A STUDY OF MATHEMATICS VERBAL PROBLEM-SOLVING THROUGH READING INSTRUCTION AMONG LOW ACHIEVING STUDENTS IN THE EIGHTH GRADE

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by

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ABSTRACT

The major purpose of this study was to determine if special instruction in specific reading skills could significantly improve low achieving students' ability to solve mathematical verbal problems. Three questions were explored:

1) Does instruction in specific reading skills cause improvement in mathematical verbal problem-solving among low achieving grade eight students?
2) Is there a relationship between sex and mathematical verbal problem-solving ability?
3) Is there an interaction effect on mathematical verbal problem-solving ability between the sex of the students and the instructional treatment used with those students?

The subjects of the study were 36 grade eight low achieving students from the Integrated Central High School, Stephenville, Newfoundland. These 36 students were randomly assigned to one of two treatment groups--an experimental group and a control group--18 students in each group. The experimental group consisted of 12 boys and 6 girls, while the control group consisted of 11 boys and 7 girls. The special instruction (experimental) treatment group received 30 lessons of instruction in the specific reading skills

involved in mathematical verbal problem-solving, while the supervised (control) group received 30 lessons of solving verbal problems using methods they had learned in the past with no emphasis on these reading skills taught to the experimental group. Analysis of results indicated that students in both groups improved from pretest to posttest on the investigator's designed Verbal Problem Test and the Canadian Test of Basic Skills subtest on problem-solving. However, the experimental group's mean scores were significantly higher than mean scores for the control group on both posttests, which indicated a positive relationship between the specific reading skills treatment and ability to solve mathematical verbal problems. No significant difference was found to support the conclusion that the sex of a student influenced mathematical verbal problem-solving ability; nor did the investigator find any significant interaction between the instructional treatment and the sex of the student.

The major conclusion of this study was that instruction in specific reading skills significantly improved students' ability to solve mathematical verbal problems.

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CHAPTER I

BACKGROUND TO THE PROBLEM

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 is necessary to determine the nature of the skills and abilities which are required for solving verbal problems. 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.

Although there is lack of agreement on factors which influence success in verbal problem-solving, there is consensus that children must be able to recognize words and comprehend thought units in the problem, logically interpret the problem situation, and organize the information in such a way as to lead to an answer to the stated question. Computation skill is also necessary in solving verbal problems but is useless without the ability to read the problem accurately.

Reading in Mathematics

Reading to solve a verbal problem involves a composite of several reading skills which differ somewhat from those used to read narrative-type materials. Suydam and Weaver (1970) stated that reading and other interpretive skills specifically related to problem-solving should be developed in the problem-solving program. Only short units of material are read at one time. In place of ten to fifteen or more pages which might be read in science, or a developmental reading lesson, no more than one or two pages are usually read in mathematics per day. There is little continuity between paragraphs. Each verbal problem may be completely unrelated in content to the previous one. The content of verbal problems is usually of little importance, only a means to an end, to interest the child in working the problem.

Mathematics writing is compact, with each word being important. Content is limited to essential ideas. The lack of rich content makes word identification difficult. The vocabulary in mathematics literature presents a stumbling block to many children. Some of the words may already be familiar but have unfamiliar meaning in mathematics context. Others are easily identified as belonging only to the field of mathematics and are seldom met in narrative-type reading. Each of these types of technical vocabulary must be recognized and the concepts carefully taught if children are to understand what they have read in mathematics.

A mixture of graphic and numerical symbols may break the reader's train of thought and prevent him from reading in completed thought units. The reader needs as good an understanding of the numerals, signs, and abbreviations used in mathematical writing as he would have if these concepts were all expressed in the uneconomical form of words. The reader tends to concentrate on the numerals in the problem since he knows they will be needed for its solution.

Reading verbal problems requires more intense concentration than that needed for reading narrative-type materials. Time must be taken periodically to reflect upon what has been read, to search for relations between the information given, and to apply appropriate mathematical skills for the solution of the problem. Analytical reading is necessary for recognizing limitations of the data given, determining relevancy of information, and recognizing relations. The reader must then be able to synthesize or integrate his ideas and infer the appropriate operation to be used in solving the problem. This type of reading is necessarily slower than that used for reading narrative-type materials.

Rereading is often unnecessary in reading narrative-type materials but is essential for successful reading of verbal problems. A quick skimming of the problem will enable the reader to get a general impression of the problematic situation to determine the main idea. He should be able to recognize what is required in the problem, i.e. what the question is. This must be held in mind as he rereads the problem to pick out the relevant details, to see the relations between the main and subordinate ideas, to organize the data, and infer a process for solving the problem. After the computation is completed, another re-reading is necessary to check the reasonableness of the answer. These rereadings are each for a different purpose and require different reading skills. Children must become aware of these differences and adjust the type of reading involved in each particular reading of the problem.

The Nature of Low Achievers

Various names have been used in the literature to describe the students who are referred to in this study as "low achievers". These names include below-average achievers, underachievers, culturally deprived, educationally deprived, reluctant learners, slow learners, rejected learners, students of limited interest or ability, and the forgotten people of education. The multiplicity of terms used to refer to the low achiever may be taken as an indication of the complexity of those students known as low achievers.

Ogle (1970) listed several characteristics of the low achiever:

1) History of failure

2) Poor self-image

3) Poor reading ability

4) Little interest in mathematics

5) High rate of absenteeism

6) Poor memory

7) Short attention span

8) Emotional and social immaturity

9) Difficulty with abstractions

10) Fails to see practical use of mathematics as it applies to him

The above list does not exhaust the characteristics of a low achiever nor do all low achievers exhibit all these characteristics, but it is probably this complexity that has limited the amount of research on the low achiever. However, there are a few research studies worth noting.

Cronbach (1967) summarized several studies conducted to investigate the affective domain in relation to cognitive learning. These studies indicated that low achievers functioned best when short-term goals were spelled out, there was a maximum of explanation and guidance, and feedback occurred at short intervals.

Leiderman (1964) in an analysis of other studies, corroborated these generalizations given by Cronbach.

Schultz (1972) indicated that it was the teacher who was the manager of instruction and he or she had to provide the necessary learning experiences to meet the needs of the low achiever.

This study analyzed selected reading skills to determine their influence on mathematical verbal problem-solving among low achieving grade eight students.

Purpose of the Study

The major purpose of this study was to investigate the following question. Does instruction in specific reading skills cause improvement in mathematical verbal problem-solving among low achieving grade eight students?

Two minor questions were also investigated in this study.

1) Does sex influence mathematical verbal problem-solving ability?

2) Is there an interaction effect on mathematical verbal problem-solving ability between the sex of the students and the instructional treatment used with those students?

Based on these problems the following null hypotheses were formulated and tested in this study.

H_{O1}: There is no significant difference in the achievement scores on a test of mathematical verbal problem-solving between low achieving students receiving instruction in specific reading skills and those low achieving students not receiving such instruction.

H_{O2}: There is no significant difference in the achievement scores on a test of mathematical verbal problem-solving between low achieving boys and low achieving girls.

H_{O3}: There is no interaction between sex and instructional treatment among low achieving students as measured on a test of mathematical verbal problem-solving.

Need for 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.

The need for studies of the relationship of specific reading skills to problem-solving ability was anticipated many years ago by such researchers as Engelhart and Monroe (1931). Illustrations of this are:

> Reading ability seems to be an important factor in the ability to respond to verbal problems, but the precise nature of its function has not been ascertained (p. 96).
>
> There is also need for more information about the function of reading in pupil responses to verbal problems and the relation to the form and vocabulary of problem statements to these responses (p. 97).

Wilson (1922) expressed even more clearly the nature of the problem:

> There is an accumulation of evidence which indicates that the reading of verbal problems calls for some specific reading skills as well as for an acquaintance with the vocabulary and conventions employed in 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 (p. 54).

Authorities believe that these reading skills are best learned within the context in which they are to be applied, rather than through instruction given during the developmental reading period (Corle & Coulter, 1962, 1964; Fay, 1965; Russell, 1961; Smith, 1963; Spache, 1969; and Treacy, 1942). Numerous suggestions for improving children's ability to solve verbal problems have been given by authorities in both the fields of reading and mathematics (Bond, 1966; Marks, 1965; Spitzer, 1954; and Van Engen, 1959).

Since girls are usually more proficient in language skills than boys, and assuming the importance of reading ability to success in solving verbal problems, it seemed probable that girls would receive higher scores on tests of ability to solve verbal problems than would boys.

In view of these suggestions, an effort to determine the effects of specific reading skills and the effect of sex on mathematical verbal problem-solving seemed in order. Subsequently, it was hoped that such a study might provide some input into future curriculum development courses for teachers of mathematics.

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.

Problem-solving ability. The trait measured by the mathematical subtest of the Canadian Test of Basic Skills and the investigator's Verbal Problem Test.

Specific reading skills. These skills included (a) recognizing and understanding vocabulary, (b) selecting the main idea, (c) recognizing the question asked in the problem, (d) noting important details which must be used in solving the problem, (e) noting when information is insufficient for the solution to be reached, (f) noting when the problem contains information not relevant to the solution of the problem, (g) organizing the information given and recognizing relations which exist in view of the question asked, (h) reading to note sequence, (i) predicting outcomes, and (j) formulating a sentence which answers the question to the problem.

Low achiever. The student who, (1) is achieving below his assigned grade level, (2) is not mentally retarded, and (3) has no serious emotional problems.

Delimitations

There were delimitations to this study. It dealt with only one geographical area of the province, and only students from one school were investigated. There was no attempt to exhaust all the socioeconomic and environmental factors associated with the students' backgrounds. The study was further limited by the selection of a particular group of specific reading skills involved in mathematical verbal problem-solving.

Outline of the Study

A review of the related literature is presented in Chapter II. Chapter III contains the procedures followed in conducting the study, and the method used in collecting and processing the data. The results of the data analysis are discussed in Chapter IV. The final chapter summarizes the conclusions reached as a result of the study, and contains implications and recommendations for further research.

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) Research on verbal problem-solving procedures; (2) Characteristics of children indicative of verbal problem-solving ability; and (3) Research on factors related to verbal problem-solving ability.

Research on Verbal Problem-Solving Procedures

Researchers have conducted many investigations to find a superior problem-solving procedure. 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 a study by Washburne and Osborne (1926) it was reported that an ability to make the type of formal analysis frequently taught in school had practically no relationship with an ability to solve problems.

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 mathematical verbal problems. 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).

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 5 arithmetic textbooks surveyed. This finding emphasizes the disagreement concerning a superior procedure for solving verbal arithmetic problems (pp. 177-182).

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. 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 (p. 285).

Characteristics of Children Indicative of Verbal Problem-Solving Ability

Piaget identified stages in the intellectual development of children with accompanying implications for arithmetic instruction. Copeland (1970) interpreted these stages and stated the 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 (p. 120).

2) The primary grade child should probably not be given problems requiring a logical process of analysis (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 (p. 145).

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

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. They concluded 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 socioeconomic levels of school environment attained higher scores in the area 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.

Bodwin (1957) conducted a study to investigate the relationship between an immature self-concept and educational disabilities in reading and arithmetic at the third and sixth grade levels. He reported these conclusions:

> 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 difference in these relationships (p. 1646).

Research on Factors Related to Verbal Problem-Solving Ability

The importance of reading improvement in verbal problem-solving was recognized many years ago. Newcomb (1922) compared four experimental groups which received special emphasis in reading 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 twenty 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 twenty-day instructional period, the Stone Reasoning Test was again administered to all subjects and the results revealed a significant gain in speed of solving problems and a slight, insignificant, gain in accuracy in favor of the experimental groups.

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 lowest combined verbal problem scores were designated as "poor achievers" and the 80 having the highest combined verbal problem scores were designated as "good achievers". Scores for the good and poor achievers were compared by t-test on each of the fifteen 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 the 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. 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. 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 (p. 544).

Balow (1964) investigated the null hypothesis: "There are no significant differences in the problem-solving ability associated with general reading ability, computation ability, or an interaction of these factors, when intelligence is controlled". His findings were in direct opposition with those of Fay (1950). When intelligence was controlled, there was a significant difference associated with computational ability as the student in the higher levels of computation produced higher scores in problem-solving. There was also 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 not 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 (pp. 21-22).

Corle and Coulter (1964) identified the reading skills which enable intermediate-grade children to interpret verbal mathematics problems as: (1) vocabulary development; (2) literal interpretation of the problem; and (3) reasoning--the selection of the proper solution process.

The importance of vocabulary development was emphasized by Fay (1965) and Vanderlinde (1964). Fay noted that while success in mathematics depends on a vocabulary of terms which provide a basis for mathematical reasoning and clues for the use of numerical process, it also depends on a child's understanding of the number system. Vanderlinde stated that students who do not comprehend the technical vocabulary used in the content area do not comprehend the important ideas within the area. These writers seem to agree that the study of the technical vocabulary of mathematics is essential to the program.

Data collected by Vanderlinde (1964) and by Lyda and Duncan (1967) indicated that the direct study of quantitative vocabulary produced a significant growth in elementary students' problem-solving abilities.

The importance of literal interpretation of the problem statement was supported by Chase (1961) who found that ability to note details in reading problems was a skill necessary for success in verbal problems.

The importance of selecting the proper solution process for a verbal problem has been treated by Cathcart and Liedtke (1969). They studied the difference in mathematical success between reflective students and impulsive students. The researchers hypothesized that reflective students would be more successful because they would reflect upon the quality of their answers; the impulsive students would give unconsidered responses. The findings indicated that the reflective students did achieve better scores than the impulsive ones in problem-solving and recalling the basic facts, but not in mathematical understanding.

Chase (1960) studied 15 variables which might affect an intermediate-grade pupil's ability to solve verbal problems. He concluded that the ability to compute, skill in noting details in reading, and a knowledge of fundamental mathematics concepts were the three major predictors of problem-solving ability. Chase also noted the importance of generalizations which underlie the number system and the ability to apply reading skills to a variety of purposes.

Glennon and Callahan (1968), after reviewing a number of studies on research in problem-solving, concluded that the following factors were most important for success:

> 1) General reading skills, including vocabulary.
>
> 2) Problem-solving reading skills, including comprehension of the problem statement, selection of relevant details, and selection of the proper solution procedure.
>
> 3) Mechanical computation and a mathematical understanding of the concept of quantity, the number system, and important mathematical relationships.
>
> 4) A spatial factor, involving the ability to visualize and conceptualize objects and symbols in more than one dimension and to use mental imagery to clarify word meanings (Laffey, 1972, pp. 150-152).

Aaron (1965) identified several specialized reading skills unique to mathematics. They include (1) the mathematics vocabulary; (2) the concept background necessary for understanding ideas; (3) the ability to select skills and rates appropriate for the mathematics being read; (4) the proficiency in the special reading tasks of mathematics such as reading word problems, equations, charts, graphs, and tables; and (5) the skill in the interpretation of mathematical symbols and abbreviations (p. 391).

In an analytical study by Engelhart (1932) identifying abilities necessary for problem-solving the following results were given:

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 variance in verbal problem-solving.

4) Unknown causes are responsible for a remaining 33.59 percent of the variance in verbal problem-solving (p. 29).

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

Summary of Related Literature

The importance of verbal problem-solving ability as the ultimate goal of mathematics instruction has long been recognized by educators, but research has failed to consistently identify those variables that might predict success for students.

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 students. The research concluded that there was no best method; the value, of any method depended upon the skills of the teacher using it.

Other researchers attempted to identify specific characteristics of students which might enable them to be high achievers in verbal problem-solving. Findings in this area are encouraging, as certain traits have been identified which would enable students to be more successful in verbal problem-solving achievement.

Another approach by researchers was an attempt to select those factors thought to be related to solving mathematical verbal problems, and by applying appropriate statistical analysis, they attempted to identify those factors without which success could not be realized. Some factors were identified as contributing to high achievement in verbal problem-solving, but research findings were conflicting.

CHAPTER III

DESIGN OF THE STUDY

Introduction

This chapter presents a description of the design of this study. It includes information about the following: the experimental design; the instrument; the sample; the procedures used in conducting the study; and the method of collecting and analyzing the data.

The Experimental Design

The experimental design used in this study was the pretest-posttest control group design (see Campbell & Stanley, 1963). This design has the following symbolic form:

$$\begin{array}{llll} RO_1 & X & O_2 \\ RO_3 & & O_4 \end{array}$$

According to Campbell and Stanley (1963) this is one of the most widely used and powerful designs in educational research. The investigator of this study had to modify the randomization of his subjects slightly. Because the investigator was unable to select his subjects from a general population, he had to randomly assign the thirty-six subjects to one of two groups--18 in each. Following this assignment the investigator randomly assigned the treatments to the groups.

The Instrument

Several standardized tests were reviewed by the investigator for selection purposes. Since the Canadian Test of Basic Skills contained norms on Canadian students with a high degree of validity and reliability in the areas of investigation for this study (see Appendix F), the investigator decided to administer alternative forms of the subtest of mathematical problem-solving as a pretest and posttest measurement.

To control the affects of reading and mathematical computation the investigator administered a reading test (a subtest of the Canadian Test of Basic Skills, Form 3, Level 14) and the Arithmetic Computation Test (a subtest of the Stanford Achievement Test, Advanced Battery, see Appendix E). Both of these tests were administered as a pretest to the experimental group and to the control group.

Sampling

Thirty-six grade eight low achievers from the Integrated Central High School in Stephenville, Newfoundland, were selected for this study. These students were selected after being identified by school cumulative records and their teachers as low achievers. The thirty-six students were randomly assigned to an experimental group and a control group--18 students in each group. Both of these groups were taught by the investigator.

Procedures

The Canadian Test of Basic Skills, Form 3, Level 14, subtests on reading and mathematical problem-solving was administered as a pretest to both the experimental group and the control group. In addition, the Arithmetic Computation Test (a subtest of the Stanford Achievement Test, Advanced Battery) and the investigator's verbal problem test, see Appendix G) were administered as pretests to both groups. The purpose of these pretests was to determine whether the two groups of students were equivalent on the factors affecting problem-solving (e.g. computation and reading) at the onset of the study which, in turn, permitted the investigator to interpret his results more accurately.

Instruction in reading skills was given each school day by the investigator during the regular mathematics period. Each group received 13 forty-minute periods of mathematics in an eight-day cycle over a four-week period. The purpose of instruction given to the students in the experimental group was to strengthen their ability to read verbal problems. The lessons stressed those reading skills given in the definition of specific reading skills for this study.

As a guide to the teaching of these special reading skills the textbook entitled Strategies for Effective Reading by Elizabeth Thorn and William Fagan was used with the experimental group. However, both groups used the same mathematical textbook as a supplement for problem-solving.

The investigator selected the problems to be taught during this study (see Appendix C). The problems used for each lesson were organized so that each lesson was somewhat more complex than the preceding lesson, even though the basic plan of the lesson was similar. Each lesson's problems required the use of all previously taught reading skills and reinforced previous learning while introducing a new skill to be learned. In general, the plan of a lesson involved a teacher directed discussion of three or four verbal problems. During this discussion the students were helped to become aware of the particular idea or skill being emphasized through that lesson. The students used a work-sheet as a guide while working the problems.

The worksheets contained the headings of Vocabulary, Main Idea, Question, Important Facts, Relation Sentence, Mathematical Sentence, Answer Sentence, as well as space for writing the appropriate information under each heading (see Appendix C). To find the main idea of the problem, the student was encouraged to read the problem quickly, skimming to get a general picture of what the problem was about. The question in the problem was noted and written in the appropriate place. Symbols were used to represent the question and the important facts which were necessary for the solution of the problem. Reading the symbols by the use of words was stressed in order to assure the students had their meaning well in mind. After the relation sentence was written, each important fact was related back to the situation in the verbal problem, and the numeral was selected which could be used to replace that fact, thus building the mathematical sentence through direct relation to the structure of the problem already delineated. The answer sentence contained the numeral found by computation, and was expressed as a transformation of the question originally posed in the problem.

The control group was given the same series of problems but they had to solve these problems using any method they wished to use and without any instruction in reading skills. The purpose of this treatment was to control the amount of time spent on mathematics, giving students in both groups equivalent time in some type of work with verbal problems.

Mathematically, both the experimental group and the control group were treated identically. The investigator gave no mathematics instruction in either group. The students were instructed to apply whatever mathematical knowledge they possessed to solve the given problems. After the students had solved the problems, the investigator performed the calculations for the students of both treatment groups and displayed these calculations on the classroom board.

Procedure for Data Analysis

When all the data were complete a two-factor analysis of variance was performed. Using unweighted means analysis (see Appendix H), F-ratios were computed to test the significance of the hypotheses investigated in this study. An analysis of covariance was also performed using the CTBS problem-solving pretest and the investigator's VPT pretest as covariates. Although the experimental group and the control group appeared to be equivalent at the onset of the study (see Table 1), the investigator carried out the analysis of covariance on the posttests to statistically test the equivalence of both of these groups.

CHAPTER IV

ANALYSIS OF DATA

Introduction

The major purpose of this study was to determine if special instruction in specific reading skills could improve students' ability to solve problems more than opportunity to practice solving many problems. Two minor hypotheses concerned the relationship of sex and the interaction of sex with instructional treatment to problem-solving. Scores made on tests of verbal problem-solving ability by boys were compared to those made by girls to discover if significant differences existed.

Thirty-six students were randomly assigned to a control group and an experimental group--18 students in each group. Then the treatment was randomly assigned to the groups. Because these students were not randomly selected and represented a relatively small sample, four pretests were administered for the purpose of verifying equivalence between the two groups. All four pretests confirmed the initial equivalence of these two groups of students. These results are reported in Table 1 below. Although the experimental group was consistently higher on all four pretests the difference between the groups was not statistically significant (t-tests).

TABLE 1

Comparison of Means on Pretest Measures of CTBS Reading, CTBS Problem-Solving, Stanford Computation, and the Investigator's VPT for each Treatment

Pretest Measures	Experimental Group (N=18) Mean	Control Group (N=18) Mean	t
CTBS Reading	24.5	23.4	0.43
CTBS Problem-Solving	10.7	9.8	0.65
Stanford Computation	24.4	23.6	0.48
Investigator's VPT	17.5	16.5	0.93

Level of significance for t-test at the .05 level is t = 2.030.

Presentation of Results

Two posttest scores were obtained for both groups of students: a posttest score on the Canadian Test of Basic Skills (CTBS), Form 4, Level 14, subtest on problem-solving and a posttest score on the investigator's Verbal Problem Test (VPT). A two-factor analysis of variance, unweighted means (see Appendix H), F-ratio, and an analysis of covariance were computed on the means of each group for both posttests. These results are reported in Table 2 through Table 5 below. The .05 level of significance was adopted for this study.

TABLE 2

Results of a Two-Factor Analysis of Variance, Unweighted Means (CTBS Posttest)

Source of Variance	df	MS	F	p
Sex (A)	1	1.031	1.46	p > .05
Treatment (B)	1	2.976	4.21*	p < .05
A x B	1	0.182	0.26	p > .05
Within cells	32			

*F-ratio significant at the $\alpha = .05$ level

TABLE 3

Results of a Two-Factor Analysis of Variance, Unweighted Means (VPT Posttest)

Source of Variance	df	MS	F	p
Sex (A)	1	0.15	0.23	p > .05
Treatment (B)	1	2.739	4.24*	p < .05
A x B	1	0.26	0.40	p > .05
Within cells	32			

*F-ratio significant at the $\alpha = .05$ level

TABLE 4

Results of an Analysis of Covariance of CTBS Posttest with CTBS Pretest as Covariate

Source	df	SS_x	SP	SS_y	df^1	SS_y^1	MS_y^1	F
Between	1	7.11	15.89	34.03	1	22.65	22.65	
Within	34	592.89	226.11	197.61	33	111.38	3.38	6.70*
Total	35	600	242	231.64	34	134.03		

*F-ratio significant at the $\alpha = .05$ level.

TABLE 5

Results of an Analysis of Covariance of VPT Posttest with VPT Pretest as Covariate

Source	df	SS_x	SP	SS_y	df^1	SS_y^1	MS_y^1	F
Between	1	8.03	15.59	30.35	1	19.48	19.48	
Within	34	391.19	143.72	175.39	33	122.59	3.71	5.25*
Total	35	399.22	159.31	205.64	34	142.07		

*F-ratio significant at the $\alpha = .05$ level.

It can be seen from Table 2 through Table 5 that the experimental group received significantly higher means on both posttests ($p < .05$). The null hypothesis, H_{O_1}, investigated in this study was, therefore, rejected. The investigator found a significant difference between those students receiving special reading instruction and those not receiving such instruction with the direction of significance in favor of the students receiving the special reading instruction.

Since solving verbal problems involves both reading and mathematics skills, and since previous research (Bond, 1966; Earle, 1976; Spache, 1969) had indicated that girls excel boys in reading, it seemed worthwhile to examine sex differences between combined mean scores obtained by boys in both treatment groups with the combined mean scores obtained by girls in both treatment groups.

The two-factor analysis of variance, F-ratio, computed on sex differences in mean scores on the two posttests indicated that sex was not a significant factor in this study ($p > .05$). These results are reported in Table 2 and Table 3 above. The null hypothesis, H_{O_2}, investigated in this study was, therefore, accepted. There was insufficient evidence to support the conclusion that the sex of a student significantly influenced mathematical verbal problem-solving ability.

Finally, the investigator computed the two-factor analysis of variance, F-ratio, to determine whether there was a significant interaction between the treatment groups and the sex of the students. The two-factor analysis of variance, F-ratio, reported in Table 2 and Table 3 above indicated that there was no significant interaction in this study ($p > .05$). The null hypothesis, H_{O_3}, investigated in this study was, therefore, accepted. Neither boys nor girls, in either the experimental group or the control group, obtained higher mean scores on the two posttests.

Discussion

The investigator of this study employed several techniques to establish the equivalence of the control group and the experimental group at the onset of the study. Because the students were randomly assigned to treatment groups but not randomly selected from the general population, and considering that the sample was small (18 students in each treatment group), the investigator administered the four pretests mentioned above to verify the equivalence of the two treatment groups.

Other variables that would have possibly affected this study were controlled to the investigator's satisfaction.

To control the teacher variable, the investigator taught and supervised both treatment groups. There was no evidence that students in either treatment group received any help with verbal problem-solving outside the regular classroom mathematical periods. Student absence was not considered significant in this study because both groups had relatively the same number of pupil days absent (Experiment 4, Control 3). Each treatment group received the same number of mathematical classroom periods. The physical conditions were controlled in that adjacent mathematical periods were scheduled for both treatment groups, while the school's eight-day cycle schedule gave a proportional number of these mathematical periods over various times in the day and various days in the week. No unusual interruptions took place during the instructional periods. The classrooms were adjacent classrooms with equivalent physical features. The sensitization of pretest effect was controlled by administering the pretest to both the experimental group and the control group.

The investigator concluded, on the basis of the above mentioned controls and the results reported in Table 2 through 5 above, that the special reading instruction treatment had the desired effect in this study of increasing a student's ability to solve mathematical verbal problems.

Although the sex of a student did not significantly relate to mathematical verbal problem-solving ability, the boys' mean scores on both posttests and for both treatment groups were higher than the girls' mean scores on these posttests. These results are reported in Table 6 below. A possible explanation for this occurrence was noted by the investigator of this study. Because the reading selections were short in the mathematical verbal problems, the boys were able to read and comprehend these short selections as well as or better than the girls. Had the reading selections been longer in these mathematical verbal problems then the girls would have been expected to obtain higher mean scores than the boys, if indeed the research on reading superiority of girls, mentioned in this study, was accurate (see Chapter V, Recommendations for Further Research).

TABLE 6

Posttest Means for Boys and Girls and Combined Means Differentiated by Treatment

Test	Experimental Group Mean Boys n=12	Experimental Group Mean Girls n=6	Experimental Group Mean Combined n=18	Control Group Mean Boys n=11	Control Group Mean Girls n=7	Control Group Mean Combined n=18
CTBS Problem-Solving	12.67	11.16	12.2	10.45	9.86	10.2
Investigator's VPT	18.90	18.0	18.6	16.73	16.71	16.7

This study did not report a significant interaction between sex of the student and the two treatments employed in the study. This finding suggested that neither the experimental treatment nor the control treatment interacted significantly with the sex of the student to produce higher mean scores for one sex over the other in either treatment group.

CHAPTER V

SUMMARY, LIMITATIONS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The major purpose of this study was to test the effect of special instruction in certain reading skills involved in solving verbal problems on the improvement of students' ability to solve verbal problems. Two minor hypotheses concerned the relationship of sex to problem-solving ability and the interaction of instructional treatment with the sex of the student. Scores made on tests of verbal problem-solving ability by boys were compared to those made by girls to discover if significant differences existed.

The subjects for this study were thirty-six grade eight low achievers who attended the Integrated Central High School, Stephenville, Newfoundland, during the 1977-1978 school year. After randomly assigning these thirty-six students to an experimental and a control group, and randomly assigning the groups to treatments, four pretests were administered (CTBS Reading, Stanford Computation, CTBS problem-solving, the investigator's Verbal Problem Test). Each group underwent four weeks of solving mathematical verbal problems using its specific treatment technique. At the end of the four weeks, two posttests were administered, the CTBS problem-solving test and the investigator's verbal problem test.

Two-factor analysis of variance, unweighted means, and an analysis of covariance, F-ratios were computed on the two treatment posttest means. These F-ratios yielded a significant difference ($p < .05$) in favor of the experimental group (the group who received the special reading instruction).

No significant difference was found to support the conclusion that the sex of a student influenced mathematical verbal problem-solving ability. The investigator also found no significant interaction between the instructional treatment and the sex of the student.

Limitations of the Study

Certain limitations of this study are noted in this section. Because the sample of students used in this study was small--thirty-six students--from one geographical area of the province and the fact that these students were not randomly selected, the threats to external validity were recognized. Any generalizations to other students must take the considerations mentioned above into account.

"Problem-solving ability" and "reading skills" were limited in this study to the traits measured by the tests used in this study in ascertaining them. There was no claim made that the specific reading skills selected were the only reading skills involved in verbal problem-solving.

The fact that the experimental group and the control group were equivalent at the onset of the study on the measured variables used in this study was not a claim that the variables measured in this study were the only variables affecting a student's verbal problem-solving ability.

Conclusions

Two-factor analysis of variance and an analysis of covariance, F-ratios, were computed for the purpose of testing the hypotheses investigated in this study. The following conclusions seem justified based on the findings in this investigation.

1) Instruction in specific reading skills in this study significantly improved the students' ability to solve mathematical verbal problems. This conclusion supported the research quoted in the study which stated that reading skills were best learned within the context in which they were to be applied, rather than through instruction given during the developmental reading period. Those who are responsible for teaching mathematical problem-solving must also be responsible for teaching the specific reading skills necessary for problem-solving.

2) The sex of students in this study did not significantly influence their mathematical verbal problem-solving ability. Although boys obtained higher mean scores than girls on both posttests used in this study, the differences were not significant.

3) There was no significant interaction in this study between sex and instructional treatment. Both sexes performed equally well in each treatment group.

Recommendations

The major purpose of this study was accomplished by indicating that instruction in specific reading skills could improve a student's ability to solve mathematical verbal problems. The investigator recommends that the following skills be stressed in eighth grade mathematics classrooms to improve pupils' skills in mathematical verbal problem-solving.

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 eighth grade mathematics student to be a better verbal problem-solver.

2) 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.

3) Learning experiences should be provided for students to determine the main idea of a mathematical verbal problem.

4) Students should have experience with selecting specific facts given in a verbal problem which are essential to the solution of the problem.

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

6) Students should have experience with verbal problems which contain unnecessary data, insufficient data, and no numbers.

7) Instruction should be provided to improve mathematical computation skills.

Recommendations for Further Research

As a result of the study, the investigator made the following recommendations for further research:

1) A study should be undertaken to investigate the effect of sex differences on the amount of reading involved in mathematical verbal problem-solving. The verbal problems should vary in length from one-sentence problems to multi-sentence problems.

2) A study, similar to this study, should be undertaken and the retention rate of the students assessed one month after the completion of the study.

3) A large scale study should be undertaken involving other grade levels to determine if instruction in specific reading skills can improve mathematical verbal problem-solving ability in these grades.

4) A study should be undertaken involving high, average, and low achieving students to compare the effect of instruction in specific reading skills with improvement in mathematical verbal problem-solving ability among the three ability groups. This study should also investigate the influence of sex on mathematical verbal problem-solving ability.

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APPENDIX A

CORRESPONDENCE

5 Viking Terrace
Stephenville, Nfld.
A2N 1K1
November 9, 1977

Mr. Edward Penney
Principal
Integrated High School
Stephenville, Nfld.

Dear Mr. Penney:

As part of the requirement for a Master of Education degree, a candidate is required to complete an internship/thesis on some aspect of his/her teaching profession. As such a candidate, I have developed a unit of work in mathematics on verbal problem-solving which I would like to teach to the low achieving grade eight students in your school.

This thesis would involve the random assignment of your grade eight low achievers to two groups--an experimental group and a control group. The experimental group would receive special instruction in specific reading skills while the control group would not receive the instruction in the special reading skills. After a period of four weeks both groups of students would be tested to ascertain their progress.

May I have your confirmation to teach the above mentioned unit to the low achieving grade eight students in your school.

Yours truly,

Wallace Rowsell

Stephenville Integrated High School
BOX 324, STEPHENVILLE, NEWFOUNDLAND
TELEPHONE: 643-5101

December 20, 1977

Mr. Wallace Rowsell
5 Viking Terrace
Stephenville, Newfoundland
A2N 1K1

Dear Mr. Rowsell:

This is to confirm that permission is granted to you to teach the unit of work in Mathematics as outlined in your letter of November 9, 1977.

I would be quite interested in seeing the results of the project after you have the results tabulated.

May I extend my personal good wishes in your future studies, and if I can be of any assistance please feel free to contact me.

Yours truly,

Edward W. Penney
Principal

APPENDIX B

COPY OF THE VERBAL PROBLEM TESTS

VERBAL PROBLEM PRETEST

DIRECTIONS: Place the <u>letter</u> of the most appropriate answer in the space provided at the right side of each problem.

1. Mr. Jones worked long hours at the station this week. On Monday he worked 10 hours; on Tuesday, 9 hours; on Wednesday, 10 hours; on Thursday, 9 1/2 hours; on Friday, he came home early. He worked 4 1/2 hours that day. How many hours did Mr. Jones work during the week?
   This problem is about:
   a) a way to live
   b) a person's work
   c) the days of the week
   d) the enjoyment gained through working 1. ____

2. Perry Hall Junior High received a shipment of 230 books. They expect 7 more shipments of the same size. What is the total cost of the books?
   To work this problem I need to be given:
   a) the name of the school
   b) the expected number of shipments
   c) the number of books in each shipment
   d) the cost of each book 2. ____

3. Sherry has 21 mystery books and 11 adventure books. Today she bought more mystery books. Now she has 32 mysteries. How many mystery books did she buy today?

To work this problem I do <u>not</u> need to know:

a) the number of adventure books

b) the number of mystery books before today's purchase

c) the total number of mystery books

d) the mystery books bought today 3. ____

4. The highest point in Asia in Mount Everest with an elevation of 29,028 feet. Mount McKinley in Alaska with an elevation of 20,300 feet is the highest point in North America. What is the difference in their altitudes?

This problem asks me to:

a) give the height of the highest point of land

b) find how many feet one point of land is higher than another

c) find the height of two points of land

d) find the height of Mount McKinley 4. ____

5. Bob bought a shirt for \$4. He also bought a jacket for \$16 more than the shirt. How much change did he get back from \$30?

This problem asks me to:

a) find how much change Bob will receive

b) find the cost of two things

c) compare the price of two things

d) find the cost of the shirt 5. ___

6. Gloria's girl scout troop is selling homemade candy. The girls made 10 pounds of candy. How many boxes of candy will they have?

To work this problem I need to know the:

a) number of girls in the scout troop

b) price of the candy per box

c) amount of candy in one box

d) number of boxes of candy 6. ___

7. Mr. Preston estimated that it would take him 3 3/4 hours to drive from his home to his sister's. He left at 9:30 a.m. and arrived at 12:50 p.m. It took him how many hours less than he expected?

This problem is about:

a) Mr. Preston's work

b) Mr. Preston's sister

c) time spent working

d) time taken to travel by automobile 7. ___

8. Charlotte's father took the family on a motor trip. The expenses included gasoline, \$18.45; oil, \$0.90;

lodging, \$37.00; meals, \$59.25; amusements, \$24.83; miscellaneous expenses, \$19.54. How much did the trip cost?

This problem is about:

a) the enjoyment of camping

b) the hazards of driving

c) the cost of a trip

d) a person's work 8. ____

9. In 1950 Miss Chadwich swam the English Channel from France to England in 13 hours 28 minutes to set a woman's record for the event. This time was how much less than a day?

To work this problem I need to know:

a) Miss Chadwich's age

b) the record time before Miss Chadwich's swim

c) the number of hours in a day

d) the distance across the English Channel 9. ____

10. Airplanes land at the municipal airport at the rate of one every five minutes. How many planes land in two and one-half hours?

This problem asks me to find:

a) the number of planes landing at an airport

b) how fast planes fly

c) how many planes refuel at an airport

d) how many planes by-pass an airport 10. ____

11. A car averages forty-five miles per hour and carries four passengers. How far will it travel in five hours? To work this problem I do <u>not</u> need to know:

a) the speed of the car

b) the number of passengers in the car

c) the number of hours the car was driven

d) all of the above 11. ____

12. The prize money for a golf tournament is $15,000. Half of it goes to first place, one-third to second place, and one-sixth to third place. How much does each of the first three winners receive?

This problem asks me to find:

a) the total amount of prize money

b) how much the first place winner receives

c) how much the second place winner receives

d) how much each of the top three winners receive 12. ____

13. Mrs. Tow promised to make 6 pounds of candy for the bazaar. She made 3 3/4 pounds of fudge. She plans to make taffy for the rest. How much taffy will she need to make?

This problem gives:

a) too much information

b) too little information

c) the right amount of information

d) information about sewing 13. ____

14. The population of Hilldale was estimated to be 20,116 thousand people in 1970. That same year, the population of Leetown was estimated to be 16,986 thousand people. How many more people lived in Hilldale?

This problem asks me to:

a) estimate the population of two towns

b) compare the population of two towns

c) give the population of Hilldale in 1970

d) none of the above 14. ____

15. The neighborhood baseball team bought 12 balls at $1.75 each and 7 bats at $1.95 each. If the 9 boys shared the cost equally, how much was each boy's share?

This problem is about:

a) cost of baseball equipment

b) winning baseball games

c) losing baseball games

d) the enjoyment of playing baseball 15. ____

16. To buy a car, Chris paid a down payment plus $78 a month for 24 months. How much did he pay for the car:

To work this problem I need to be given:

a) how much the car cost

b) the number of payments made

c) the amount of the down payment

d) the amount of each monthly payment 16. ____

17. Mrs. Jones has an income of $9,522 from which she bought a sofa for $295, a chair for $79 and two tables for $53 each. She paid a deposit of $50. How much more does she owe on the furniture? To work this problem I do <u>not</u> need to know:

a) the cost of the two tables

b) Mrs. Jones' income

c) the amount of the deposit

d) the cost of the sofa 17. ____

18. Mrs. Brown bought the following items at the supermarket: a loaf of bread for 35¢, one-half gallon of milk for 62¢, 2 cans of dog food for 49¢, 2 dozen eggs at 79¢ per dozen, 1 pound of butter at 83¢ per pound, and 5 pounds of potatoes for 59¢. How much change did Mrs. Brown get from a $5 bill?

This problem asks me to find the:

a) cost of goods purchased

b) cheapest goods

c) most expensive goods

d) amount of change 18. ____

19. Mr. Smith's annual income is $12,750. His budget includes 30% of his income for food, 25% for rent and utilities, 10% for clothes, and 5% for savings. What amount of his income remains for other purposes?

This problem is about:

a) the amount of money a person earns

b) the amount of money spent on different items

c) Mr. Smith's grocery bill

d) none of the above 19. ____

20. Mr. Barry is an automobile salesman. He has a choice of receiving a weekly salary of $50 plus 5% commission on all sales or a weekly salary of $150 plus 2% commission on all sales. Which would be the better deal?

To work this problem I need to know:

a) the amount of the sales he makes

b) his monthly salary

c) the price of each automobile sold

d) his yearly income 20. ____

21. An electric train is on sale at 1/3 off. The marked price is $33.60. What does the train cost on sale?

To work this problem I need to:

a) add

b) multiply

c) multiply and subtract

d) multiply and add 21. ____

22. Robin got 80% of the problems on her mathematics test correct. There were fifty problems on the test. How many did she miss?

This problem asks me to:

a) find the number of problems correctly answered

b) find the per cent of the problems answered incorrectly

c) find the number of problems answered incorrectly

d) all of the above 22. ____

23. Mr. Stephen owns a house that is valued at \$40,000. The house is insured for 80% of its value for which Mr. Stephen pays \$52.40. What is the insured value of the house?

To work this problem I do not need to know:

a) the cost of the insurance

b) the value of the house

c) the insured value of the house

d) all of the above 23. ____

24. Find the perimeter of a rectangle 16 inches long and 5 inches wide.

To work this problem I need to know:

a) the meaning of the word "perimeter" alone

b) the meaning of the word "rectangle" alone

c) the meaning of the words "perimeter" and "rectangle"

d) none of the above 24. ____

25. A car that cost $2500 depreciated 2% a month for the first 3 months. What was the value of the car at the end of three months?

To work this problem I need to:

a) divide

b) divide first, then add

c) multiply

d) multiply first, then subtract 25. ____

VERBAL PROBLEM POSTTEST

DIRECTIONS: Place the letter of the most appropriate answer in the space provided at the right side of each problem.

1. A secretary began work at 8:30 a.m., had a half-hour for lunch, and stopped work at 5 p.m. How many hours did she work during the day?

   This problem is about:

   a) the enjoyment of working

   b) what a person had for lunch

   c) a person's work

   d) what a person did after work 1. ____

2. The seating capacity at the new Jackson High School athletic field is 4,120. The stands at the old field held only 1,584 people. How many more spectators can now be seated?

   This problem asks me to:

   a) find the total number of seated spectators in the new athletic field

   b) compare the number of spectators in the new field with the number of spectators in the old field

   c) find the total number of spectators that can be seated in both fields

   d) none of these 2. ____

3. How far can a car go on a tankful of gasoline if it averages 16 miles per gallon?

To work this problem I need to be given the:

a) number of miles the car travelled

b) amount of gasoline in the tank

c) speed of the car

d) mileage reading on the car's instrument panel 3. ____

4. Pat bought three rose bushes at $4 each and two azalea plants at $6 each. How much did they cost in all?

To work this problem I need to:

a) add

b) subtract and add

c) divide and add

d) multiply and add 4. ____

5. Mrs. Brown has 10 pounds of meat in her fridge. She decides to cook 2 3/4 pounds of the meat for dinner. She plans to cook the remainder next week. How much meat will she cook next week?

This problem gives:

a) too much information

b) too little information

c) the right amount of information

d) information on cooking meat 5. ____

6. An airplane averages 360 miles per hour and carries 432 passengers. How far will it travel in 3 hours? To work this problem I do not need to know:
   a) the number of passengers on the airplane
   b) the speed of the airplane
   c) the number of hours the airplane was flying
   d) all of the above 6. ____

7. Woolworth received a shipment of 123 television sets. They expect 3 more shipments of the same size. What is the total cost of the television sets? To work this problem I need to be given the:
   a) name of the company
   b) expected number of shipments
   c) number of television sets in each shipment
   d) cost of each television set 7. ____

8. What is the area of a rectangle with sides measuring 15 centimetres by 12 centimetres? To work this problem I need to know:
   a) the meaning of the word "area" alone
   b) the meaning of the word "rectangle" alone
   c) the meaning of both "area" and "rectangle"
   d) none of the above 8. ____

9. There were a total of 15 questions on a French test. Sue answered 60% of the questions correctly.

How many were incorrectly answered?

This problem asks me to:

a) find the number of questions answered incorrectly

b) find the number of questions answered correctly

c) find the per cent of the problems answered incorrectly

d) all of the above 9. ____

10. A salesman receives a commission of 10% on sales under $1000 and a commission of 15% on sales over $1000. How much commission will the salesman earn in a month if his sales total $2050?

To work this problem I need to:

a) add

b) multiply, subtract, and add

c) divide, and add

d) subtract, divide, and add 10. ____

11. David has a $100 bill. He bought trousers for $12 and two shirts at $9 each. How much change did he receive?

This problem asks me to:

a) find the cost of two things

b) compare the price of two things

c) find the cost of two shirts

d) find how much change is received 11. ____

12. Mr. Jones' class went on a field trip. The expenses included $20 for the bus, $5.50 for meals, and $3.75 for miscellaneous expenses. How much did the trip cost?

This problem is about the:

a) enjoyment of field trips

b) cost of a field trip

c) hazards of a field trip

d) best time to take a field trip 12. ____

13. During the year Mr. Berry bought the following amounts of stove oil to heat his house: 155 gallons, 202 gallons, 253 gallons, and 234 gallons. How many gallons of stove oil did he buy in all?

This problem is about:

a) the amount of stove oil purchased in a year

b) the amount of money spent on stove oil in a year

c) the comforts of stove oil heat

d) why people buy stove oil 13. ____

14. Harry bought a new suit costing $44.95; shoes, $10.75; hat, $6.85; shirt, $4.98; and tie, $1.50. How much money is left after he pays for these articles?

To work this problem I need to know the:

a) cost of one shoe

b) size of his new suit

c) size of his new suit and the size of his shirt

d) amount of money he had before making the purchases 14. ____

15. A baby weighed 6 1/4 pounds at birth. Six weeks later the baby weighed 9 3/4 pounds. How many pounds did the baby gain since birth?

This problem asks me to:

a) find the weight of a baby at birth

b) compare the weight of a baby at birth with its weight at six weeks of age

c) find the weight of a baby at six weeks of age

d) none of these 15. ____

16. Mr. Reid estimated it would take him 2 1/4 hours to complete a job. He started to work at 9:30 a.m. and finished at 10:45 a.m. It took him how many hours less than he expected?

This problem is about:

a) Mr. Reid's occupation

b) time spent working

c) Mr. Reid's family

d) the enjoyment gained through working 16. ____

17. In April, 1972, Jimmy Dale ran in a race and won it in a time of 5 minutes and 28 seconds which set

a new school record for the event. This time was how much less than a day?

To work this problem I need to know:

a) the record time before Jimmy's run

b) Jimmy's age

c) the number of hours in a day

d) the distance Jimmy had to run 17. ____

18. There are 135 boys and girls in the freshman class at the Carson High School, 118 boys and 139 girls in the sophomore class, 169 boys and 129 girls in the junior class, and 107 boys and 158 girls in the senior class. What is the total enrollment?

To work this problem I do not need to know:

a) the number of girls enrolled

b) the number of boys enrolled

c) the number of boys and girls enrolled

d) none of the above 18. ____

19. My mother bought the following items at a supermarket: a gallon of milk for $2.50; 3 cans of dog food for 89¢; 2 dozen eggs at 99¢ per dozen; and a pound of tea at 82¢ a pound. How much change did she get from a $10 bill?

This problem asks me to find the:

a) total cost of goods purchased

b) most expensive goods purchased

c) amount of change

d) cheapest goods 19. ____

20. The hockey association of Reedsville offers $10,000 as prize money for its top three scorers. Half of the money goes to the top scorer, one-third goes to the second highest scorer, and one-sixth goes to the third highest scorer. How much does the third place scorer receive?

This problem asks me to find:

a) how much money the third highest scorer receives

b) how much money the top scorer receives

c) the total amount of prize money

d) how much money each of the top three scorers receives 20. ____

21. The high school basketball team purchased 4 basketballs at $8.75 each; 6 school uniforms at $15.95 each; and 2 basketball nets at $5.75 each. If there are 8 boys on the basketball team and each shared the cost of the equipment with each boy paying the same amount, how much was each boy's cost?

This problem is about:

a) the enjoyment of playing basketball

b) cost of basketball equipment

c) winning basketball games

d) losing basketball games 21. ___

22. John Berry sells truck tires on commission. The company has offered him a choice of accepting a $75 salary plus a 8% commission on his weekly sales <u>or</u> a salary of $175 plus a 3% commission. Which is the better choice?

To work this problem I need to know:

a) his yearly income

b) his monthly salary

c) the price of each tire sold

d) the total of his weekly sales 22. ___

23. Mrs. Turner bought a washing machine for $216. She paid 25% in cash and the balance is to be paid in 12 equal monthly installments which are due on the 25th day of each month. How much must she pay each month?

To work this problem I do <u>not</u> need to know the:

a) cost of the washing machine

b) number of monthly payments

c) date each payment is due

d) per cent paid in cash 23. ___

24. A house worth $9,600 is insured for 80% of its value. How much would the owner receive if the

house were destroyed by fire?

This problem aske me to find:

a) how much a house is worth

b) the insured value of a house

c) the cost of insurance for a house

d) none of the above 24. ____

25. A suit is on sale at 40% off. The marked price is $120. What does the suit cost on sale?

To work this problem I need to:

a) add

b) multiply

c) multiply and subtract

d) multiply and add 25. ____

APPENDIX C

MATHEMATICAL VERBAL PROBLEMS

AND

SAMPLE WORKSHEET

MATHEMATICS WORKSHEET

PROBLEM-SOLVING

1. During the year Mr. Smith bought the following amounts of fuel oil to heat his house: 175 gallons, 208 gallons, 246 gallons, 239 gallons. How many gallons of fuel oil did he buy in all?

2. Last year Joan's father received $5,350 salary, $1,785 commission, and $495 bonus. Find the total amount of his earnings for the year.

3. What is a student's average mark in arithmetic if he receives the following marks: 87, 94, 72, 65, 81, 100, 75, and 90?

4. A salesman's automobile mileage for the past year was 25,642 miles. If 6,954 miles represent pleasure driving, how many miles was the car driven for business purposes?

5. Mr. Warren paid $17,450 for his house 4 years ago. If the house depreciated in the amount of $1,396, what would its present value be?

6. If a box contains 144 envelopes, how many envolopes will there be in 26 boxes?

14. What is the perimeter of a triangle if its three sides measure 6 3/8 inches, 4 11/16 inches, and 5 3/4 inches, respectively?

15. The running time of a crack steamliner from Toronto to Chicago is 14 3/4 hours. Another train takes 15 2/3 hours to make the same trip. How much faster is the first train?

16. How much will a trip over a distance of 12 miles cost at 7 3/4 cents per mile?

17. A house worth $19,500 is assessed at 2/3 of its value. What is the assessed value of the house?

18. Mr. Johnson needs boards with the following lengths: 2 3/4 feet, 5 1/2 feet, and 4 1/4 feet.
   a) What is the total length of the three boards?
   b) If he buys a board 14 feet long, how much will he have left over after he cuts his three boards?

19. How many athletic association membership cards 1 3/8 inches wide can be cut from stock 22 inches wide?

20. The fuel consumption of a certain airplane is 32 1/2 gallons per hour. Find the number of hours the airplane can fly on a tankful of gasoline.

7. Tom's average reading rate is 205 words per minute. How many words can he read in half an hour?

8. Mr. Harris is a car salesman. In one month he sold 18 cars. How much money did he take in?

9. Carolyn used 78 yards of material to make draperies for 13 windows of the same size. How much material was needed for each window?

10. A boat sailed from Panama to Jacksonville, a distance of 1,560 miles in 78 hours. What speed did it average for the trip?

11. In a stamp book there are 6 rows of stamps on each page. Each row contains 9 stamps. There are 50 pages in the book. How many stamps are on a page?

12. What is the overall length of a certain machine part consisting of 3 joined pieces measuring 2 9/16 inches, 1 27/32 inches, and 7/8 inches?

13. The running time of a train from Chicago to San Francisco was changed to 49 1/3 hours. If this schedule saves 13 3/4 hours, how long did the trip take before the change was made?

21. A French newspaper said that a new airplane had travelled 350 kilometres in 1/2 hour. What was its average speed?

22. In planting a new lawn, Mr. Smith used 3 1/2 kilograms of blue grass, 5 1/4 kilograms of red fescula, and 2 kilograms of annual rye. What was the total cost of the seed?

23. A taxi charges 20¢ for the first 1/4 mile and 5¢ for each additional 1/4 mile. Find the taxi fare for a trip of 1 3/4 miles.

24. A boy ran the 100 metre dash in 13.4 seconds, then later ran the same distance in 11.7 seconds. How many seconds less did he take the second time?

25. Marilyn bought her graduation outfit. Her dress cost $19.98; shoes, $12.50; hat, $7.49; and bag, $4.75. How much did she spend? How much change did she receive from a $100 bill?

26. A certain plane on a flight used 43.8 gallons of gasoline per hour. If its flight lasted 4.5 hours, how many gallons of gasoline were used?

spend in school?

35. Sam answered 80% of his test questions correctly. There were 15 questions on the test. How many did he miss?

36. Mrs. Ritter stored her fur coat for the winter and was charged 2% of its value. If the coat is valued at $750, how much did she pay?

37. Mr. Warren bought a camera at a 15% discount. If the regular price was $56, how much did he pay?

38. Mr. Lee is a real estate agent. He sold Mr. Kelley's house for $20,000. Mr. Lee's rate of commission is 5%.

a) How much commission did he receive?

b) How much did Mr. Kelley receive from the sale of his house?

39. A salesman sold 9 window fans at $39.95 each and 7 air conditioners at $279.75 each. At 4% commission, how much did he earn?

40. Mr. Brown is an automobile salesman. He receives a salary of $150 per week plus a commission of 3% of

27. A typist charges 50¢ a page for copying manuscripts plus 12¢ a page for each carbon copy. Find the cost to type 40 pages with 3 carbon copies of each page.

28. Mrs. Williams pays Tom by the hour to cut her grass. How much will he earn if he works 4 hours?

29. Robert's father earns $10,400.50 in a year. He saves $252.30 each month. How much does he save in a year?

30. The fuel consumption of a certain airplane is 32.5 gallons per hour. Find the number of hours the airplane can fly if its tank holds 175.5 gallons.

31. To buy a car, Chris paid a $500 down payment plus $78 a month for 24 months. How much did he pay for the car?

32. A refrigerator costs $265 cash or $80 down and 12 payments of $17.08 each. How much do you save by paying cash?

33. The cost of 1000 bricks is $75.50. At that rate, what is the average cost of one brick? of 2500 bricks?

34. Bert estimated that on school days he spends 25% of his time in school. How many hours a day does he

his total sales. One week he sold one automobile at $2,700 and another at $4,200. How much did he earn that week? How much would he earn if he had made no sales?

41. Authur's father earns $6,800 a year. He plans to use the following budget: food, 25%; shelter, 20%; clothing, 15%; savings, 10%; miscellaneous, 30%. How much does he plan to spend for each item?

42. Mr. Hixson bought an electric typewriter listed at $435 at a discount of 15%. Find the discount and the net price.

43. What are the carrying charges on a freezer which sells for $298 cash or 20% down and $14.50 each month for 18 months?

44. Linda is an apprentice beautician. She earns a salary of $40 per week plus 20% of her fees over $100. One week her fees totaled $300. Find her week's pay.

45. A manufacturer lists a bicycle to sell at $49.50. If he allows a trade discount of 20% and an additional 3% cash discount, what is the net price of the bicycle?

MATHEMATICS WORKSHEET

PROBLEM-SOLVING

1. During the year Mr. Smith bought the following amounts of fuel oil to heat his house: 175 gallons, 208 gallons, 246 gallons, 239 gallons. How many gallons of fuel oil did he buy in all?

A. Vocabulary ?

B. Main Idea The amount of fuel oil purchased in a year.

C. Question □ - How many gallons of fuel oil did he buy in all?

D. Important Facts △ - 175 gallons ; ▭ - 208 gallons ; ○ - 246 gallons ; ▽ - 239 gallons.

E. Relation sentence (words) Add the four purchases of fuel oil together.

F. Relation sentence (symbols)

△ + ▭ + ○ + ▽ = □

G. Mathematical sentence

$175 + 208 + 246 + 239 = 868$

H. Answer sentence Mr. Smith purchased 868 gallons of fuel oil in all.

WORK SPACE:

46. A cabinet sink sells for $142 cash or $10 down and $11.66 a month for 12 months. How much does Ethel's mother save by buying it for cash? What rate of interest is being charged?

47. A finance company can be repaid on a loan of $100 in 6 monthly payments of $18.15, 12 monthly payments of $9.75, or 18 monthly payments of $6.97. Find the amount paid back and the interest under each plan.

48. A dealer bought a table for $38.40 and two chairs at $7 each. He marked the table to sell for a profit of 35% on the cost. If he finally sold it at a reduction of 10% on the marked price, what was the selling price and the amount of profit for the table?

49. The pep club is buying banners for the next home game. The regular price of each banner is 5¢. The manager of the store tells Mary Gleason, the president of the club, that there will be a 5% discount if they buy 100 banners, and a 7% discount if they buy 200 banners. How much would 100 banners cost? How much would 200 banners cost? If they buy 200 banners, what is the cost per banner?

50. A wage earner receives $4 an hour for a 40-hour week and time-and-a-half for time worked over the 40 hours. What are his earnings when he works 44 hours in a week?

APPENDIX D

RELATED LITERATURE

RELATED LITERATURE

The following textbooks in mathematics were analyzed in preparing the mathematical verbal problems and verbal problem tests used in this study.

Brown, K., Snader, D. & Simon, L. Introduction to High School Mathematics. River Forest, Illinois: Laidlaw Brothers, 1970.

Consumer Mathematics, Book A. Ontario: Addison-Wesley, 1974.

Consumer Mathematics, Book B. Ontario: Addison-Wesley, 1974.

Keedy, M., Jameson, R., Johnson, P., Purvis, N. & Atkinson, T. Exploring Modern Mathematics, Book 1. Toronto: Holt, Winehart & Winston of Canada, Limited, 1965.

Keedy, M., Johnson, P., Smith, S. & Jameson, R. Exploring Modern Mathematics, Book 1. New York: Holt, Rinehart & Winston, Inc., 1971.

Keedy, M., Johnson, P., Smith, S. & Jameson, R. Exploring Modern Mathematics, Book 2. New York: Holt, Rinehart & Winston, Inc., 1971.

Kravitz, W. & Brant, V. Consumer Related Mathematics. New York: Holt, Rinehart & Winston, Inc., 1971.

Stein, E. Refresher Arithmetic. Boston: Allyn and Bacon, Inc., 1961.

Stein, H. Winston Mathematics, Book 1. Toronto: The John C. Winston Company, Limited, 1957.

APPENDIX E

STANFORD ACHIEVEMENT TEST

(ADVANCED BATTERY)

STANFORD ACHIEVEMENT TEST

(ADVANCED BATTERY)

The Stanford Achievement Test is a series of tests intended to provide dependable measures of knowledge and skills considered desirable outcomes of the major areas of the curriculum. Subtest scores are available in vocabulary, reading comprehension, mathematics application, spelling, language, social science, and science.

The mathematics computation subtest 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 whole number sentences, and understandings of percent.

Two types of reliability coefficients are provided in the teacher's manual: one in terms of split-half estimates based on odd-even scores corrected by Spearman-Brown Formula, and the second based on the Kuder-Richardson Formula 20. The reliability coefficient for mathematics computation using the Spearman-Brown Formula was .90. Using the Kuder-Richardson Formula it was .89. The above coefficients were obtained from the grade eight level at the beginning of the school year.

Content validity was established by providing instructional objectives for each of the tests in Stanford

Achievement Test, as well as item grouping within subtests. By comparing these instructional objectives with the objectives of the school curriculum, the examiner can judge the content validity of the test for his/her particular purpose.

APPENDIX F

CANADIAN TESTS OF BASIC SKILLS

(FORMS 3 AND 4)

CANADIAN TESTS OF BASIC SKILLS

(FORMS 3 AND 4)

The Canadian Tests of Basic Skills is a series of tests which provides information on the progress of pupils in the following important areas: vocabulary development, reading comprehension, the mechanics of written expression, application of special reading techniques to work-study materials, and mathematical understandings.

The skills tested in reading comprehension are classed under four headings: details, purpose, organization, and evaluation. The selections vary in length from a few sentences to a full page. The passages were chosen in an attempt to represent many of the types of material encountered by the pupils in their everyday reading. Some suggestions for developing those reading skills are given in the teacher's manual.

The major skill categories tested in mathematics problem-solving are: currency (money); decimals, fractions, geometry, measurement, per cent, ratio and proportion, and whole numbers. These skills are tested in a functional setting of challenging and practical problem situations.

Reliability coefficients provided in the manual using the split-half method corrected by the Spearman-Brown Prophecy Formula are: reading comprehension, .91; mathematics problem-solving, .79. The above coefficients were obtained from a twelve per cent representative sample of answer sheets taken by selecting approximately every eighth answer sheet - 498 papers were selected.

The equivalence of Forms 3 and 4 was established by assembling both forms concurrently to the same content and difficulty specifications from the same pool of pre-tried items. Raw scores using 1,611 students were equated for Forms 1, 3, and 4 using a carefully selected sample of Canadian schools.

Content validity is based on the judgement of the examiner. After reading the manual and the test, the examiner must decide if the test has content validity for his/her purpose.

APPENDIX G

VERBAL PROBLEM TESTS

(PRE AND POST)

VERBAL PROBLEM TESTS
(PRE AND POST)

These tests were designed by the investigator to measure student's ability to use certain reading skills in reading mathematical verbal problems. The reading skills measured included recognizing and understanding vocabulary, determining the main idea, visualization, relating the situation in the problem to one's own experience, recognizing what is being asked, deciding which given information is necessary for solution of the problem and which is irrelevant to the solution, recognizing when the information given is insufficient for a solution, inferring the mathematical operation which is appropriate for relating essential information and solving the problem, determining the appropriate sequence of operations when several steps are necessary for a solution, and interpreting the results of completed computation in terms of the question stated in the problem.

Reliability coefficients were computed by the investigator using the split-half method corrected by the Spearman-Brown Prophecy Formula. The reliability coefficient for the Pre-Verbal Problem Test was .79; for the Post-Verbal Problem Test the reliability coefficient was .75.

Content validity was established by a thorough analysis of a wide range of verbal problems found throughout several mathematics textbooks. These textbooks were supplied to the schools by the government and recommended as textbooks to be used by low achievers at the grade seven and grade eight levels.

APPENDIX H

TWO-FACTOR ANALYSIS OF VARIANCE

UNWEIGHTED MEANS

TWO-FACTOR ANALYSIS OF VARIANCE

UNWEIGHTED MEANS

The unweighted means analysis is the simplest and one of the most justifiable techniques for analyzing disproportional designs (Glass & Stanley, 1970).

Rationale

Suppose that data was gathered in a two-factor design with disproportional cell frequencies. Next, replace the n_{ij} observations in any one cell by a single observation $\bar{X}_{ij}$, the mean of those n_{ij} scores. Now we have a new layout of data: IJ cells in a two-factor design with one observation per cell, the mean of the original n_{ij} scores in the cell. This new layout has proportional cell frequencies; indeed, the n's are all equal to 1. It is possible to calculate MS^1_A, MS^1_B, and MS^1_{AB} on this new layout of data. (The primes indicate that these are not the MS's based on the original individual observations). However, there exist no degrees of freedom within cells when n = 1; hence, we cannot calculate a MS_W from the two-factor array of cell means.

MS^1_W is thus calculated by using the following formula:

$$MS^1_W = MS_W \frac{\sum\limits_{ij}^{IJ}\sum \frac{1}{n_{ij}}}{IJ},$$ where MS_W is the average of the

reciprocals of the number of observations in the IJ cells.