. Non-Verbal Intelligence
4. Total Intelligence
   Creativity:
5. Fluency
6. Flexibility
7. Originality
8. Elaboration

Mathematical Assessments

9. Arithmetic Computation
10. Arithmetic Concepts
11. Knowledge of Basic Facts
12. Unnecessary Data
13. Problems without Numbers
14. Insufficient Data
15. Mathematical Vocabulary
    Formal Analysis:
16. What is Asked?
17. What is Given?
18. What Process?

Reading Assessments

19. Total Vocabulary
20. Following Directions
21. Reference Skills
22. Interpretations Skills
23. Total Reading

Personality Assessments

24. Self Reliance
25. Personal Worth
26. Personal Freedom
27. Feeling of Belonging
28. Withdrawal Tendencies
29. Nervous Symptoms
30. Total Personal Adjustment
31. Social Significance
32. Social Skills
33. Anti-Social Tendencies
34. Family Relations
35. Social Relations
36. Community Relations
37. Total Social Adjustment
38. Total Adjustment

Table 2

Correlation Coefficients Between Mathematical Verbal Problem Solving and 38 Selected Mental, Mathematical, Reading, and Personality Assessments

Selected Assessments	r	P
Total Intelligence	.823	.01
Verbal Intelligence	.792	.01
What Process Must You Use?	.790	.01
Non-Verbal Intelligence	.779	.01
Total Reading	.775	.01
Reference Skills in Reading	.749	.01
Arithmetic Concepts	.741	.01
Reading Vocabulary	.722	.01
Problems with No Numbers	.664	.01
Following Directions in Reading	.616	.01
Arithmetic Computation	.609	.01
Problems with Unnecessary Data	.600	.01
What is Given in the Problem?	.597	.01
Problems with Insufficient Data	.596	.01
Interpretation Skills in Reading	.593	.01
What is Asked in the Problem	.539	.01
Basic Facts in Mathematics	.516	.01
Feeling of Personal Worth	.379	.01
Total Personal Adjustment	.377	.01
Total Adjustment	.375	.01
Flexibility	.369	.01
Mathematical Vocabulary	.356	.01
Social Significance	.318	.01
Total Social Adjustment	.302	.01
Originality	.289	.01
Level of Intellectual Development	.284	.01
Social Relations	.284	.01
Self Reliance	.282	.01
Nervous Symptoms	.270	.01
Social Skills	.266	.01
Feeling of Personal Freedom	.264	.01
Community Relations	.259	.01
Fluency	.252	.05
Feeling of Belonging	.177	NS
Elaboration	.171	NS
Withdrawal Tendencies	.166	NS
Anti-Social Tendencies	.142	NS
Family Relations	.051	NS

The correlation coefficients between each of the 8 mental assessments and the mathematical verbal problem solving criterion score for all students is presented in Table 3. The Level of Intellectual Development, an indication of abstract thinking ability, had a relationship with mathematical verbal problem solving of .284, significant at the .01 level of confidence. The relationship indicates that the ability to develop mental operations for solving problems is related to the ability to solve verbal problems in mathematics.

Verbal, Non-Verbal, and Total Intelligence each had correlation coefficients significant at the .01 level of confidence. These coefficients were .792, .779, and .823 respectively, indicating that intelligence is highly related to the ability to solve verbal problems in mathematics.

Four areas of creativity were tested by The Torrance Test of Creative Thinking. The correlation coefficients received when each area was correlated with mathematical verbal problem solving ability were: (1) Fluency, .252; significant at the .05 level of confidence; (2) Flexibility, .369, significant at the .01 level of confidence; (3) Originality, .289, significant at the .01 level of confidence; and (4) Elaboration, .171, not significant. Fluency, the ability to think of a large number of ideas in a given period of time appeared to be only slightly related to verbal problem solving ability. Flexibility, thinking of different categories of ideas, and Originality, thinking of ususual categories of ideas, appeared to be moderately related to verbal problem solving ability. Elaboration, building details into an idea, was not significantly related to verbal problem solving ability.

Table 3

Summary of the Correlation Coefficients Between Mathematical Verbal Problem Solving and Eight Mental Assessments

Mental Assessments	r	P
Level of Intellectual Development	.284	.01
Verbal Intelligence	.792	.01
Non-Verbal Intelligence	.779	.01
Total Intelligence	.823	.01
Fluency	.252	.05
Flexibility	.369	.01
Originality	.289	.01
Elaboration	.171	NS

The correlation coefficients between the 10 mathematical assessments and the mathematical verbal problem solving score were significant beyond the .01 level of confidence indicating that each mathematical skill was highly related to the ability to solve verbal problems in mathematics. Arithmetic Computation tested the ability to solve mathematical operations involving regrouping of tens and correlated .609 with mathematical verbal problem solving. Knowledge of Basic Facts, testing knowledge of the 100 basic combination facts in addition and subtraction, and the 90 basic combination facts in multiplication and division, correlated .516 with mathematical verbal problem solving scores. Arithmetic Concepts, indicating the ability to apply fundamental principles of mathematics, was highly related to solving verbal problems as a correlation coefficient of .741 was obtained.

Solving Problems with Unnecessary Data, Solving Problems with Insufficient Data, and Solving Problems with No Numbers, developed by Dr. Horace Otis Beldin, received correlation coefficients of .600, .596, and .664 respectively. Solving Problems with Unnecessary Data was composed of verbal problems which contained numerals not essential to the correct solution of the problem. Solving Problems with Insufficient Data tested the ability to recognize that numerals necessary to the correct solution of the problem had been omitted. Solving Problems with No Numbers examined the skill of solving mathematical situations involving words rather than numerals in the solution. Results of the correlation statistic indicated that each area was highly related to solving verbal problems in mathematics.

Mathematical Vocabulary received a correlation coefficient of .356 with mathematical verbal problem solving when the Pearson product moment correlation coefficient was computed. An understanding of the mathematical terms used in verbal problems was found to be related to mathematical verbal problem solving ability as the correlation coefficient was significant at the .01 level of confidence.

Correlation coefficients obtained for the three steps of formal analysis were: (1) What is Asked in the Problem? .539; (2) What is Given in the Problem? .597; and (3) What Process Must You Use? .790. The first step examines the ability to determine specifically the question raised in the verbal problem. Determining the facts necessary to solution of the problem is tested by the second step of formal analysis. The third step, determining the mathematical process appropriate to problem solution, appeared to be the most difficult step for the low achievers and resulted therefore in a high relationship to verbal problem solving ability. The correlation coefficients between each of the 10 mathematical assessments and verbal problem solving ability are presented in Table 4.

Table 4

Summary of the Correlation Coefficients Between Mathematical Verbal Problem Solving and Ten Mathematical Assessments

Mathematical Assessments	r	P
Arithmetic Computation	.609	.01
Arithmetic Concepts	.741	.01
Knowledge of Basic Facts	.516	.01
Solving Problems with Unnecessary Data	.600	.01
Solving Problems with Insufficient Data	.596	.01
Solving Problems with No Numbers	.664	.01
Mathematical Vocabulary	.356	.01
What is Asked in the Problem?	.539	.01
What is Given in the Problem?	.597	.01
What Process Must You Use?	.790	.01

The five reading assessments tested by the California Reading Test obtained correlation coefficients significant beyond the .01 level of confidence. Reference Skills in Reading received the highest correlation with mathematical verbal problem solving of any single reading skill, .749. The large correlation coefficients obtained indicate that a high relationship exists between reading skills and the ability to solve verbal problems in mathematics.

Reading Vocabulary, composed of items which sample mathematics, science, social science, general, and reading terms, correlated .772 with mathematical verbal problem solving scores. Following Directions in Reading tests the ability to follow directions involving simple and complex choices and correlated .616 with mathematical verbal problem solving scores. Reference Skills in Reading, measuring the extent to which pupils possess the vocabulary and skills needed for reference work and simple research, correlated .749 with mathematical verbal problem solving scores. The items test familiarity with parts of books, tables of contents, indexes, ability to alphabetize, and graph and map reading skills. Interpretation Skills in Reading measured the ability to comprehend facts, select topics or main ideas, make inferences and deductions, and reconstruct sequences of ideas and received the lowest correlation coefficient with verbal problem solving scores, .593. The Total Reading score reflected a combination of each individual reading skill tested by the reading achievement test and correlated .775 with mathematical verbal problem solving scores. Table 5 summarizes the correlation coefficients obtained between mathematical verbal problem solving scores and the five reading scores obtained.

Table 5

Summary of the Correlation Coefficients Between Mathematical Verbal Problem Solving Scores and Five Reading Assessments

Reading Assessments	r	P
Reading Vocabulary	.722	.01
Following Directions in Reading	.616	.01
Reference Skills in Reading	.749	.01
Interpretation Skills in Reading	.593	.01
Total Reading	.775	.01

Scores for 12 separate factors of personality and 3 total adjustment scores were obtained using the California Test of Personality. Each area with the exception of Feeling of Belonging and Withdrawal Tendencies was significantly correlated at the .01 level of confidence with mathematical verbal problem solving scores. The 6 indices of personal adjustment and correlation coefficients obtained when computed in a Pearson product moment correlation were: (1) Self-Reliance, directing one's own activities, .282; (2) Sense of Personal Worth, believing that others have faith in your future success, .379; (3) Sense of Personal Freedom, setting the general policies that govern one's life, .264; (4) Feeling of Belonging, representing membership in the peer group, .177; (5) Withdrawal Tendencies, substituting fantasy for success in real life, .166; and (6) Nervous Symptoms, exhibiting physical expressions of emotional conflicts, .270. The Total Personal Adjustment score reflects a combination of the six individual personality characteristics tested and received a correlation coefficient of .377.

Correlation coefficients obtained with 6 social adjustment characteristics were: (1) Social Standards, recognizing the rights of others and understanding what is regarded as right or wrong, .318; (2) Social Skills, showing a liking for people, .266; (3) Anti-Social Tendencies, endeavoring to get satisfaction in ways that are damaging and unfair to others, .142; (4) Family Relations, having a sense of security and self-respect with various members of the family, .051; (5) School Relations, finding school work adapted to appropriate levels of interest and maturity, .284; and (6) Community Relations, taking pride in community improvements and dealing tolerantly with strangers and foreigners, .259. Total Social Adjustment represents a combination of the six individual social characteristics tested and received a correlation coefficient of .302. Anti-Social Tendencies and Family Relations were not significantly correlated with mathematical verbal problem solving; [illegible] other areas of social adjustment were significantly [illegible]d with mathematical verbal problem solving at the .01 level of confidence. The Total Adjustment score reflected a combination of personal and social traits and correlated with mathematical verbal problem solving .375, significant at the .01 level of confidence. Table 6 presents a summary of the correlation coefficients between mathematical verbal problem solving scores and the 15 personality assessments.

Table 6

Summary of the Correlation Coefficients Between Mathematical Verbal Problem Solving and Fifteen Personality Assessments

Personality Assessments	r	P
Self-Reliance	.282	.01
Sense of Personal Worth	.379	.01
Sense of Personal Freedom	.264	.01
Feeling of Belonging	.171	.01
Withdrawal Tendencies	.166	.01
Nervous Symptoms	.270	.01
Total Personal Adjustment	.377	.01
Social Standards	.318	.01
Social Skills	.266	.01
Anti-Social Tendencies	.142	.01
Family Relations	.051	.01
Social Relations	.284	.01
Community Relations	.259	.01
Total Social Adjustment	.302	.01
Total Adjustment	.375	.01

COMMON VARIANCE IN MATHEMATICAL VERBAL PROBLEM SOLVING ACCOUNTED FOR BY THE INDIVIDUAL ASSESSMENTS

The second question posed in this investigation was:

What percent of the common variance in a verbal problem solving situation in mathematics can be accounted for by the individual mental, mathematical, reading, and personality assessments?

The computed Pearson product moment correlation coefficients were squared to determine how accurately each of the 38 assessments approximates 100 percent of the variance in the ability to solve mathematical verbal problems. The difference between the actual contribution of the assessments and 100 percent is error variance, or variance due to skills of mathematical verbal problem solving not identified in this study.

The mental assessment identifying the largest amount of variance was Total Intelligence, 67.7 percent. Verbal Intelligence was the second highest with 62.7 percent of the variance identified, followed by Non-Verbal Intelligence, 60.0 percent. The creativity tests identified a combined 31.1 percent with the individual tests as follows: (1) Fluency, 6.3 percent; (2) Flexibility, 13.6 percent; (3) Originality, 8.3 percent; and (4) Elaboration, 2.9 percent. Level of Intellectual Development identified 8.1 percent.

The largest percent of variance identified by the mathematical assessments was What Process Must You Use, 62.4 percent. Knowledge of Basic Facts and What is Asked in the Problem identified approximately the same amount of variance, 26.6 percent and 29.0 percent respectively. All other mathematical assessments identified percentages ranging from 35.5 percent to 54.9 percent.

Total Reading identified 60 percent of the variance and was followed by Reference Skills in Reading, 56.1 percent. Reading Vocabulary also accounted for a large percent of the variance, 52.1 percent. Following Directions in Reading, 37.9 percent, and Interpretation Skills in Reading, 35.1 percent were not as effective in identifying variance. Reference Skills in Reading appears to be the reading skill most useful in solving verbal problems in mathematics.

Although most areas of the personality assessments were significantly correlated with mathematical verbal problem solving, the variance identified by each assessment individually was extremely small. The largest percent of variance identified was 14.3 percent, Sense of Personal Worth. The smallest percent of variance identified was .2 percent, Anti-Social Tendencies. Table 7 presents a summary of the common variances between each of the 38 assessments and mathematical verbal problem solving.

Table 7

Common Variance in Mathematical Verbal Problem Solving Accounted for by the 38 Individual Assessments

Selected Assessments	r	Percent of Common Variance	Percent of Error Variance
Mental Assessments			
Level of Intellectual Development	.284	8.1	91.9
Verbal Intelligence	.792	62.7	37.3
Non-Verbal Intelligence	.779	60.6	39.4
Total Intelligence	.823	67.7	32.3
Creativity:			
Fluency	.252	6.3	93.7
Flexibility	.369	13.6	86.4
Originality	.289	8.3	91.7
Elaboration	.171	2.9	97.1
Mathematical Assessments			
Arithmetic Computation	.609	37.0	63.0
Arithmetic Concepts	.741	54.9	45.1
Knowledge of Basic Facts	.516	54.9	45.1
Solving Problems with Unnecessary Data	.600	36.0	64.0
Solving Problems with Insufficient Data	.596	35.5	64.5
Solving Problems with No Numbers	.664	44.0	56.0
Formal Analysis:			
What is Asked in the Problem?	.539	29.0	71.0
What is Given in the Problem?	.597	35.6	64.4
What Process Must You Use?	.790	62.4	37.6

Table 7 Continued

Selected Assessments	r	Percent of Common Variance	Percent of Error Variance
Reading Assessments			
Total Vocabulary	.722	52.1	47.9
Following Directions in Reading	.616	37.9	62.1
Reference Skills in Reading	.749	56.1	43.9
Interpretation Skills in Reading	.593	35.1	64.9
Total Reading	.775	60.0	40.0
Personality Assessments			
Self-Reliance	.282	7.9	92.1
Personal Worth	.379	14.3	85.7
Personal Freedom	.264	6.9	93.1
Feeling of Belonging	.177	3.1	96.9
Withdrawal Tendencies	.166	2.7	97.3
Nervous Symptoms	.270	7.2	92.8
Total Personal Adjustment	.377	14.2	85.8
Social Significance	.318	10.1	89.9
Social Skills	.266	7.0	93.0
Anti-Social Tendencies	.142	2.0	98.0
Family Relations	.051	.2	99.8
Social Relations	.284	8.0	92.0
Community Relations	.259	6.7	93.3
Total Social Adjustment	.302	9.1	90.0
Total Adjustment	.375	14.0	86.0

SELECTION OF PREDICTOR ASSESSMENTS FOR THE FOUR DISCRIMINANT ANALYSIS TEST BATTERIES

The third question posed in this investigation was:

> Can a combination of mental, mathematical, reading, and personality assessments predict the high and low achievers in mathematical verbal problem solving?

The 38 mental, mathematical, reading, and personality assessments were statistically evaluated to select a combination of assessments having high predictive power in discriminating high and low achievers in mathematical verbal problem solving. The scores of 56 high achievers and 56 low achievers were examined by the following statistical methods: (1) Pearson product moment correlation; (2) _t_ test for independent groups; and (3) factor analysis. Four batteries having high prediction value were obtained.

The Pearson product moment correlation coefficient indicated the strength of the relationship between mathematical verbal problem solving and the 38 assessments. These correlation coefficients were rank ordered, as revealed in Table 2, and a battery of the 11 assessments having highest relationships with mathematical verbal problem solving was obtained. Eleven assessments were chosen on the basis of 10 students per assessment as requred for the discriminant analysis statistic. The assessments in this battery referred to herein as "The Correlation Test Battery," were: (1) Total Intelligence; (2) Verbal Intelligence; (3) What Process Must You Use?

(4) Non-Verbal Intelligence; (5) Total Reading; (6) Reference Skills in Reading; (7) Arithmetic Concepts; (8) Reading Vocabulary; (9) Solving Problems with No Numbers; (10) Following Directions in Reading; and (11) Arithmetic Computation.

The Correlation Battery operated with 70 percent accuracy, correctly placing 39 of the 56 high achievers into the high group. Thirty-seven of the 56 low achievers were correctly placed into the low group representing 66 percent accuracy for the battery. A Mahalanobis D^2 of 23.480 was found to be significant at the .05 level of confidence. Table 8 summarizes the assessments in this battery and the effectiveness with which the discriminant analysis differentiated between high and low achievers in verbal problem solving.

Table 8

Discriminant Analysis of High and Low Achievers in Verbal Problem Solving Using the Correlation Test Battery

Test Battery	r	D^2	P	Percent Placed High	Percent Placed Low
Total Intelligence	.823				
Verbal Intelligence	.792				
What Process Must You Use?	.790				
Non-Verbal Intelligence	.779				
Total Reading	.775				
Reference Skills	.749	23.480	.05	70	60
Arithmetic Concepts	.741				
Reading Vocabulary	.722				
Problems with No Numbers	.664				
Following Directions	.616				
Arithmetic Computation	.609				

The second battery of assessments computed in a discriminant analysis of high and low achievers in verbal problem solving was selected through the process of analysis of variance. All 38 scores for the 112 pupils were statistically converted to standard T scores and group mean scores were obtained for high and low achievers on each assessment. The *t* test for independent groups was computed between the group mean scores of high and low achievers on each of the 38 mental, mathematical, reading, and personality assessments. Table 9 presents these values in rank order and Figure 1 presents a summary of the separation of mean scores for both groups of pupils. The assessments which had the 11 largest *t* values were combined for the second battery, "The *t* Test Battery." This battery consisted of: (1) What Process Must You Use? (2) Total Intelligence; (3) Total Reading; (4) Verbal Intelligence; (5) Non-Verbal Intelligence; (6) Reference Skills in Reading; (7) Reading Vocabulary; (8) Interpretations Skills in Reading; (9) Arithmetic Concepts; (10) Solving Problems with No Numbers; and (11) What is Given in the Problem?

The *t* Test Battery correctly placed 39 of 56 high achievers into the high group reflecting a 70 percent degree of accuracy. Operating with 68 percent accuracy, the *t* Test Battery correctly placed 38 of 56 low achievers into the low group. A Mahalanobis D^2 of 21,565 was obtained indicating a separation of high and low achievers significant at the .05 level of confidence as shown in Table 10.

Table 9

Summary of the t Test Values Between-Group Mean Scores of High and Low Achievers on 38 Selected Assessments

Assessment	High	Low	t	P
What Process Must You Use?	57.946	42.089	14.221	.001
Total Intelligence	57.928	42.125	13.576	.001
Total Reading	57.750	42.472	12.553	.001
Verbal Intelligence	57.500	42.535	11.991	.001
Non-Verbal Intelligence	57.553	42.553	11.727	.001
Reference Skills	57.321	42.678	11.324	.001
Reading Vocabulary	57.267	42.696	11.191	.001
Interpretation Skills	55.250	44.000	10.653	.001
Arithmetic Concepts	56.571	43.589	9.135	.001
Problems with No Numbers	56.571	43.785	8.903	.001
What is Given?	56.232	44.240	7.756	.001
What is Asked?	55.464	44.309	7.224	.001
Unnecessary Data	55.642	44.428	7.206	.001
Arithmetic Computation	55.553	44.375	7.092	.001
Knowledge of Basic Facts	55.553	44.464	7.063	.001
Following Directions	55.607	44.596	6.929	.001
Insufficient Data	54.982	45.071	6.084	.001
Flexibility	59.910	49.375	5.174	.001
Mathematical Vocabulary	53.303	46.678	3.707	.001
Intellectual Development	53.482	47.000	3.668	.001
Personal Worth	53.196	46.250	3.527	.001
Total Personal Adjustment	53.196	46.982	3.510	.001
Total Adjustment	52.892	47.035	3.239	.01
Self-Reliance	52.910	47.107	3.207	.01
Fluency	59.375	51.964	3.165	.01
Social Significance	52.877	47.803	2.753	.01
Originality	58.508	51.636	2.668	.01
Personal Freedom	52.392	47.535	2.642	.05
Nervous Symptoms	52.321	47.750	2.470	.05
Social Relations	52.089	47.696	2.436	.05
Total Social Adjustment	52.178	47.803	2.371	.05
Social Skills	52.125	47.839	2.321	.05
Withdrawal Tendencies	51.660	48.375	1.768	NS
Anti-Social Tendencies	51.196	48.803	1.276	NS
Community Relations	50.649	48.160	1.260	NS
Feeling of Belonging	51.071	48.785	1.187	NS
Elaboration	42.719	41.403	.837	NS
Family Relations	49.303	50.410	.588	NS

Figure 1

Summary of the Group Mean Scores of High and Low Achievers on 38 Selected Assessments

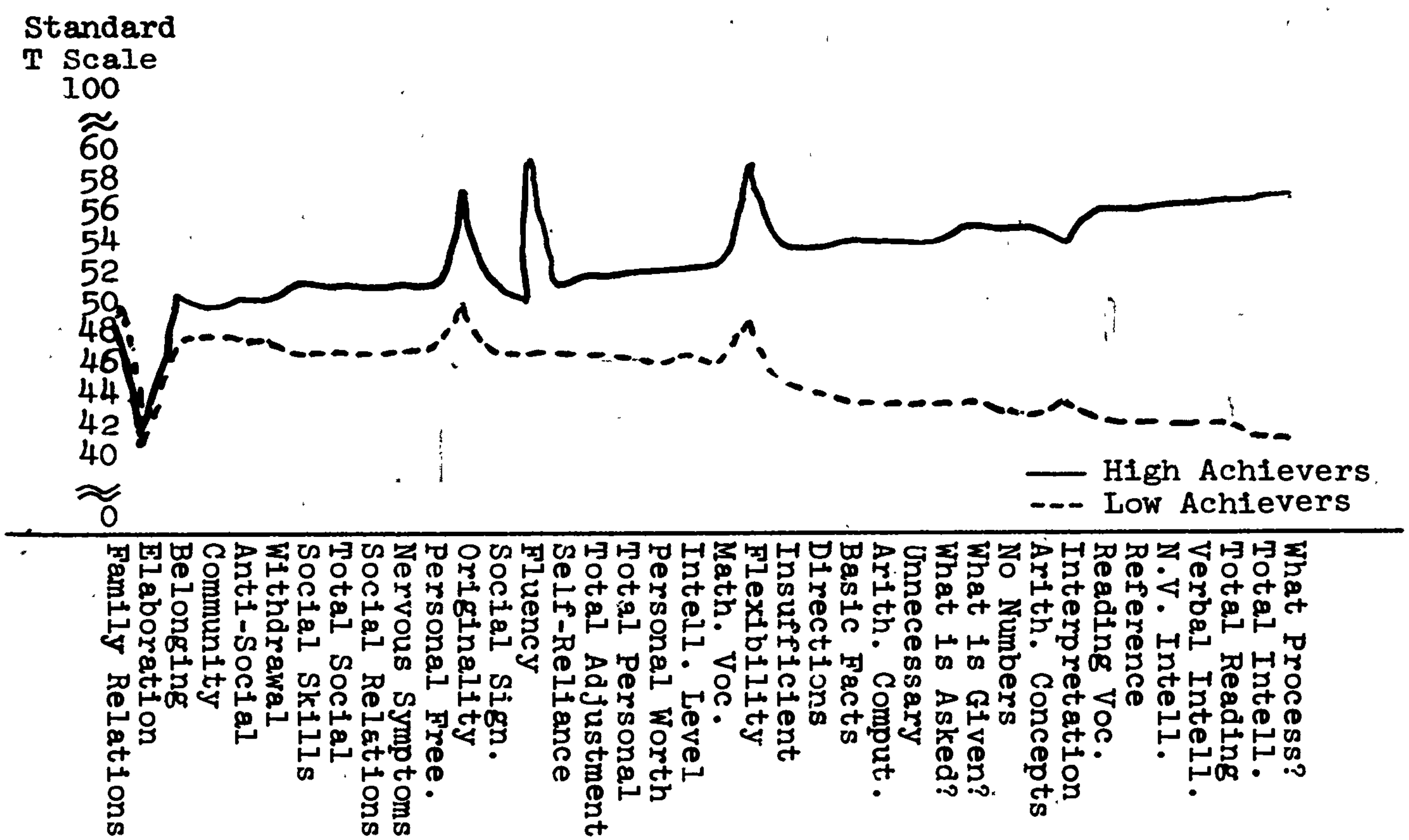


Table 10

Discriminant Analysis of High and Low Achievers in Verbal Problem Solving Using the t Test Battery

Test Battery	t Value	D^2	P	Percent Placed High	Percent Placed Low
What Process Must You Use?	14.221				
Total Intelligence	13.576				
Total Reading	12.553				
Verbal Intelligence	11.991				
Non-Verbal Intelligence	11.727				
Reference Skills in Reading	11.324	21.565	.05	70	68
Reading Vocabulary	11.191				
Interpretation Skills	10.653				
Arithmetic Concepts	9.135				
Problems with No Numbers	8.903				
What is Given?	7.756				

The third and fourth batteries for discriminant analysis resulted from the factor analysis statistical procedure. Seventy-two percent of the variation in the 38 scores for 112 pupils was accounted for by seven basic categories, or factors (see Table 11).

The third test battery, referred to herein as "The Short Factor Analysis Battery," was formed by selecting two assessments to represent Factor VI and one assessment to represent each of the other six factors. The eight assessments selected as representative of the seven factors were: (1) Total Intelligence, Factor I; (2) Total Social Adjustment, Factor II; (3) Fluency, Factor III; (4) Withdrawal Tendencies, Factor IV; (5) What is Asked? Factor V; (6) Mathematical Vocabulary, Factor VI; (7) Family Relations, Factor VI; and (8) Level of Intellectual Development, Factor VII. All assessments had low intercorrelations (Table 12) and high factor loadings (Table 13).

Table 11

Rotated Factor Matrix of 38 Mental, Mathematical, Reading, and Personality Assessments

Assessments	I	II	III	Factors IV	V	VI	VII
Level of Intellectual Development	0.24962	0.03248	-0.01095	0.03315	0.05303	-0.02580	0.84851
Verbal Intelligence	0.88293	0.14976	0.15118	0.15443	0.05021	-0.12534	0.01261
Non-Verbal Intelligence	0.85217	0.09116	0.14267	0.12655	0.07362	-0.06275	0.06743
Total Intelligence	0.91986	0.11707	0.17080	0.12387	0.04654	-0.09507	0.04089
Fluency	0.14201	0.01164	0.89340	-0.05266	-0.09566	-0.00065	-0.07370
Flexibility	0.23793	0.07331	0.87752	0.05873	0.14538	-0.04910	-0.02942
Originality	0.18909	0.02098	0.85423	0.03210	0.09219	0.04910	0.12469
Elaboration	0.12932	0.22932	0.50059	0.02120	-0.42416	-0.10831	-0.03216
Arithmetic Computation	0.59820	0.21202	0.06290	0.00958	0.14552	-0.06558	0.46368
Arithmetic Concepts	0.74796	0.01475	0.03224	0.14429	0.18509	0.08231	0.17414
Basic Facts in Mathematics	0.65930	-0.08026	0.01111	0.15988	0.31254	-0.01505	0.01234
Unnecessary Data in Problems	0.66911	0.05111	-0.09291	0.19498	0.29806	-0.14434	-0.00694
Insufficient Data in Problems	0.61092	0.19840	0.23381	0.17189	0.15337	0.04494	0.10985
Problems with No Numbers	0.75134	0.18608	0.07529	0.06653	0.16442	-0.03890	0.09462
Mathematical Vocabulary	0.46611	0.09633	-0.01706	0.12488	0.17333	-0.52605	0.08837
What is Asked in the Problem?	0.65507	0.06709	0.21696	0.15074	0.50679	-0.06615	-0.02936
What is Given in the Problem?	0.60193	0.12105	0.35107	0.04643	0.42649	-0.09724	0.11947
What Process Must You Use?	0.80624	0.05184	0.25514	0.11022	0.21976	-0.09584	0.10053
Reading Vocabulary	0.87205	0.11457	0.09527	0.05218	0.01989	-0.01628	-0.02216
Following Directions in Reading	0.78258	0.34312	0.05903	0.11289	0.01250	0.07644	-0.00449
Reference Skills in Reading	0.83394	0.24603	0.08230	0.04414	0.01575	0.01911	0.10335
Interpretation Skills in Reading	0.71358	0.19095	0.00117	-0.01284	0.16192	-0.03612	-0.01460
Total Reading	0.92210	0.21333	0.08620	0.01789	0.01855	0.00550	0.02433
Self Reliance	0.23271	0.48071	0.15320	0.37025	0.03921	0.31850	0.21138
Feeling of Personal Worth	0.25099	0.29996	0.33690	0.55302	-0.25369	-0.19264	0.09187
Feeling of Personal Freedom	0.11298	0.17864	0.08314	0.42995	-0.22752	-0.57018	-0.01099
Feeling of Belonging	0.03646	0.37283	0.16965	0.59163	-0.12734	-0.22314	0.01567
Withdrawal Tendencies	0.00656	0.11962	0.10312	0.85589	0.18423	-0.07735	0.07796
Nervous Symptoms	0.23055	0.14780	-0.11045	0.74061	0.08565	0.04770	-0.10879
Total Personal Adjustment	0.21667	0.37312	0.10144	0.84699	-0.07969	-0.20772	0.05098
Social Significance	0.24983	0.68046	0.11067	-0.00997	0.01933	-0.22861	-0.07266
Social Skills	0.16455	0.79380	0.00525	0.09672	-0.25115	0.09702	-0.11498
Anti-Social Tendencies	0.07983	0.68340	-0.09971	0.28833	0.12431	-0.03249	0.18980
Family Relations	-0.10435	0.46170	0.08083	0.26304	0.04828	-0.61775	0.03681
Social Relations	0.17474	0.67809	0.04825	0.40631	0.00288	0.00330	0.00669
Community Relations	0.21233	0.75508	0.11186	0.07207	0.01434	-0.09446	0.06883
Total Social Adjustment	0.17692	0.90855	0.03314	0.27750	0.00382	-0.20239	0.04004
Total Adjustment	0.21794	0.71517	0.07389	0.61270	-0.04027	-0.22620	0.05060

Table 12

Intercorrelations of Assessments in the Short Factor Analysis Battery

	Assessments	1	2	3	4	5	6	7	8
1.	Total Intelligence	1.000							
2.	Total Social Adjustment	.341	1.000						
3.	Fluency	.281	.039	1.000					
4.	Withdrawal Symptoms	.100	.369	.120	1.000				
5.	What is Asked?	.618	.222	.188	.166	1.000			
6.	Mathematical Vocabulary	.515	.312	.042	.220	.369	1.000		
7.	Family Relations	.086	.628	.027	.313	.037	.281	1.000	
8.	Intellectual Development	.273	.112	.038	.065	.185	.158	.083	1.000

Table 13

Rotated Factor Matrix of Assessments in the Short Factor Analysis Battery

Assessments	Factors I	II	III	IV	V	VI	VII
Total Intelligence	.91986	.11707	.17080	.12387	-.04654	-.09507	.04089
Total Social Adjustment	.17692	.90855	.03314	.27750	.00382	-.20239	.04004
Fluency	.14201	-.01164	.89340	-.05266	-.09566	-.00065	-.07370
Withdrawal Symptoms	.00656	.11962	-.10312	.85569	.18423	-.07735	.07796
What is Asked?	.65507	.06709	.21696	.15074	.60579	-.06615	-.02936
Mathematical Vocabulary	.46611	.09633	-.01706	.12488	.17333	.52605	.08837
Family Relations	.10436	.46170	.08083	.26304	.04828	.61775	.03681
Intellectual Development	.24962	.03248	-.01095	.03315	.05303	.02580	.84851

Using The Short Factor Analysis Battery, 52 of 56 high achievers were correctly placed into the high group reflecting 93 percent accuracy. Fifty-one of 56 low achievers were correctly placed into the low group, representing 91 percent accuracy. The discriminating power of The Short Factor Analysis Battery was revealed in a Mahalanobis D^2 of 231.829, significant beyond the .001 level of confidence. Table 14 presents the results of the discriminant analysis using The Short Factor Analysis Battery.

Table 14

Discriminant Analysis of High and Low Achievers in Verbal Problem Solving Using the Short Factor Analysis Battery

Test Battery	Factor Loading	D^2	P	Percent Placed High	Percent Placed Low
Total Intelligence	.91986				
Total Social Adjustment	.90855				
Fluency	.89340				
Withdrawal Tendencies	.85589	231.829	.001	93	91
What is Asked?	.50679				
Mathematical Vocabulary	.52605				
Family Relations	.61775				
Intellectual Development	.84851				

The fourth battery, "The Long Factor Analysis Battery," included the eight assessments of the Short Factor Analysis Battery and three additional assessments: (1) Total Reading; (2) Flexibility; and (3) Originality. The Total Reading score was included because of a high factor loading on Factor I (see Table 11). The partial correlation statistic was computed between mathematical verbal problem solving and total intelligence with the effects of total reading removed in an effort to substantiate that the residual relationship was meaningful. The effects of total intelligence were removed from the relationship of mathematical verbal problem solving and total reading in like manner. Both residual relationships were significant when investigated with the t test of significance. The partial correlation statistic was employed to verify that although variance is shared between Total Intelligence and Total Reading, both tests have variance independent of the other. A summary of the partial correlation results is in Table 15.

Table 15

Summary of Two Partial Correlation Procedures

Source	r	t	P
Relation of Mathematical Verbal Problem Solving and Intelligence with Effects of Total Reading Removed	.476	10.818	.001
Relation of Mathematical Verbal Problem Solving and Total Reading with Effects of Intelligence Removed	.201	2.871	.01

Flexibility and Originality were taken from Factor III to accompany Fluency as all are measures of creativity. The intercorrelations of this Long Factor Analysis Battery are in Table 16 and the factor loadings taken from the rotated factor matrix are found in Table 17.

Table 16

Intercorrelations of Assessments in the Long Factor Analysis Battery

Assessments	1	2	3	4	5	6	7	8	9	10	11
1. Total Intelligence	1.000										
2. Total Social Adjustment	.341	1.000									
3. Fluency	.281	.039	1.000								
4. Withdrawal Tendencies	.100	.369	.120	1.000							
5. What is Asked in the Problem?	.618	.222	.188	.166	1.000						
6. Mathematical Vocabulary	.515	.312	.042	.220	.369	1.000					
7. Family Relations	.086	.628	.027	.313	.037	.281	1.000				
8. Level of Intellectual Development	.273	.112	-.038	.085	.185	.158	.038	1.000			
9. Total Reading	.876	.345	.199	.057	.638	.441	.051	.299	1.000		
10. Flexibility	.400	.183	.804	.008	.385	.148	.180	.075	.317	1.000	
11. Originality	.323	.057	.693	.041	.308	.197	.030	.125	.239	.781	1.000

Table 17

Rotated Factor Matrix of Assessments in the Long Factor Analysis Battery

Assessments	I	II	III	IV	V	VI	VII
Total Intelligence	.91986	.11707	.17080	.12387	-.04654	-.09507	.04089
Total Social Adjustment	.17692	.90855	.03314	.27750	.00382	-.20239	.04004
Fluency	.14201	-.01164	.89340	-.05266	-.09566	-.00065	-.07370
Withdrawal Symptoms	.00656	.11962	-.10312	.85589	.18423	-.07735	.07796
What is Asked?	.65507	.06709	.21696	.15074	.50679	-.06615	-.02936
Mathematical Vocabulary	.46611	.09633	-.01706	.12488	.17333	.52605	.08837
Family Relations	.10436	.46170	.08083	.26304	.04828	.61775	.03681
Intellectual Development	.24962	.03248	-.01095	.03315	.05303	.02580	.84851
Total Reading	.92210	.21333	.08620	.01789	.01855	.00550	.02433
Flexibility	.23793	.07331	.87752	.05873	.14538	.08025	.02942
Originality	.18909	.02098	.85423	.03210	.09319	.04910	.12469

The percent of correct placement using The Long Factor Analysis Battery was the highest attained with any of the four batteries; 95 percent of the high achievers and 93 percent of the low achievers were placed into the proper classifications. A Mahalanobis D^2 of 272.480, significant beyond the .001 level of confidence, was obtained as revealed in Table 18.

Table 18

Discriminant Analysis of High and Low Achievers in Verbal Problem Solving Using the Long Factor Analysis Battery

Test Battery	Factor Loading	D^2	P	Percent Placed High	Percent Placed Low
Total Intelligence	.91986				
Total Social Adjustment	.90855				
Fluency	.89340				
Withdrawal Tendencies	.85589				
What is Asked?	.50679				
Mathematical Vocabulary	.52605	272.480	.001	95	93
Family Relations	.61775				
Intellectual Development	.84851				
Total Reading	.83394				
Flexibility	.87752				
Originality	.85423				

SUMMARY OF THE DISCRIMINANT ANALYSES OF HIGH AND LOW ACHIEVERS IN MATHEMATICAL VERBAL PROBLEM SOLVING

The purpose of this investigation was to select a combination of assessments from the 38 mental, mathematical, reading, and personality assessments capable of distinguishing between high and low achievers in mathematical verbal problem solving. These assessments could then be emphasized as areas of concentration in elementary classrooms to enable more pupils to be high achievers in mathematical verbal problem solving.

Using three statistical techniques, Pearson product moment correlation, _t_ test of independent groups, and factor analysis, four combinations of assessments were selected that had high predictive powers in differentiating between high and low achievers in mathematical verbal problem solving. Each test battery computed in a discriminant analysis was effective in placing the high and low achievers in mathematical verbal problem solving into the same classifications as the criterion for placement, the Arithmetic Applications score of the Stanford Achievement Test. Table 19 presents a summary of the percent of correct placement using the four batteries as compared with 100 percent placement by the verbal problem solving criterion score.

The first combination, The Correlation Test Battery, was composed of 11 assessments selected on the basis of their rank ordered correlation coefficients with mathematical verbal problem solving: (1) Total Intelligence; (2) Verbal Intelligence; (3) What Process Must You Use? (4) Non-Verbal Intelligence; (5) Total Reading; (6) Reference Skills in Reading; (7) Arithmetic Concepts; (8) Reading Vocabulary; (9) Solving Problems with No Numbers; (10) Following Directions in Reading; and (11) Arithmetic Computation.

Table 19

Summary of Four Discriminant Analyses of High and Low Achievers in Mathematical Verbal Problem Solving

Test Battery	D^2	P	Placement by Criterion		Placement by Battery	
			Number	Percent	Number	Percent
Correlation Test Battery	23.480	.01				
High Achievers			56	100	39	70
Low Achievers			56	100	37	66
T Test Battery	21.565	.05				
High Achievers			56	100	39	70
Low Achievers			56	100	38	68
Short Factor Analysis Battery	231.829	.001				
High Achievers			56	100	52	93
Low Achievers			56	100	51	91
Long Factor Analysis Battery	272.480	.001				
High Achievers			56	100	53	95
Low Achievers			56	100	52	93

The Correlation Test Battery in a discriminant analysis yielded a Mahalanobis D^2 of 23.480, significant beyond the .05 level of confidence. Thirty-nine of 56 high achievers were correctly placed representing 70 percent accuracy. In the low achiever group, 37 of 56 pupils were correctly placed for a 66 percent degree of accuracy.

The second combination is known as The t Test Battery and the variables were: (1) What Process Must You Use? (2) Total Intelligence; (3) Total Reading; (4) Verbal Intelligence; (5) Non-Verbal Intelligence; (6) Reference Skills in Reading; (7) Reading Vocabulary; (8) Interpretation Skills in Reading; (9) Arithmetic Concepts; (10) Solving Problems with No Numbers; and (11) What is Given in the Problem? A Mahalanobis D^2 of 23.565 resulted from the battery and was significant beyond the .05 level of confidence. The t Test Battery placed 70 percent of the high achievers, 39 of 56 pupils, and 68 percent of the low achievers, 38 of 56 pupils.

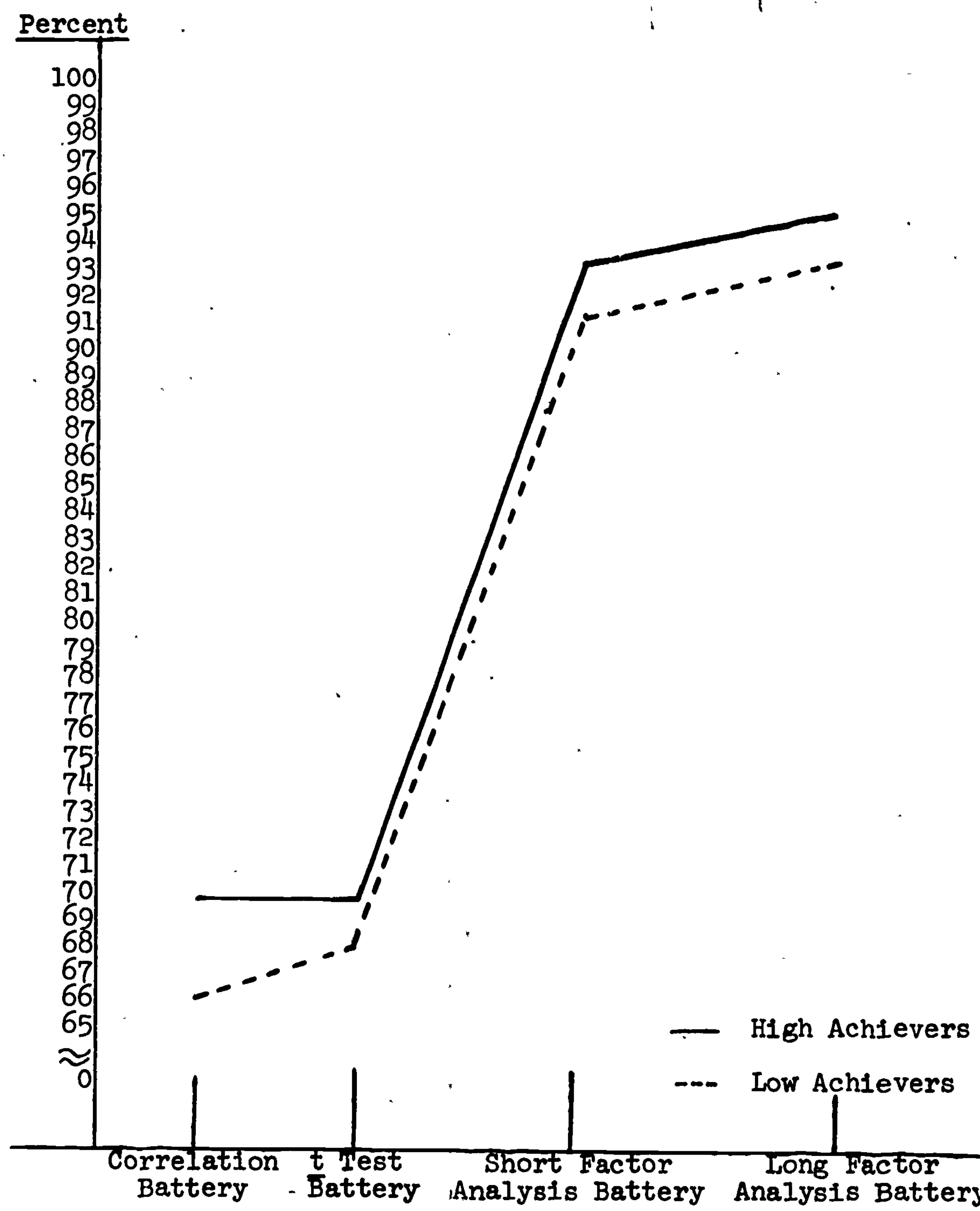
The third battery, The Short Factor Analysis Battery, consisted of: (1) Total Intelligence; (2) Total Social Adjustment; (3) Fluency; (4) Withdrawal Tendencies; (5) What is Asked in the Problem? (6) Mathematical Vocabulary; (7) Family Relations; and (8) Level of Intellectual Development. Fifty-two of 56 high achievers were correctly placed in a discriminant analysis of the Short Factor Analysis Battery representing a 93 percent degree of accuracy. Fifty-one of the 56 low achievers were correctly placed representing an accuracy of 91 percent. A Mahalanobis D^2 of 231.829, significant beyond the .001 level of confidence, resulted using this battery.

A fourth battery, The Long Factor Analysis Battery, incorporated The Short Factor Analysis Battery and three additional assessments: (1) Total Reading; (2) Flexibility; and (3) Originality. A Mahalanobis D^2 of 272.480, significant beyond the .001 level of confidence, resulted with the use of The Long Factor Analysis Battery. Fifty-three of 56 high achievers, 95 percent, and 52 of 56 low achievers, 93 percent, were correctly placed into the respective groupings using the long battery.

Figure 2 presents a line graph of the four batteries to visualize the effectiveness of the separations into the high and low achiever classifications.

Figure 2

Summary of the Correct Placement into High and Low Achiever Classifications Using Four Test Batteries Computed in Discriminant Analyses



CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

The purpose of this investigation was to determine if selected mental, mathematical, reading, and personality assessments of sixth grade pupils could predict high achievers in mathematical verbal problem solving. The study was designed to analyze selected skills and abilities individually and in combination to determine their effectiveness in solving verbal problems in mathematics. The resulting assessments would then offer direction in elementary mathematics classrooms to enable more pupils to be high achievers in mathematical verbal problem solving.

The subjects for this study were an incidental sample of 112 sixth grade students selected from the total sixth grade population of 259 pupils in the city schools of Natchitoches, Louisiana, during the 1972-1973 school year. Fifty-six of the students were classified as high achievers in mathematical verbal problem solving and 56 were classified as low achievers according to criterion verbal problem solving scores available in cumulative school records.

Fifteen tests were administered during the two weeks of November 1, 1972 to November 15, 1972, yielding 38 mental, mathematical, reading, and personality assessments for each student. The tests used in the mental, mathematical, reading, and personality areas to obtain the assessments were:

Mental

1. Piaget's Pendulum Problem
2. California Short Form Test of Mental Maturity
3. Torrance Test of Creative Thinking, Figural Form

Mathematical

4. Stanford Achievement Test, Arithmetic Computation
5. Stanford Achievement Test, Arithmetic Concepts
6. Adston Diagnostic Test
7. Solving Problems with Unnecessary Data
8. Solving Problems without Numbers
9. Solving Problems with Insufficient Data
10. Mathematical Vocabulary
11. What is Asked in the Problem?
12. What is Given in the Problem?
13. What Process Must You Use?

Reading

14. California Reading Test

Personality

15. California Test of Personality

The 38 scores for each student were analyzed by the statistical techniques of correlation, analysis of variance, and factor analysis to determine combinations of assessments capable of identifying high and low achievers in mathematical verbal problem solving when computed in discriminant analyses.

Four batteries of assessments resulted from the statistical analyses of the scores in this investigation. The first battery, The Correlation Battery, operated with 70 percent accuracy in placing high achievers into the high group and with 66 percent accuracy in placing low achievers into the low group. The battery consisted of: (1) Total Intelligence; (2) Verbal Intelligence; (3) What Process Must You Use? (4) Non-Verbal Intelligence; (5) Total Reading; (6) Reference Skills in Reading; (7) Arithmetic Concepts; (8) Reading Vocabulary; (9) Solving Problems with No Numbers; (10) Following Directions in Reading; and (11) Arithmetic Computation.

The second battery, The *t* Test Battery, placed high achievers into the high classification with 70 percent accuracy and low achievers into the low classification with 68 percent accuracy. The assessments in this battery were: (1) What Process Must You Use? (2) Total Intelligence; (3) Total Reading; (4) Verbal Intelligence; (5) Non-Verbal Intelligence; (6) Reference Skills in Reading; (7) Reading Vocabulary; (8) Interpretation Skills in Reading; (9) Arithmetic Concepts; (10) Solving Problems with No Numbers; and (11) What is Given in the Problem?

The third and fourth batteries resulted from the factor analysis statistical procedure. The Short Factor Analysis Battery placed high achievers into the correct classification with 93 percent accuracy and low achievers with 91 percent accuracy. Assessments in this battery were: (1) Total Intelligence; (2) Total Social Adjustment; (3) Fluency; (4) Withdrawal Tendencies; (5) What is Asked in the Problem? (6) Mathematical Vocabulary; (7) Family Relations; and (8) Level of Intellectual Development.

The Long Factor Analysis Battery contained the eight assessments of The Short Factor Analysis Battery with three additional assessments: (1) Total Reading; (2) Flexibility; and (3) Originality. The most accurate separation of the groups was obtained using the long battery; 95 percent of the high achievers and 93 percent of the low achievers were placed into the classification as determined by the criterion verbal problem solving score.

CONCLUSIONS

Four discriminant analyses were computed for the purpose of identifying skills capable of differentiating between high and low achievers in mathematical verbal problem solving. The following conclusions seem justified based on the findings of the discriminant analyses in this investigation:

1. The Long Factor Analysis Test Battery is the best combination of assessments to correctly predict high achievers in mathematical verbal problem solving (see Table 18).

2. Total Intelligence is the greatest individual contributor to high achievement in verbal problem solving and was identified by all four batteries in discriminant analyses of high and low achievers in mathematical verbal problem solving.

3. Total Reading was selected as a variable in discriminant analysis for three of the four batteries and is useful in differentiating high and low achievers in mathematical verbal problem solving.

4. Determining the fundamental process to use when solving a verbal problem was identified by two of the four batteries as useful in differentiating between high and low achievers in mathematical verbal problem solving.

5. Reference Skills in Reading is the most effective single reading skill tested in differentiating between high and low achievers in mathematical verbal problem solving.

6. The individual who is intelligent and flexible in his thinking is likely to be a high achiever in mathematical verbal problem solving.

7. The level of intellectual development achieved by a pupil determines the ability to think abstractly and form mental operations for the solution of mathematical verbal problems.

RECOMMENDATIONS

The purpose of this investigation has been accomplished by identifying skills which in combination were capable of differentiating between high and low achievers in mathematical verbal problem solving. The author recommends that the following skills be stressed in sixth grade elementary mathematics classrooms to improve pupils' skills in mathematical verbal problem solving. As intelligence is not an assessment that can be taught directly, the assessment is excluded from consideration in the recommendations.

Recommendations offered are:

1. Providing activities to stress the reading interpretation skills of selecting main ideas, making inferences

and deductions, and constructing sequences of ideas should enable the sixth grade mathematics student to be a better verbal problem solver.

2. Activities designed to foster growth in following directions involving simple and complex choices should be provided in sixth grade mathematics classrooms.

3. Graph and map reading skills should be stressed in a mathematical verbal problems context.

4. Instruction in mathematical connotations of words used in verbal problems should be provided before the terms are used in a problem solving situation in mathematics.

5. Learning experiences should be provided for children to determine the main idea of a mathematical verbal problem.

6. Children should have experience with selecting specific facts given in the verbal problem which are essential to the solution of the problem.

7. Opportunities should be provided for children to choose the fundamental process or processes required for solution of mathematical verbal problems.

8. Children should have experience with verbal problems which contain unnecessary data, insufficient data, and no numbers.

9. Instruction should be provided to improve mathematical computation skills.

10. The elementary mathematics program should be relaxed and free of stress to encourage optimum personal and social adjustment.

11. A variety of mathematical learning experiences should be provided to increase opportunities for growth of creative potential.

12. Verbal problems involving abstract thought should be delayed until the children are capable of functioning at a formal operational stage of intellectual development.

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APPENDIX

APPENDIX A

The Committee of Seven

The Committee of Seven consisted of the following men: (1) Harry O. Gillet, principal of the University Elementary School, University of Chicago; (2) Floyd Goodier, superintendent of schools, Chicago Heights; (3) Raymond Osborne, principal of the Francis W. Parker School, Chicago, vice-chairman; (4) W. C. Reavis, principal of the University High School, University of Chicago; (5) J. R. Skiles, superintendent of schools, District 76, Evanston; (6) H. C. Storm, superintendent of schools, Batavia, secretary; (7) Carleton W. Washburne, superintendent of schools, Winnetka, chairman (Washburne & Osborne, 1926, p. 219).

APPENDIX B

Level of Intellectual Development
Piaget's Pendulum Problem

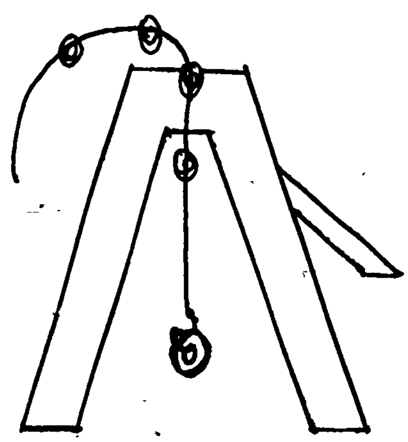
Thought processes advance because of neurological development, proper social and educational environment, experience, and internal cognitive reorganization according to Piagetian theory of intellectual development (Ginsburg & Opper, 1969, pp. 205-206).

Piaget describes the problem solving procedures of the pre-operational child (below 7 years of age) as haphazard, involving no overall plan or pattern. The concrete operational child (approximately 7 to 12 years of age) shows considerable improvement in a problem solving process but lacks the ability to formulate a plan for the solution or draw correct conclusions. The formal operational child (approximately 12 years of age and above) has reached the stage of planning procedures for solving problems and drawing logical conclusions from observations (Ginsburg & Opper, 1969, pp. 185-185).

The test used to indicate the level of mental operation at which a child functioned was Piaget's Pendulum Problem. A pendulum was constructed in the form of a weight suspended on a string. Each subject, tested individually, was shown how to vary the length of the string, change the weight of the suspended object, release the pendulum from various heights, and push the weight with varying degrees of force. The subject was required to discover which of the four factors, length, weight, height, or force, alone or in combination with others, affects the pendulum's frequency of oscillation. The correct response was that the major factor is length of the string.

The child functioning at the pre-operational stage of intellectual development is expected to haphazardly manipulate the device and may or may not reach the correct solution. The approach to the problem by the concrete operations child will be more systematic and very probably will reveal the correct solution, but without evidence of a plan or approach. The child functioning at the formal operational level can be expected to: (1) plan the test; (2) observe results accurately; and (3) draw logical conclusions from observations.

The apparatus used for the Pendulum Problem was constructed similar to the following model (Copeland, 1970):



Weights will be easily removable for varying the amounts. The string can be adjusted by lifting it out of a groove in the frame. A score of one will be assigned for the pre-operational level, two for the concrete operational level, and three for the formal operational level.

APPENDIX C

California Short Form Test
of Mental Maturity

The California Short Form Test of Mental Maturity provides information about the functional capacities basic to learning, solving problems, and responding to new situations. The test results are grouped into two sections, Language and Non-Language that differentiate between responses to stimuli that are primarily verbal in nature and responses to stimuli that are essentially non-verbal or pictorial.

The Language and Non-Language sections of the test each contain 60 items. The mean difficulty level and range of the two sections are similar. The total intelligence score is obtained by adding the Language and Non-Language sections together.

The technical manual which accompanies the California Short Form Test of Mental Maturity reports the following reliability coefficients determined by the Kuder-Richardson formula 21: (1) Language, .78; (2) Non-Language, .85; and (3) Total Intelligence, .89.

Content validity was established by direct comparison of the California Test with the Stanford-Binet Intelligence Scale. Item analysis procedures were followed to determine the effectiveness of each test item to differentiate between upper and lower ability pupils. The discriminating power for the sections were: (1) Language, 59.9; (2) Non-Language, 58.4; and (3) Total Intelligence, 59.2. The difficulty levels for the sections were: (1) Language, 23.8; (2) Non-Language, 18.7; and (3) Total Intelligence, 21.3

The Stanford-Binet Intelligence Scale was also used to establish criterion referenced validity. The mean intelligence score on the Stanford-Binet Intelligence Scale is 106.0 and for the California Test, 103.7. A comparison of these two intelligence scores yielded a correlation coefficient of .68 (Technical Report, 1965, pp. 15-25).

APPENDIX D

Torrance Tests of Creative Thinking
Figural Form, Activity 3: Parallel Lines

Creativity must be defined in a way that permits objective observation and measurement, and in a way that is compatible with common and historical usage. E. Paul Torrance defines creativity as:

> a process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on: identifying the difficulty; searching for solutions, making guesses; or formulating hypotheses about the deficiencies; testing and retesting these hypotheses and possibly modifying and retesting them; and finally communicating the results (Torrance, 1966, p. 6).

Torrance recognized creativity as a process in terms of the kinds of abilities necessary for successful operation of the process. Creativity is further recognized in terms of the qualities of the products of a creative act and the kinds of personality characteristics that facilitate or impede the functioning of a creative process.

Construct validity was established by basing the test stimuli, tasks, instructions, and scoring on analyses of the lives of recognized creative people, research concerning their lives, and the nature of performances recognized as creative.

Three studies establishing test-retest reliability for the instrument have reported the following correlation coefficients: (1) figural fluency, .71, .50, and .80; (2) figural flexibility, .73, .63, and .64; (3) figural originality, .85, .60, and .60; and (4) figural elaboration, .83, .71, and .80 (Torrance, 1966, p. 21).

Test scorer reliability was reported by two studies with the following mean coefficients of correlation reported: (1) fluency, .96; (2) flexibility, .94; (3) originality, .85; and (4) elaboration, .90 (Torrance, 1966, p. 19).

Scores for the Parallel Lines Activity are obtained in fluency, flexibility, originality, and elaboration. A brief explanation of these scores and methods of obtaining them are given as follows.

Fluency. The fluency score of the activity is interpreted as the number of responses made minus the number of duplications and irrelevant responses.

Flexibility. The flexibility score is obtained by counting the number of different categories into which the subject's responses can be classified. The categories described in the technical manual cover over 99 percent of the responses given in a study of 381 subjects ranging from kindergarten to high school.

Originality. Responses found in 20 percent or more of the tests are given no credit; 5 to 19 percent, one point; and in 2 to 4 percent, two points. All other responses showing creative strength and imagination are given three points.

Elaboration. The objective here is to determine the number of ideas communicated by each object in addition to the basic idea portrayed (Torrance, 1967, pp. 25-33).

APPENDIX E

Stanford Achievement Test

The Stanford Achievement Test is a series of tests intended to provide dependable measures of knowledges and skills considered desirable outcomes of the major areas of the elementary curriculum. Sub-test scores are available in Paragraph Meaning, Spelling, Language, Arithmetic Computation, Arithmetic Concepts, Arithmetic Application, Social Studies and Science.

The Arithmetic Application sub-test served as the criterion for verbal problem solving ability in this investigation. This section contains 39 problems in which the general reading vocabulary and computation difficulty have been controlled below the problem solving level measured.

The Arithmetic Computation sub-test measures proficiency in computation drawn from the fundamental operations of addition, subtraction, multiplication, and division. These operations are extended to include computation with fractions, solutions of number sentences, and understandings of percent.

The Arithmetic Concepts sub-test measures understanding of place value, Roman numerals, operational terms, fractions, interrelationships of the fundamental operations (addition and multiplication) and their inverses (subtraction and division), directional numbers, number series, number names, estimation, averages, number sentences, meaning of percent, decimal fractions, rounding, and geometric terms.

Reliability coefficients provided in the manual using the split-half method corrected by the Spearman Brown Prophecy Formula are: (1) Arithmetic Applications, .89; (2) Arithmetic Computation, .89; and (3) Arithmetic Concepts, .85. The Kuder-Richardson Formula 20 provided additional reliability coefficients: (1) Arithmetic Application, .89; (2) Arithmetic Computation, .87; and (3) Arithmetic Concepts, .87. The above coefficients were obtained from a random sample of 1,000 pupils in the sixth grade. The sample was drawn from an original test population of 850,000 pupils tested in 264 school systems representing 50 states.

Content validity was established by a thorough analysis of the most widely used series of elementary arithmetic textbooks and of research literature pertaining to children's concepts, experiences, and vocabulary at the fifth and sixth grades. Content of the test was established according to proportions revealed in the analyses (Kelley and others, 1964, pp. 3-7, 24-25).

APPENDIX F

Adston Diagnostic Test

The Adston Diagnostic Test measures understanding of the basic facts in each operation, addition, subtraction, multiplication, and division. The validity of the test is unquestionable as every basic fact of the four operations in arithmetic is tested. The internal consistency of each diagnostic instrument has been computed in terms of a coefficient of reliability using the Kuder-Richardson Formula 20. The coefficients are: (1) addition, .88; (2) subtraction, .92; (3) multiplication, .93; and (4) division, .94 (Adams & Ellis, 1971, p. 3).

APPENDIX G

Dr. Horace Otis Beldin's Tests

Problems with Unnecessary Data
Problems with Insufficient Data
Problems with No Numbers

Dr. Horace Otis Beldin conducted an investigation entitled "A study of selected arithmetic verbal problem solving skills among high and low achieving sixth grade children." The three tests selected for use in the present investigation were successful in identifying the high and low achievers in the investigation.

Validity of the tests constructed by Beldin was established by seeking consensus of opinion of experts in the field of education. Reliability coefficients were reported by the author as: (1) .517 for problems with unnecessary data; (2) .508 for problems with insufficient data; and (3) .461 for problems with no numbers (Beldin, 1960).

Permission was granted by the author to duplicate and use the test instruments in this investigation.

APPENDIX H

Mathematical Vocabulary

A survey was made of mathematics textbooks used in each of the five schools selected for this investigation. A multiple-choice test was constructed based on 34 randomly selected terms used by these textbooks.

The 34-item test was administered to 206 sixth grade pupils in five northern parishes of Louisiana to compute the item-analysis procedure. A test of significant differences in proportions was computed between the upper and lower 27 percent of pupils. This procedure determined whether an item was successful in discriminating between the upper and lower pupils. Appendix I presents the findings of this procedure. The original 34 items were reduced to the 22 items which significantly discriminated between the two groupings. Two additional items were excluded because of ambiguous wording resulting in a 20-item test for use in the investigation (see Appendix J).

A reliability coefficient of .659, representing internal consistency, was obtained using the Split-Half reliability formula. The formula for computing the coefficient in this investigation was (Gronlund, 1971, p. 106):

$$r = \frac{2 \text{ X Reliability on } \frac{1}{2} \text{ Test}}{1 + \text{Reliability on } \frac{1}{2} \text{ Test}}$$

APPENDIX I

Test of Significance of Differences in Proportions between Upper and Lower 27 Percent in Achievement on Mathematical Vocabulary

Item	t-Value	Probability
1	4.123	.01
2	.644	NS
3	1.369	NS
4	2.466	.05
5	4.706	.01
6	3.023	.01
7	4.630	.01
8	2.600	.01
9	2.318	.05
10	.338	NS
11	1.170	NS
12	3.023	.01
13	1.119	NS
14	2.307	.01
15	.984	NS
16	3.253	.01
17	1.982	.05
18	3.523	.01
19	3.907	.01
20	3.174	.01
21	3.677	.01
22	2.969	.01
23	1.460	NS
24	3.576	.01
25	1.491	NS
26	.100	NS
27	1.460	NS
28	3.192	.01
29	2.542	.05
30	2.330	.05
31	2.889	.01
32	1.553	NS
33	4.915	.01
34	.828	NS

APPENDIX J

Mathematical Vocabulary

DIRECTIONS: For each item, choose the answer that will best complete the statement.

1. The degree measure of an acute angle is ___.

   (1) more than 0° but less than 90°.
   (2) more than 90° but less than 180°.
   (3) more than 180° but less than 270°.
   (4) more than 270° but less than 360°.

2. A triangle having all sides equal in length is ___.

   (1) isosceles.
   (2) right.
   (3) equivalent.
   (4) equilateral.

3. Numbers which are multiplied to form a product are called ___.

   (1) fields.
   (2) factors.
   (3) finite numbers.
   (4) functions.

4. The operations of addition, subtraction, multiplication, and division are called ___.

   (1) fundamental operations.
   (2) functional operations.
   (3) finite operations.
   (4) frequency operations.

5. A closed geometric plane figure having six sides and six vertices is a ___.

   (1) hectogon.
   (2) heptagon.
   (3) decagon.
   (4) hexagon.

6. A graph showing the distribution of frequencies within a set of data is a ___.

(1) line graph.
(2) bar graph.
(3) histogram.
(4) grid.

7. An example of an identity equation is ___.

(1) $2 < 5$.
(2) $6 = 6$.
(3) $9 > 8$.
(4) $+7 = -7$.

8. The arithmetic mean of a group of numbers is the ___.

(1) largest number.
(2) smallest number.
(3) average.
(4) midpoint.

9. In the equation, $8 - 5 = 3$, 8 is the ___.

(1) minuend.
(2) subtrahend.
(3) difference.
(4) succession.

10. The sum of the lengths of the sides of closed geometric plane figures is the ___.

(1) parameter.
(2) peripheral.
(3) parity.
(4) perimeter.

11. Any closed figure formed by line segments is a ___.

(1) polynomial.
(2) quadrilateral.
(3) polygon.
(4) polygraph.

12. Expressing 2,345 as $(2 \times 10^3) + (3 \times 10^2) + (4 \times 10^1) + (5 \times 10^0)$ is known as ___.

(1) expanded notation.
(2) place-value arithmetic.
(3) positional arithmetic.
(4) polynomial form.

13. Any whole number greater than one and that only has itself and one as factors is called a ___.

(1) positional number.
(2) prime number.
(3) composite number.
(4) negative number.

14. "If you interchange the factors, the product remains the same," is a statement of the ___.

(1) commutative property of multiplication.
(2) associative property of multiplication.
(3) identity property of multiplication.
(4) inverse operation of multiplication.

15. When one number is subtracted from another number, the result could correctly be called the ___.

(1) product.
(2) sum.
(3) difference.
(4) quotient.

16. The straight line segment from the center of a circle a point on the circle is the ___.

(1) diameter.
(2) radius.
(3) radical.
(4) ratio.

17. The degree measure of an obtuse angle is ___.

(1) more than 0°, but less than 90°.
(2) more than 90°, but less than 180°.
(3) more than 180°, but less than 270°.
(4) more than 270°, but less than 360°.

18. 1/100th of a meter is a ___.

    (1) decimeter.
    (2) centimeter.
    (3) millimeter.
    (4) kilometer.

19. When two sets are joined, the resulting set is called their ___.

    (1) intersection.
    (2) subset.
    (3) composite.
    (4) union.

20. A set having no limit to the number of members it contains is called ___.

    (1) finite.
    (2) infinite.
    (3) continuous.
    (4) empty.

APPENDIX K

Formal Analysis

The test used to measure the sequential steps in formal problem analysis was constructed by the investigator. Verbal problems selected for this test instrument involved only the fundamental operations of addition, subtraction, multiplication, and division to assure measuring the skills of formal analysis and no advanced arithmetical concepts. Thirty verbal problems were written requiring three steps in the solution. Reading difficulty was controlled by selecting verbal problems from various third and fourth grade mathematics textbooks.

Coefficients of reliability were obtained by administering the 30-item test to 89 sixth grade pupils in Caddo Parish, Louisiana. The split-half procedure of establishing reliability was computed yielding the following coefficients of reliability for each step of formal analysis: (1) What is asked in the problem? .973; (2) What facts are given in the problem? .965; and (3) What process must you use? .891. A copy of the formal analysis test is found in Appendix K.

APPENDIX L

Formal Analysis

DIRECTIONS: In the following verbal problems, three questions are asked about each problem. Answer each question in your own words using the information given in each problem.

Study the sample problem, then work the remaining verbal problems.

SAMPLE: In a parking lot, there are 9 spaces for cars in each row. If 63 cars arrive, how many rows will be filled?

(1) What is asked in the problem?

(the number of rows to be filled)

(2) What facts are given in the problem?

(9 spaces on a row, 63 cars arrive)

(3) What process must you use?

(division)

1. A marching band contained 8 rows with the same number of band members in each row. If there were 96 members in the band, how many were in each row?

(1) What is asked in the problem?

____

(2) What facts are given in the problem?

____

(3) What process must you use?

____

2. A school library ordered 53 science books, 28 history books, and 89 reading books. How many books did the library order?

   (1) What is asked in the problem?

   ____

   (2) What facts are given in the problem?

   ____

   (3) What process must you use?

   ____

3. A newsboy delivers 270 newspapers in 5 days. If he delivers the same number of newspapers each day, how many newspapers does he deliver each day?

   (1) What is asked in the problem?

   ____

   (2) What facts are given in the problem?

   ____

   (3) What process must you use?

   ____

4. Mr. Jones drove 80 miles and used 5 gallons of gasoline. How many miles did he travel on each gallon of gasoline?

   (1) What is asked in the problem?

   ____

   (2) What facts are given in the problem?

   ____

   (3) What process must you use?

   ____

5. A large tank held 1,750 gallons of gasoline. A smaller tank held 1,575 gallons. How many more gallons of gasoline were in the larger tank than in the smaller tank?

   (1) What is asked in the problem?

   ____

   (2) What facts are given in the problem?

   ____

   (3) What process must you use?

   ____

6. A milkman delivers 1,248 quarts of milk on Tuesday, 1,096 quarts of milk on Thursday, and 982 quarts of milk on Saturday. How many quarts of milk does the milkman deliver in the three days?

   (1) What is asked in the problem?

   ____

   (2) What facts are given in the problem?

   ____

   (3) What process must you use?

   ____

7. A farmer delivered 14 loads of potatoes to the market. Each load had a weight of 850 pounds. What was the total weight of the potatoes?

   (1) What is asked in the problem?

   ____

   (2) What facts are given in the problem?

   ____

   (3) What process must you use?

   ____

8. A truck loaded with furniture weighs 12,575 pounds. The empty truck weighs 8,800 pounds. What is the weight of the furniture?

(1) What is asked in the problem?

____

(2) What facts are given in the problem?

____

(3) What process must you use?

____

9. Warren Elementary School has 14 classes of pupils. There are 35 pupils in each class. How many pupils are there in Warren Elementary School?

(1) What is asked in the problem?

____

(2) What facts are given in the problem?

____

(3) What process must you use?

____

10. Mr. Watson teaches 175 pupils a day. If each class has 35 pupils, how many different classes does he teach each day?

(1) What is asked in the problem?

____

(2) What facts are given in the problem?

____

(3) What process must you use?

____

11. Jim has 135 marbles. His brother gave him 45 more. How many marbles does Jim have now?

    (1) What is asked in the problem?

    ____

    (2) What facts are given in the problem?

    ____

    (3) What process must you use?

    ____

12. Sally made 48 cookies. Ann made 36 cookies. Together they made how many cookies?

    (1) What is asked in the problem?

    ____

    (2) What facts are given in the problem?

    ____

    (3) What process must you use?

    ____

13. Don and Lee together caught 62 fish. Don caught 38 of them. How many of them did Lee catch?

    (1) What is asked in the problem?

    ____

    (2) What facts are given in the problem?

    ____

    (3) What process must you use?

    ____

14. June's book has 148 pages in it. She has read 63 pages. How many more pages does she have to read?

    (1) What is asked in the problem?

    ____

    (2) What facts are given in the problem?

    ____

    (3) What process must you use?

    ____

15. A train travels 56 miles in an hour. Traveling at this speed, how long will it take the train to travel 672 miles?

    (1) What is asked in the problem?

    ____

    (2) What facts are given in the problem?

    ____

    (3) What process must you use?

    ____

16. If one crate of grapefruit weighs 38 pounds, how many pounds would 125 crates of grapefruit weigh?

    (1) What is asked in the problem?

    ____

    (2) What facts are given in the problem?

    ____

    (3) What process must you use?

    ____

17. There are 126 students in the fifth grade at a certain school. How many baseball teams of 9 players each could be formed?

    (1) What is asked in the problem?

    ____

    (2) What facts are given in the problem?

    ____

    (3) What process must you use?

    ____

18. Mrs. Boyd saves thrift stamps. If she has 1,584 stamps and can put 48 stamps on each page of her savings book, how many pages can she fill?

    (1) What is asked in the problem?

    ____

    (2) What facts are given in the problem?

    ____

    (3) What process must you use?

    ____

19. May practices the piano 55 minutes each day. How many minutes will she practice in 24 days?

    (1) What is asked in the problem?

    ____

    (2) What facts are given in the problem?

    ____

    (3) What process must you use?

    ____

20. A rancher bought 73 cows, 37 calves, and 12 horses at an auction. How many animals did he buy?

(1) What is asked in the problem?

____

(2) What facts are given in the problem?

____

(3) What process must you use?

____

21. A shepherd had 68 sheep and 21 lambs. How many more sheep did he have than lambs?

(1) What is asked in the problem?

____

(2) What facts are given in the problem?

____

(3) What process must you use?

____

22. Jane read four books having 121 pages, 133 pages, 200 pages, and 306 pages. How many pages did she read in all?

(1) What is asked in the problem?

____

(2) What facts are given in the problem?

____

(3) What process must you use?

____

23. There are 421 boys and 408 girls in a school. There are 34 teachers in this school. How many teachers and pupils are there in the school?

(1) What is asked in the problem?

____

(2) What facts are given in the problem?

____

(3) What process must you use?

____

24. Four boys have kite strings. Sam's is 125 feet long, Don's is 162 feet long, Bill's is 105 feet long, and Joe's is 147 feet long. Together, how much string do they have?

(1) What is asked in the problem?

____

(2) What facts are given in the problem?

____

(3) What process must you use?

____

25. David rode his bicycle 84 miles in 6 days on his paper route. How many miles does he ride on his paper route each day?

(1) What is asked in the problem?

____

(2) What facts are given in the problem?

____

(3) What process must you use?

____

26. A sports shop had 32 bicycle tires. This is enough tires to replace both tires on how many bicycles?

    (1) What is asked in the problem?

    ___

    (2) What facts are given in the problem?

    ___

    (3) What process must you use?

    ___

27. Joe walked 6 blocks from school to the library. Then, he walked home. If he walked 11 blocks in all, how many blocks is it from the library to his home?

    (1) What is asked in the problem?

    ___

    (2) What facts are given in the problem?

    ___

    (3) What process must you use?

    ___

28. On a field trip, John saw 14 robins, 32 sparrows, and 12 blackbirds. How many birds did he see on the trip?

    (1) What is asked in the problem?

    ___

    (2) What facts are given in the problem?

    ___

    (3) What process must you use?

    ___

29. Mary weighs 62 pounds and her mother weighs 127 pounds. They both get on the same scale. What weight should the scale show?

    (1) What is asked in the problem?

    ____

    (2) What facts are given in the problem?

    ____

    (3) What process must you use?

    ____

30. On Monday, 212 pupils were present at Lincoln School and 57 were absent. How many pupils go to Lincoln School?

    (1) What is asked in the problem?

    ____

    (2) What facts are given in the problem?

    ____

    (3) What process must you use?

    ____

APPENDIX M

California Reading Test

The California Achievement Tests are comprehensive tests designed for the purposes of facilitating evaluation, educational measurement, and diagnosis. The reading skills tested and a brief description of each are:

<u>Reading Vocabulary</u>

The Reading Vocabulary Test is composed of 50 items which sample mathematics, science, social science, general, and reading terms.

<u>Following Directions</u>

Twenty items based mainly on mathematics and language test the student's ability to follow simple directions, directions involving simple and involved choices, and comprehending definitions.

<u>Reference Skills</u>

> The twenty items included in this section measure the extent to which the pupil possesses the vocabulary and skills needed for reference work and simple research appropriate to his level. These items test familiarity with parts of books, tables of contents, indexes, the ability to alphabetize, and graph and map reading skills (Tiegs & Clark, 1963, pp. 5-6).

<u>Interpretations</u>

The emphasis in this test is upon comprehension, not memory. Pupils are directed to read three short stories and answer a total of 30 questions. The test situations reveal the pupil's ability to comprehend facts, select topics or main ideas, make inferences and deductions, and reconstruct sequences of ideas.

Coefficients of reliability have been computed using the Kuder-Richardson formula 21 with the following findings in reading: (1) Reading Vocabulary, .91; and (2) Comprehension (including following directions, reference skills, and interpretations), .92.

Content validity has been determined for the California Achievement Tests over the years since 1934. Analyses of course outlines, textbooks, and curriculum objectives have determined the facts comprising these tests. Curriculum experts, research specialists, college professors, teachers, and state department of education personnel have critically reviewed the tests (Tiegs & Clark, 1963, pp. 5-8).

APPENDIX N

California Test of Personality

The California Test of Personality is a 144-item test which measures 12 individual areas of personality and reveals three composite scores. The areas tested and a brief description of each are:

Personal Adjustment

Self-Reliance. An individual may be said to be self-reliant when his overt actions indicate that he can do things independently of others, depend upon himself in various situations, and direct his own activities.

Sense of Personal Worth. An individual possesses a sense of being worthy when he feels he is well regarded by others, when he feels that others have faith in his future success, and when he believes that he has average or better than average ability. To feel worthy means to feel capable and reasonably attractive.

Sense of Personal Freedom. An individual enjoys a sense of freedom when he is permitted to have a reasonable share in the determination of his conduct and in setting the general policies that govern his life.

Feeling of Belonging. An individual possesses a feeling of belonging when he feels that he is an accepted member of the peer group and when he believes that his opinions are worthy of consideration by the group.

Withdrawing Tendencies. The individual who is said to withdraw is the one who substitutes the joys of a fantasy world for actual successes in real life. Such a person is characteristically sensitive, lonely, and given to self-concern.

Nervous Symptoms. The individual who is classified as having nervous symptoms is the one who suffers from one or more of a variety of physical symptoms such as loss of appetite, frequent eye strain, inability to sleep, or tendency to be chronically tired. People of this kind may be exhibiting physical expressions of emotional conflicts.

Social Adjustment

Social Standards. The individual who recognizes desirable social standards is the one who has come to understand the rights of others and who appreciates the necessity of subordinating certain desires to the needs of the group. Such an individual understands what is regarded as being right or wrong.

Social Skills. An individual may be said to be socially skillful or effective when he shows a liking for people, when he inconveniences himself to be of assistance to them, and when he is diplomatic in his dealings with both friends and strangers.

Anti-Social Tendencies. An individual would normally be regarded as anti-social when he is given to bullying, frequent quarreling, disobediences and destructiveness to property. The anti-social person is the one who endeavors to get his satisfactions in ways that are damaging and unfair to others.

Family Relations. The individual who exhibits desirable family relationships is the one who feels that he is loved and well-treated at home and who has a sense of security and self-respect in connection with the various members of his family.

School Relations. The student who is satisfactorily adjusted to his school is the one who feels that his teachers like him, who enjoys being with other students, and who finds the school work adapted to his level of interest and maturity.

Community Relations. The individual who may be making good adjustments in his community is the one who mingles happily with his neighbors, who takes pride in community improvements, and who is tolerant in dealing with both strangers and foreigners (Thorpe, Clark, & Teigs, 1953, pp. 3-4).

Total scores are available in Total Personal Adjustment, Total Social Adjustment, and Total Adjustment, in addition to each of the twelve sub-tests.

The Kuder-Richardson formula was used to establish reliability coefficients. The coefficients are: (1) Self-Reliance, .82; (2) Sense of Personal Worth, .86; (3) Sense of Personal Freedom, .96; (4) Feeling of Belonging, .98; (5) Withdrawal Tendencies, .91; (6) Nervous Symptoms, .96; (7) Social Standards, .97; (8) Social Skills, .86; (9) Anti-Social Tendencies, .92; (10) Family Relations, .96; (11) School Relations, .92; (12) Total Personal Adjustment, .96; (13) Total Social Adjustment, .97; and (14) Total Adjustment, .96.

Validity was established by consulting publications of psychologists for specific adjustment patterns. Those adjustment patterns which they considered to be best indicators of adjustment (or the lack of it) were selected from the literature. Educational and clinical psychologists judged the appropriateness of the test items (Thorpe, Clark, & Tiegs, 1953).

APPENDIX O

Score Card for Variables

Date of Birth ____________________ Name ____________________
Month Day Year First Last
School ____________________ Classification ____________________

1. Level of Intelligence ______
   Pre Operational (1)
   Concrete (2)
   Formal (3)
2. Verbal Intelligence ______
3. Non-Verbal Intelligence ______
4. Total Intelligence ______
   Creativity:
   5. Fluency ______
   6. Flexibility ______
   7. Originality ______
   8. Elaboration ______
9. Arith. Computation ______
10. Arith. Concepts ______
11. Basic Facts ______
12. Unnecessary Data ______
13. Insufficient Data ______
14. No Numbers ______
15. Math. Vocabulary ______
    Formal Analysis:
    16. What Asked? ______
    17. What Given? ______
    18. What Process? ______

<u>Back of Score Card</u>

19. Total Vocabulary ______
20. Following Directions ______
21. Reference Skills ______
22. Interpretation ______
23. Total Reading ______
24. Self-Reliance ______
25. Personal Worth ______
26. Personal Freedom ______
27. Feeling of Belonging ______
28. Withdrawal ______
29. Nervous Symptoms ______
30. Total Personal ______
31. Social Sign. ______
32. Social Skills ______
33. Anti-Social ______
34. Family Relations ______
35. Social Relations ______
36. Community Relations ______
37. Total Social ______
38. Total Adjustment ______

APPENDIX P

OFFICE OF

NATCHITOCHES PARISH SCHOOL BOARD

NATCHITOCHES, LA. 71457

September 12, 1972

ALLEN H. PLUMMER
SUPERINTENDENT

Dr. L. F. Fowler
Mr. James LaRoue
Mr. Wallace Van Sickle
Mr. L. P. Vaughn

Gentlemen:

Mrs. Carolyn Talton, who is working on her Doctorate, has contacted me relative to her research and dissertation. She wishes to conduct a certain amount of testing in the sixth grades in the City of Natchitoches between November 1 and November 14.

Mrs. Talton has my permission to contact you concerning her requirements.

Sincerely yours,

Allen H. Plummer
Superintendent

AHP/nwh

VITA

CAROLYN FLANAGAN TALTON

Birth

Date: March 6, 1942
Place: Winnsboro, Louisiana

Education

Institution	Entered	Graduated	Degree
Louisiana Polytechnic University Ruston, Louisiana	September 1960		
Northeast Louisiana State University Monroe, Louisiana	September 1962	May 1965	B.A.
Northwestern State University of Louisiana Natchitoches, Louisiana	August 1968	August 1970	M.A.
Northwestern State University of Louisiana Natchitoches, Louisiana	August 1970	May 1973	Ed.D.

Experience

Position	Institution	Dates
Teacher, Third Grade	Oak Hill Elementary Bastrop, Louisiana	1965-1966
Teacher, Fourth Grade	Caddo Heights Shreveport, Louisiana	1968-1969
Teacher, Seventh and Eighth Mathematics and Science	Northwestern State University Laboratory School Natchitoches, Louisiana	1970-1971
Teacher, Graduate Assistant	Northwestern State University Natchitoches, Louisiana	1971-1973