5. A farmer took 40 bushels of potatoes to market. He sold 32 bushels. What percent did he sell?

Answer ________

6. John, who enjoys being outdoors, earns money by mowing lawns. He charges $3.50 to mow a lawn. If he mows 3 yards on Saturday and 4 yards on Sunday, how much money will he earn?

Answer ________

7. Bill has spent $3.25 on supplies for his camping trip. He bought 3 cans of beans and 1 package of hot dogs. If the package of hot dogs costs $1.00, how much does 1 can of beans cost?

Answer ________

8. Mr. Jones and Mr. Brown spent the same amount of money to fertilize their fields. Mr. Jones used 12 pounds of fertilizer for his field and Mr. Brown used 16 pounds. If Mr. Jones spent 8 cents per pound for fertilizer, how much per pound did Mr. Brown spend?

Answer ________

9. After picking strawberries, Alice put them into 2 baskets. The first basket contains 60 more strawberries than the second basket. If the second basket contains 40 strawberries, how many strawberries are there altogether?

Answer ________

10. Betty visited an orchard this past summer. She noticed that for every 2 apple trees, there were 3 cherry trees. If the orchard had 18 apple trees, how many cherry trees were there?

Answer ________

2

Name ______________________________ Teacher ____________________________

Directions: Work each of the problems below as best you can. Please show your work in the space provided Put your answer in the blank.

1. Mr. Brown is a cashier in a clothing store. If a customer purchases 5 shirts at $6.00 per shirt, how much should Mr. Brown charge?

Answer _____

2. A person with pencil and paper can work $\frac{1}{6}$ as many addition problems as a person with a calculator. How many addition problems can the person with pencil and paper work while the person with a calculator works 180?

Answer _____

3. Sue likes to figure out distances while traveling in a car. The car she is in went 150 miles. If the car was traveling 50 miles per hour and gets 10 miles per gallon, how long did the car travel?

Answer _____

4. Being treasurer of his high school class, Gary is in charge of getting a group for the dance. He found a group of folksingers that charges $105 for a $3\frac{1}{2}$ hour program. What does the group charge per hour?

Answer _____

5. Jill took a math test which had 40 problems. She solved 32 of them correctly. What percent did she solve correctly?

Answer ______

6. Mr. Smith is a bookkeeper who earns extra money by figuring people's income tax. He charges $3.50 an hour. If he worked 3 hours on Saturday and 4 hours on Sunday, how much money did he earn?

Answer ______

7. Frank has sold $3.25 worth of tickets for the eighth grade play. He has sold 3 student tickets and 1 adult ticket. If an adult ticket cost $1.00 how much does 1 student ticket cost?

Answer ______

8. Bill measured a line segment using two different sticks as rulers. He found using stick I the line is 12 sticks long and using stick II the line is 16 sticks long. If stick I measures 8 inches in length, how long is stick II?

Answer ______

9. Alice was selected to count the number of votes in an election between 2 candidates. The first candidate received 60 more votes than the second candidate. If the second candidate received 40 votes, how many votes were cast in the election?

Answer ________

10. Betty figured out her savings from summer work this year. For every $2.00 she saved last year she has saved $3.00 this year. If she saved $18.00 last year, how much did she save this year?

Answer ________

3

Name ______________________________ Teacher ______________________________

Directions: Work each of the problems below as best you can. Please show your work in the space provided. Put your answer in the blank.

1. Mr. Brown raises white mice for scientific reasons. If he has 5 cages and 6 white mice per cage, how many white mice does Mr. Brown have?

Answer ______

2. Due to different forces of gravity, the weight of a man on the moon is $\frac{1}{6}$ of the weight of the man on the earth. How much is the weight on the moon of a man who weighs 180 pounds on earth?

Answer ______

3. Hoping to combat a rare disease, Dr. Jones purchased some new medicine. The medicine cost $150. If the medicine came in containers each costing $50 and weighing 10 pounds, how many containers did Mr. Jones buy?

Answer ______

4. Mrs. Davis wants the students in her science class to conduct some electrical experiments. She has 105 feet of wire and each student needs $3\frac{1}{2}$ feet of wire. How many students can participate in the experiment?

Answer ______

5. A chemical alloy weighs 40 grams. It contains 32 grams of aluminum. What percent of the chemical alloy is aluminum?

Answer ______

6. The chemical, silver nitrate, is used in the construction of lenses for telescopes. It costs $3.50 a pound. If 3 pounds are purchased in June and 4 pounds in July, how much will it cost?

Answer ______

7. Bill has spent $3.25 for the science laboratory in his garage. He has bought 3 beakers and 1 thermometer. If the thermometer cost $1.00, how much does 1 beaker cost?

Answer ______

8. Frank used lead weights and steel weights to weigh an object on a pan balance. He found that the object weighed either 12 lead weights or 15 steel weights. If a lead weight weighs 8 ounces, how much dces a steel weight weigh?

Answer ______

9. Alice has 2 beakers of water. There are 60 more milliliters of water in the first beaker than there are in the second beaker. If the second beaker has 40 milliliters in it, how many milliliters of water do they have altogether?

Answer ______

10. Betty was interested in the gear ratio of her bicycle. For every 2 revolutions of her pedal, the back wheel makes 3 revolutions. When the pedal makes 18 revolutions, how many revolutions does the back wheel make?

Answer______

B I B L I O G R A P H Y

BIBLIOGRAPHY

Bowman, H. L. The relation of reported preference to performance in problem-solving. Columbia, Mo.: University of Missouri, 1929.

Bramhall, E. W. An experimental study of two types of arithmetic problems. Journal of Experimental Education, 1939, 8, 36-38.

Brown, K. E., Simon, L., & Snader, D. General mathematics. Book two. River Forest, Ill.: Laidlaw Brothers, 1963.

Brownell, W. A., & Stretch L. B. The effect of unfamiliar settings on problem-solving. Duke University Research Studies in Education, Number 1, 1931.

Buswell, G. T. Arithmetic. In H. W. Chester (Ed.). Encyclopedia of educational research. New York: Macmillan, 1960, 63-77.

Commission on Postwar Plans. The second report of the Commission on Postwar Plans. Mathematics Teacher, 1945, 38, 195-221.

Connors, W. L. & Hawkins, G. C. What materials are most useful to children in learning to solve problems. Educational Method, 1936, 16, 21-29.

De Garmo, C. Interest and education. London: Macmillan Company, 1902.

De Roche, E. F. Motivation: An instructional technique. Clearing house, 1967, 41. 403-406.

Dewey, J. Interest and effort in education. New York: Houghton Mifflin Company, 1913.

Dewey, J. The child and the curriculum. Chicago, Ill.: University of Chicago Press, 1902.

Edwards, A. L. Experimental design in psychological research (4th ed.). New York: Holt, Rinehart, & Winston, 1972.

Gibb, E. G., Mayor, J. R., & Treenfels, E. Mathematics. In C. W. Harris (Ed.). Encyclopedia of educational research. Third edition. New York: Macmillan, 1960, 796-807.

Hartung, M. L. Motivation for education in mathematics. In H. Fehr (Ed.). The learning of mathematics: its theory and practice. Twenty-first yearbook of the NCTM. Washington, D.C., 1953.

Hensell, K. C. Children's interests and the content of problems in arithmetic. (Doctoral dissertation, Stanford University, 1956). Dissertation abstracts, 1956, 17, 1857.

Holtan, B. Motivation and general mathematics students. Mathematics Teacher, 1964, 57, 20-25.

Hydle, L. L., & Clapp, F. L. Elements of difficulty in the interpretation of concrete problems in arithmetic. Bureau of Educational Research Bulletin. Number 9. Madison, Wisconsin: University of Wisconsin, 1927.

Jones, P. S., & Coxford, A. F. Mathematics in the evolving schools. In P. S. Jones (Ed.), A history of mathematics education in the United States and Canada. Thirty-second Yearbook of the NCTM. Washington, D.C.: 1970.

Kramer, G. A. Effect of certain factors in the verbal arithmetic problems upon children's success in the solution. The Johns Hopkins University Studies in Education. Number 20. Baltimore, Md.: The Johns Hopkins Press, 1933.

Kuder, G. F. General interest survey manual, vocational form E. Chicago, Illinois: Science Research Associates, 1964.

Lyda, W. J. Direct, practical experiences in mathematics and success in solving realistic verbal 'reasoning' problems in arithmetic. Mathematics Teacher, 1947, 40, 166-167.

Monroe, P. History of education. New York: Macmillan Company, 1909.

Monroe, W. S. How pupils solve problems in arithmetic. Bureau of Educational Research Bulletin. Number 44. Urbana, Ill.: University of Illinois, 1929.

Monroe, W. S. & Engelhart, M. D. A critical summary of research relating to the teaching of arithmetic. Bureau of Educational Research Bulletin. Number 58. Urbana, Ill.: University of Illinois, 1931.

Monroe, W. S. Development of arithmetic as a school subject. Bureau of Educational Bulletin. Number 10. Washington, D.C.: Department of the Interior, 1917.

McDonald, F. J. The influence of learning theories on education. In F. R. Hilgard (Ed.). Theories of learning and instruction. Sixty-third yearbook of the NSSE, pt. 1. Chicago, Ill.: University of Chicago Press, 1964.

McNabb, W. K., Carry, L. R., Lipman, S. M., & Rucker, I. P. Field mathematics program. Grade 8. Palo Alto, California: Field Educational Publications, 1974.

National advisory committee on mathematical education. Overview and analysis of school mathematics: Grades K-12. Washington, D.C., 1975.

NCTM. An analysis of new mathematics programs. Washington, D.C.: NCTM, 1963.

Nunnally, J. C. Psychometric theory. New York: McGraw-Hill, 1967.

Ryans, D. G. Motivation in learning. Forty-first yearbook. N.S.S.E., Part II. 1942, 289-331.

Schunert, J. The association of mathematical achievement with certain factors resident in the teacher, in the teaching, in the pupil, and in the school. Journal of Experimental Education, 1951, 19, 219-238.

Strong, E. K. Vocational interests of men and women. Palo Alto, California: Stanford University Press, 1943.

Sutherland, J. An investigation into some aspects of problem-solving in arithmetic. British Journal of Educational Psychology, 1941, 11, 215-222.

Sutherland, J. An investigation into some aspects of problem-solving in arithmetic. British Journal of Educational Psychology, 1942, 12, 35-46.

Thorndike, E. L., et. al. The psychology of wants, interests and attitudes. New York: Appleton-Century, 1935.

Thorndike, E. L., et.al. The psychology of algebra. New York: Macmillan, 1923.

Travers, K. J. A test of pupil preference for problem-solving situations in junior high school mathematics. Journal of Experimental Education, 1967, 35, 9-18.

Ward, J. H., & Jennings E. Introduction to linear models. Englewood Cliffs, New Jersey: Prentice-Hall, 1973.

University of Illinois Committee on School Mathematics. High school mathematics. Units one through four. (Teacher's edition). Urbana, Illinois: University of Illinois Press, 1959.

Veldman, D. J. Fortran programming for the behavioral sciences. New York: Holt, Rinehart, & Winston, 1967.

Washburne, C. W., & Morphett, M. Unfamiliar situations as a difficulty in solving arithmetic problems. Journal of Educational Research. Oct. 1928, 18, 220-224.

Washburne, C. W. & Osborne, R. Solving arithmetic problems. Elementary School Journal, 1926, 27, 219-226.

Wheat, H. G. The relative merits of conventional and imaginative types of problems in arithmetic. (Doctoral dissertation, Teachers College, Columbia University, 1929).

Wilson, G. M. Arithmetic. In W. S. Monroe (Ed.). Encyclopedia of educational research. New York: Macmillan, 1940, 42-58.

Wilson, G. M. Functional arithmetic number. Education, 1945, 65, 455-479.

V I T A

Martin Paul Cohen was born in Houston, Texas, on June 28, 1947, the first son of Melvin and Roselle Cohen. After completing his work at Westbury High School, Houston, Texas, in June 1965, he entered the University of Houston, where he received the degree of Bachelor of Science, in January 1970. From February 1970 to August 1970, he was employed by the U.S. Department of Commerce as a field statistician. In September 1970, he entered the graduate school of the Pennsylvania State University, University Park, Pennsylvania. From September 1971 to December 1971, he taught mathematics at Schenley High School, Pittsburgh, Pennsylvania. From February 1972 to June 1973, he taught mathematics at Jefferson Davis High School, Houston, Texas. In March 1973, he was awarded the degree of Master of Education in Mathematics Education from the Pennsylvania State University. In September 1973, he entered the Graduate School of The University of Texas at Austin. During the school years 1973-74 and 1975-76, he was employed as a teaching assistant with the Department of Mathematics. From August 1974 to June 1975, he was employed as a research associate with the Project for the Mathematical Development of Children.

Permanent Address: 5202 Spellman
Houston, Texas 77035

interests and instincts (Jones & Coxford, 1970). Herbart (1776-1841), who profoundly influenced American education through his disciples, viewed education as the process of stimulating the spontaneous interests of the individual. Interest, he thought, is aroused in order to secure attention to the lesson but even more in order to secure complete appropriation of the new ideas (Strong, 1943). The methods of these educational philosophers coexisted with a belief in mental discipline as a goal and, later, an associated faculty psychology.

In America, prior to 1821, the dominant pedagogy in the mathematics classroom was to state a rule, give examples, and provide problems (Jones & Coxford, 1970). Warren Colburn repudiated this view and introduced instead, in 1821, his first Lessons in Arithmetic on the Plan of Pestalozzi with Some Improvements, which was designed to:

> . . . furnish the child with practical examples which required arithmetical operations and to provide exercises for drill upon the combinations which the child discovers are needed to solve examples proposed. With a few exceptions the practical examples were taken from situations in the life of children or from situations which children easily understood. (Monroe, 1917, p. 65)

Colburn made little change in the total content of arithmetic, his great contribution being in the field of method, the purpose being to "discipline" and develop the mind through the inductive approach (Wilson, 1940).

Colburn's influence on the teaching of arithmetic was profound, and for 50 years following the publication of his textbook, Intellectual Arithmetic (1812), the teaching of arithmetic was enlivened in the school. By the end of the century, however, the load of content became so heavy and the teaching so formal (faculty psychology) that the Committee of Ten in 1893 and the Committee of Fifteen in 1895 recommended radical changes in the teaching of the subject and insisted that arithmetic should be both "abridged and enriched" (Buswell, 1960). The work of William James in the 1890's questioning the theory of mental discipline provided the impetus for this educational reform (Osborne & Crosswhite, 1970).

At the turn of the century, John Dewey and Charles DeGarmo, both disciples of Herbart, revived the essentials of the doctrine of interest and especially it emphasis that a curriculum should be designed around the interests of children. In his classic, The Child and the Curriculum, John Dewey (1902) discussed the child's interests as they relate to the educational process:

> Interests in reality are but attitudes toward possible experiences; they are not achievements; their worth is in the leverage they afford, not in the accomplishment they represent. (p. 15)

Comparing the doctrine of effort (mental discipline) with that of the doctrine of interest, DeGarmo (1902) in his work entitled Interest and Education maintained:

> One theory, that of effort, maintains that the sheer dead lift of will is the only sure means of getting the child to the goal, and the only way whereby his mind can be trained to do the hard things that are sure to confront him in later life. The other theory, that of pleasurable excitation, holds that it is only by making the object interesting that the mind will work freely and without constraint. (p. 23)

Furthermore he stated:

> We must arouse interest in subjects now uninteresting, not alone through charm and skill, but also by showing how these subjects contribute to ends in which interest is already aroused . . . . It should be possible to arouse the interest of a high school student in any subject that is plainly contributory to the purpose he has already formed. (p. 120)

After his theories of the "new education" were put into practice in the laboratory school at the University of Chicago, Dewey (1913) became more dynamic and more forceful in asserting his ideas concerning educational reforms. This is evidenced in his later book, Interest and Effort in Education:

> The major difficulty with our schools is that they have not adequately enlisted the interest and energies of children in school work. (p. vii)
>
> The parent and the attendance officer, reinforced by the police power of the state can guarantee only one thing--the physical presence of the child at school. It is left to the teacher to insure his mental attendance by a sound appeal to his active interests. (p. viii)

Edward Lee Thorndike, who some authorities designate as dealing the death blow to mental discipline (Kolesnik, 1958), developed further the theory of interest in education, and in particular, mathematics education. In his textbook, The Psychology of Algebra, in which Dewey's influence is particularly noticeable, Thorndike (1923) maintained:

> In arithmetic it is found serviceable to introduce each new item of computational method by some genuine and interesting problem whose solution is facilitated by the computation in question. Students of algebra can doubtless get along without such stimulants better than students of arithmetic, who are younger and duller; and may gain less from them. But they, too, will gain much from such introductory problems showing the service which the computation performs. (p. 134)

With the impetus provided by Dewey and Thorndike, the prevailing doctrine of "social utility" gained strength, and for the next three decades, emphasis was on the motivational value of functional aspects of mathematics (McDonald, 1964). The Second Report of the Commission on Post-War Plans (1945), a document sponsored by the National Council of Teachers of Mathematics, presented "suggestions for improving mathematical instruction from the beginning of the elementary school through the last year of junior college" (Commission on Post-War Plans, 1945). Consideration was given to the "social aims" of arithmetic and it was suggested that:

> Children appreciate the value of arithmetic when it helps them to meet needs of vital importance to them. (p. 200)
>
> Experiences to develop meanings need to be arranged and ordered as carefully as are the experiences by which we develop computational skills. The first encounter with meanings should ordinarily occur in concrete situations of large personal significance to the learner. (p. 201)
>
> Today good teachers of algebra . . . use a few simple, interesting, and practical applications to motivate each new principle and topic. (p. 208)

In 1951, the University of Illinois Committee on School Mathematics (UICSM) was formed to "investigate problems concerning the content and teaching of high school mathematics" (NCTM, 1963). The work of the UICSM was initiated primarily as a means of correcting the weakness in secondary school programs which left students short of minimum needs. In its widely known text material for the high school, the UICSM (1959) declared in the teacher's commentary:

> Since we believe that <u>interest</u> is a necessary condition for learning, we have tried to set the development of mathematical ideas in situations which are inherently <u>interesting</u> to young people. One of our standard devices when approaching a new idea is to create a fanciful situation which embodies or illustrates it. (pp. 1-2)

It seems noteworthy that using the interest of the learner as a motivational technique in the mathematics classroom is not an outdated practice. A high school mathematics text (Laidlaw Brothers, 1963) pointed out in its preface:

> Each chapter is . . . divided into a series of consecutive lessons which are composed of motivational material, developmental exercises, and exercises. The motivational material usually consists of a concrete, meaningful problem, the solution of which requires knowledge and skill in the phase of mathematics to be developed in the accompanying development exercises. (p. 5)

A more contemporary mathematics textbook (Field Mathematics Program, 1974) has stated in its preface to the teacher's edition:

> The student activities and teaching procedures have been carefully developed to relate to the environment of the everyday world and to the <u>interests</u> and con- conceptual abilities of the students. The program utilizes mathematics to solve problems from everyday

> experiences and other subject fields. Conversely it utilizes everyday experineces, known areas of mathematics, and other subject fields to establish material problems and concepts. (p. 2)

These comments have a striking parallel with Thorndike's quotations cited earlier and are a further reminder that the problem of motivating the learning of mathematics through an appeal to student interest remains a live issue.

Interest and Problem Solving in Mathematics

Carleton Washburne's Committee of Seven (1926) attacked the question of why training children to solve arithmetic problems is one of the hardest and most discouraging tasks of the teacher. In one phase of the project a test was devised consisting of pairs of problems, one dealing with a "familiar" and the other with an "unfamiliar" situation. For example, a "familiar" problem given was:

> Three bars of chocolate sell for 10 cents. How many bars can I buy for 40 cents?

And an "unfamiliar" problem situation given was:

> In France, two liters of petrol cost 9 francs. How many liters of petrol can be bought for 90 francs?

The results indicated that while the element of unfamiliarity with the situation entered as a difficulty in problem solving, it was not as large an element as might be supposed.

In a follow-up study, Washburn's committee (1928) presented eight pairs of problems to 441 fifth graders. The pairs of problems involved the same sentence structure and length, the same arithmetic process, and numbers of the same order of difficulty. The tests were scored on the basis of process and accuracy. Whenever a significant difference occurred in the percentage of children solving correctly the two sets of problems, it was always the problem involving the more familiar, childlike situation which received the higher score. The authors then stated:

> . . . part of the difficulty that children have in applying their arithmetic to textbook problems lies in the problem, not in the children. Textbook makers and teachers alike should make the problems they expect children to solve, childlike and real. (p. 224)

Hydle and Clapp (1927) devised pairs of problems which were nearly alike, except in respect to an element of difficulty, whose effect was being studied. Two groups of intermediate grade children (n=3000) who had been equated on the basis of school achievement were assigned problems from the pairs. The investigators found that certain factors were to some extent significant causes of difficulty in problem solving and concluded that if the problem could be visualized, it became almost as easy as if it had occurred in the child's experience.

In a study of the performances of a large number of seventh-grade pupils on a relatively simple problem test, Monroe (1929) concluded that a large percent of the pupils did not reason in attempting to solve verbal problems. If the problem was stated in the terminology with which the pupils were familiar and if there were no irrelevant data, then the response was likely to be correct. Monroe claimed, however, that if the problems were expressed in unfamiliar terminology, relatively few pupils attempted to reason. Instead they either did not attempt to solve it or gave an incorrect solution.

Brownell and Stretch (1931) conducted a more comprehensive analysis of problem solving in order to search for a relation between the degree of familiarity of the problem settings and the proficiency with which children solved the problems. Instead of simply comparing familiar and unfamiliar problems, the investigators developed a test made up of problems of four degrees of familiarity and secured evidence of the validity of their ratings. The test was then given to fifth-grade children (n = 256) in four schools. Considering the test as a whole, the correct choice of operations showed a positive relation to degree of familiarity, but for certain problems, this was not the case. In accuracy of computation, the results were mixed. Brownell and Stretch concluded:

> More refined methods of treating the results not only failed to substantiate such a relation but even produced evidence that such a simple statement of the relation between setting and problem solving was partially erroneous and . . . wholly misleading. (p. 72)

Bowman (1929) examined the relationship between expressed interest in problem types and success in solving problems. By "interest," the researcher meant preference for some one situation over another. Problems of five types--adult, child, science, puzzle, and computation--were presented to 640 male and female, high and low ability, seventh-, eighth-, and ninth-grade students, who were asked to attempt to solve all of the problems on a given page and then indicate which of the five types they liked best. Bowman found that the high achieving students exhibited no decided preference for any problem type and performed "nearly equally well" on them all, while the low achieving students more consistently reported preference for the computational type problems. A correlation of .56 between preference for problems and success in their solution was reported.

Bowman's study seems to suggest that problems judged to be more interesting contribute little to the motivation of problem solving. Pupil preference for types of problems is based upon the expectation of success in solving problems. In other words, pupils prefer the kinds of problems which they believe that they can solve.

Kramer (1933) sought to identify the effect of interest, along with three other factors (reading ability, knowledge of fundamentals, mastery of mathematical vocabulary), upon children's success with arithmetic problems. She devised problems that were deemed by the criteria as "interesting" or "uninteresting." Since her subjects were unable to perform better on the interesting problems, she concluded:

> There is little evidence in these data that children prefer their arithmetic to concern itself with their plays, games and social activities . . . interest does not initiate substantially improved arithmetical thinking. (pp. 52-53)

In an uncontrolled experiment, Connor and Hawkins (1936) reported "considerable growth in problem-solving ability" resulting from the use of problems collected by the pupils and teachers from their environments.

Bramhall (1939) conducted a study to determine through experimentation the relative effectiveness of two types of arithmetic problems in the improvement of problem-solving ability of sixth-grade pupils. The types of problems (conventional vs. imaginative) were those described by Wheat (1929). For example, a "conventional" problem given was:

> How much will six baseballs cost at $1.25, each with a discount of 10 percent?

And an "imaginative" problem given was:

> Bill Jones is manager of the Tigers baseball team. . . . Mr. Williams, who owns a sporting goods store, told Bill that he would give the Tigers a 10 percent discount. How much then would Bill have to pay for six balls at $1.25 each?

An experimental group (n = 213) and a control group (n = 214) were equated by covariance on the basis of IQ. The problems for both groups were exactly the same except for the method of stating the problem. The control group worked conventional problems and the experimental group worked imaginative problems. The researcher concluded:

> Results of the final "Problem Test" showed a slight advantage for experimental pupils. However, this advantage is not great enough to consider as a basis for the exclusive use of imaginative problems. (p. 38)

Sutherland (1941) administered a battery of tests including arithmetic problems using "familiar" and "unfamiliar" situations to 134 eleven-year olds. The battery of tests was factor analyzed and the investigator reported:

> Since there was so little difference in the factorial analysis of the two tests, we seem to be justified in supposing they are parallel in every detail except the situation and that the sole reason for the difference in scores in the two tests was therefore the unfamiliarity of the situation. (p. 221)

Sutherland (1942) found that the subjects could score 35 percent higher on the arithmetic problems set in a familiar situation than on those set in an unfamiliar situation, and further that this difference was greatest in the least intelligent children, growing steadily less as the more able students were considered.

After reviewing a number of studies at Boston University, Wilson (1945) found support for the thesis that problem units developed by pupils under teacher direction afford a more effective basis for engendering problem-solving ability than the problems presented by a conventional text.

Lyda (1947) administered a self-constructed mathematical experience checklist by the use of the group-interview technique to selected seventh-grade students, who, in turn, indicated whether or not they had had a given mathematical experience often, seldom, or never. This group of thirty realistic verbal reasoning problems was then administered as a written test to these same pupils. The students were grouped as below average, average, and above average in intelligence. The researcher concluded:

> Direct, practical mathematical experience based upon the situation of a realistic verbal "reasoning" problem in arithmetic is a more potent conditioning factor in success in solving such a problem for students below average in intelligence than for students average or above average in intelligence. Similarly, it is a more potent conditioning factor for students average in intelligence than for those who are above average in intelligence. (p. 167)

Employing an elaborate statistical design, Schunert (1951) investigated possible factors "resident in the teacher, in the teaching, in the pupil, and in the school," which are related to achievement in mathematics. One of the many implications of the findings which were found to be significantly associated with mathematical achievement was that:

> Algebra classes in which life applications were regularly studied exceeded the achievement of classes in which life applications were seldom studied. (p. 233)

Hensell (1956) proposed to examine the literature and to establish criteria for evaluation of problem-solving content in arithmetic textbooks, Grades 3-6. A review of existing studies produced qualifying categories consisting of children's interests by which the problem-solving materials could be evaluated. The author determined that current textbook services did not make extensive use of children's interests as defined.

Holtan (1963) studied the relative effectiveness of different interests as "motivational vehicles" in teaching mathematics to ninth-grade general mathematics students by means of programmed instruction. The topic, inequalities, was developed in four treatment programs centered upon four interest areas: automotive, farming, social utility, and intellectual curiosity. One hundred thirty-six male mathematics students from two large high schools in a central Illinois city were classified into interest groups according to their highest and lowest scores on the Kuder Preference Record (Vocational) scales: Mechanical, Outdoor, Social Service, and Computational. The results of postexperimental and retention tests, partialing out pretest scores on a mathematics ability test, indicated that adapting instruction to the student's particular interest increases his achievement in mathematics. Holtan added:

> This has particular value in the construction of remedial and enrichment programmed materials and textbooks. The total experimental study did not present evidence to indicate that any of the motivational vehicles was superior to others. Thus the classroom teacher could defensibly choose any of these for classroom motivational use provided they are geared to the student's interest. (p. 25)

Travers (1967) devised a research test in an attempt to identify preferences of high school freshman mathematics students for solving problems from three situations commonly used in textbooks: mechanical-scientific, social-economic, and abstract. A sample of 240 subjects was drawn in equal numbers from two large high schools in two central Illinois cities. Two levels of students were established in each school: the high achieving students from the college preparatory algebra classes and the low achieving students from the general mathematics programs. The pupils were assigned to equal sized (n = 10) interest groups on the basis of their highest scores on the Kuder Preference Record (Vocational). Travers found that the interest groups differed in the number of mechanical-scientific and social-economic problems chosen. More abstract problems were chosen by high achievers. Problem-solving success was analyzed by means of a simple application of binomial probability theory and revealed that the number of students with success ratios greater in the "preferred" situations than in the "nonpreferred" situations did not differ from that which would be expected by chance.

Summary

The results of studies cited in this chapter are inconsistent. Some demonstrate either no relationship or an insignificant relationship between interest and problem-solving ability among secondary school mathematics students. Some others indicate a moderate positive relationship. The lack of clear, consistent definitions of problem solving and interest are undoubtedly contributing factors to these contradictory results.

However, advances in techniques of measurement and experimental design and the appearance of carefully researched instruments such as the Strong Vocational Interest Blank and the Kuder Preference Record may serve to alleviate these problems. In particular the evolution of the Kuder General Interest Survey, Form E, has resulted in an interest inventory designed specifically for secondary school students with high reliabilities being reported (Kuder, 1964). Consequently, this instrument was selected as an interest measure in this study.

CHAPTER III

DESIGN AND PROCEDURES

This study was designed to examine tendencies for students to be more successful in solving verbal problems based on situations which reflect the students' interests than in solving verbal problems based on situations which do not reflect the students' interests. Although the results of studies reviewed in Chapter II have been inconsistent, there remains an indication that when more refined interest measures are used, and when more refined statistical comparisons are made, interest may be shown to be related to problem solving.

Definitions

For the purpose of this study, the following definitions were adopted:

Interest. Interest is defined as preference for particular activities (Kuder, 1964). The interests of each subject were measured by his responses on the subscales, outdoor, computational, and scientific, of the Kuder General Interest Survey (GIS), Form E. (More detail on the GIS can be found later in the chapter).

Arithmetic Reasoning. Arithmetic reasoning is operationally defined as the scores from the concepts and problems section of the California Achievement Test.

Problem Setting. Three verbal problem-solving tests were constructed by the investigator. These tests were assumed to be parallel in accordance with a specified set of criterions (see Instruments Used for more information). However, the problems in each test were set in a specific context as related to the three interest areas mentioned above. Hence, one test contained problems set only in an outdoor context. Similarly, the other two tests contained problems set only in a computational and scientific context, respectively. Thus problem setting is defined as the situational embodiments (context) contained in a set of problems.

Independent and Dependent Variables

The independent variable was problem setting. This consisted of three levels: outdoor, computational, and scientific.

Concomitant variables included interest and arithmetical reasoning. These variables are not referred to as independent variables since they were not manipulated by the researcher.

The dependent variable for the study was the score on one of the forms of the verbal problem-solving test.

Hypotheses

This study was an investigation of the relationships among interest and verbal problem-solving behavior of eighth-grade mathematics students as measured by the Kuder General Interest Survey, Form E, and problem-solving tests designed by the investigator, respectively.

Based on the research reviewed in the previous chapter and the assumption by the investigator of the existence of a moderate positive relationship between interest and problem-solving achievement among secondary school mathematics students, it was intended that this study answer certain educational questions regarding this relationship. The questions were:

1. Based on the knowledge of a student's interests and arithmetical reasoning, is it possible to

predict on what type (context) of problems that student will be most successful as measured by a verbal problem-solving test?

2. Based on the knowledge of a student's interests alone, is it possible to predict on what type (context) of problems that student will be most successful as measured by a verbal problem-solving test?

In order to answer the questions posed, it was first necessary to construct problems that were different in terms of problem setting, but "equivalent" in terms of other aspects (e.g., reading level, mathematical operations involved, computational difficulty). In this study, three problem settings were selected: outdoor, computational, and scientific. Consequently, three sets of problems, each containing ten items and each reflecting one problem setting, were constructed. It was expected that the mean achievement scores on each problem set be approximately equal.

Furthermore, if a student had a high measured interest in one of the areas, then it was expected that his score would be greater on a problem-solving test whose problem setting complemented that measured interest than on a problem-solving test whose problem setting did not reflect that measured interest. This study is designed, then, to allow predictive ability with interest scores and arithmetic reasoning in predicting problem-solving success across three levels of problem setting.

The specific hypotheses tested were:

1. The mean scores on the problem-solving test across problem settings will not be significantly different from each other.

2. When scores on the verbal problem-solving test are regressed on an outdoor interest variable and arithmetic reasoning, the regression planes across groups (problem settings) will not be parallel.

3. When scores on the verbal problem-solving test are regressed on a computational interest variable and arithmetic reasoning, the regression planes across groups (problem settings) will not be parallel.

4. When scores on the verbal problem-solving test are regressed on a scientific interest variable and arithmetic reasoning, the regression plans across groups (problem settings) will not be parallel.

5. When scores on the verbal problem-solving test are regressed on an outdoor interest variable, the regression lines across groups (problem settings) will not be parallel.

6. When scores on the verbal problem-solving test are regressed on a computational interest variable, the regression lines across groups (problem settings) will not be parallel.

7. When scores on the verbal problem-solving test are regressed on a scientific interest variable, the regression lines across groups (problem settings) will not be parallel.

Several other statistical tests were conducted in order to facilitate the interpretation of the results. It was expected that:

8. The regression weights of the outdoor interest measure will be significantly different from zero only in the outdoor problem-setting group.

9. The regression weights of the computational interest measure will be significantly different from zero only in the computational problem-setting group.

10. The regression weights of the scientific interest measure will be significantly different from zero only in the scientific problem-setting group.

Each of the above hypotheses were tested twice, once for males and once for females.

Statistical Design

The statistical design used in the study to test Hypothesis 1 was a one-way analysis of variance with three levels (Edwards, 1972). The three levels refer to the three problem settings. The actual computations for the data analysis were carried out through the use of Veldman's (1974) computer program AOV123.

The procedure utilized to test Hypotheses 2 through 10 is based upon a technique of multiple linear regression set forth by Ward and Jennings (1973). A brief outline of the general procedure is given below.

Given a score for each individual on some dependent variable (also called a criterion variable), together with a corresponding score or scores for an independent variable or variables (also called a predictor variable), the following equation, called a full model, can be written:

$$Y = a_1X_1 + a_2X_2 + . . . a_nX_n + E_1.$$

$Y, X_1, X_2, X_3, . . . X_n$ are vectors, the components of which are scores obtained by the students on a criterion or predictor. The a_i's are called the regression coefficients. E_1 is an error vector.

A technique known as "least squares" (Ward & Jennings, 1973) is employed to compute a multiple correlation coefficient (R) between the criterion variable and a linear combination of the predictor variables.

To test a certain hypothesis, restrictions are imposed on the full model. For example, one might impose the following restriction: $a_1 = a_2 = a_3 = . . . = a_n$. Hence, the resulting equation, called the restricted model, is written in the following form:

$$Y = a_1X_1 + a_2X_2 + a_3X_3 + . . . + a_nX_n + E_1$$

$$= a_1(X_1 + X_2 + X_3 + . . . + X_n) + E_2$$

Letting $W = X_1 + X_2 + X_3 + . . . X_n$, the equation becomes:

$$Y = a_1W + E_2$$

Many different restrictions could be imposed on the full model.

As before, a multiple correlation coefficient may be computed between the criterion variable and a linear combination of the predictor variables in the restricted model.

The test of the hypothesis is based upon a comparison of the squared coefficient of multiple correlation, R_f^2, in the full model and the squared coefficient of multiple correlation, R_r^2, in the restricted model.

If R_f^2 and R_r^2 are the previously defined squared coefficients of multiple correlation for the full and restricted models, respectively, f is the number of linearly independent predictors in the full model, r is the number of linearly independent predictors in the restricted model, and k is the number of cases in the sample, then

$$\frac{\dfrac{R_f^2 - R_r^2}{df_1}}{\dfrac{1 - R_f^2}{df_2}}$$

is F-distributed with $df_1 = f - r$ and $df_2 = k - f$, as the appropriate degrees of freedom.

The actual computations for the data analysis involving multiple linear regression were carried out through the use of Veldman's (1974) computer program REGRAN.

The investigator chose a significance level of .05 for all stated hypotheses; that is, results would be considered statistically significant if the appropriate differences would have occurred by chance less than 5 percent of the time (i.e., accept the stated hypothesis if $p<.05$).

Instruments Used

Kuder General Interest Survey, Form E

The Kuder General Interest Survey (GIS), Form E, has been designed to measure an individual's preferences in ten broad areas of interest: Outdoor, Mechanical, Computational, Scientific, Persuasive, Artistic, Literary, Musical, Social Service, and Clerical. Its vocabulary and reading level have been extended downward to sixth grade and is thus suitable for junior high school students.

In addition to the ten areas of interest, a verification scale has been established by the test author in order to indicate subjects who answer the items carelessly, who answer without understanding the directions, or who tend to give ideal rather than sincere responses.

The GIS consists of 504 statements that are grouped into 168 triads. The individual exhibits his preference by indicating which of three activities in each test item he likes most and which he likes least. For example, the thirteenth triad in the GIS is:

Build birdhouses
Write articles about birds
Draw sketches of birds

Norms supplied by the GIS Manual transform the raw scores into percentiles. Separate norms are established for males and females. (This was the reason for testing each hypothesis twice.)

A description (Kuder, 1964) of the three interest areas utilized in this investigation follows:

> Outdoor interest means preference for work or activity that keeps you outside most of the time--usually work dealing with plants and other growing things, animals, fish, and birds. Foresters, naturalists, fisherman, telephone linemen, and farmers are among those high in outdoor interest. (p. 3)
>
> Computational interest indicates a preference for working with numbers and an interest in math courses in school. Bookkeepers, accountants, bank tellers, engineers, and many kinds of scientists are usually high in computational interest. (p. 3)
>
> Scientific interest is an interest in the discovery or understanding of nature and the solution of problems, particulary with regard to the physical world. If you have a high score in this area, you probably enjoy working in the science lab, reading science

> articles, or doing science experiments as a hobby. Physician, chemist, engineer, laboratory technician, meteorologist, dietitian, and aviator are among the occupations involving high scientific interest. (p. 3)

These areas were selected due to the fact that the intercorrelations among them are low (Kuder, 1964) and that earlier investigations (Holtan, 1964; Travers, 1965) using similar populations have revealed that these areas are more popular than the others.

California Achievement Test (CAT)

The CAT is a standardized achievement test which measures a student's verbal and quantitative ability. The quantitative part of the test consists of two parts: computation, and concepts and problems. The score on the concepts and problems section of the CAT was ascertained for each subject and used as a measure of his arithmetical reasoning.

Verbal Problem-Solving Test

Three parallel forms of a verbal problem-solving test, corresponding to the interest areas of outdoor, computational, and scientific, were constructed by the investigator. These three tests appear in Appendix A. Each form consisted of ten verbal problems. It was desired that only one feature of the problems on the three parallel forms, that of the context in which they were placed, would vary. In other words, the first problem in each of the three forms was similar except for context. Likewise, this procedure was used for problems two through ten. Care was exercised to control for the following aspects of the statements of the "equivalent" problems:

1. length of problem (nearly same number of words)
2. style of phrasing ("if . . . then . . . given . . . find," etc.)
3. verbal clues ("how much more . . .," etc.)
4. reading level (comparable vocabulary difficulty)
5. mathematical operations involved (addition, subtraction, etc.)
6. computational difficulty (same numbers, same answers)

The following are examples from the verbal problem-solving test:

Outdoor

Jill planted tomatoes in her backyard. If there are 5 rows and 6 tomato plants per row, how many tomato plants does Jill have?

Computational

Mr. Brown is a cashier in a clothing store. If a customer purchases 5 shirts at $6.00 a shirt, how much should Mr. Brown charge?

Scientific

Mr. Brown raises white mice for scientific reasons. If he has 5 cages and 6 white mice per cage, how many white mice does Mr. Brown have?

The mathematics topics included in the verbal problem-solving test were chosen to be within the grasp expected of eighth-grade students. They were:

1. Add, subtract, multiply, and divide whole numbers.
2. Add, subtract, multiply, and divide rational numbers.
3. Solve for a percent.
4. Solve proportions where all members are whole numbers.

The level of difficulty of the test items was judged appropriate for eighth-grade students by an inservice eighth-grade mathematics teacher and a former eighth-grade mathematics teacher. It was also important that the test items reflect certain specified interests. An educational psychologist who was familiar with the Kuder General Interest Survey, Form E, validated the test in this regard. In addition, the parallelism of the test items among the three tests was checked by two mathematics educators. The criterion test was thus validated on three points.

Procedure

Arrangements for administration of the study were provided by the mathematics supervisor of the Waco (Texas) Independent School District. Through his efforts, the principal and the mathematics faculty of Lake Air Junior High School agreed to participate in the study.

On April 13, 1976, the investigator administered the Kuder General Interest Survey, Form E, to approximately one-half of the entire eighth-grade student body. The remainder of the students was administered the survey on the following day. Although there is no time limit for this interest inventory, most students completed it in 45 to 75 minutes. The tests were hand scored by the investigator.

A total of 305 students completed the interest survey. From this total, 67 students were eliminated either for failure to pass the verification scale or for not following directions.

Since separate norms are established for males and females in determining interest scores, the 238 subjects who remained in the study were separated by sex. The male subjects were randomly assigned to each of three problem settings by means of a random number table. A similar procedure was followed for female subjects. The problem settings included outdoor, computational, and scientific. The problem-solving test, whose content reflected outdoor interest, was administered to those students who had been randomly assigned to the outdoor problem-setting group. Likewise, the computational problem-setting group and the scientific problem-setting group were administered the problem-solving test whose content reflected computational and scientific interests, respectively.

On May 10, 1976 the investigator met with the three teachers who were to participate in the study. The rationale and need for the study were explained. In addition, each teacher was provided with a sufficient number of the three problem-solving tests and was told which students were to receive which test.

On May 11, 1976, the teachers administered the problem-solving tests in their respective classrooms. All teachers indicated that, in general, they felt their students made a sincere effort to work the test. Most of the tests were completed within 45 minutes.

The tests were hand scored by the investigator. In deciding whether to give a subject credit for correctly solving a problem, the following criteria were established:

1. If the answer is numerically correct, credit will be given.
2. If the answer is numerically incorrect, or if the problem has not been attempted, no credit will be given.

As anticipated, several students were not present during the administrat[illegible] the problem-solving tests. This resulted in 15 cases with incomplete data. Consequently, 223 subjects were included in the final analysis (Table 3.1 presents the size of each group). In order to maintain anonymity, the subjects in each group were assigned numerical codes.

Summary

In this chapter the definition of terms to be used in the study and a discussion of the relevant variables were presented. Also the hypotheses were stated and a description of the instruments given. In addition,

TABLE 3.1

GROUP SIZE

Group	Size
Male	
Outdoor	38
Computational	38
Scientific	38
Female	
Outdoor	36
Computational	35
Scientific	38

a description of the administrative procedures of the study was presented.

Results of the analysis of the data are presented in Chapter IV.

CHAPTER IV

DATA ANALYSIS

Analysis of the data for testing and interpreting the hypotheses stated in the previous chapter is presented in this chapter. Any secondary analyses necessary to interpret the findings are also discussed.

Descriptive Statistics

Tables 4.1 and 4.2 report means and standard deviations of all tests used for males and females, respectively.

Comparison of Group Means

Hypothesis 1 was stated as follows:

1. The mean scores on the problem-solving test across problem settings will not be significantly different from each other.

An analysis of variance technique was used in order that the means of the three problem-setting groups be compared on the problem-solving test. Table 4.3 and 4.4 summarize these results for males and females, respectively. For males and females, the hypothesis of equal means on the problem-solving tests was not rejected at the .05 level.

A careful examination of the arithmetic reasoning scores suggests that the student groups used in this study

TABLE 4.1

MEANS AND STANDARD DEVIATIONS OF TESTS FOR MALES IN THE OUTDOOR, COMPUTATIONAL, AND SCIENTIFIC PROBLEM-SETTING GROUPS

Test	Maximum Score Possible	Groups					
		Outdoor[a]		Computational[a]		Scientific[a]	
		Mean	SD	Mean	SD	Mean	SD
Outdoor interest	100	52.24	29.18	37.42	26.01	40.92	28.66
Computational interest	100	55.71	26.97	65.03	26.42	54.50	29.58
Scientific interest	100	36.47	25.84	37.39	25.31	32.32	24.87
Arithmetic reasoning	100	65.26	23.40	57.66	26.86	64.95	23.71
Problem-solving	10	7.47	1.87	6.82	2.71	7.00	2.47

[a] N = 38 for the outdoor, computational, and scientific groups.

TABLE 4.2

MEANS AND STANDARD DEVIATIONS OF TESTS FOR FEMALES IN THE OUTDOOR, COMPUTATIONAL, AND SCIENTIFIC PROBLEM-SETTING GROUPS

Test	Maximum Score Possible	Groups					
		Outdoor[a]		Computational[a]		Scientific[a]	
		Mean	SD	Mean	SD	Mean	SD
Outdoor interest	100	50.89	27.55	45.17	29.25	49.57	21.25
Computational interest	100	45.53	25.57	53.11	29.87	51.80	26.90
Scientific interest	100	47.56	28.37	35.94	24.43	36.40	22.88
Arithmetic reasoning	100	53.56	27.27	50.83	26.98	54.03	26.23
Problem-solving	10	6.25	2.76	6.20	2.54	6.06	2.61

[a]N = 35, 36, and 38 for the outdoor, computational, and scienfific, respectively.

44

TABLE 4.3

TEST FOR EQUAL MEANS--MALES

Source	SS	df	MS	F	p
Between Groups	8.7544	2	4.3772	.7531	.48
Within Groups	645.1842	111	5.8125		

were somewhat unusual. Since the arithmetic reasoning scores are percentile scores from the California Achievement Test (CAT) they may be intuitively compared to the norming sample for the CAT. Each group in this study yielded means slightly higher than that of the norming sample and standard deviations on the order of one and one-half times that of the norming sample. It seems likely that the study sample consists of a much more heterogeneous group than was anticipated.

Reliability Coefficients

Reliability coefficients for the problem-solving tests were computed within the outdoor, computational, and scientific problem-setting groups. Since each item on the problem-solving tests was scored on a dichotomous scale (right or wrong), the Kuder-Richardson Formula 20 is an appropriate measure of reliability (Nunnally, 1967). The results are reported in Table 4.5. Each of the three reliability coefficients reflected a moderate degree of internal consistency. This finding was expected since the problem-solving tests contained only 10 items.

Correlation Coefficients within Groups

Pearson product moment correlation coefficients are presented for each problem-setting group. The results for males are reported in Tables 4.6, 4.7, and 4.8.

TABLE 4.4

TEST FOR EQUAL MEANS--FEMALES

Source	SS	df	MS	F	p
Between Groups	3.6799	2	1,8400	.2555	.78
Within Groups	763.4026	106	7.2019		

TABLE 4.5

RELIABILITY COEFFICIENTS FOR THE PROBLEM-SOLVING TESTS

Group	Reliability Coefficient
Outdoor	.76
Computational	.79
Scientific	.79

TABLE 4.6

WITHIN GROUP CORRELATION COEFFICIENTS

OUTDOOR GROUP--MALES

Test	Correlations				
	1	2	3	4	5
1. Outdoor interest		-.14	-.36*	.03	.03
2. Computational interest			.16	.17	.06
3. Scientific interest				.30	.33*
4. Arithmetic reasoning					.68*
5. Problem-solving					

*Denotes a significant correlation coefficient at the .05 level.

TABLE 4.7

WITHIN GROUP CORRELATION COEFFICIENTS

COMPUTATIONAL GROUP--MALES

Test	Correlations				
	1	2	3	4	5
1. Outdoor interest		-.14	-.16	.13	.17
2. Computational interest			.33*	.27	.18
3. Scientific interest				.14	.19
4. Arithmetic reasoning					.83*
5. Problem-solving					

*Denotes a significant correlation coefficient at the .05 level.

TABLE 4.8

WITHIN GROUP CORRELATION COEFFICIENTS

SCIENTIFIC GROUP--MALES

Test	Correlations				
	1	2	3	4	5
1. Outdoor interest		-.20	-.08	.21	.19
2. Computational interest			.22	.17	.29
3. Scientific interest				.20	.09
4. Arithmetic reasoning					.75*
5. Problem-solving					

*Denotes a significant correlation coefficient at the .05 level.

It should be noted that the intercorrelations among the three interest variables in each group are quite low. This result tends to support the results of past studies (Holtan, 1964; Kuder, 1964; Travers, 1967) and strengthens the claim that these interest tests are measuring different attributes.

The high correlations between arithmetic reasoning and problem-solving achievement in each of the three groups were certainly expected. These tests all shared common characteristics.

In only one out of nine cases, the correlation between an interest variable (scientific) and problem solving (outdoor) was significant. This was an unexpected finding in view of the hypothesis that outdoor interest will predict success in the outdoor problem-setting group. Similarly, it was expected that computational interest and scientific interest would predict success in the computational and scientific problem-setting groups, respectively. Such was not the case.

The correlation coefficients for females within each of the three groups are presented in Tables 4.9, 4.10, and 4.11.

There are several important observations to be noted in Tables 4.9, 4.10, and 4.11. First, there were no

TABLE 4.9

WITHIN GROUP CORRELATION COEFFICIENTS

OUTDOOR GROUP--FEMALES

Test	Correlations				
	1	2	3	4	5
1. Outdoor interest		-.42*	.07	.04	-.02
2. Computational interest			.10	-.04	-.01
3. Scientific interest				.16	.06
4. Arithmetic reasoning					.91*
5. Problem-solving					

*Denotes a significant correlation coefficient at the .05 level.

TABLE 4.10

WITHIN GROUP CORRELATION COEFFICIENTS

COMPUTATIONAL GROUP--FEMALES

Test	Correlations				
	1	2	3	4	5
1. Outdoor interest		-.56*	-.01	.30	.25
2. Computational interest			-.06	-.01	-.18
3. Scientific interest				-.07	-.04
4. Arithmetic reasoning					.66*
5. Problem-solving					

*Denotes a significant correlation coefficient at the .05 level.

TABLE 4.11

WITHIN GROUP CORRELATION COEFFICIENTS

SCIENTIFIC GROUP--FEMALES

Test	Correlations				
	1	2	3	4	5
1. Outdoor interest		-.10	-.33	-.35	-.26
2. Computational interest			-.14	-.30	-.43*
3. Scientific interest				.23	.19
4. Arithmetic reasoning					.81*
5. Problem-solving					

*Denotes a significant correlation coefficient at the .05 level.

significant positive correlations among the three interest variables in each group. This is similar to the finding for males. Also, there was a strong positive relationship between arithmetic reasoning and problem solving in each of the three groups.

The correlation between an interest variable (computational) and problem solving (science) was significant in only one out of nine cases. This was a negative correlation, however.

Heterogeneity of Regression--Two Predictors

The hypotheses (2, 3, and 4) involving two predictors were:

2. When scores on the verbal problem-solving achievement test are regressed on an outdoor interest variable and arithmetic reasoning, the regression plane across groups will not be parallel.

3. When scores on the verbal problem-solving achievement test are regressed on a computational interest variable and arithmetic reasoning, the regression planes across groups will not be parallel.

4. When scores on the verbal problem-solving achievement test are regressed on a scientific interest

variable and arithmetic reasoning, the regression planes across groups will not be parallel.

A multiple linear regression technique (see Chapter III) was used to test these hypotheses. Tables 4.12 and 4.13 present the statistics relevant to Hypotheses 2, 3, and 4 for males and females, respectively.

The test for the parallelism of the regression planes predicting the verbal problem-solving achievement test from two predictor variables, an interest variable and arithmetic reasoning, was not rejected at the .05 level. Thus, there was no evidence of interaction between problem setting and a linear combination of interest and arithmetical reasoning in predicting problem-solving.

Heterogeneity of Regression--One Predictor

To investigate the existence of interaction using each interest variable as the only predictor of performance on the verbal problem-solving test, tests for parallelism of regression lines (Hypotheses 5, 6, and 7) were performed using multiple linear regression. The hypotheses were:

5. When scores on the verbal problem-solving achievement test are regressed on an outdoor interest

TABLE 4.12

TEST FOR HETEROGENEITY OF REGRESSION

TWO PREDICTORS--MALES

Test	R_f^2	R_r^2	df_1	df_2	F	p
Outdoor interest and arithmetic reasoning	.6050	.5873	4	105	1.177	.32
Computational interest and arithmetic reasoning	.6147	.5866	4	105	1.917	.11
Scientific interest and arithmetic reasoning	.6104	.5864	4	105	1.616	.17

TABLE 4.13

TEST FOR HETEROGENEITY OF REGRESSION

TWO PREDICTORS--FEMALES

Predictors	R_f^2	R_r^2	df_1	df_2	F	p
Outdoor interest and arithmetic reasoning	.6633	.6450	4	100	1.362	.25
Computational interest and arithmetic reasoning	.6803	.6568	4	100	1.837	.13
Scientific interest and arithmetic reasoning	.6635	.6451	4	100	1.364	.25

variable, the regression lines across groups will not be parallel.

6. When scores on the verbal problem-solving achievement test are regressed on a computational interest variable, the regression lines across groups will not be parallel.

7. When scores on the verbal problem-solving achievement test are regressed on a scientific interest variable, the regression lines across groups will not be parallel.

Tables 4.14 and 4.15 present the statistics relevant to Hypotheses 5, 6, and 7 for males and females, respectively.

The test for parallelism of the regression lines predicting achievement on the verbal problem-solving test from an interest variable was not rejected at the .05 level. Again, there was no evidence of interaction between problem setting and interest in predicting problem solving.

Equations of Regression Lines

In order to facilitate the interpretation of the data, the following hypotheses were tested:

TABLE 4.14

TEST FOR HETEROGENEITY OF REGRESSION

ONE PREDICTOR--MALES

Predictors	R_f^2	R_r^2	df_1	df_2	F	p
Outdoor interest	.0392	.0316	2	108	.430	.66
Computational interest	.0589	.0489	2	108	.577	.57
Scientific interest	.0528	.0482	2	108	.263	.77

TABLE 4.15

TEST FOR HETEROGENEITY OF REGRESSION

ONE PREDICTOR--FEMALES

Predictor	R_f^2	R_r^2	df_1	df_2	F	p
Outdoor interest	.0367	.0053	2	103	1.680	.19
Computational interest	.0688	.0425	2	103	1.453	.24
Scientific interest	.0132	.0082	2	103	.272	.77

8. The regression weights of the outdoor interest measure will be significantly different from zero only in the outdoor problem-setting group.

9. The regression weights of the computational interest measure will be significantly different from zero only in the computational problem-setting group.

10. The regression weights of the scientific interest measure will be significantly different from zero only in the scientific problem-setting group.

The results for males and females are exhibited in Tables 4.16 and 4.17 respectively.

For males, scientific interest predicted success only in the outdoor group. However, for females, computational interest predicted success only in the scientific group. Consequently, Hypotheses 8, 9, and 10 cannot be accepted at the .05 level.

Summary

The F-test for testing the hypothesis of equal means on the problem-solving tests for the outdoor, computational, and scientific groups failed to reach significance at the .05 level. Thus, the hypothesis of equal means was not rejected.

TABLE 4.16

REGRESSION OF PROBLEM-SOLVING TEST ON EACH INTEREST VARIABLE INDIVIDUALLY--MALES

Interest Test	Group	Intercept	Raw Wt.	Std. Wt.	Mult R	F[a]	
	O	7.39	.0016	.0254	.0254	.023	.87
Outdoor	C	6.15	.0177	.1697	.1697	1.067	.31
	S	6.31	.0186	.1943	.1943	1.413	.24
	O	7.25	.0034	.0584	.0584	.123	.73
Computational	C	6.66	.0186	.1815	.1815	1.226	.28
	S	5.66	.0246	.2945	.2945	3.419	.07
	O	6.61	.1080	.3266	.3286	4.357	.04
Scientific	C	6.07	.0199	.1858	.1858	1.287	.26
	S	6.72	.0086	.0865	.0865	.271	.61

[a]Degrees of freedom for the outdoor, computational, and scientific groups are (1, 36).

TABLE 4.17

REGRESSION OF PROBLEM-SOLVING TEST ON EACH INTEREST

VARIABLE INDIVIDUALLY--FEMALES

Interest Test	Group	Inter-cept	Raw Wt.	Std. Wt	Mult R	F[a]	p
	O	6.56	-.0022	-.0223	.0223	.018	.89
Outdoor	C	5.21	.021[illegible]	.2572	.2572	2.2[illegible]	.14
	S	6.98	-.0236	-.1947	.1947	1.418	.24
	O	6.28	-.0007	-.0066	.0066	.001	.97
Computational	C	7.01	-.0153	-.1796	.1796	1.100	.30
	S	7.94	-.0406	-.3986	.3986	6.803	.01
	O	5.98	.0056	.0574	.0574	.112	.74
Scientific	C	6.34	-.0038	-.0362	.0362	.043	.83
	S	5.25	.0157	.1415	.1415	.736	.40

[a]Degrees of freedom for the outdoor, computational, and scientific groups are (1,34), (1,33), and (1,36) respectively.

No evidence was exhibited supporting the hypotheses that the three problem sets interacted with arithmetic reasoning and an interest variable or an interest variable alone. Many of the findings were contradictory to what was expected. It may be the case that the wide variation of student achievement, as exhibited by the inflated standard deviations on the CAT, reduced the likelihood of finding significant statistics even if the expected relationships hold.

C H A P T E R   V

SUMMARY AND CONCLUSIONS

This study tested the existence of a positive relationship between interest and problem solving when problems are set in the area of interest among secondary school students. Previously conducted research and the investigator's own beliefs suggested that it may be possible to predict on what type (context) of verbal problems a student will be most successful based on a knowledge of his interests and arithmetical reasoning ability.

Three parallel forms of a verbal problem-solving test, corresponding to the interest areas of outdoor, computational, and scientific, were constructed by the investigator. It was intended that only one feature of the problems on each of three parallel forms, that of the context in which they were placed, would vary. Otherwise, corresponding problems on each of the three forms were designed to be equivalent (e.g., reading level, mathematical operations involved, computational difficulty).

The Kuder General Interest Survey (GIS), Form E, was administered to 305 eighth grade mathematics students in the Waco (Texas) School District. Separate norms are established for males and females on the GIS. Hence, students were randomly assigned, by sex, to each of three problem settings (outdoor, computational, and scientific). The problem-solving test, with content reflecting outdoor interest, was administered to those students who had been randomly assigned to the outdoor problem-setting group. A similar procedure was followed for the students randomly assigned to the computational or scientific problem-setting groups.

Hypotheses were tested using multiple linear regression.

Conclusions and Discussions

The questions that were attempted to be answered by empirical tests of the hypotheses formulated in this study were:

1. Based on the knowledge of a student's interests and arithmetical reasoning, is it possible to predict on what type (context) of problems that student will be most successful as measured by a verbal problem-solving test?

2. Based on the knowledge of a student's interests alone, is it possible to predict on what type (context) of problems that student will be most successful as measured by a verbal problem-solving test?

Responses to the above listed questions are based on the results of the hypotheses testing presented in Chapter IV. The answers to the questions, relative to the conditions of this investigation, are discussed below.

Answer to Question 1. There was no evidence in the data obtained to support the expectation that it would be possible to predict on what type (context) of problems a student would be most successful as measured by his score on a verbal problem-solving test if prior knowledge of his interests and arithmetical reasoning were known.

Answer to Question 2. There was no evidence in the data obtained to support the expectation that it would be possible to predict on what type (context) of problems a student would be most successful as measured by a verbal problem-solving test if prior knowledge of his interests were known.

In view of the related research referred to in Chapter II and the literature on motivation, it was somewhat surprising not to find affirmative evidence for the two questions. It may be the case that if interests serve as motives, they tend to be very weak as predictors of problem solving.

The lack of support for Hypotheses Two through Ten may have been due to the inability of the problem-solving tests to reflect a specified area of interest. Consequently, the tests would not have any differential effects as far as interests were concerned. In other words, the students may have found no distinctions among the three tests. One further consideration of the problem-solving tests is important at this point. As indicated in Chapter IV, the reliability coefficients on each of the three forms reflect only a moderate degree of internal consistency. The correlation between two variables will be lower if one or both of the measures have only a modest reliability as opposed to a high reliability. Hence, an increase in the reliability of the problem-solving tests may in turn, increase the correlation among interest and problem solving.

It was stated in Chapter III that many students were eliminated from the study for failure to pass the verification scale on the Kuder General Interest Survey.

This seems to have resulted in an overabundance of high mathematics achievers, as revealed by the CAT scores. Consequently, the mean on each of the three problem-solving tests was above six (ten items comprised each test). For these high achievers, the role of interest may have been neglig...

Limitations of the Study

When evaluating the results and conclusions of the study, certain limitations should be considered.

1. The problem-solving tests were relatively short. It is the opinion of the investigator that a longer test, in which more situations could be embodied, may provide different results.

2. Only three interest areas were taken into account. Consequently, generalizations to other interest areas should be made with caution.

3. One possible source of contamination was interaction among the students during the administration of the problem-solving tests. It was suspected that students who completed the test in the morning may have discussed it with other students prior to their taking it in the afternoon.

Recommendations for Future Research

For future research in the area of this investigation, the investigator recommends:

1. Additional work needs to be conducted in developing the problem-solving tests. More evidence is necessary to claim that the tests actually do reflect a specified area of interest.

2. The same basic design should be replicated using different interest areas. It is the opinion of the researcher that interest areas in which students have had more hands-on experience (e.g., sports, automechanics, music) will serve as stronger motives than those used in this study. It may be necessary to use interest measures other than the GIS. A suggested test may be Ewen's Activity Experience Inventory.

3. Interest may serve as a strong motive during the 'learning' stage of a new concept. One might investigate this through the construction of different learning packets on the topic of simultaneous linear equations, for example, in which the only difference among the packets is in the situational embodiments contained in the example problems illustrating the concept. These

problems should reflect different interest areas. Learning, retention, and transfer tests may then be administered.

Concluding Statement

While the results of this study are not particularly promising, the investigator does not wish to convey the impression that other studies in this area should not be conducted. With appropriate changes in the measuring instruments (e.g., stronger validation of the problem-solving tests, more items on the problem-solving tests, different interest measures), a significant relationship between interest and problem solving may still be found. Any avenue of research which may facilitate the development of problem-solving skills, an important outcome of mathematics instruction, should be investigated.

A P P E N D I X   A

PROBLEM-SOLVING TESTS

1

Name ______________________ Teacher ______________________

Directions: Work each of the problems below as best you can. Please show your work in the space provided. Put your answer in the blank.

1. Jill planted tomatoes in her backyard. If there are 5 rows and 6 tomato plants per row, how many tomato plants does Jill have?

Answer ________

2. A man with an axe can cut down $\frac{1}{6}$ as many trees as a man with a power saw. How many trees will a man with an axe cut down while a man with a power saw cuts down 180 trees?

Answer ________

3. A rancher has a herd of cattle. The cattle consume 150 pounds of vitamin mineral supplement each month. If the supplement comes in 50 pound bags and costs $10.00 a bag, how many bags of supplement does the rancher buy each month?

Answer ________

4. Sue's family enjoys going to the beach each Sunday. In order to get to the beach and back, they travel 105 miles in a total of $3\frac{1}{2}$ hours driving time. What is their speed in miles per hour?

Answer ________