THE EFFECT OF VOCABULARY INSTRUCTION ON THE STUDENTS' PROBLEM SOLVING ABILITY IN ELEMENTARY SCHOOL MATHEMATICS: AN EXPERIMENTAL STUDY USING THE VIDEOCASSETTE RECORDER

By

Thomas D. Russell

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

College of Education

1987

ABSTRACT

THE EFFECT OF VOCABULARY INSTRUCTION ON THE STUDENTS' PROBLEM SOLVING ABILITY IN ELEMENTARY SCHOOL MATHEMATICS: AN EXPERIMENTAL STUDY USING THE VIDEOCASSETTE RECORDER

By

Thomas D. Russell

The purpose of this study was to investigate the effect of mathematical vocabulary instruction, utilizing the videocassette recorder, on the achievement level of fifth grade students in solving simple and complex translation problems. One class of students participated in the development of vignettes that depict the meaning of selected mathematical terms and phrases, acted in those vignettes, and viewed a videocassette recording of the vignettes. A second class of students viewed the videocassette recording of the vignettes that depict the meaning of selected mathematical terms and phrases. A third class of students acted as the Control Group.

The data were collected from pretest and posttest results of the Iowa Problem Solving Project (IPSP) Problem Solving Test (Forms 561 and 562). Statistical

analysis of pretest and posttest results was completed using two-way and three-way analysis of covariance and correlation analysis.

The analysis of the data resulted in the following findings:

1. The treatment administered during the study did not produce a significant difference in the scores achieved by the Control and Treatment Groups.

2. The treatment administered during the study did not produce a significant difference in scores achieved by males and females.

3. There was a significant difference in scores achieved by high, medium, and low achieving students, as determined by the Stanford Achievement Test (SAT) Basic Battery Total.

4. The treatment administered during the study did not produce a significant difference in the scores achieved on the subtests of the IPSP Problem Solving Test by the Control and Treatment Groups.

The following recommendations for future research were generated from the study:

1. The study should be replicated with modifications that include a vocabulary test given midway and at the conclusion of the study to the Control and Treatment Groups.

2. A study should be completed using a video dictionary that just defines words or phrases and gives examples.

3. A longitudinal study using a similar design may produce results that contrast with the present study.

4. A similar study should be completed that incorporates a measure of the students' attitude toward mathematics.

To

Mr. and Mrs. John L. Russell

ACKNOWLEDGMENTS

There are a number of persons who must be acknowledged for their part in helping me complete the doctoral program.

First among them is Dr. William Cole, mentor, guide, friend, and chairperson of my committee. I am grateful to Dr. Cole for his patient accompaniment throughout my doctoral work. His suggestions and criticisms were invaluable during the completion of my dissertation.

I am also grateful to my other committee members, Dr. Janet Alleman, Dr. Charles Blackman, and Dr. Laurence LeZotte for their interest and involvement in my graduate program.

A special thanks to my colleagues, Mr. David Goff and Mrs. Eleanor Hanes, for their assistance during the study.

Finally, my appreciation is extended to my wife, Gail, and daughter Elizabeth Ann, for their support and encouragement in reaching an important goal in my life.

TABLE OF CONTENTS

CHAPTER

CHAPTER

APPENDIX

APPENDIX

LIST OF TABLES

TABLE

CHAPTER I

STATEMENT OF THE PROBLEM

The increase in students' problem solving ability is an important goal of elementary school mathematics programs. Although interest in problem solving skills has increased in recent years, the problem solving component of elementary school mathematics programs has been recognized for many years. In 1949 Morton commented on the role of problem solving in the arithmetic program by saying, "Inasmuch as teaching pupils to solve problems is the chief purpose of arithmetic instruction, the problem-solving program is perhaps the most important part of the entire arithmetic curriculum."

Evidence of the continuing importance of problem solving in arithmetic is found in 1959 when Grossnickel and Brueckner said,

> It is a primary function of the arithmetic program to arrange experiences that will develop in children the ability to 'think through' problematic situations that they encounter and to deal with them intelligently and skillfully. Problem solving is the highest level of quantitative thinking.

In 1964 VanderLinde concluded that,

> One major responsibility in mathematics instruction beginning in elementary grades is

> to help pupils develop the ability to do quantitative thinking and to reason logically. An understanding of mathematical theories, concepts, and relationships is vital to the solution of problems that arise in quantitative situations. If pupils are to improve in these skills, the arithmetic program should be based largely on problem-solving.

The National Council of Teachers of Mathematics (NCTM) has recognized the importance of problem-solving in mathematics in _An Agenda for Action: Recommendations for School Mathematics of the 1980s_ (1980). This publication contains eight recommendations for the mathematics curriculum with the first one being:

> Problem solving must be the focus of school mathematics in the 1980s (p. 1).

It is further stated that problem solving in mathematics should include a broad range of strategies, processes, and modes of presentation. The NCTM continued its recognition of problem solving as an important part of mathematics by making it the theme of their 1980 yearbook.

Although interest in problem solving skills in elementary school mathematics has increased in recent years, Cheves and Parks (1983) have stated that the results of the 1980 and 1983 mathematics assessments by the National Assessment of Educational Progress (NAEP) clearly indicated that the focus on basic skills during the 1970s produced students who had mastered computational skills and the routines associated with solving one-step word problems. However, these same students had difficulty with multi-step problems and problems containing extraneous information. Cheves and Parks concluded that students attempted to solve the nonroutine problems as if they were one-step problems to which an algorithm could be applied.

Clearly there is a need to emphasize problem-solving skills in mathematics programs. Grouws and Thomas (1981) stated, "Problem solving is appropriately considered a basic skill in the teaching of any mathematics course."

The NCTM emphasis on the problem solving component of mathematics has encouraged many elementary schools to utilize a wide variety of problems to enhance students' problem solving abilities. Charles and Lester (1982) say the various types of problems have different purposes in the mathematics curriculum. They have identified the following problem types and the purpose for each type of problem (p. 10):

1. Drill exercises provide students with practice in using an algorithm and help them maintain mastery of basic computational facts.

2. Simple translation problems provide students with experience in translating real-world situations into mathematical expressions. They reinforce students'

understanding of mathematical concepts and help maintain computational proficiency.

3. Complex translation problems provide students with the same experience as the simple translation problems except that more than one translation is involved and more than one operation may be involved.

4. Process problems lend themselves to exemplifying the processes inherent in thinking through and solving a problem. They serve to develop general strategies for understanding, planning, and solving problems, as well as evaluating attempts at solutions.

5. Applied problems provide an opportunity for students to use a variety of mathematical skills, processes, concepts, and facts to solve realistic problems. They make students aware of the value and usefulness of mathematics in everyday problem situations.

6. Puzzle problems allow students an opportunity to engage in potentially enriching recreational mathematics. They point out the importance of flexibility in attacking a problem and the value of looking at problems from various perspectives.

Appendix G contains an example of each type of problem identified by Charles and Lester (1982).

Although many teachers employ the various types of problems discussed by Charles and Lester as a part of their mathematics curriculum, they are often frustrated by these problem solving activities. Ballew and Cunningham (1982) say problem solving is a complex process that involves the integration of several skills to produce a successful result. Knowing the individual components or skills of problem solving does not guarantee a successful solution. These skills must be mastered both separately and in relationship to each other for successful problem solving to occur.

The ability to read is an important aspect of the problem solving process in elementary school mathematics. One of the difficulties students encounter in mathematical problem solving is the special language used in mathematics (Earle, 1976; Dunlap and McKnight, 1978). Aiken (1977) says success in problem solving will be limited unless pupils have a firm grasp of the mathematics vocabulary.

Stauffer (1966) found many of the mathematical terms and phrases that are utilized in mathematical problem solving are not dealt with in the students' reading program. Fry and Sakiey (1986) caution reading teachers that their basal reading series may not be as all-encompassing a language development tool as they thought. They have identified many common English words, some with mathematical implications, that were not introduced in five major American basal reading series. However, research does indicate that knowledge of mathematics vocabulary leads to an improvement in problem solving skills (Johnson, 1944; VanderLinde, 1962; Lyda, 1967; and Skrya, 1979).

Muth and Glynn (1985) say teachers should be trained to integrate reading and arithmetic skills in their teaching. This training would enable teachers to take an active role in helping students to integrate their reading comprehension and arithmetic computation skills. The result would be an improvement in problem solving skills (Ballew and Cunningham, 1982; Muth, 1984). One aspect of this integration process is the teaching of new mathematics vocabulary to students (Muth and Glynn, 1985). Muth and Glynn say arithmetic teachers should design activities to help students comprehend new vocabulary words.

In the research completed by Johnson (1944), VanderLinde (1962), Lyda (1967), and Skrypa (1979) various combinations of the following methods were used to teach new mathematics vocabulary:

1. Daily, oral drill on selected words
2. Using the dictionary to obtain word meanings
3. Individual notebooks--pupils record meanings of difficult words
4. Mimeographed instructional materials and drills to supplement the textbook
5. Teacher presentation and explanation
6. Class discussion
7. Vocabulary exercises and objective tests--followed by reteaching
8. Filmstrips and motion pictures

9. Concrete models
10. Pictures

Some of the traditional methods of instruction are gradually being supplemented with methods and equipment that are the result of advances in electronic technology. Two such advances, the videotape recorder, and more recently, the videocassette recorder, have been used in educational settings since the early 1970s.

Initially the videocassette recorder was thought to be too expensive (Gibbon, 1982) to have wide market appeal. In recent years the price of the videocassette recorder has dropped drastically (Consumer Reports, 1985) and this decline in price has made the purchase of a videocassette recorder a reality for many individuals. Block (1985) reported sales of the videocassette recorder were 7.6 million in 1984 and were projected to be over 9 million during 1985.

Reider (1984) describes the arrival of the videocassette recorder as a quiet technological revolution. Reider says the videocassette recorder will have widespread application to schools because it is inexpensive, easy to use, and accessible (that is, programs can be easily recorded).

Quality Education Data, Inc. (QED) (1986) found that as the 1985-1986 school year opened, 79 percent of all schools used videocassette recorder (VCR) equipment for instruction. If this growth continues, QED projects 90 percent of all schools will have video equipment during the 1986-1987 school year (p. 49). Quality Education Data, Inc. concludes that video technology is beginning to replace 16 mm film in education. In their research, QED identified four important trends that are encouraging this shift (p. 50):

1. Video programming costs substantially less than 16 mm film. . . .
2. Teachers are more familiar with video technology. Unlike microcomputers, VCRs require little technical expertise and can be integrated easily into the classroom.
3. The use of VCRs makes instructional television programming more flexible. . . .
4. Most important, video software is being purchased directly by individual schools. . . .

As a result of these trends, the videocassette recorder is currently being used by schools in a variety of ways. Chiodo and Klausmeier (1984) found the videocassette recorder useful in role-playing situations. McGee and Tompkins (1981) suggest videotapes of the teacher reading to provide independent activity for young children. In 1978 McGee demonstrated that children remembered more from viewing a teacher read a story via videotape than from listening to the same teacher read the story "live." Tapes from the videocassette recorder have also been used in art classes (Malsam,

1979) and science classes (Mayhew and Whitfield, 1982). Kahanec (1985) found that using the videocassette recorder was useful in assisting students in high school algebra classes. DiPillo (1978) emphasizes two advantages when using the videotape recorder in the classroom. First, the overwhelming advantage of videotape is the ability to replay any situation. Second, the videotape recorder can be tailored to fit any teacher's specific needs in the classroom. Kaplan (1980) feels there are many positive aspects to using video in the classroom. He states:

> Many curriculum areas are incorporated into a television production. Language skills, research, organization, scriptwriting, speaking, listening, art, music, and the interpersonal skills necessary to complete a videotape contribute to the students' social, emotional, and academic learning (p. 9).

It is apparent from the literature that the problem solving component of elementary mathematics is extremely important. Further, it is clear that knowledge of mathematics vocabulary leads to an improvement in mathematical problem solving skills. Many methods have been utilized in preceding studies to teach mathematical vocabulary to elementary school students. However, this researcher has not located any studies that utilized the videocassette recorder as a part of the treatment process.

Purpose of the Study

This study investigates the effect of mathematical vocabulary instruction, utilizing the videocassette recorder, on the achievement level of fifth grade students in solving simple and complex translation problems. One class of students participated in the development of vignettes that depict the meaning of selected mathematical terms and phrases, acted in those vignettes, and viewed a videocassette recording of the vignettes. A second class of students viewed the videocassette recording of the vignettes that depict the meaning of selected mathematical terms and phrases. A third class of students was utilized as a control group.

Significance of the Problem

In the investigation of the literature this researcher has found no research studies at the elementary level that show the effect of mathematical vocabulary instruction, utilizing the videocassette recorder, on pupil achievement in solving simple and complex translation problems. There is clearly a need in elementary school mathematics to discover methods of teaching mathematical vocabulary to students. A review of the literature indicates a strong relationship between the students' mathematical vocabulary knowledge and mathematical problem solving skills. This experimental study will produce results that will assist elementary mathematics educators in evaluating this method of instruction to teach mathematical vocabulary to enhance the achievement level of students in solving simple and complex translation problems.

Hypotheses of the Experiment

The experimental hypotheses were tested statistically by casting them in the null hypothesis form in Chapter III. In order to indicate the purpose of the experiment more clearly, the hypotheses are stated here in the positive form.

H_0 The fifth grade students who complete and view the vignettes will show improvement in scores achieved over the fifth grade students in the control group.

H_1 The fifth grade students who view the vignettes will show improvement in scores achieved over the fifth grade students in the control group.

H_2 The fifth grade students who complete and view the vignettes will show improvement in scores achieved over the fifth grade students who view the vignettes.

H_3 The fifth grade male and female students who complete and view the vignettes will show improvement in scores achieved over the fifth grade male and female students in the control group.

H_4 The fifth grade male and female students who view the vignettes will show improvement in scores achieved over the fifth grade male and female students in the control group.

H_5 The fifth grade male and female students who complete and view the vignettes will show improvement in scores achieved over the fifth grade male and female students who view the vignettes.

H_6 The high achieving fifth grade students will show improvement in scores achieved over medium achieving fifth grade students.

H_7 The high achieving fifth grade students will show improvement in scores achieved over low achieving fifth grade students.

H_8 The medium achieving fifth grade students will show improvement in scores achieved over low achieving fifth grade students.

H_9 The fifth grade students who complete subtest 1 of the pretest will show improvement in scores achieved on subtest 1 of the posttest.

H_{10} The fifth grade students who complete subtest 2 of the pretest will show improvement in scores achieved on subtest 2 of the posttest.

H_{11} The fifth grade students who complete subtest 3 of the pretest will show improvement in scores achieved on subtest 3 of the posttest.

H_{12} The fifth grade students in the control class and two experimental classes will show improvement on selected items of the pretest and posttest that contain vocabulary terms and phrases used in the study.

Limitations of the Study

This study was limited to a population of fifth grade students in attendance in one public school system. Further, only three of the five classrooms of students that comprise the total population of fifth grade students in this public school district were a part of this study.

This study was limited to a particular group of mathematical terms and phrases that are found in both the Heath Mathematics (1981) fifth grade textbook and the Iowa Problem Solving Project (IPSP) Problem Solving Test (1979). Terms and phrases were selected for use in this study that have mathematical implications. That is, the selected group of terms and phrases have a close connection with elementary mathematics vocabulary.

This study was limited by the length in weeks of the study and by the amount of time students will have during their mathematics class to meet in small groups to develop vignettes that depict the meaning of selected terms and phrases. This study was conducted over a twelve week period. The students spent approximately fifteen to twenty minutes three days per week developing the vignettes.

An Overview of the Study

This thesis will consist of four additional chapters. Chapter II contains a review of the literature that is pertinent to elementary school mathematics problem solving. Chapter III provides the design of the experiment and associated descriptive data. Chapter IV contains the analysis of the data that was collected from the experiment. Finally, Chapter V includes a summary of the experiment, conclusions drawn from the experiment, and this researcher's recommendations for future research.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

This chapter, divided into six sections, investigates some of the literature pertaining to interpretation of problem solving, vocabulary as a factor in problem solving, strategies students might employ to solve mathematics problems (heuristics), reading and problem solving in mathematics problems, reasoning, creativity and intelligence--factors in problem solving, and utilization of the videotape recorder and the videocassette recorder in an educational setting. The first five categories were included in this review of the literature because they are relevant to the problem solving process in elementary school mathematics. The last category is necessary because of the utilization of the videocassette recorder in the design of this research study.

Interpretation of Problem Solving in Mathematics

House, Wallace, and Johnson (1983) say a common definition of a mathematical problem is a situation that involves a goal to be achieved, has obstacles to reaching that goal, and requires deliberation, since no known algorithm is available to solve it. The situation is usually quantitative or requires mathematical techniques for its solution, and it must be accepted as a problem by someone before it can be called a problem.

Bell (1980) says a problem exists when a person is confronted by a situation that suggests a solution, is motivated to achieve the solution, and is at least temporarily frustrated in attaining the solution. Problem solving takes place when a person, after exerting some effort and creativity, succeeds in attaining a solution. Bell distinguishes this activity from exercise solving. Exercise solving, according to Bell, takes place when a person is not temporarily frustrated in finding a solution but is immediately able to use a previously learned procedure to formulate the solution.

Solving a problem, according to Polya (1962), means finding a way out of difficulty, a way around an obstacle, attaining an aim which was not immediately attainable. Polya says that solving problems is the specific achievement of intelligence, and intelligence is the specific gift of mankind: solving problems can be regarded as the most characteristically human activity.

Lester (1982) refers to problem solving as a process of coordinating previous experiences, knowledge, and intuition in an effort to determine an outcome of a situation for which a procedure for determining the outcome is not known.

Krulik and Rudnick (1980) view problem solving as a situation, quantitative or otherwise, that confronts an individual or group of individuals, that requires resolution, and for which the individual sees no apparent or obvious means or path to obtaining the solution. Krulik and Rudnick state that as people develop mathematically, what were problems initially are reduced to routine exercises. What is perceived as a problem by one individual may be an exercise to another individual.

These interpretations of problem solving may be too abstract and theoretical to be understood by elementary aged students. Nevertheless, if students are involved in problem solving activities, they assume many of the characteristics of the previously stated positions. In general, problem solving in the elementary school involves providing students simple and complex translation problems which they attempt to solve.

Vocabulary as a Factor in Problem Solving in Elementary Mathematics

There are many studies which show that elementary students are often discouraged with problem solving activities in mathematics because of their inability to comprehend the given problem situation. Research also indicates that knowledge of mathematics vocabulary is crucial if students are to have success in mathematical problem solving.

Hollander (1977) points out that reading the language of mathematics textbooks is very different from reading the narrative in traditional basal textbooks. Students need to be taught how to read in a mathematics course. Hollander recommends teaching skills that are relevant to the content area of mathematics. Such skills include noting details, following directions, and seeing relationships. The reading style used in mathematics must be deliberate in order to understand mathematics reading material. This is in contrast to the narrative reading style pupils are accustomed to using in their basal reader. Hollander says teachers should not assume an automatic transfer of skills will occur from reading in the basal series to reading in a mathematics textbook.

Students often have difficulty attaching a literal meaning to a word in mathematics. Earle (1976) mentions three types of vocabulary in mathematics. The word types are general, technical, and special. Words in the general vocabulary group are words used in all walks of life. Examples would be chair, love, tree, and water. Words in the technical vocabulary are peculiar to a particular field of study. Examples in mathematics would be hypotenuse, addend, and quotient. Earle says students have the greatest difficulty understanding the special vocabulary. Words in this category have one meaning in everyday life but a different, or specialized, meaning in the context of mathematics. Some examples of special vocabulary are plane, reduce, and point. Earle concludes:

> Teachers of mathematics certainly realize the importance of a large vocabulary to success in their subject. Inaccurate or imprecise definitions of essential terms make successful reading or learning difficult or impossible (p. 17).

Dunlap and McKnight (1978) have identified the three-level translation of vocabulary in mathematics as a major problem in the students' ability to solve mathematical word problems. They identify the vocabulary areas as general, technical, and symbolic. Dunlap and McKnight say students must understand the components of each vocabulary, and be able to translate from one vocabulary to another, and think in each vocabulary. Because many words appear in both the general and technical vocabulary, and have different meanings in each, students often have difficulty reading mathematical materials.

It is apparent that success in problem solving will be limited unless students have a firm grasp of the mathematics vocabulary. Aiken (1977) has stated that the first hurdle a student must face in learning to do mathematics is understanding the language.

In 1944 Johnson conducted a study to determine if improvement in specific mathematical vocabulary leads to an improvement in the solution of problems which involve the use of the specific mathematical terms. The study was conducted at the seventh grade level. The experimental classes in this research project completed various practice exercises designed to develop a meaningful understanding of vocabulary beyond that which was provided by the textbook itself. The following types of exercises were considered as a treatment method:

1. Daily, oral drills on selected words
2. Individuals' use of a dictionary to obtain word meanings
3. Use of individual notebooks, in which pupils would record meanings of difficult words
4. Mimeographed instructional materials and drills to supplement the textbook.

To provide control of the experiment the researcher elected to use mimeographed materials. These materials were prepared by the researcher. Johnson designed the exercises so that words relating to a common topic were grouped and discussed so as to bring out their individual meanings and their inter-relationships. The experiment used exercises classified as recall and matching type. Johnson supplied a different set of exercises for each period of the experiment. This experimental project continued for fourteen weeks. During this period the control group relied completely on the textbook and regular class discussions for learning the mathematical terms.

The results of this experiment indicated that the experimental group achieved significantly greater gains than did the control group in both vocabulary and problem solving. Additionally, the superiority of the experimental group maintained itself for students of practically all levels of mental ability and initial status in the area under study. Johnson recommended that training in vocabulary become an integral part of mathematics curriculum.

In 1962 VanderLinde completed an experiment to determine the effect of the study of quantitative vocabulary on the arithmetic problem solving ability of fifth grade pupils. The sample consisted of twenty-four fifth grade classrooms. Twelve classes were randomly assigned to the control group and twelve classes were randomly assigned to the experimental group. VanderLinde had the twelve teachers with the experimental classes use the following teaching techniques:

1. Initial presentation
2. Class discussion
3. Teacher explanation
4. Using the dictionary

VanderLinde's statistical analysis of the data collected from the study produced the following conclusions (p. 97):

1. Pupils who have studied quantitative vocabulary using the direct study techniques described achieve significantly higher on a test of arithmetic problem solving than pupils who have not devoted special attention to the study of quantitative vocabulary.

2. Pupils who have studied quantitative vocabulary using the direct study techniques described achieve significantly higher on a test of arithmetic concepts than pupils who have not devoted special attention to the study of quantitative vocabulary.

3. The direct study of quantitative vocabulary does not tend to result in improvement in general vocabulary or in reading comprehension.

4. The experimental method is not more effective with one sex than the other.

5. The experimental method is more effective with pupils who have above average intelligence than with pupils who have below average intelligence.

6. Effective vocabulary study can be made a part of the regular arithmetic program without sacrificing pupil achievement in the subject matter of arithmetic.

VanderLinde recommended that vocabulary study become an integral part of the instructional program in arithmetic beginning in the primary grades. He suggests students be provided with a variety of experiences that will furnish a background for the new terms to be encountered. Finally, VanderLinde recommended that elementary classrooms be equipped with a variety of arithmetic teaching aids to assist in the clarification of the meanings of quantitative terms.

Lyda conducted a study in 1967 to determine the effect of quantitative vocabulary study on the problem solving of second grade students. Lyda used the following teaching techniques during a part of the regular arithmetic period:

1. Initial presentation by the teacher
2. Explanation by the teacher
3. Class discussion
4. Vocabulary exercises
5. Objective tests
6. Analysis of results of objective tests
7. Reteaching, directed toward mastery

Lyda's findings indicated that direct study of quantitative vocabulary contributed significantly to growth in problem solving. Lyda recommended that teachers consider the feasibility of incorporating direct study of quantitative vocabulary into the arithmetic curriculum.

In 1979 Skrypa completed research to determine the effectiveness of mathematical vocabulary training in problem solving ability of third- and fourth-graders. Skrypa's control and treatment group each had thirty-three pupils. The experimental third and fourth grade were taught separately. The researcher's rationale for this procedure was: "The experimental third and fourth grades were taught separately because smaller instructional groups are easier to manage" (p. 26).

This experiment was conducted over an eight-week period. Skrypa used the following teaching techniques:

1. Filmstrips and motion pictures
2. Concrete models
3. Pictures
4. Students kept notebooks of mathematical terms
5. Drill and reinforcement were provided through discussions and games.

The mathematical vocabulary training took place four days a week, for forty-five minutes each day. The analysis of pretest and posttest results for the control group and experimental group indicated a significant relationship between the knowledge of specific mathematics terms and the solution of verbal problems involving those terms.

Problem Solving Techniques in Mathematics--Heuristics

This portion of the review of literature will discuss heuristics or strategies that a problem solver might use to solve a problem. Polya (1957) viewed the use of heuristics as helping the problem solver gain insight into a problem. Heuristics are used to solve a problem when no known algorithm is available to solve it (House, Wallace, and Johnson, 1983).

Polya, perhaps the dominant educator in the area of problem solving in mathematics, developed a problem solving model for mathematics. This four-step model is described in his book, How To Solve It (1957), and involves the following:

1. Understanding the problem
2. Devising a plan
3. Carrying out the plan
4. Looking back

The first step in this problem solving model requires the problem solver to understand the problem and want to answer it (p. 6). The problem solver must recognize what is known, what is unknown, and what is the condition. In the second step the problem solver might consider his own experiences to find a related problem. He might simplify the problem. Perhaps rewording the problem would help. During the third step of this model the problem solver carries out the plan devised in step two. During this phase the teacher should insist the student check each step so that it is correct. In the last step the problem solver checks the solution against the data and conditions in step one.

Gibney and Meiring (1983) identified a number of problem solving strategies that were helpful in starting to solve problems. The strategies are:

Look for a pattern	Select appropriate notation
Construct a table	Restate the problem
Account for all possibilities	Identify wanted, given, and needed information
Act it out	Write an open sentence
Make a model	Identify a subgoal
Guess and check	Solve a simpler problem
Work backwards	Change your point of view
Make a drawing, diagram, or graph	Check for hidden assumption

This group of strategies was developed as a result of adults attempting to solve problems. During the problem solving sessions they were led to examine their own thinking, to become consciously aware of the methods they were employing (whether successful or not), and to label techniques which were helpful in making progress toward resolving problems.

Riley and Pachtman (1978) suggest the Directed Reading Method to help solve verbal mathematics problems. The Directed Reading Method consists of the following steps:

1. Read the problem slowly
2. Reread the problem slowly to determine what is asked
3. Decide the facts of the problem
4. Decide the process to be used
5. Estimate the answer
6. Compute the answer

Riley and Pachtman say the Directed Reading Method assumes the student can understand and apply the appropriate mathematical concepts.

Earle (1976) suggests the following method be used in mathematics problem solving activities (p. 49):

Step 1: Read through the problem quickly. Try to obtain a general grasp of the problem situation and visualize the problem as a whole. Don't be concerned with the actual names, numbers, or values.

Step 2: Examine the problem again. Try to understand exactly what you are asked to find. This may be stated as a question or command. Although it often comes at the end of the problem, it may appear anywhere in the problem.

Step 3: Read the problem again to note what information is given. At this point you are looking for exact numbers and values.

Step 4: Analyze the problem carefully to note the relationship of information given to what you are asked to find (Steps 2 and 3). Note information which seems to be missing. Also [note] surplus information.

Step 5: Translate the relationships to mathematical terms.

Step 6: Perform the necessary computation.

Step 7: Examine the solution carefully. Label it to correspond to what the problem asks you to find. Finally, check the value against your grasp of the problem situation to judge whether it seems sensible.

Earle comments that all steps require the accurate perception of symbols--general, technical, and special. Steps 1, 2, and 3 require the reader to attach literal meaning. Steps 4 and 5 require the reader to analyze relationships among the explicitly stated details. Steps 6 and 7 demand that he apply his computational ability to the set of relationships and judge the result critically in light of the original purpose.

Robinson (1975) suggests the following heuristic model for problem solving:

1. Read the problem thoroughly, asking, "What am I to find here?"

2. Reread the problem, asking, "What am I to find here?"

3. Ask yourself, "What facts are given?"

4. Plan your attack

5. Estimate the answer. Ask yourself, "What would a reasonable answer be?"

6. Carry out the operations

7. Check your work

Reutzel (1983) says optimal problem solving is achieved when teachers demonstrate how data can be organized in a predictable fashion. While most students have been shown a problem solving schema for computation, few have been shown a schema for solving story problems. In summarizing the various heuristic models for problem solving Reutzel says:

> Any problem solving schema has five basic functions: to provide an organization that can be used repeatedly, to integrate information toward a solution, to put the problems data into proper sequence, to discriminate relevant from irrelevant information, and to specify the mathematical operation (p. 29).

While Krulik and Rudnick (1981) welcome the re-emphasis on problem solving, they are not convinced that heuristic models are really what classroom teachers need. They say, "We firmly believe that the problem solving model in itself is not nearly as important as how the classroom teacher approaches problem solving in the classroom" (p. 37).

Krulik and Rudnick continue:

> The problem solving process suggests that a set of heuristics be developed jointly by the teacher and students. Whether these be Polya's four-step heuristics, or some other set of five, seven, eight, or even more steps is not important. What is important is that the student develops an organized set of "questions" to ask himself, and that he constantly refer to them when he is confronted by a problem situation.

According to Krulik and Rudnick, the problem solving process is a skill, and like any skill, it can be taught.

Reading and Problem Solving in Mathematics

This section of the chapter will review pertinent literature related to reading mathematical problems. Earle (1976) believes the solution of word problems is one of the most sophisticated of all tasks in mathematics, at least from the reading point of view. Earle proposes that reading in the content area of mathematics occurs in a hierarchy. The reading levels are:

1. Perceiving symbols
2. Attaching literal meaning
3. Analyzing relationships
4. Solving word problems

Earle defines perceiving symbols as recognizing and pronouncing. Symbols refers to words essential to mathematical reading, as well as other symbols such as + or =. No comprehension is implied at this level. At this level the reader recognizes a printed symbol as more or less familiar and pronounces it aloud. During the second level the reader attaches a literal meaning to the symbols. The reader's comprehension at this level depends on two basic elements: symbol meaning and symbol order.

Most content objectives in mathematics require the reader to grasp several literally stated facts or ideas. Earle notes that some objectives require the student to identify important unstated relationships among those literal facts, and state them in the form of interferences, generalizations, conclusions, or equations. This type of response requires the reader to examine his collection of literal meanings carefully to note common characteristics, facts which do not belong, equalities, and direct and inverse variations. Earle concludes: "It is at this level of reading that students tend to operate least effectively (perhaps because we teachers tend to teach least effectively at this level)" (p. 7).

The fourth level in Earle's reading model for mathematics is solving word problems. Dependent on the previous levels of the reading process model, Earle considers the solution of word problems to be the most sophisticated reading task in mathematics. Earle says,

> A major goal of instruction in mathematics is to develop readers who can solve problems

> successfully and independently. . . . The solution of word problems represents the most common application of knowledge and skills to intellectual or physical problems--real or simulated--in mathematics (p. 7).

Teaching reading in the content area of mathematics involves necessary guidance at all the preceding levels in this model. As a general rule, the reader must be successful at one level of reading before he can hope to achieve success at the next level.

Nelson-Herber (1986) contends that facts and concepts of content materials are communicated in words. She feels students with limited content vocabularies will be limited in their ability to comprehend the written materials of the content areas. Nelson-Herber says research provides evidence that vocabulary instruction is more effective when it involves the learner in the construction of meaning through interactive processes rather than in memorizing definitions or synonyms. She concludes:

> To put it simply, extensive reading can increase vocabulary knowledge, but direct instruction that engages students in construction of word meaning, using a context and prior knowledge, is effective for learning specific vocabulary and for improving comprehension of related materials (p. 627).

Krulik (1980) notes several researchers have found a high correlation between problem solving in mathematics and comprehension in reading. Yet, the area of reading in mathematics is largely overlooked by many mathematics teachers. Krulik feels the content area teachers are best qualified to provide effective instruction in reading in their own subject field. The difficulties students have in reading mathematics go hand in hand with the skills that are necessary for reading mathematics. Krulik mentions the need for students to realize that not all mathematics is read from left to right. Often reading mathematics is a slow, step by step process.

In a 1980 study Stover had mentally gifted sixth and eighth grade students rewrite word problems eliminating reading and language variables they felt contributed to arithmetic word problem difficulty. The revisions produced a set of problems that were easier for the students to understand. The most frequent changes were simplifying vocabulary, making a long sentence into shorter sentences, removing extraneous information, eliminating "if" and "about," adding information or changing the story line to make the problem situation relevant, and changing verbs to the present tense.

Many of the mathematical terms and phrases that are utilized in mathematical problem solving are not dealt with in the students' reading program. Stauffer (1966) completed a study that compared vocabulary presented in seven different basic reading series, and in three series in each of three content areas--health, science, and arithmetic. In arithmetic, for grades ones, two, and three, Stauffer found a total of 1,331 words were presented that were not dealt with in the basic reading series for those grade levels.

Fry and Sakiey (1986) believe there is a common assumption among reading teachers that a major basal reading series teaches most of the common English words. Their research indicates that this is not true. Taking as their criterion the 3,000 most common English words (see Sakiey and Fry, 1984) and surveying five major American basal reading series, they found that the highest percentage of these common words taught by any of the basals was 59 percent. The lowest percentage taught was 50 percent. In addition, Fry and Sakiey developed a list of 382 common English words that were not introduced in the five major American basal reading series, K-6. The following words that have mathematical implications appeared on the list:

addends	equivalent	radius
altogether	factors	segment
amount	fraction	slope
congruent	height	subset
cube	increase	subtract
decimal	multiplication	tenth
denominator	numerator	ton
depth	ounces	total

divisible	perpendicular	vertical
division	plus	weight
equation	quotient	width

This research leads Fry and Sakiey to caution reading teachers that their basal reading series may not be as all-encompassing a language development tool as they thought. The obvious answer, they conclude, is for the teachers to supplement basal readers with their own word learning lessons, and encourage as much extra reading as possible.

Earp and Tanner (1980) say effective reading is based on a well-developed oral language. The process of reading is that of decoding and bringing meaning to symbols that form the vocal communicative system. They contend that mathematical terms are not nearly as likely to be a part of a student's oral language. Hence, the student's understanding of the mathematical vocabulary is less than his understanding of the nonmathematical vocabulary. Reading in mathematics is likely to improve when students speak the related oral language.

Research related to the placement of the question in verbal mathematics problems was completed by Threadgill-Sowder (1983). The results were in agreement with earlier experiments and indicated that question placement apparently has no effect on the ability of students to solve word problems, regardless of length and complexity of problems or the age of the students.

Students find reading mathematics is different and often more difficult than reading other materials. Aiken (1977) says some of the reasons for this difficulty are (a) confusing charts, diagrams, and number languages patterned differently from the decimal system; (b) the complexity of the language of expressing functions and ratios; and (c) the specialized skills needed to read computational procedures. Aiken concludes,

> The central importance of reading skills indicated by this list is the reason why the results of investigations in mathematics education reveal that instruction in reading mathematics improves performance in this subject (p. 252).

Ballew and Cunningham (1982) conducted a study to determine why sixth grade students were having difficulty solving word problems. They designed a test to measure four abilities that are involved in solving word problems. The abilities that were assessed were computation, problem interpretation, reading-problem interpretation, and reading-problem solving. The computation portion of the test measured the number of problems the student correctly solved when the problems were set up for the student. The problem interpretation section of the test measured how accurately students could set up problems that were read to them. The reading-problem interpretation section measured how accurately students could set up a problem after reading the problem on their own. The fourth part of the test, reading-problem solving (or total problem solving) determined how accurately students could solve problems after reading them on their own. Results of this study indicated that for 26 percent of the students the weakest area was computation. Problem interpretation was the weakest area for 19 percent of the students. The third area, reading-problem interpretation, was the weakest ability for 29 percent of the students. The last skill area, total problem solving, was the weakest area for 26 percent of the students.

Ballew and Cunningham concluded that each of the four areas was the greatest immediate need for a sizable portion of the sixth graders tested. There is simply not one area that is <u>the</u> problem for students in general. Further, results of this study suggest that an inability to read problems is a major obstacle for these sixth graders. Finally, knowing the components or individual skills of solving word problems (computation, problem interpretation, and reading-problem interpretation) is not sufficient for success since these skills must be integrated into a whole process. The several skills of problems solving must be mastered both separately and in relationship to each other for successful problem solving.

Muth (1984) completed research that produced results similar to those of Ballew and Cunningham (1982). Muth used the reading comprehension and arithmetic computation subtests of the Comprehensive Tests of Basic Skills (1976) to determine the relative contributions of reading comprehension ability and arithmetic computation ability on students' problem solving ability. A fifteen item arithmetic word problem test was also used in the study. The word problems were adaptations of sample problems supplied by the National Assessment of Educational Progress (1977). The problems tested the ability to add, subtract, multiply, and divide. The analysis of data from the study indicated that both reading comprehension and arithmetic computation ability contributed to success in solving arithmetic word problems.

Muth and Glynn (1985) suggest teachers be trained to integrate reading and arithmetic skills. This training would increase arithmetic teachers' awareness of basic reading processes and reading teachers would increase their awareness of basic arithmetic processes. This awareness would enable teachers to take an active role in helping students to integrate their reading l

l

ma

the

in

ple

gra

Abi

ties

tion

the

Stone

comprehension and arithmetic computation skills. Muth and Glynn say this shared awareness would be reflected in the lesson plans. That is:

> The lesson plans of reading teachers would include activities designed to enhance students' comprehension of passages that deal with problems in mathematics and science. Similarly, the lesson plans of arithmetic teachers would include activities designed to (1) help students comprehend new vocabulary words (e.g., fraction, ratio, and percentage), and (2) help students reduce complex word problems to a set of simple propositions (p. 36).

Reasoning, Creativity, and Intelligence--Factors in Problem Solving in Mathematics

This portion of the chapter will review pertinent literature related to reasoning, creativity, and intelligence as they affect students' ability in the mathematical problem solving ability of children.

J.T. Johnson (1949) conducted research to determine the role of general intelligence, reasoning, and memory in arithmetic problem solving. His experiment was completed with the Chicago Public Schools. The eighth grade students had been given the Chicago Primary Mental Abilities (CPMA) tests. The six primary mental abilities on the test were Number, Vocabulary, Space Perception, Word Fluency, Reasoning, and Memory. To add to the study three more tests were given. One was the Stone Reasoning Test. The two remaining tests were the ordinary problem-solving type. One set of questions contained numbers and the other a set of parallel problems but containing no numbers. The set of problems containing numbers required the student to read the problem and solve it. The problems without numbers asked the student to show what operation(s) would be necessary to solve the problem. The analysis of data from this research indicated:

> With problems containing numbers Vocabulary as a factor of intelligence as measured by the CPMA tests is a potent factor in problem-solving in arithmetic with Reasoning standing next. The correlations with problems without numbers were just reversed (p. 114).

Houtz and Denmark (1983) completed a study at the fourth, fifth, and sixth grade levels designed to assess the relationships of students' perceptions of cognitive classroom structure on the development of their creative thinking and problem solving skills. Cognitive classroom structure refers to "the intended organization and focus of the teacher on the reinforcement and encouragement of a variety of higher level thinking skills (analysis, application, synthesis, and evaluation) within the everyday classroom curriculum" (p. 21). Results of this research appear to indicate that in those classes where there is perceived by the students to be an increased emphasis on higher level thinking skills, there is likely to be more fluent thinking (a c

c

vi

inc

cas

stu

woul

greater number of relevant ideas). Greater fluency appears to occur in classes where students perceive a climate of acceptance and support for independence, divergence or ideas, humor, and enthusiasm for learning. Emphasis on higher level thinking skills in the classroom tends to improve students' problem solving skills.

Videocassette Technology in Education

Although the status of videocassettes in education is, at most, in a stage of infancy, literature does reveal a number of instances where the videocassette has been utilized in education. Reider (1984) believes a quiet technological revolution is occurring within education. He states:

> It is unknown to the educational establishment. It is unheralded in the literature. It is uncharted by the research. Whether it will ever gain status in the mass media and receive the recognition it deserves cannot be ascertained at this time. But one thing is certain: videocassette technology is permeating education through a groundswell which will predictably result in its widespread application to schools (p. 12).

First marketed in the early 1970s, Reider says videocassette recorder (VCR) sales have continued to increase each year. During 1984 7.6 million videocassette recorders were sold (Block, 1985). A 1982 study (Gibbons) concluded that videocassette recorders would have limited marketability due to their appeal only to persons in the upper income brackets. However, Reider notes that prices of the videocassette recorders have dropped drastically in recent years. This decline in price has made the purchase of a videocassette recorder a reality for many individuals. Block (1985) says sales of videocassette recorders have nearly doubled in the last three years. Further, Block reported that 1985 sales would probably exceed 9 million units. Gilman (1986) says that about 40 percent of American households own videocassette recorders.

Reider (1984) believes the videocassette will be utilized by teachers because it is inexpensive, easy to use, and accessible. The capability of recording programs provides the basis for its accessibility (p. 13). The teacher will have the ability to schedule a videocassette recording when it is most appropriate--no longer dependent on the centralized "request and schedule" loan system that typically governs the use of 16 mm films.

Quality Education Data, Inc. (1986) found that as the 1985-1986 school year opened 79 percent of all schools used VCR equipment for instruction. If growth continues, the 1986-1987 preliminary figures indicate 90 percent of all schools will have video equipment (p. 49). Quality Education Data, Inc. (QED) concludes that video technology is beginning to replace 16 mm film in education. In their research, QED identified four important trends that are encouraging this shift (p. 50):

1. Video programming costs substantially less than 16 mm film. The typical price of an instructional film is more than three hundred dollars. Some prerecorded videocassettes, on the other hand, now cost less than eighty dollars and prices continue to drop. With volume discounts, larger districts will be able to purchase multiple copies for less; duplication rights and licensing agreements with manufacturers make some video programming even less expensive.

2. Teachers are more familiar with video technology. Unlike microcomputers, VCRs require little technical expertise and can be integrated easily into the classroom.

3. The use of VCRs makes instructional television programming more flexible. VCRs enable time-shifting of regularly scheduled programming. In other words, a biology program broadcast at 10:00 a.m. by the district can be recorded on a junior high's VCR at the time of broadcast and shown later to a biology class at 1:00 p.m.

4. Most important, video software is being purchased directly by individual schools. The high cost of 16 mm films meant that films were purchased and housed centrally in the district media center. Schools obtained films only through the slow process of scheduling and borrowing films from the district. The low cost of video software means it can be purchased now at all levels within the district and is available for classroom use without elaborate scheduling.

A review of the literature produced several examples of the videocassette recorder being used in the classroom. Chiodo and Klausmeier (1984) found the videocassette recorder useful in role-playing situations. Referred to as social role-playing by Fannie and George Shaftel (1967), the process begins with the teacher introducing the problem, selecting players, setting the stage, preparing observers, presenting the enactment, and finally discussing and evaluating with the role-playing students and entire class. Chiodo and Klausmeier found this process effective in aiding student learning, but say it may fail to produce maximum results because:

1. Some students may fail to develop a thorough understanding of the problem being analyzed in the discussion stage of the procedure.

2. Students involved in acting out a role may find it hard to remember what their classmates said. This happens because they are so involved in organizing and presenting their own views that they fail to listen intently to other students.

3. Student observers may be focusing on one role-player and not on others.

Chiodo and Klausmeier found that the role-playing process can be improved by adding an extra step to the role-playing model. They recommend videotaping the role-playing situation to enable both teacher and students to focus more clearly on the problem and solution developed in the role-playing activity.

McGee and Tompkins (1981) used videotapes of a teacher reading to provide independent activity for young students who are not yet reading or who have limited reading ability. The authors say activities that emphasize story structure, how certain story structures combine in patterns to form a meaningful story, are effective in improving children's reading comprehension. The videotape should contain the teacher giving an appropriate introduction to the story, the story structure, and directions for listening which help focus attention on the relevant structure. McGee and Tompkins say follow-up activities should be included on the videotape that will help students attend to the story structures.

In 1978 McGee demonstrated that students remembered more from viewing a teacher read a story via videotape than from listening to the same teacher read the story "live."

Malsam (1979) describes an art program that utilized videotapes. The videotaped program known as VISTA (Video Instruction for Students in the Teaching of Art) features an art specialist that presents new art techniques and ideas. Prior to showing the videotaped art lessons to students, teachers are provided with inservice training to acquaint them with the program objectives, motivational techniques, and follow-up activities. The VISTA project director had the following comment on the program: "Classroom teachers with little or no background in art will be able to present an art lesson in a broad and accurate context" (p. 24).

Kahanec (1985) found that using the videocassette recorder was useful in assisting students in high school algebra classes. Daily lessons were taped and could be used by students in the privacy of a mathematics resource room or in their own homes. Kahanec's film crew consisted of ten "talented" (no explanation given) students who made the tapes on weekends and after school. The tapes were used in the following manner:

1. Other faculty members used the tapes in their classes.

2. Students lacking self-confidence often used the tapes to review or study for tests.

3. Absent students were able to review missed lessons.

4. The tapes seemed to encourage unmotivated students.

Kahanec concludes, "The high-tech revolution is upon us, and it offers an interesting new teaching style. . . . Future research and testing will help us to evaluate this method of instruction" (p. 262).

DiPillo (1978) says the overwhelming advantage of videotape use in the classroom is the ability to replay any situation. The videotape recorder can be tailored to fit any teacher's specific needs in the classroom. More important, DiPillo says, the teacher can "use the making process" as a vital ingredient of the lesson.

Mayhew and Whitfield (1982) found that videotaping can be an effective way to involve students in classroom science. A science experiment can be recorded on videotape, played back, and analyzed. Additional advantages of the videotaped science experiment are:

1. Completed experiments are never lost.

2. The recorder can be stopped and started to review and discuss a particular aspect of an experiment with students.

3. A class can analyze the experiment's purpose, its components, and students' techniques performing it.

4. If an experiment is unsuccessful or produces unexpected results, the videotape can be reviewed with students to discover and analyze mistakes.

5. Observational skills can be developed by furnishing students with a checklist of things to look for during an experiment. Anything they miss can be pointed out during a review of the videotape.

Mayhew and Whitfield suggest that videotaped science also provides opportunities for sharing students' activities with parents. Mayhew and Whitfield say parent conferences, special school programs, and open houses offer ideal opportunities for displaying students' efforts via videotape recording.

Kaplan (1980) feels there are many positive aspects to using video in the classroom. He states:

> Many curriculum areas are incorporated into a television production. Language skills, research, organization, scriptwriting, speaking, listening, art, music, and the interpersonal skills necessary to complete a videotape contribute to students' social, emotional, and academic learning (p. 9).

This concludes the review of literature. Chapter III describes the research design of this experiment.

CHAPTER III

RESEARCH DESIGN--DESCRIPTIVE DATA

General Design of the Experiment

This study investigated the effect of mathematical vocabulary instruction, utilizing the videocassette recorder, on the achievement level of fifth grade pupils in solving simple and complex translation problems. Terms and phrases were selected for use in this study that have mathematical implications. The chosen terms and phrases are a part of the elementary school mathematics vocabulary (Appendix L).

The fifty-nine students that participated in this study came from three fifth grade classes. One class of students acted as a control group while the second and third classes were utilized as treatment groups. Treatment Group One completed and viewed vignettes that depicted the meaning of selected mathematical terms and phrases. Treatment Group Two viewed the vignettes completed by Treatment Group One. The control group neither completed nor saw the vignettes.

All data were collected from the Iowa Problem Solving Project (IPSP) Problem Solving Test (1979).

Form 561 of the IPSP Problem Solving Test was administered to students as a pretest for the experiment. At the conclusion of the experiment Form 562 of the IPSP Problem Solving Test was administered to students as a posttest. Pretest and posttest results were then analyzed to test hypotheses that were relevant to the experiment. The hypotheses that were tested are listed in the following section in the null form.

Hypotheses to be Tested

H_0 There will be no significant difference in the scores achieved by the Control Group and Treatment Group One (Completed and viewed the vignettes).

H_1 There will be no significant difference in the scores achieved by the Control Group and Treatment Group Two (Viewed the vignettes completd by Treatment Group One).

H_2 There will be no significant difference in the scores achieved by Treatment Group One (Completed and viewed the vignettes) and Treatment Group Two (Viewed the vignettes completed by Treatment Group One).

H_3 There will be no significant difference in the scores achieved by males and females in the Control Group and males and females in Treatment Group One (Completed and viewed the vignettes).

H_4 There will be no significant difference in the scores achieved by males and females in the Control Group and males and females in Treatment Group Two (Viewed the vignettes completed by Treatment Group One).

H_5 There will be no significant difference in the scores achieved by males and females in Treatment Group One (Completed and viewed the vignettes) and males and females in Treatment Group Two (Viewed the vignettes completed by Treatment Group One).

H_6 There will be no significant difference in the scores achieved by high achieving students and medium achieving students.

H_7 There will be no significant difference in the scores achieved by high achieving students and low achieving students.

H_8 There will be no significant difference in the scores achieved by medium achieving students and low achieving students.

H_9 There will be no significant difference in the scores achieved on subtest 1 of the pretest and subtest 1 of the posttest.

H_{10} There will be no significant difference in the scores achieved on subtest 2 of the pretest and subtest 2 of the posttest.

H_{11} There will be no significant difference in the scores achieved on subtest 3 of the pretest and subtest 3 of the posttest.

H_{12} There will be no significant difference in the scores achieved by students in each group on selected items of the pretest and posttest that contain vocabulary terms and phrases used in the study.

Hypotheses H_0 through H_8 were tested using Three-Way Analysis of Covariance. Hypotheses H_9 through H_{11} were tested using Two Way Analysis of Covariance. The final hypothesis, H_{12}, was tested using Three-Way Analysis of Covariance. Further, Pearson Correlation Analysis was used to identify some of the relationships between variables.

Instrumentation

The Iowa Problem Solving Project (IPSP) Problem Solving Test (1979) was developed as a part of the Iowa

Problem Solving Project directed by George Immerzeel of the University of Northern Iowa. The test was developed by Harold L. Schoen and Theresa M. Oehmke. Test data that are pertinent to the IPSP Problem Solving Test are located in Appendix J.

A summary of the test validation (Oehmke, 1979) concluded:

> First the test was shown to have a high degree of internal consistency. Estimates of reliability of forms 561 and 781 were computed by grade level using a modified KR-8 formula. The reliability coefficients ranged from .63 for a specific step to .86 for the entire test (based on a sample of over 1,000 Iowa students at each grade level), well within the desired range for a test with ten items for each subtest and a total of 30 item (p. 72).

A complete discussion of the test validation can be found in Oehmke (1979).

The IPSP Problem Solving Test is based on Polya's four step model of the problem solving process. In addition to a total score for each child, the test provides sub-scores that measure the students' ability to: understand the problem (Subtest 1), carry out the plan (Subtest 2), and look back at the solution (Subtest 3). These are three of the four steps included in Polya's model. Polya's step two, choosing a strategy, is not included in this test.

The IPSP test consists of two essentially equivalent forms for grades five and six (561 and 562) and two

I

c

lc

Th

ad

gra

gen

with

auto

are

capa

dist

The

dents

this

forms for grades seven and eight (781 and 782). Each of the four forms consists of a thirty item test.

This study will utilize only Forms 561 and 562. Form 561 will be used to collect pre-treatment data for both treatment groups and the control group. Form 562 will be used to collect post-treatment data from the treatment groups and control group.

Details of the Experiment

Description of Sample

The participants of this study were three classes of fifth grade students in a suburban school district located in the proximity of Michigan's capital city. This community has two small business districts; in addition, several farms are included in the same geographical area. The employed residents of the district generally work in a large automotive facility nearby or with various manufacturers working ancillary to the automobile industry; in addition, a number of residents are employed with the State of Michigan in various capacities. Further, a small percentage of the district's employed population are professional people. The school district has approximately two thousand students enrolled in kindergarten through twelfth grade.

Fifth grade students were selected as subjects for this study because they are able to read and are

T

f

sc

Ba

Tre

385

rang

Basi

stude

annua

trict,

Stanfo

each c

of the

to the

Th

study w

in both

required to complete simple and complex translation problems in their mathematics classes. The classes that participated in the study each contained approximately twenty students. The classes were assigned to a control group and two treatment groups.

A wide range of abilities exists in each classroom. This conclusion is supported by the results of the Stanford Achievement Test (Appendix H). The Control Group's scores on the Stanford Achievement Test (SAT) Basic Battery ranged from a high of 392 to a low of 216. Treatment Group One had scores ranging from a high of 385 to a low of 193. Treatment Group Two had scores ranging from a high of 371 to a low of 226. If the SAT Basic Battery Total was not available for a student, the student was deleted from the study.

The Stanford Achievement Test is administered annually to the elementary students of this school district. The test scores contained in Appendix H are the Stanford Achievement Test (SAT) Basic Battery Total for each child. These individual test scores are the result of the Stanford Achievement Test that was administered to the participants of this study in April of 1986.

The mathematical vocabulary utilized during this study were mathematical terms and phrases that are found in both the <u>Heath Mathematics</u> (1981) fifth grade m

t

du

th

the

the

was

grade

group

compl

phrase

timely

textbook and the Iowa Problem Solving Project (IPSP) Problem Solving Test (1979). The Heath Mathematics (1981) textbook is currently being used by all fifth grade students in this public school. Permission to use selected materials from the Heath Mathematics textbook was obtained from the publisher (Appendix C).

Description of the Three Treatments

The researcher and two other fifth grade teachers shared responsibility for instruction in the three mathematics classes participating in the study. The teachers rotated mathematics classes every three weeks during the first nine weeks of the study to eliminate the possibility of "teacher effect" on the outcome of the study.

The Control Group and Treatment Groups completed the following activities during this study:

Control Group. The Control Group for this study was made up of all the students in one of the fifth grade classrooms that participated in the study. This group did not view the videocassette recording that was completed by Treatment Group One. Some of the terms and phrases used in this study may have been discussed routinely in the normal day to day operation of this class.

g

d

s

le

fi

de

giv

dur

toge

depi

The

who

group

in th

A

group'

nettes

During the study the Control Group continued with the regular day to day activities that are included in the Heath Mathematics (1981) textbook. See Appendix D for sample lesson plans for the Control Group.

Treatment Group One--Completed and Viewed the Vignettes. Treatment Group One consisted of all the students in the researcher's fifth grade class. This group of students was divided into groups of five children. This grouping process was accomplished by first selecting five students that were known classroom leaders to chair each group. These leaders were identified by their fourth grade teachers. The remaining students were assigned in equal numbers to the groups.

Each group of students in Treatment Group One was given one mathematical term or phrase every three weeks during the study (Appendix M). Each group worked together to develop a three to five minute vignette depicting the meaning of the selected term or phrase. The researcher (or one of two other fifth grade teachers who rotated classes during the experiment) moved from group to group to monitor student activities and assist in the planning and development of the vignettes.

A videocassette recording was made of each small group's vignette. The researcher kept a log of the vignettes as they were recorded. This log listed the term v

u

i

ar

be

and

stu

voc

matc

pass

answ

score

refer

nette

record

locate

review

terms a

groups.

or phrase defined in each vignette and specified a counter number identifying the location of the definition(s) on the tape. The videocassette recording of the vignettes was then used to review the meaning of mathematical terms or phrases presented during the twelve weeks of the study. This recording of vignettes was utilized as a "video dictionary" during the study. That is, students with questions on the mathematical terms and phrases that were presented in the vignettes could be referred to the videocassette recording to clarify and reinforce understanding of the new vocabulary.

After six weeks of the study were completed the students in Treatment Group One were given a simple vocabulary test (Appendix N). This test consisted of matching exercises and fill in the blank questions. A passing score on this test was 90 percent correct answers. Four students failed to achieve a satisfactory score. Students failing to meet this criterion were referred to the videocassette recording of the vignettes. By utilizing the log of the videocassette recording of the vignettes students were able to quickly locate appropriate terms and phrases for review. The review of the specific vignettes that dealt with failed terms and phrases was completed individually or in small groups.

t

v

c

e

g

or

Gr

the

pro

two

tion

have

only

Group

In addition to developing the vignettes and videocassette recording sessions, Treatment Group One also continued with the regular day to day activities that are included in the <u>Heath Mathematics</u> (1981) textbook. See Appendix E for sample lesson plans for Treatment Group One.

<u>Treatment Group Two--Viewed the Vignettes Completed by Treatment Group One</u>. Treatment Group Two consisted of all the students in a third fifth grade class. This group of students viewed the videocassette recording that was completed by Treatment Group One. Students in this group viewed the videocassette recording of the vignettes individually, in small groups, or as an entire class. The initial viewing was always presented to the entire class. Later, if an individual student or small group of students had a question about a particular term or phrase, the tape was available for use. Treatment Group Two did not participate in a class discussion of the vignettes presented by Treatment Group One. This procedure was followed because the researcher wanted the two treatments to be distinct. That is, the introduction of a class discussion in Treatment Group Two would have made the two treatments fairly similar. Hence, the only difference between the Control Group and Treatment Group Two was the presence of the video recording.

Testing Time

This experiment was conducted during a twelve-week period at the beginning of the 1986-87 school year. Form 561 of the Iowa Problem Solving Project (IPSP) Problem Solving Test (1979) was administered by this researcher to the Control Group and two Treatment Groups during the second week of the school year. Pretesting was conducted during the second week of school because after one week in attendance students would be acclimated to the routine of school. Students who were absent during the pretest were tested by this researcher when they returned to school.

Following twelve weeks of the experiment, Form 562 of the IPSP Problem Solving Test (1979) was administered by this researcher to the three groups participating in the study. Students who were absent during the posttest were tested by this researcher when they returned to school.

Pilot Study

A pilot study was completed near the end of the 1985-86 school year to discover any problems that might exist in completing the experiment. The pilot study was conducted over a three week period with twenty-five fifth grade students.

r

w

m

fo

ti

ei

ta

abo

gro

in

obse

minu

the

The students participating in the pilot study were given background information on the proposed project and the rationale for the study. The students were excited about the prospect of participating in vignettes and being recorded for viewing on television.

The pilot study classroom was then divided into five groups of students. This grouping process was completed by first selecting five students that were known to this researcher as classroom leaders to chair each group. The remaining students were assigned in equal numbers to the groups. A mathematical term or phrase was assigned to each group.

The students met in small groups for twenty minutes. The first session was used to develop plans for their vignette. These small groups continued three times per week for a total of nine sessions. Sessions eight and nine of the pilot study were reserved for taping the vignettes. These recording sessions lasted about twenty minutes each. The researcher moved from group to group to monitor student activities and assist in the planning and development of vignettes. It was observed that group sessions lasting longer than twenty minutes tended to become unproductive.

The following observations were made as a result of the completed pilot study:

1. Identifying five group leaders was a successful strategy. These students kept the groups organized and were a source of motivation for the groups.

2. Some groups were able to develop a vignette that depicted the meaning of a mathematical term or phrase sooner than other groups. This researcher believes this occurred for two reasons. First, some groups had better leadership than other groups and were able to produce a vignette rapidly. Second, it became apparent that some students had considerable aptitude for developing and acting in a vignette.

3. It would be necessary to record each vignette more than once. The first recording, typically, had areas that needed improvement.

4. Students needed a chance to become accustomed to the television camera (see comments by Kaplan below).

5. Visuals were excellent--for example, a piece of wood cut out like a square or rectangle.

6. Students needed to be encouraged to speak up and enunciate clearly.

7. Many students told this researcher that they enjoyed creating the vignettes and acting them out in front of other classmates and the camera. A discussion with several parents about the study confirmed that the pilot study had been a positive experience for many of the students.

Kaplan (1986) suggests the following activities to familiarize students with the operation of the videocassette recorder, camera, and television. First, give students some time to just look at themselves before trying more structured activities. Kaplan says students should be allowed to make a face or say how they feel about being on television. Kaplan also suggests mirror exercises (exercises where one student imitates the movements of another). These exercises should begin with two students facing each other. When one moves closer, the other moves closer; when one shakes a foot, so does the other. Kaplan says these activities should be simultaneous, so the leader must move slowly, giving the partner a chance to be a true reflection. After taping this sequence of events, Kaplan suggests replaying the video to see if other students can identify the leader and the follower.

Based upon this pilot study, the following modifications were made in the experimental study:

1. Taping of vignettes always included at least one practice session. Students could then note problem areas in the vignette and make the necessary modifications.

2. Students were given several opportunities to become accustomed to the camera and television. This was accomplished by doing some of the activities suggested by Kaplan (1986).

3. The students were encouraged to use visuals (for example, a piece of wood cut to the shape of a square) and props. This resulted in students dressing up in various outfits (e.g., like a doctor) or having music playing during the vignette.

4. This researcher purchased an external microphone for the video camera. This eliminated most of the difficulty caused by students not speaking loudly enough. Also, a tripod was added to stabilize the camera.

5. This researcher became aware of the need to be patient and realize that developing and acting out a vignette may be difficult for some groups. This information was discussed with the teachers participating in this experimental study.

This concludes the discussion of the research design and descriptive data. Chapter IV contains the analysis of the data that was collected from this experiment.

CHAPTER IV

ANALYSIS OF THE DATA

Discussion of Analytic Procedures

In the third chapter, the experimental hypotheses were set forth in null hypothesis form. In this chapter the statistical results supporting or rejecting each of the null hypotheses is presented in turn.

The data collected in this study were analyzed using two- and three-way analysis of covariance (ANCOVA). A three-way analysis of covariance was performed on the posttest scores using treatment, sex, and level of achievement as factors. The pretest scores were also analyzed using treatment, sex, and level of achievement as factors. A two-way analysis of covariance was performed for the subtest scores of the posttest using treatment and sex as variates. The subtest scores of the pretest were analyzed using treatment and sex as factors. The hypotheses in this experiment were tested at an alpha level of 0.05.

Campbell and Stanley (1966) assert that the analysis of covariance is the recommended method of data analysis when intact classes have been assigned to treatments. The class means are used as the basic observations, and the treatment effects are tested against variations in these means. A covariance analysis would use pretest means as the covariate (Campbell and Stanley, 1966).

Further, this study used a design where the treatment groups and control group did not have pre-experimental sampling equivalence. The groups in this study constituted naturally assembled collectives, as similar as availability permits. Campbell and Stanley (1966) say the assignment of a treatment to one group or the other is assumed to be random and under the experimenter's control.

Wildt and Ahtola (1978) present the following linear model for the completely randomized factorial analysis of covariance with two factors and one covariate:

$$Y_{ijk} = \mu + \alpha_i + \gamma_j + (\alpha\gamma)_{ij} + \beta(X_{ijk} - \bar{X}) + e_{ijk};$$

$i = 1, \ldots, p;\ j = 1, \ldots, q;$

and $k = 1, \ldots, n;$

where Y_{ijk} is the observed value of the dependent variable for the kth observation within the ith level of factor A and the jth level of factor B, μ is the true mean effect, α_i is the effect due to the ith level of factor A with $\Sigma\alpha_i = 0$, γ_j is the effect due to the jth level of factor B with $\Sigma\gamma_j = 0$, $(\alpha\gamma)_{ij}$ is the effect due to the interaction of the ith level of factor A with the jth level of factor B with $\Sigma_i(\alpha\gamma)_{ij} = 0$ and $\Sigma_j(\alpha\gamma)_{ij} = 0$, β is the (regression) coefficient of the covariate, X_{ijk} is the observed value of the covariate, $\bar{X}$ is the general mean of the covariate, and e_{ijk} is the random error which is normally and independently distributed with mean zero and variance σ^2 (p. 70).

Further, Wildt and Ahtola (1978) state:

For this two-factor factorial design there are three major hypotheses of interest. In each case an F-ratio is the appropriate test statistic. The first hypothesis considered is the null hypothesis of no factor A effects, i.e., $\alpha_i = 0$ for all i. The test statistic is the F-ratio,

$$F_A = \frac{A_{yy(adj)}/(p-1)}{E_{yy(adj)}/N-pq-1)}$$

which under the null hypothesis has an F-distribution with p-1 and N-pq-1 degrees of freedom. The next hypothesis is the null hypothesis of no factor B effects, i.e., $\gamma_j = 0$ for all j. The test statistic is the F-ratio,

$$F_B = \frac{B_{yy(adj)}/(q-1)}{E_{yy(adj)}/N-pq-1)}$$

which under the null hypothesis has an F-distribution with q-1 and N-pq-1 degrees of freedom. The third hypothesis is that of no interaction effect, i.e., $(\alpha\gamma)_{ij} = 0$ for all i and j. The test statistic is the F-ratio,

$$F_{AB} = \frac{AB_{yy(adj)}/(p-1)(q-1)}{E_{yy(adj)}/N-pq-1)}$$

> which under the null hypothesis has an F-distribution with (p-1)(q-1) and N-pq-1 degrees of freedom (p. 74).

Finally, Wildt and Ahtola (1978) say that to use the analysis of covariance technique in a valid manner, the following assumptions are made:

> (1) The scores on the dependent variable are a linear combination of four independent components: an overall mean, a treatment effect, a linear covariate effect, and an error term.
>
> (2) The error is normally and independently distributed with mean zero and variance σ^2_ε.
>
> (3) The (weighted) sum over all groups of the treatment/group effect is zero.
>
> (4) The coefficient of the covariate (slope of the regression line) is the same for each treatment/group.
>
> (5) The covariate is a fixed mathematical variable measured without error, not a stochastic variable (p. 89).

The two-way ANCOVA model indicated above is similar and can be extended to a three-way ANCOVA model by introducing the third factor and its interactions:

$$\psi_k + (\alpha\psi)_{ik} + (\gamma\psi)_{jk} + (\alpha\gamma\psi)_{ijk}$$

where ψ_k is the effect of the third factor, while $(\alpha\psi)_{ik}$, $(\gamma\psi)_{jk}$, and $(\alpha\gamma\psi)_{ijk}$ are the interaction effects.

The F-ratio for the three-way ANCOVA is also calculated by the mean square due to the factors divided by the mean square error.

The following section of the chapter will present an analysis of the data collected during the experiment.

Analysis of Data for the Study Based on Scores Achieved on Forms 561 and 562 of the IPSP Problem Solving Test

Pretest and posttest data for the Control and Treatment Groups are listed in Tables 4.1 and 4.2. Data presented for the pretest and posttest include subtest scores for each of the three groups.

Pretest and posttest data for students participating in the study are broken down by sex in Tables 4.3 and 4.4. In this study Sex 1 denotes a male student and Sex 2 a female student. The data presented for the pretest and posttest include subtest scores for the students participating in the study.

Pretest and posttest data based on the achievement level of students participating in the study are presented in Tables 4.5 and 4.6. Level of achievement in this study was based on the students' Stanford Achievement Test (SAT) Basic Battery Total. Students in each class were ranked from high to low based on their SAT Basic Battery Total (Appendix H). Then each class was divided into three groups of equal or nearly equal

Table 4.1. Means and Standard Deviations of Groups for Pre-Subtests 1, 2, 3, and Pretest of Form 561 of the IPSP Problem Solving Test.

		Pre-Subtest 1		Pre-Subtest 2		Pre-Subtest 3		Pretest	
Group	N	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Control Group	19	6.211	2.175	7.158	1.463	5.211	2.106	18.579	4.550
Treatment Group 1	19	6.737	2.051	6.947	1.779	5.053	2.527	18.737	5.184
Treatment Group 2	21	6.381	2.578	7.047	1.987	5.095	2.700	18.619	6.289

Table 4.2. Means and Standard Deviations of Groups for Post-Subtests 1, 2, 3, and Posttest of Form 561 of the IPSP Problem Solving Test.

		Post-Subtest 1		Post-Subtest 2		Post-Subtest 3		Posttest	
Group	N	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Control Group	19	7.263	1.593	7.053	1.224	5.895	1.853	20.211	3.489
Treatment Group 1	19	7.316	1.734	6.947	1.311	5.737	2.051	20.000	3.367
Treatment Group 2	21	7.048	1.857	6.667	1.560	5.905	2.278	19.619	4.811

Table 4.3. Means and Standard Deviations by Sex for Pre-Subtests 1, 2, 3, and Pretest of Form 561 of the IPSP Problem Solving Test.

		Pre-Subtest 1		Pre-Subtest 2		Pre-Subtest 3		Pretest	
	N	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Sex 1	29	6.621	2.412	7.586	1.524	5.310	2.727	19.517	5.616
Sex 2	30	6.267	2.132	6.533	1.795	4.933	2.067	17.800	4.986

Table 4.4. Means and Standard Deviations by Sex for Post-Subtests 1, 2, 3, and Posttest of Form 562 of the IPSP Problem Solving Test.

		Post-Subtest 1		Post-Subtest 2		Post-Subtest 3		Posttest	
	N	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Sex 1	29	7.000	1.753	7.103	1.496	5.724	2.068	19.828	4.158
Sex 2	30	7.400	1.673	6.667	1.213	5.967	2.042	20.033	3.737

Table 4.5. Means and Standard Deviations by Level for Pre-Subtests 1, 2, 3, and Pretest of Form 561 of the IPSP Problem Solving Test.

		Pre-Subtest 1		Pre-Subtest 2		Pre-Subtest 3		Pretest	
Level	N	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Level 1	21	8.191	2.015	7.905	1.578	7.238	1.814	23.333	4.531
Level 2	19	6.000	1.633	7.158	1.741	5.000	1.700	18.263	3.314
Level 3	19	4.947	1.779	6.000	1.374	2.895	1.243	13.842	2.754

Table 4.6. Means and Standard Deviations by Level for Post-Subtests 1, 2, 3, and Posttest of Form 562 of the IPSP Problem Solving Test.

		Post-Subtest 1		Post-Subtest 2		Post-Subtest 3		Posttest	
Level	N	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Level 1	19	8.619	1.322	7.429	1.399	7.429	1.248	23.476	2.960
Level 2	19	6.737	1.240	6.842	1.214	5.684	1.565	19.263	2.446
Level 3	21	6.105	1.449	6.316	1.293	4.263	1.910	16.684	2.730

number. The upper third of each class was considered high achievers (Level 1), the middle third of each class was considered medium achievers (Level 2), and the bottom third of each class was considered low achievers (Level 3). If the SAT Basic Battery Total was not available for a student, the student was deleted from the study. The data presented for the pretest and posttest include subtest scores for each level of achievement.

Analysis of Covariance on the Dependent Variable Posttest

A three-way analysis of covariance (ANCOVA) was performed on the posttest of the IPSP Problem Solving Test. The pretest of the IPSP Problem Solving Test was the covariate, while the Control and Treatment Groups, Sex, and Level were the factors. The results of this analysis are presented in Table 4.7. The observed F value was 8.525. The observed significance level was 0.006. These results indicate that the pretest is a strong predictor of posttest results for all groups. Thus, a student who has a high test score on the pretest in this study will very likely have a high test score on the posttest.

The data for analysis of covariance for main effects are presented in Table 4.7. The analysis of covariance with the Control and Treatment Groups as the

Table 4.7. Three-Way Analysis of Covariance on the Dependent Variable Posttest.

Source of Variation	Degrees of Freedom	Observed F Value	Observed Significance Level
Pretest (Covariate)	1	8.525	0.006*
Main Effects	5	2.396	.054
Control and Treatment Groups	2	.298	.744
Sex	1	.944	.337
Level	2	3.878	.029*
Two-Way Interaction	8	.702	.688
Control and Treatment Groups - Sex	2	1.237	.301
Control and Treatment Groups - Level	4	.449	.772
Sex - Level	2	.851	.435

*Significant at 0.05.

source of variation had an observed F value of 0.298. The observed significance level was 0.744. The analysis of covariance with Sex as the source of variation had an observed F value of 0.944 and an observed significance level of 0.337. The analysis of covariance with Achievement Level (based on the Stanford Achievement Test Basic Battery Total) as the source of variation had an observed F value of 3.878 and an observed significance level of 0.029.

Although there is a finding of significance for each level of achievement in this study, it must be noted that this result can be misleading. Level of achievement was determined by the students' SAT Basic Battery Total. Much like a high pretest score predicting a high posttest score, a Level I (high achieving on the SAT Basic Battery) student would be expected to also have a high posttest score.

The data for analysis of covariance for two-way interaction are also presented in Table 4.7. The analysis of covariance for two-way interactions with the Control and Treatment Groups and Sex as the sources of variation had an observed F value of 1.237 and an observed significance level of 0.301. The analysis of covariance for two-way interactions with the Control and Treatment Groups and Achievement Level as the sources of variation had an observed F value of 0.449 and an observed significance level of 0.772. The analysis of covariance for two-way interactions, with Sex and Achievement Level as the sources of variation, had an observed F value of 0.851 and an observed significance level of 0.435.

In summary, the results presented in Table 4.7 show only two factors to be significant. First, the covariate (pretest) had an observed significance level of 0.006. Second, the achievement level had an observed significance level of 0.029.

Analysis of Covariance on the Dependent Variable Post Subtests 1-3

A two-way analysis of covariance (ANCOVA) on the dependent variable post subtests 1-3 of the IPSP Problem Solving Test was performed using the pre-subtests 1-3 of the IPSP Problem Solving Test as covariates, while the Control and Treatment Groups and Sex were the factors. The results of this analysis are presented in Table 4.8. With pre-subtest 1 as the covariate and post-subtest 1 as the dependent variable, the observed F value was 19.810 and the observed significance level was 0.001. With pre-subtest 2 as the covariate and post-subtest 2 as the dependent variable, the observed F value was 15.389 and the observed significance level was 0.001.

Table 4.8. Two-Way Analysis of Covariance on the Dependent Variable Post-Subtests 1-3.

Dependent Variable	Independent Variable	Observed F Value	Observed Significance Level
Post-Subtest 1	Pre-Subtest 1 (Covariate)	19.810	.001*
	Main Effects		
	Control and Treatment Groups	.104	.902
	Sex	.738	.392
	Two-Way Interactions		
	Control and Treatment Groups - Sex	.913	.409
Post-Subtest 2	Pre-Subtest 2 (Covariate)	15.389	.001*
	Main Effects		
	Control and Treatment Groups	.559	.576
	Sex	.537	.468
	Two-Way Interactions		
	Control and Treatment Groups - Sex	.370	.693
Post-Subtest 3	Pre-Subtest 3 (Covariate)	20.435	.001*
	Main Effects		
	Control and Treatment Groups	.101	.904
	Sex	.077	.783
	Two-Way Interactions		
	Control and Treatment Groups - Sex	.975	.385

*Significant at 0.05.

With pre-subtest 3 as the covariate and post-subtest 3 as the dependent variable, the observed F value was 20.435 and the observed significance level was 0.001. From this analysis it is apparent that the pre-subtests are strong predictors of results on the post-subtests. That is, a student with a high pre-subtest 1 score will very likely have a high test score on post-subtest 1.

The data for analysis of covariance for main effects is presented in Table 4.8. The analysis of covariance with the Control and Treatment Groups as the source of variation, for post-subtest 1 with pre-subtest 1 as a covariate, had an observed F value of 0.104 and an observed significance level of 0.902. The analysis by sex for pre- and post-subtest 1 had an observed F value of 0.738 and an observed significance level of 0.392. The analysis of covariance with the Control and Treatment Groups as the source of variation, for post-subtest 2 with pre-subtest 2 as a covariate, had an observed F value of 0.559 and an observed significance level of 0.576. The analysis by Sex for pre- and post-subtest 2 had an observed F value of 0.537 and an observed significance level of .468. The analysis of covariance with the Control and Treatment Groups as the source of variation, for post-subtest 3 with pre-subtest 3 as a covariate, had an observed F value of 0.101 and an observed significance level of 0.904. The analysis by Sex for pre- and post-subtest 3 had an observed F value of 0.077 and an observed significance level of 0.783.

The data for analysis of covariance for two-way interactions is also presented in Table 4.8. The analysis of covariance for two-way interactions with the Control and Treatment Groups and Sex as the sources of variation for pre-subtest 1 and post-subtest 1 had an observed F value of 0.913. The observed significance level for this analysis was 0.409. The analysis of covariance for two-way interactions with the Control and Treatment Groups and Sex as the sources of variation for pre-subtest 2 and post-subtest 2 had an observed F value of 0.370. The observed significance level for this analysis was 0.693. The analysis of covariance for two-way interactions with the Control and Treatment Groups and Sex as the sources of variation for pre-subtest 3 and post-subtest 3 had an observed F value of 0.975 and an observed significance level of 0.385.

In summary, the results presented in Table 4.8 indicate the only factors to be significant were the covariates. Each pre-subtest had an observed significance level of 0.001 with the corresponding post-subtest.

Correlation Analysis: Pearson Correlation Coefficients

The results of the correlation analysis are presented in Table 4.9. The independent variables are the pretest, the pre-subtests, and achievement level as determined by the Stanford Achievement Test. The dependent variable is the posttest or post-subtests. The observed level of significance for each analysis is 0.004 or less. The Pearson Correlation Coefficient (r) for the pretest-posttest analysis is 0.7075. This means that 50.06 percent of the variation in posttest results was explained by the pretest (when $r = .7075$, $r^2 = .5006$ or 50.06 percent).

Analysis of Data for the Study Based on Scores Achieved on Selected Items of Forms 561 and 562 of the IPSP Problem Solving Test

Given the preceding results, this researcher was concerned that gains made during the study were undetected by the instrument being used. Specifically, would the results of the study be different if an analysis was completed only on items on the pretest and posttest that contain terms and phrases that were taught during the study.

The following list of vocabulary words were identified from Appendix M as terms and phrases that appeared

Table 4.9. Correlation Analysis for Pearson Correlation Coefficients.

Dependent Variable	Independent Variable	Correlation Coefficient (r)	N	Observed Significance Level
Posttest	Pretest	.7075	59	.001*
	Level	.7363	59	.001*
Post-Subtest 1	Pre-Subtest 1	.4804	59	.001*
	Level	.5901	59	.001*
Post-Subtest 2	Pre-Subtest 2	.4098	59	.001*
	Level	.3666	59	.004*
Post-Subtest 3	Pre-Subtest 3	.4964	59	.001*
	Level	.6734	59	.001*

*Significant at 0.05.

in both Forms 561 and 562 of the IPSP Problem Solving Test:

total	wide/width
altogether	rectangle/rectangular
total cost	length

Seven items were identified on Form 561 (pretest) that contained the terms and phrases listed above. Thirteen items were also identified on Form 562 (posttest) that contained the same terms and phrases.

Pretest and posttest data for this analysis are summarized in Table 4.10. The data in Table 4.10 are listed by Control and Treatment Groups, Achievement Level, and Sex.

Analysis of Covariance on the Dependent Variable Posttest Vocabulary (POSTVOC)

A three-way analysis of covariance (ANCOVA) on the dependent variable posttest vocabulary (POSTVOC) was performed. The pretest vocabulary (PREVOC) was the covariate, while the Control and Treatment Groups, Sex, and Level were factors. The results of this analysis are presented in Table 4.11. The observed F value was 29.648. The observed significance level was 0.001. Once again, the results indicate that the pretest is a strong predictor of posttest results. As can be seen in Table 4.11, the only other factor that showed significance was the achievement level. Achievement level had

Table 4.10. Means and Standard Deviations of Groups, Levels, and Sex for Selected Items on the IPSP Problem Solving Test Forms 561 and 562.

		Pretest Vocabulary		Posttest Vocabulary	
Group	N	Mean	Standard Deviation	Mean	Standard Deviation
Control Group	19	4.211	1.619	8.368	2.362
Treatment Group 1	19	4.263	1.485	8.368	2.266
Treatment Group 2	21	4.381	1.774	8.238	2.719
Level 1	19	5.571	1.028	10.427	1.568
Level 2	19	4.368	1.212	7.790	1.988
Level 3	21	2.790	1.182	6.526	1.837
Sex 1	29	4.483	1.595	8.069	2.604
Sex 2	30	4.100	1.626	8.567	2.254

Table 4.11. Three-Way Analysis of Covariance on the Dependent Variable Posttest Vocabulary (POSTVOC).

Source of Variation	Degrees of Freedom	Observed F Value	Observed Significance Level
PREVOC (Covariate)	1	29.648	0.001*
Main Effects	5	3.400	.011*
Control and Treatment Groups	2	.017	.984
Sex	1	.749	.391
Level	2	6.957	.002*
Two-Way Interaction	8	.514	.839
Control and Treatment Groups - Sex	2	1.232	.301
Group - Level	4	.116	.976
Sex - Level	2	.820	.447

*Significant at 0.05.

an observed F value of 6.957 and an observed significance level of 0.002. However, this is the expected result as achievement level tends to predict the degree of success a student had on the pretest and posttest.

In summary, the analysis indicates that the treatments used in this study did not have a significant effect on the groups receiving them. Further, these results indicate no significance for treatment by Sex. Finally, this analysis produced no level of significance for any of the two-way interactions. Most of the variation in posttest results were explained by the pretest.

Summary of Results

1. The null hypotheses regarding scores achieved by the Control Group and Treatment Groups One and Two were not rejected. The treatment provided in this study did not produce a significant difference in the scores achieved by the Control and Treatment Groups.

2. The null hypotheses regarding scores achieved by males and females in the Control and Treatment Groups were not rejected. The treatment provided in this study did not produce a significant difference in the scores achieved by males and females.

3. The null hypotheses regarding scores achieved by high, medium, and low students in the Control and Treatment Groups were rejected. There was a significant difference in the scores achieved by high, medium, and low achieving students. The high achieving students, as determined by the Stanford Achievement Test (SAT) Basic Battery Total, scored significantly higher on the pretest and

posttest than medium and low achieving students. Further, medium achieving students on the SAT Basic Battery scored significantly higher on the pretest and posttest than low achieving students on the SAT Basic Battery.

4. The null hypotheses regarding scores achieved on the subtests by the Control Group and Treatment Groups were not rejected. The treatment provided in this study did not produce a significant difference in the scores achieved on the subtests by the Control and Treatment Groups.

5. The null hypothesis regarding scores achieved by students in the Control Group and Treatment Groups on selected items of the pretest and posttest was not rejected. The treatment provided in this study did not produce a significant difference in the scores achieved on selected items of the pretest and posttest.

6. There was a strong relationship between pretest and posttest results on the IPSP Problem Solving Test and Stanford Achievement Test Basic Battery results. That is, posttest results depended almost entirely on pretest results and pretest results were predicted by the achievement Level of a student as determined by the student's SAT Basic Battery Total.

The conclusions and interpretations to be derived from the data in this chapter are presented in Chapter V, the final chapter in this dissertation.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Restatement of the Problem

The purpose of this study was to determine the effect of mathematical vocabulary instruction, utilizing the videocassette recorder, on the achievement level of fifth grade pupils in solving simple and complex translation problems. For comparison purposes, one control and two experimental classes involving fifty-nine fifth grade students were used. The data were collected over a twelve-week period during the 1986-87 school year and consisted of student pretest and posttest scores on the Iowa Problem Solving Project (IPSP) Problem Solving Test. The data showed that the treatment administered during the experiment was not significantly more effective in enhancing the achievement level of students in solving simple and complex translation problems than the traditional method of instruction administered to the Control Group.

In this final chapter, the variables under investigation, the findings of the statistical analysis, and the conclusions based upon these findings will be presented.

Findings and Conclusions

In looking at the thirteen hypotheses in Chapter IV it became apparent that they were clustered around five basic ideas. For purposes of this chapter the hypotheses will be clustered and presented in the following manner: first, hypotheses 0, 1, and 2; second, hypotheses 3, 4, and 5; next, hypotheses 6, 7, and 8; then, hypotheses 9, 10, and 11; and last, hypothesis 12. Hypotheses 0, 1, and 2 dealt with the achievement level of students as measured by the IPSP Problem Solving Test. Hypotheses 3, 4, and 5 were concerned with the achievement level of students, as measured by the pretest and posttest, based on gender. Hypotheses 6, 7, and 8 were interested in the achievement level of students on the IPSP Problem Solving Test, with students assembled by achievement level, based on their Stanford Achievement Test Basic Battery Total. Hypotheses 9, 10, and 11 were concerned with differences that might arise on subtests of the testing instrument. Hypothesis 12 considered differences in achievement on the pretest and posttest when only selected items of the instrument were analyzed.

Hypotheses 0, 1, and 2

H_0 There will be a significant difference in the scores achieved by the Control Group and Treatment Group One (Completed and viewed the vignettes).

H_1 There will be a significant difference in the scores achieved by the Control Group and Treatment Group Two (Viewed the vignettes completed by Treatment Group One).

H_2 There will be a significant difference in the scores achieved by Treatment Group One (Completed and viewed the vignettes) and Treatment Group Two (Viewed the vignettes completed by Treatment Group One).

Findings. The criteria for measuring achievement in problem solving were the students' performance on the IPSP Problem Solving Test, administered as a pretest and as a posttest. Analysis by means of three-way analysis of covariance showed there was not a significant gain in the total number of problems correct on the posttest when compared to the pretest between the Control Group and the Treatment Groups.

Conclusions. Since there was not a significant difference in the scores achieved by the Control Group, Treatment Group One, and Treatment Group Two over the duration of the experiment, hypotheses 0, 1, and 2 were rejected. Thus, it was concluded that the treatments administered to Treatment Group One (Completed and viewed the vignettes) and Treatment Group Two (Viewed the vignettes completed by Treatment Group One) were not significantly more effective in teaching mathematical vocabulary than the traditional method of instruction administered to the Control Group.

It appears, from the data collected in this experiment, that participating in the development of vignettes that depict the meaning of selected mathematical terms and phrases, acting in those vignettes, and viewing a videocassette of the vignette(s) is as effective a method of teaching mathematical vocabulary to elementary school students as the traditional method utilized by the Control Group. Further, the data suggest that simply viewing a videocassette recording of vignette(s) that depict the meaning of selected mathematical terms and phrases is as effective a method of teaching mathematical vocabulary to elementary school students as the traditional method utilized by the Control Group.

Although the Treatment Groups that participated in this experiment felt it was a positive experience, the analysis of data indicates that students did not acquire a significant amount of mathematical vocabulary as a result of the treatments. In analyzing these results, the researcher has the following additional conclusions:

1. The students in Group One were overly involved in the process of developing vignettes and participating in the recording of the vignettes. That is, the students lost sight of the intended goal. Further, the viewing of the vignettes to acquire knowledge of mathematical

vocabulary became secondary to watching classmates perform on television.

2. Many students in Treatment Group Two viewed the videocassette recording of Treatment Group One from an entertainment perspective (similar to a television program at home) and failed to acquire the intended mathematical vocabulary.

The data collected and analyzed in this experiment should be taken into account as educators in elementary school mathematics access the role of the videocassette recorder in instructing students in mathematical vocabulary.

Hypotheses 3, 4, and 5

H_3 There will be a significant difference in the scores achieved by males and females in the Control Group and males and females in Treatment Group One (Completed and viewed the vignettes).

H_4 There will be a significant difference in the scores achieved by males and females in the Control Group and males and females in Treatment Group Two (Viewed the vignettes completed by Treatment One).

H_5 There will be a significant difference in the scores achieved by males and females in Treatment Group One (Completed and viewed the vignettes) and males and females in Treatment Group Two (Viewed the vignettes completed by Treatment Group One).

Findings. The criteria for measuring achievement in problem solving were the male and female students' performance on the IPSP Problem Solving Test, administered as a pretest and as a posttest. Analysis by means of three-way analysis of covariance indicates there was not a significant gain in the total number of problems correct between males and females on the posttest when compared to males and females on the pretest in the Control Group and Treatment Groups.

Conclusions. Inasmuch as there was not a significant difference in the scores achieved by males and females in the Control Group, Treatment Group One, and Treatment Group Two over the course of the experiment, hypotheses 3, 4, and 5 were rejected. Hence, it was concluded that the treatment administered to male and female students in Treatment Group One (Completed and viewed the vignettes) and male and female students in Treatment Group Two (Viewed the vignettes completed by Treatment Group One) was as effective in teaching mathematical vocabulary as the traditional method of instruction administered to the males and females in the Control Group.

From the data collected in this experiment it appears that neither sex benefited more from the treatments that were administered. These results are important when one considers that male and female students assumed similar roles during this experiment. Male and female students were represented in approximately equal numbers as small group leaders. Likewise, the small groups of students that developed vignettes were composed of an equal or nearly equal number of males and females. Further, the roles students assumed in the vignettes (lead versus a supporting role) were varied sufficiently by sex so as not to favor either gender. These results are positive and give the appearance that in elementary school mathematics instruction it may be appropriate, to enhance the students' achievement level in mathematical vocabulary, to expose students to a variety of roles in the instructional setting, and not limit them to the stereotypical roles that are often present in our culture.

<u>Hypotheses 6, 7, and 8</u>

H_6 There will be a significant difference in the scores achieved by high achieving students and medium achieving students.

H_7 There will be a significant difference in the scores achieved by high achieving students and low achieving students.

H_8 There will be a significant difference in the scores achieved by medium achieving students and low achieving students.

<u>Findings</u>. The criteria for measuring achievement in problem solving were the students' performance on the IPSP Problem Solving Test, administered as a pretest and as a posttest. Analysis by means of three-way analysis of covariance indicated there was a significant gain in the total number of problems correct between Levels of achievement on the posttest compared to Levels of

achievement on the pretest for the Control Group and Treatment Groups.

Conclusions. There was a significant difference in the scores achieved by high, medium, and low achieving students in the Control Group, Treatment Group One, and Treatment Group Two over the duration of the study. Thus, hypotheses 6, 7, and 8 were accepted. However, these results may be misleading. Since level of achievement was based on the students' Stanford Achievement Test Basic Battery Total, it follows that high achieving students would have greater scores on the pretest and posttest than medium and low achieving students. Further, it follows that medium achieving students would have greater scores on the pretest and posttest than low achieving students. The significant difference in scores achieved by high, medium, and low achieving students is predictable and independent of the effects of the treatments utilized in the study.

The above conclusion is supported by the correlation analysis for Pearson Correlation Coefficients (Table 4.9). This analysis indicates that 50.06 percent of the variation in posttest results was explained by the pretest. In addition, the data for two-way interactions presented in Table 4.7 indicate that the Control Group and Treatment Groups interacting with level of achievement (noted as Level in Table 4.7) had an observed significance level of 0.772. Thus, the treatments administered during this experiment were not significantly more effective than the traditional method of instruction administered to the Control Group, regardless of Treatment Group and level of achievement (as determined by the Stanford Achievement Test Basic Battery Total).

Hypotheses 9, 10, and 11

H_9 There will be a significant difference in the scores achieved on subtest 1 of the pretest and subtest 1 of the posttest.

H_{10} There will be a significant difference in the scores achieved on subtest 2 of the pretest and subtest 2 of the posttest.

H_{11} There will be a significant difference in the scores achieved on subtest 3 of the pretest and subtest 3 of the posttest.

Findings. The criteria for measuring achievement in problem solving were the students' performance on the subtests of the IPSP Problem Solving Test, administered as a pretest and as a posttest. Analysis by means of two-way analysis of covariance showed there was not a significant gain in the total number of problems correct on subtests one, two, and three of the posttest when compared to subtests one, two, and three of the pretest between the Control Group and the Treatment Groups.

Conclusions. Inasmuch as there was not a significant difference in the scores achieved by the Control Group, Treatment Group One, and Treatment Group Two on the subtests of the pretest and posttest over the duration of the experiment, hypotheses 9, 10, and 11 were rejected. Rejecting these hypotheses indicates that the treatments administered to the Treatment Groups in this experiment were as effective in assisting students to understand the problem (Subtest 1), carry out the plan (Subtest 2), and look back at the solution (Subtest 3) as the traditional method of instruction utilized by the Control Group. Although the treatment administered during this experiment did not specifically deal with Polya's problem solving model, the researcher was interested to learn if some spin-off effect was present. Since there was no significant difference in the statistical analysis of the entire test instrument, this researcher suspected there would be no significant difference in the analysis of the subtests.

If the strategy used to teach mathematical vocabulary in this experiment was significantly more effective than the traditional method of instruction, it is apparent that the students did not transfer all of the newly acquired knowledge to any specific subtest of the posttest. Again, this researcher concludes that the participants were overly involved in the process of developing vignettes and/or viewing them and lost sight of the desired goal of the experiment.

Hypothesis 12

H_{12} There will be a significant difference in the scores achieved by students in each group on selected items of the pretest and posttest that contain vocabulary terms and phrases used in the study.

Findings. The criteria for measuring achievement in problem solving were the students' performance on selected items of the IPSP Problem Solving Test, administered as a pretest and as a posttest. Analysis by means of three-way analysis of covariance showed there was not a significant gain in the total number of problems correct on selected items of the posttest when compared to selected items of the pretest between the Control Group and Treatment Groups.

Conclusions. Since there was not a significant difference in the scores achieved by the Control Group and the Treatment Groups (on selected items of the pre-test and posttest) over the duration of the experiment, hypothesis 12 was rejected. Rejecting hypothesis 12 provides strong evidence that the treatments administered to Treatment Group One and Treatment Group Two during this experiment were not significantly more effective than the traditional method of instruction employed by the Control Group.

Summary

Although the analysis of the data from this study indicates there was no significant difference in the scores achieved by the three groups of students that participated in the study, this researcher believes the students in Treatment Group One (completed and viewed the vignettes) and Treatment Group Two (viewed the vignettes completed by Treatment Group One) were the recipients of a number of benefits that were not measured by the instruments used for data collection.

Several curriculum areas are incorporated into a videocassette recording production. Language skills, research, organization, scriptwriting, speaking, listening, art, music, and the interpersonal skills necessary to complete a video tape are factors that contribute to students' social, emotional, and academic learning. The students that completed vignettes for this study had to integrate, to some degree, the above skills as they worked together to complete vignettes. Without this integration of skills, the completion of the vignettes that depict the meaning of mathematical terms and phrases used in this study would not have been successful. Finally, the students that participated in the production of the vignettes had a challenging but enjoyable experience. The students found it difficult at times to create a vignette that would depict the meaning of a mathematical term or phrase. However, once the script was finalized, the production of the vignette and viewing were positive experiences.

There may have been derivative effects that transpired as a result of this experiment. For example, students that participated in the development and completion of vignettes may have enhanced their language skills, organizational abilities, writing, speaking, listening, and interpersonal skills. Further, students that participated in the experiment may have had an attitudinal change toward mathematics.

The researcher believes the results of this experiment could be tempered as specific vocabulary used in the experiment was limited to a narrow sampling of mathematical terms and phrases. The terms and phrases utilized in this experiment were found in the students' mathematics textbook (Heath Mathematics, 1981) and on the IPSP Problem Solving Test (1979). That is, only terms and phrases found in both the textbook and testing instrument were a part of the experiment. It is likely that the students participating in the experiment had some knowledge of the terms and phrases prior to the study. Thus, the failure to show a significant difference between pretest and posttest scores in the Control and Treatment Groups may have been predictable and not necessarily an indication of treatment effect. Different results might have been obtained by utilizing more terms of a more difficult nature (e.g., hypothenuse). Also, a vocabulary pretest given prior to the study could have been used to eliminate vocabulary words that were already known to the students.

Recommendations for Future Research

The scope and sequence of appropriate instructional materials, emphasis on, and methods of utilization of technology for improving mathematical problem solving should be investigated continuously. Perhaps no best way will be devised, but better and more efficient ways can be developed by imaginative research. The following suggestions for additional investigation are offered as a result of this study:

1. Replication of the study: This study should be replicated at the fifth grade level with a different sample population. The study should also be replicated at other grade levels. The following modifications are recommended by this researcher. First, a vocabulary test should be administered to Treatment Group One (Completed and viewed the vignettes) at the conclusion of the experiment. Also, a vocabulary test should be administered to Treatment Group Two (Viewed the vignettes completed by Treatment Group One) and the Control Group midway through the study and at the conclusion of the study. This would

provide evidence of gains in vocabulary knowledge separate from the results of a problem solving instrument. This would enhance the generalizability of the present study.

2. A study should be completed using a video dictionary that just defines words or phrases and gives examples.

3. It is still not clear what the appropriate role of the teacher should be in utilizing videocassettes in the classroom. For example, should the teacher assume a role in each vignette? If yes, what is the degree of involvement?

4. One could also investigate if time taken away from mathematics instruction to develop vignettes tends to have an effect on the results. (Perhaps it would be advantageous not to have the development process be a part of the mathematics class, but, for example, a part of art class.)

5. Would the outcome of the experiment be different if only a select few students from a class participated in the completion of the vignettes? That is, would an experiment with students who have an aptitude toward organizing and acting in vignettes produce a different result?

6. A longitudinal study using a similar design may produce different results. That is, students that participated in the original treatment groups may generate different results in a similar study following a six month or one year period.

7. A similar study should be completed that incorporates a measure of the students' attitude toward mathematics.

When answers to some of the above questions are discovered, a better understanding of problem solving in the mathematics classroom will result. Hopefully, answers to these questions will also guide decisions on current and future research, thus providing more information about students, curricula, and methodology in the teaching of problem solving.

APPENDICES

APPENDIX A

LETTER OF PERMISSION TO COMPLETE THE STUDY FROM THE SUPERINTENDENT OF SCHOOLS

DEWITT PUBLIC SCHOOLS
608 WILSON
DEWITT, MICHIGAN 48820

OFFICE OF THE SUPERINTENDENT

March 12, 1986

Mr. Thomas D. Russell
1320 Cedarhill Drive
East Lansing, Michigan 48823

Dear Mr. Russell:

Your request to conduct a research project as outlined in your application submitted February 28, 1986, has been carefully reviewed and your application is approved.

It is my understanding that the study will take approximately 10 weeks, will involve three fifth grade classes, and will require no change in the curriculum or textbooks used. It is also understood that all use of student test scores and names will be kept confidential.

May I wish you the best as you complete your Ph.D. requirements and will be very interested in reviewing your study when it is completed.

Sincerely,

Stephen C. Garrett
Superintendent

dej

Enc.

APPENDIX B

INFORMATIONAL LETTER TO PARENTS OF CHILDREN PARTICIPATING IN THE STUDY AND CONSENT FORM

September 3, 1986

Dear Parents:

During the next twelve weeks of this school year I will be completing a study that will involve three fifth grade classes of children and three fifth grade teachers in the DeWitt Public Schools. This research will be included in a dissertation to complete my Doctor of Philosophy degree from Michigan State University at East Lansing, Michigan.

The purpose of this study is to determine the effect of mathematical vocabulary instruction, utilizing the videocassette recorder, on the achievement level of fifth grade pupils in solving word or story problems.

Students in elementary mathematics classes are taught new terms and phrases from time to time. A knowledge of mathematical vocabulary is important if students are to have success in solving story problems. This study will utilize selected terms and phrases that are found in the students' mathematics textbook. These terms and phrases are normally presented and discussed in the day-to-day operation of your child's mathematics class. This study will fit into the day-to-day operation of the mathematics class.

Each class of students participating in this study will take a pretest prior to the study and a posttest at the conclusion of the study. Pretest and posttest scores will not be used to determine students' grades in their mathematics class. Students will not be graded on their participation in this study.

Groups of students in my class will develop skits, or vignettes, that depict the meaning of selected mathematical terms and phrases. This process will take about thirty minutes per week. These vignettes will be recorded using a videocassette recorder and camera. This recording will be replayed to my class. Students in this group will use the recording of the vignettes to review the meaning of terms and phrases should questions arise.

A second classroom will view the videocassette recording completed by my students. This group will also have the option of referring to the recording to clarify the meaning of terms and phrases as questions arise. The viewing of this recording will take about fifteen minutes per week.

A third class will not view the recording. This group will continue with the normal day-to-day operation of their mathematics class.

The three teachers participating in this study will change or rotate classes at approximately three week intervals. They will teach only the mathematics class during this change.

The videocassette recording of the vignettes completed for this research will be erased at the conclusion of this study. The tape will not be used for further research.

A statistical analysis of the Stanford Achievement Test (SAT) scores for students participating in the study will be completed. This analysis will be completed to show that there is no significant difference in the ability levels of the three classes participating in the study. Identifying information has been deleted from the SAT scores.

Attached to this letter is a consent form that is required to permit your child to participate in this study. There is no penalty for students that do not participate in this study. Supplemental mathematics activities will be provided for students that do not participate in the study. Your child is free to discontinue participation in this study at any time with no consequences.

The results of this study will be treated with strict confidence and all students will remain anonymous. On request, and within these restrictions, results of this study will be made available to parents of children participating in this study.

Please return this letter and the consent form to school. Thank you for your assistance in this research.

Sincerely,

Tom Russell
Fifth Grade Teacher

My child, _________________________, (has, does not have) permission to participate in the research project being completed by Tom Russell, a fifth grade teacher in the DeWitt Public School system.

____
Parent's signature

____
Date

APPENDIX C

LETTER OF PERMISSION FROM D.C. HEATH COMPANY

HEATH

D.C. Heath and Company

125 Spring Street
Lexington, Massachusetts 02173
Telephone (617) 862-6650

August 29, 1985

Mr. Thomas D. Russell
1320 Cedarhill Drive
East Lansing, MI 48823

Dear Mr. Russell:

We are pleased to grant you permission to use specified material from HEATH MATHEMATICS, (c)1981 as you requested. This may be material may be used free of charge.

The reproduced material is to be used as part of your dissertation at Michigan State University and is limited to 15 copies. Additional permission must be obtained if this is to be published for commercial purposes.

No deletions from, additions to, or changes in the text or illustrations should be made without written approval.

All materials so reproduced must carry the title, copyright date and the legend "Reprinted by permission of D. C. Heath and Company."

The permission does not include any copyrighted matter from other sources incorporated in the material. The rights hereby granted may not be assigned or transferred.

If these conditions are satisfactory, please sign and return to me the enclosed copy of this letter.

Sincerely,

Dorothy B. McLeod

Dorothy B. McLeod
Rights and Permissions

Signature ______________________________

Date ______________________________

APPENDIX D

SAMPLE LESSON PLANS FOR CONTROL GROUP

APPENDIX D

SAMPLE LESSON PLANS FOR CONTROL GROUP

Weeks 1, 4, 7, 10, and 12

Week One

Monday - Check p. 27 #7-27. Complete pp. 28-29 and Keeping Skills Sharp.

Tuesday - Check pp. 28-29. Complete p. 30-31 #20-39.

Wednesday - Check p. 30-31 #20-39. Complete pp. 32-33 Times Test.

Thursday - Check pp. 32-33. Complete pp. 34-35.

Friday - Check pp. 34-35. Complete pp. 36-37 in class. Complete pp. 38-39. Complete Pre-test (Form 561).

Week Four

Monday - Check pp. 57-58. Complete pp. 60-61.

Tuesday - Check pp. 60-61. Complete pp. 62-63.

Wednesday - Check pp. 62-63. Complete pp. 64-65 Times Test.

Thursday - Check pp. 64-65. Complete pp. 66-67.

Friday - Check pp. 66-67. Complete pp. 68-69.

Week Seven

Monday - Correct p. 80 #1-21. Play "Around the World." Complete p. 82 and Set 21.

Tuesday - Correct p. 82 and Set 21. Complete Chapter Three Posttest and Set 23 (even).

Wednesday - Correct Chapter Three Posttest and Set 23 (even). Review division p. 86. Complete p. 87. Assign board work and Set 24.

Thursday - Correct Set 24 and board work. Discuss p. 90. Do together #1-6. Assign rest of pp. 90-91.

Friday - Correct pp. 90-91. Do Basic Worksheet 26 and 27, and Enrichment Worksheet 27.

Week Ten

Monday - Check pp. 103 #11-28. Complete p. 105 #9-18 and Set 29.

Tuesday - Check p. 105 #9-18 and Set 29. Complete p. 105 #19-28 and Keeping Skills Sharp. Also Set 30.

Wednesday - Check p. 105 #19-28 and Keeping Skills Sharp. Check Set 30.

Thursday - Check p. 107 #1-12. Assign #13-18 and Basic Worksheet 29.

Friday - Check p. 107 #13-18 and Basic Worksheet 29. Complete p. 108.

Week Twelve

Monday - Check p. 114 Review. Complete Posttest for Chapter Four. Complete pp. 2-3.

Tuesday - Check pp. 2-3. Complete pp. 4-5.

Wednesday - Check pp. 4-5. Complete pp. 6-7.

Thursday - Thanksgiving Vacation

Friday - Thanksgiving Vacation

Week Twelve Continued

Monday - Check pp. 6-7. Complete pp. 8-9.

Tuesday - Complete Posttest (Form 562). Correct pp. 8-9. Complete pp. 10-11.

APPENDIX E

SAMPLE LESSON PLANS FOR TREATMENT GROUP ONE

(COMPLETED AND VIEWED THE VIGNETTES)

APPENDIX E

SAMPLE LESSON PLANS FOR TREATMENT GROUP ONE

(COMPLETED AND VIEWED THE VIGNETTES)

Weeks 1, 4, 7, 10, and 12

<u>Week One</u>

Monday	- Correct p. 326 Set 8. Review place value. Discuss p. 6. Complete p. 7.
Tuesday	- Correct p. 7. Discuss p. 8 and complete p. 9. Do Set 9 p. 327.
Wednesday	- Correct p. 9 and Set 9. Complete pp. 10-11.
Thursday	- Correct pp. 10-11. Collect. Review three digit addition. Complete ditto 10. Complete Pretest (Form 561). Assign students to groups for vignettes.
Friday	- Correct ditto 10. Assign terms for first vignettes: total score, farther, total cost, total, and miles per gallon. Do warm up activities with VCR, television, and camera. Orally complete p. 12. Complete Set 10, p. 327.

<u>Week Four</u>

Monday	- Correct pp. 38-39. Discuss p. 40. Complete p. 41 and Keeping Skills Sharp.
Tuesday	- Correct p. 41. Discuss p. 42. Complete p. 43 #1-22.
Wednesday	- Correct p. 43 #1-22. Assign terms for vignettes: how many altogether, find the cost, square, average, average rate. Work on vignettes fifteen minutes. Complete Set 14 p. 328.

Thursday - Correct Set 14 p. 328. Discuss p. 44. Do #17-20 on board. Complete #1-16 on own. Practice vignettes.

Friday - Correct p. 44 #1-16. Work on vignettes for fifteen minutes. Discuss p. 46. Complete p. 47 together. Complete Set 16. Students viewed the tape of the first five terms and phrases in small groups.

Week Seven

Monday - Correct Basic Worksheet 20 and p. 65 #21-29. Complete #30-32 on board. Discuss p. 66. Complete p. 67 #1-23 and Skills Practice.

Tuesday - Correct p. 67. Discuss p. 68. Complete p. 69 #1-36. Complete Enrichment Worksheet 20.

Wednesday - Correct p. 69 and Worksheet 20. Assign new terms and phrases to groups: less than, wide/width, rectangle/rectangular, length, and twice as many. Discuss p. 70. Complete p. 71 #1-15.

Thursday - Correct p. 71. Work fifteen minutes on vignettes. Discuss two by two digit multiplication. Complete p. 71 #16-29. Give Vocabulary Test on first ten terms and phrases.

Friday - Correct p. 71 #16-29. Work on developing vignettes for fifteen minutes. Complete Basic Worksheet 22. Individual students review tape of vignettes.

Week Ten

Monday - Correct p. 82 #1-15 and Set 25. Complete Chapter Three Posttest. Review one digit division. Complete Set 1 pp. 342-343. Viewed tape of the first fifteen vignettes.

Tuesday - Correct Chapter Three Posttest and Set 1. Discuss factors. Complete p. 87 and factors ditto. Assign last two terms and phrases to groups: total amount and how much more.

Wednesday - Correct p. 87 and factors ditto. Complete Basic Worksheet 26 and factors ditto. Practice vignettes.

Thursday - Correct Basic Worksheet 26 and factors ditto. Complete division ditto and factors ditto. Practice vignettes fifteen minutes.

Friday - Correct division and factors ditto. Discuss G.C.F. and fractions p. 90. Complete p. 90 #1-18 and division ditto.

Week Twelve

Monday - Correct p. 99 #1-20. Viewed complete tape of vignettes. Complete p. 99 #20-35.

Tuesday - Correct p. 99 #20-35. Complete pp. 100-101. Discuss two digit division.

Wednesday - Correct pp. 100-101. Review two digit division. Complete ditto on two digit division.

Thursday - Thanksgiving Vacation

Friday - Thanksgiving Vacation

Week Twelve Continued

Monday - Correct ditto on two digit division. Review two digit division. Complete Basic Worksheet 30.

Tuesday - Correct Basic Worksheet 30. Review two digit division. Complete Posttest (Form 562).

APPENDIX F

SAMPLE LESSON PLANS FOR TREATMENT GROUP TWO

(VIEWED THE VIGNETTES COMPLETED BY

TREATMENT GROUP ONE)

APPENDIX F

SAMPLE LESSON PLANS FOR TREATMENT GROUP TWO

(VIEWED THE VIGNETTES COMPLETED BY

TREATMENT GROUP ONE)

Weeks 1, 4, 7, 10, and 12

Week One

Monday - Go over pp. 10-11. Complete pp. 12-13 and ditto 5.

Tuesday - Roman Numerals. Complete pp. 14-15 and ditto 6.

Wednesday - Chapter Checkup p. 16. Complete Pretest (Form 561).

Thursday - Chapter Review p. 18. Challenge p. 19 and Major Checkup.

Friday - Posttest Chapter One.

Week Four

Monday - Correct p. 49. Then do Chapter Checkup p. 50 and hand in.

Tuesday - Do Chapter Review p. 52 and Major Checkup p. 54. View the tape of vignettes.

Wednesday - Do Posttest Chapter Two (hand in). Try Challenge on p. 53.

Thursday - Go over pp. 56-57. Do p. 58. Check and time themselves.

Friday - Do dittos 17 (Basic and Enrichment). Play "Around the World."

Week Seven

Monday - Exchange and correct Set 19 p. 329 and Set 21 p. 330. Hand in. Discuss thoroughly p. 72. Do #1, 17, and 31 as examples. Assign p. 73 (all except #1, 17, and 31).

Tuesday - Correct p. 73. Assign Basic Worksheet 23 and Enrichment Worksheet 23.

Wednesday - Correct Worksheets 23. Discuss thoroughly p. 74. Assign p. 75 and Keeping Skills Sharp.

Thursday - Correct p. 75. Assign pp. 76-77.

Friday - Correct pp. 76-77. Assign Sets 22 and 23 on p. 330.

Week Ten

Monday - Correct p. 91 #35-48. Assign dittos 27 (Basic and Enrichment).

Tuesday - Correct and discuss dittos 27 (Basic and Enrichment). Go over pp. 92-93 together. Do Set 5 pp. 350-351.

Wednesday - Discuss p. 94. Viewed tape of first fifteen vignettes. Complete Set 28.

Thursday - Correct Set 28. Assign dittos 28-29.

Friday - Correct dittos 28-29. Assign dittos 7-8.

Week Twelve

Monday - Go over and then assign p. 108 (all).

Tuesday - Go over p. 110 together. Assign dittos 33 (Basic and Enrichment). View complete tape of vignettes.

Wednesday - Correct dittos 33 (Basic and Enrichment). Do and hand in Chapter Checkup p. 112. Review p. 114 and Major Checkup p. 116.

Week Twelve Continued

Thursday	- Thanksgiving Vacation
Friday	- Thanksgiving Vacation
Monday	- Review Chapter and p. 115. Then do Chapter Posttest.
Tuesday	- Board work (five problems of the four operations). Discuss pp. 118-119. Do dittos 34 (Basic and Enrichment). Complete Posttest (Form 562).

APPENDIX G

EXAMPLES OF PROBLEM TYPES IDENTIFIED BY CHARLES AND LESTER (1982)

APPENDIX G

EXAMPLES OF PROBLEM TYPES IDENTIFIED

BY CHARLES AND LESTER (1982)

<u>Drill Exercise</u>

1. $\begin{array}{r} 346 \\ \underline{\times\ 28} \end{array}$

<u>Simple Translation Problem</u>

2. Jenny has 7 tropical fish in her aquarium. Tommy has 4 tropical fish in his aquarium. How many more fish does Jenny have than Tommy?

<u>Complex Translation Problem</u>

3. Ping-Pong balls come in packs of 3. A carton holds 24 packs. Mr. Collins, the owner of a sporting goods store, ordered 1800 Ping-Pong balls. How many cartons did Mr. Collins order?

<u>Process Problem</u>

4. A chess club held a tournament for its 15 members. If every member played one game against each other member, how many games were played?

<u>Applied Problem</u>

5. How much paper of all kinds does your school use in a month?

Puzzle Problem

6. Draw 4 straight line segments to pass through all 9 dots in Figure 1. Each segment must be connected to an endpoint of at least one other line segment.

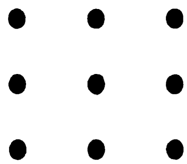


Figure 1

APPENDIX H

STANFORD ACHIEVEMENT TEST RESULTS FOR STUDENTS PARTICIPATING IN THE STUDY RANKED FROM HIGH TO LOW

APPENDIX H

STANFORD ACHIEVEMENT TEST RESULTS FOR

STUDENTS PARTICIPATING IN THE STUDY

RANKED FROM HIGH TO LOW

Test Date 4/21/86

Data for the Control Group

Student Number	Basic Battery Total (Total Possible 407)	Achievement Level*
1	392	1
2	371	1
3	355	1
4	345	1
5	340	1
6	330	1
7	329	1
8	324	2
9	307	2
10	304	2
11	298	2
12	297	2
13	288	2
14	286	3
15	281	3
16	279	3
17	265	3
18	246	3
19	216	3

Data for Treatment Group One--
Completed and Viewed the Vignettes

Student Number	Basic Battery Total (Total Possible 407)	Achievement Level*
20	385	1
21	351	1
22	347	1
23	339	1
24	337	1
25	335	1
26	333	1
27	327	2
28	324	2
29	315	2
30	302	2
31	284	2
32	277	2
33	276	3
34	275	3
35	245	3
36	229	3
37	223	3
38	193	3

Data for Treatment Group Two--Viewed the Vignettes Completed by Treatment Group One

Student Number	Basic Battery Total (Total Possible 407)	Achievement Level*
39	371	1
40	365	1
41	365	1
42	363	1
43	358	1
44	345	1
45	333	1
46	330	2
47	304	2
48	288	2
49	288	2
50	287	2
51	286	2
52	280	2
53	273	3
54	270	3
55	258	3
56	243	3
57	235	3
58	232	3
59	226	3

*Level of Achievement was obtained by dividing each Group into three groups of equal, or nearly equal, number. Level 1 = High Achievers, Level 2 = Medium Achievers, and Level 3 = Low Achievers.

APPENDIX I

IPSP PROBLEM SOLVING TEST RESULTS FOR STUDENTS PARTICIPATING IN THE STUDY--PRETEST-POSTTEST RESULTS FOR EACH SUBTEST AND PRETEST-POSTTEST TOTALS FOR FORMS 561 AND 562

APPENDIX I

IPSP PROBLEM SOLVING TEST RESULTS FOR STUDENTS PARTICIPATING IN THE STUDY--PRETEST-POSTTEST RESULTS FOR EACH SUBTEST AND PRETEST-POSTTEST TOTALS FOR FORMS 561 AND 562

Data for the Control Group

Student Number	Pre-Post Subtest 1	Pre-Post Subtest 2	Pre-Post Subtest 3	Pretest/ Posttest Total
1	10-10	10-9	8-10	28-29
2	10-8	8-8	7-7	25-23
3	9-9	9-8	9-8	27-25
4	7-7	8-7	9-6	24-20
5	9-10	7-6	5-7	21-23
6	8-8	7-8	6-7	21-23
7	5-7	5-8	5-6	15-21
8	6-7	7-8	6-7	19-22
9	5-7	6-7	4-5	15-19
10	7-6	7-7	2-4	16-17
11	5-7	9-6	4-8	18-21
12	7-6	4-7	6-6	17-19
13	4-7	9-9	6-4	19-20
14	4-3	7-6	3-6	14-15
15	4-6	7-6	3-6	14-18
16	4-9	6-5	5-2	15-16
17	6-7	6-6	4-4	16-17
18	5-7	7-5	3-4	15-16
19	3-7	7-8	4-5	14-20

Data for Treatment Group One--
Completed and Viewed the Vignettes

Student Number	Pre-Post Subtest 1	Pre-Post Subtest 2	Pre-Post Subtest 3	Pretest/ Posttest Total
20	9-9	8-8	10-8	27-25
21	9-10	8-5	6-7	23-22
22	10-8	10-7	10-7	30-22
23	8-10	10-7	4-7	22-24
24	3-10	5-6	5-8	13-24
25	4-7	6-5	6-8	16-20
26	8-8	7-6	7-8	22-22
27	9-6	10-8	7-7	26-21
28	7-8	8-8	5-6	20-22
29	8-7	6-7	3-5	17-19
30	8-7	6-8	8-5	22-20
31	5-5	5-8	6-4	16-17
32	5-8	4-5	4-7	13-20
33	7-5	7-9	3-5	17-19
34	6-8	7-7	2-4	15-19
35	5-4	6-5	2-1	13-10
36	4-6	8-9	3-4	15-19
37	3-7	5-7	2-2	15-16
38	5-6	6-7	3-6	14-19

Data for Treatment Group Two--Viewed the Vignettes Completed by Treatment Group One

Student Number	Pre-Post Subtest 1	Pre-Post Subtest 2	Pre-Post Subtest 3	Pretest/ Posttest Total
39	10-8	7-9	7-7	24-24
40	9-7	9-9	6-8	24-24
41	10-9	7-7	8-8	25-24
42	10-10	10-8	10-9	30-27
43	9-10	10-9	8-9	27-28
44	7-6	7-6	7-4	21-16
45	8-10	8-10	9-7	25-27
46	4-9	8-6	5-9	17-24
47	3-4	9-6	3-3	15-13
48	7-8	7-6	4-5	20-19
49	7-5	8-4	6-7	21-16
50	7-8	9-7	8-4	24-19
51	4-6	8-6	3-6	15-18
52	6-7	6-7	5-6	17-20
53	5-7	7-7	0-7	12-21
54	5-5	4-6	1-6	10-17
55	1-7	4-5	3-3	8-15
56	7-6	7-5	5-6	19-17
57	3-4	3-5	2-5	8-14
58	4-6	6-6	4-0	14-12
59	8-6	4-6	3-5	15-17

APPENDIX J

THE IPSP PROBLEM SOLVING TEST

The University of Iowa
Iowa City, Iowa 52242

College of Education

Division of Secondary Education
Main Office, N297 Lindquist Center

(319) 353-5601

1847

March 21, 1985

Tom Russell
1320 Cedar Hill Dr.
East Lansing, MI 48823

Dear Mr. Russell:

Enclosed is a copy of the IPSP Problem Solving Test. You have the authors' permission to make as many copies as you need for research or teaching purposes.

We would appreciate receiving a copy of any studies in which you use the test.

Sincerely,

Harold L. Schoen
Professor,
Mathematics & Education

cb

Enclosure

THE IPSP PROBLEM SOLVING TEST

Developed By

Harold L. Schoen
Theresa M. Oehmke

Purpose

The IPSP Problem Solving Test* is a multiple-choice paper-pencil test designed to provide individual student and class profiles which illustrate the performance of fifth through eighth graders at each of three steps of the problem solving process. A modified version of the four-step problem solving process model proposed by Polya served as the IPSP testing model. Polya's step 2, choosing a strategy, is not included in the testing model.

Each test consists of three subtests designed to measure the following skills which it is presumed are prerequisites, or components, of the ability to solve verbal problems.

IPSP TEST MODEL

Step 1. Get to know the problem

A. Determine insufficient information

B. Determine extraneous information

C. Write a question for the problem setting

Step 2. Do it

A. Choose the necessary computation

B. Estimate from a diagram

C. Compute from a diagram

D. Use a table

E. Compute from an equation

Step 3. Look Back

A. Relate problems that can be solved in the same way as a given one

B. Vary conditions in a given problem

C. Check a solution with the conditions of the problem

* The IPSP Problem Solving Test was developed as a part of the Iowa Problem Solving Project directed by George Immerzeel.

Description of the Test

The IPSP test consists of two essentially equivalent forms for grades 5 and 6 (561 and 562) and two forms for grades 7 and 8 (781 and 782). These forms are each 30-item tests with 10 items in each of three subtests. The 10 items in each subtest are dispersed throughout the test. Each fifth and sixth grade form has 15 items in common with each seventh and eighth grade form (i.e. 561 and 781, 562 and 782). The forms in each pair are of equivalent difficulty and very similar content.

Test Data

Pertinent test data are included in the following tables. A complete discussion of the test validation can be found in Oehmke (1979).

Test Form 561

This test was administered to a sample of Iowa fifth and sixth graders on or about October 1, 1978. Pertinent results by grade level are reported here.

	SUBTESTS		
	1. Get to Know Problem	2. Do It	3. Look Back
Items Included	6, 8, 9, 13, 15, 19 22, 26, 27, 29	1, 2, 3, 4, 5, 20 23, 24, 25, 30	7, 10, 11, 12, 14 16, 17, 18, 21, 28

	Grade 5 (N = 1215)			Grade 6 (N = 1314)		
Subtest	$\overline{X}$	S.D.	Reliability	$\overline{X}$	S.D.	Reliability
1	5.41	2.54	0.77	6.62	2.44	0.77
2	6.44	2.10	0.72	7.23	1.87	0.68
3	4.96	2.47	0.78	5.99	2.36	0.77
Total	16.81	6.22	0.87	19.83	5.76	0.86

Percentile Ranks

Raw Score	Subtest 1 5th	Subtest 1 6th	Subtest 2 5th	Subtest 2 6th	Subtest 3 5th	Subtest 3 6th
10	97	94	97	95	99	98
9	89	80	88	81	95	90
8	81	66	74	62	86	77
7	71	51	58	42	76	62
6	59	38	40	25	64	48
5	46	27	25	13	51	34
4	32	17	14	6	37	22
3	19	9	6	3	25	13
2	10	4	3	1	14	6
1	4	1	1	1	6	2
0	1	1	1	1	1	1

Test Form 561

30-Item Total Test Percentile Ranks

Raw Score	Grade 5	Grade 6	Raw Score	Grade 5	Grade 6
30	99	99	15	41	23
29	99	97	14	36	18
28	97	94	13	30	14
27	95	89	12	24	11
26	92	84	11	19	8
25	88	78	10	15	5
24	85	72	9	11	3
23	80	67	8	8	2
22	76	60	7	5	1
21	72	53	6	3	1
20	67	48	5	2	1
19	63	42	4	1	1
18	58	36	3	1	1
17	53	32	2	1	1
16	47	27	1	1	1

Test Form 562

This test was administered to a sample of Iowa fifth and sixth graders on or about March 15, 1979. Pertinent results by grade level are reported here.

	SUBTESTS		
	1. Get to Know Problem	2. Do It	3. Look Back
Items Included	7, 8, 12, 14, 15 19, 20, 22, 27, 29	1, 2, 3, 4, 5 21, 23, 24, 25, 30	6, 9, 10, 11, 13 16, 17, 18, 26, 28

	Grade 5 (N = 1161)			Grade 6 (N = 1184)		
Subtest	$\overline{X}$	S.D.	Relia-bility	$\overline{X}$	S.D.	Relia-bility
1	6.40	2.16	0.69	7.25	2.05	0.71
2	7.04	1.62	0.58	7.57	1.56	0.59
3	5.50	2.22	0.71	6.39	2.14	0.71
Total	18.94	4.98	0.81	21.20	4.75	0.81

Percentile Ranks

	Subtest 1		Subtest 2		Subtest 3	
Raw Score	5th	6th	5th	6th	5th	6th
10	96	93	98	96	99	97
9	87	78	88	81	94	89
8	74	60	69	57	85	75
7	58	41	46	33	72	58
6	42	26	26	15	58	41
5	26	15	13	6	42	26
4	15	8	4	2	27	14
3	7	3	1	1	15	7
2	3	2	1	1	6	3
1	1	1	1	1	2	1
0	1	1	1	1	1	1

Test Form 562

30-Item Total Test Percentile Ranks					
Raw Score	Grade 5	Grade 6	Raw Score	Grade 5	Grade 6
30	99	99	15	23	10
29	99	98	14	17	7
28	98	95	13	13	5
27	96	91	12	9	3
26	92	85	11	6	2
25	88	77	10	4	2
24	83	69	9	2	1
23	77	61	8	1	1
22	70	53	7	1	1
21	63	44	6	1	1
20	56	36	5	1	1
19	49	29	4	1	1
18	42	23	3	1	1
17	36	18	2	1	1
16	30	14	1	1	1

Test Form 781

This test was administered to a sample of Iowa seventh and eighth graders on or about October 1, 1978. Pertinent results by grade level are reported here.

SUBTESTS			
	1. Get to Know Problem	2. Do It	3. Look Back
Items Included	4, 5, 7, 12, 15 24, 25, 27, 28, 30	1, 2, 3, 8, 13, 19 20, 21, 23, 29	6, 9, 10, 11, 14 16, 17, 18, 22, 26

	Grade 7 (N = 1078)			Grade 8 (N = 1101)		
Subtest	$\bar{X}$	S.D.	Relia-bility	$\bar{X}$	S.D.	Relia-bility
1	6.16	2.43	0.77	6.93	2.30	0.77
2	5.86	2.10	0.67	6.48	2.08	0.68
3	5.37	2.18	0.69	5.96	2.19	0.70
Total	17.38	5.72	0.84	19.38	5.57	0.84

Percentile Ranks

	Subtest 1		Subtest 2		Subtest 3	
Raw Score	7th	8th	7th	8th	7th	8th
10	96	94	99	97	99	98
9	86	79	94	88	95	92
8	73	61	83	74	87	80
7	59	45	68	56	74	65
6	46	32	50	39	60	49
5	33	21	34	25	45	34
4	22	13	21	13	29	20
3	13	7	11	6	16	10
2	6	3	4	3	6	4
1	1	1	1	1	2	1
0	1	1	1	1	1	1

Test Form 781

30-Item Total Test Percentile Ranks					
Raw Score	Grade 7	Grade 8	Raw Score	Grade 7	Grade 8
30	99	99	15	35	23
29	99	98	14	30	19
28	99	96	13	25	15
27	97	93	12	21	12
26	94	88	11	16	8
25	90	83	10	12	6
24	85	78	9	8	4
23	80	71	8	5	2
22	76	64	7	3	2
21	70	57	6	1	1
20	64	51	5	1	1
19	59	44	4	1	1
18	53	37	3	1	1
17	47	32	2	1	1
16	41	27	1	1	1

Test Form 782

This test was administered to a sample of Iowa seventh and eighth graders on or about March 15, 1979. Pertinent results by grade level are reported here.

SUBTESTS			
	1. Get to Know Problem	2. Do It	3. Look Back
Items Included	4, 5, 7, 12, 14 19, 24, 25, 29, 30	6, 8, 9, 10, 15 16, 17, 18, 21, 26	1, 2, 3, 11, 13 20, 22, 23, 27, 28

	Grade 7 (N = 910)			Grade 8 (N = 1024)		
Subtest	$\bar{X}$	S.D.	Relia-bility	$\bar{X}$	S.D.	Relia-bility
1	6.28	2.15	0.70	6.76	2.13	0.72
2	6.04	2.14	0.66	6.60	2.13	0.68
3	5.61	2.39	0.73	6.15	2.29	0.72
Total	17.93	5.67	0.83	19.51	5.55	0.84

Percentile Ranks

	Subtest 1		Subtest 2		Subtest 3	
Raw Score	7th	8th	7th	8th	7th	8th
10	97	95	98	97	98	97
9	88	84	91	87	92	87
8	75	68	79	70	81	76
7	61	51	63	53	68	62
6	44	35	48	36	55	46
5	29	22	33	23	41	32
4	16	12	19	13	28	20
3	7	6	10	6	16	10
2	3	2	3	3	7	4
1	1	1	1	1	3	1
0	1	1	1	1	1	1

Test Form 782

30-Item Total Test Percentile Ranks					
Raw Score	Grade 7	Grade 8	Raw Score	Grade 7	Grade 8
30	99	99	15	32	22
29	99	98	14	27	18
28	98	95	13	22	14
27	95	92	12	17	11
26	92	87	11	13	8
25	88	82	10	9	5
24	83	76	9	6	4
23	78	69	8	4	2
22	73	63	7	2	1
21	68	57	6	1	1
20	62	51	5	1	1
19	56	44	4	1	1
18	50	39	3	1	1
17	44	33	2	1	1
16	38	28	1	1	1

Directions for administering the IPSP problem solving test

1. There are 30 problems in each test booklet and the test is designed to be 35 minutes in length. Assure your students that they are not expected to get all items correct. They should do their best.
2. Answers are to be marked on the answer sheet which is distributed along with the test booklet. Demonstrate to the class the procedure for blackening the circle on the scoring sheets.
3. Read to the class: "In each problem choose the one best answer. Blacken the circle which corresponds to it. You have 35 minutes."
4. When you are sure everyone understands the directions allow them to begin.
5. After 35 minutes from the time the test begins, collect the answer sheets and the test booklets.

Note: These directions assume a computer answer sheet is used. If the test booklet alone is used, students may just circle their choice.

561

I P S P P R O B L E M S O L V I N G T E S T

Harold L. Schoen
Theresa M. Oehmke

Name ____

Last First

Mike enjoys guessing the weight of his classmates. Here is a chart he made. Refer to it in items 1 - 5.

Name	Mike's Guess	Actual Weight
Tim	89	91
David	100	97
Kate	79	79
Larry	71	66
Lynn	98	101

1. Whose actual weight was less than Mike's guess?
   1) Kate and Lynn
   2) Tim, Kate and Lynn
   3) Kate and Larry
   4) David and Larry

2. Who actually weighed the most?
   1) David
   2) Lynn
   3) Tim
   4) Larry

3. Who did Mike guess weighed the most?
   1) David
   2) Lynn
   3) Tim
   4) Larry

4. Whose weight did Mike guess correctly?
   1) Larry
   2) Tim
   3) Kate
   4) Lynn

5. Whose weight was exactly 3 pounds more than Mike guessed?
   1) Lynn
   2) David
   3) Tim
   4) Larry

---

6. You threw a baseball 5 meters farther than Tom did. You want to know how far your throw went. You could solve the problem if you knew:
   1) Tom's throw was 5 meters shorter than yours.
   2) A meter is a little more than a yard.
   3) A baseball is 8 inches around.
   4) Tom's throw was 34 meters.

7. In baseball it is 90 feet from home plate to first base. To find how many yards it is from home plate to first base divide 90 by 3 and the answer is 30 yards. Which problem below can be solved using exactly the same steps?
   1) Three identical baseball gloves cost $90 together. How much does one glove cost?
   2) A baseball costs $3. How much do 90 baseballs cost?
   3) There were 90 baseballs in a large box. The coach put in 3 more. How many are now in the box?
   4) There were 90 baseballs in a large box. The coach took 3 out. How many are left in the box?

8. Two children together had $5.00. They paid $2.80 for candy and a book. They each took half of the remaining money. Which question below could be answered using this information?
   1) How much did the book cost?
   2) How much money did each child have left?
   3) How much did the candy cost?
   4) Could the children buy another book at the same price?

9. A motorist drove 250 miles. She found that she had used 13 gallons of gasoline. Which question below could be answered using this information?
   1) How long did it take her to drive the 250 miles?
   2) What was her average speed over the 250 miles?
   3) How much gasoline did she have left at the end of 250 miles?
   4) How many miles did she drive per gallon of gasoline?

(Go on to next page)

HOMEWORK PROBLEM

Jill made these scores on 4 homework lessons.

Lesson	Score
1	8
2	6
3	9
4	10
Total	33

Use the above information to answer items 10 - 12.

10. In the Homework Problem, suppose Jill's score on Lesson 2 was changed to 8. How could her total be found?
    1) Add 6 and 8
    2) Subtract 8 from 33
    3) Add 2 to 33
    4) Add 8 to 33

11. In the Homework Problem, suppose Jill lost Lesson 4 and had to change that score to 0. How could her total be found?
    1) Subtract 10 from 33
    2) Subtract 9 from 33
    3) Subtract 8 from 33
    4) Subtract 6 from 33

12. In the Homework Problem, suppose Jill needed to hand in one more lesson. Her total score on all 5 lessons was 40. How could her score on the last lesson be found?
    1) Add 5 to 40
    2) Divide 40 by 5
    3) Subtract 5 from 40
    4) Subtract 33 from 40

13. Fred wants to buy a sweater for $13 including tax. He has $2.50 plus the $5.20 he borrowed from his mother. Which question below could be answered using this information?
    1) How much more money does Fred need to buy the sweater?
    2) How much is the tax on the sweater?
    3) What is the price of the sweater before tax is added?
    4) Can Fred afford to buy a baseball glove?

14. I have 3 books. One has 126 pages, the second has 53 pages and the third has 295 pages. To find the number of pages in the 3 books, I added 126 + 53 + 295 and got 474 pages. My brother gave me a fourth book for my birthday. It has 110 pages. How many pages are in the 4 books altogether?
    1) 474 + 110
    2) 474 - 110
    3) 110 x 4
    4) 584 ÷ 4

15. A bag contains 25 marbles. You want to buy 125 marbles and wonder what the cost will be. Which choice below would you need to know?
    1) The marbles cost 19¢ per bag.
    2) The marbles are the XL-50 brand.
    3) The marbles come in 5 different colors.
    4) If you buy 10 bags of marbles, you get one bag free.

Library Problem

Trevor checked out 8 books from the library. He returned them 2 days after they were due. The library charged him 5¢ per day for each book. The bill looked like this.

8 books x 5¢ per book x 2 days late
Cost: 80¢

Use the above problem to answer items 16 - 18.

16. In the Library Problem, suppose Trevor had checked out only 6 books instead of 8. What could be done to find the cost?

1) Multiply 8 x 6¢ x 2.
2) Multiply 6 x 80¢.
3) Multiply 6 x 5¢ x 2.
4) Subtract 6 from 80.

17. In the Library Problem, suppose Trevor had returned the 8 books just 1 day late. What could be done to find the cost?

1) Divide 8 by 2.
2) Multiply 8 x 5¢ x 1.
3) Multiply 8 x 5¢ x 4.
4) Multiply 2 x 80¢.

18. In the Library Problem, suppose the library charged 10¢ per day for each book. What could be done to find the cost?

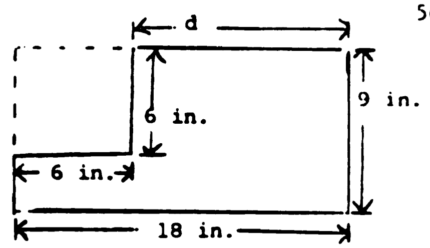
1) Multiply 2 x 80¢.
2) Multiply 8 x 10¢ x 1.
3) Add 10¢ to 80¢.
4) Multiply 10 x 80¢.

---

19. The school cafeteria had 230 kg of milk to be shared by 46 children. The cook wanted to know how many glasses of milk each child could have. The cook could solve the problem if he <u>also</u> knew:

1) There are 1000 grams in a kilogram.
2) Each glass holds 0.2 kg of milk.
3) The children all like milk.
4) Each glass is 8 cm high.

20.



A 6 inch square was cut from the corner of the above rectangle. How long is d?

1) 3 in. 3) 12 in.
2) 6 in. 4) 15 in.

21. A farmer wishes to plant a row of trees 982 yards long for a windbreak. He will start at the old family tree and plant a tree every 2 feet. To find the number of trees he will need to plant he multiplied 982 yards by 3 and got 2946 feet. He then divided 2946 by 2, getting 1473 trees. Which problem below could be solved using exactly the same steps?

1) The length of your step is 2 feet. How many yards will you walk in 982 steps?
2) If the length of your step is 2 feet, how many steps must you take to walk 982 yards?
3) You walk 982 yards in 2 minutes. On the average, how many yards do you walk each second?
4) If the length of a very tall man's step is 2 yards, how many steps must he take to walk 982 feet?

22. Andy has a one-dollar bill and several coins. Tim has a 5 dollar bill and 31 cents in coins. The boys want to find out how much they have together. What else do they need to know?

1) Andy has 43¢ in coins.
2) Tim has a quarter, a nickel and a penny.
3) Andy has exactly 7 coins.
4) Together Tim and Andy have less than $10.

Use this information to answer items 23-25.

In football a touchdown is worth 6 points, the point after touchdown is 1 point and a field goal counts 3 points.

23. North High scored 2 touchdowns and one field goal in a game with East High, while East High scored one touchdown, a point after touchdown and 2 field goals. What was the final score?

    1) East High won 15 - 13.
    2) North High won 15 - 12.
    3) It was a 13 - 13 tie.
    4) North High won 15 - 13.

24. The Vikings scored 8 points by scoring a touchdown and a safety. How many points are given for a safety?

    1) 1   3) 5
    2) 2   4) 8

25. The Bears scored 3 touchdowns, 3 points after touchdown and some field goals. They scored a total of 30 points. How many field goals did they score?

    1) 2   3) 9
    2) 3   4) 10

---

26. A car can carry 6 children or 5 adults. The school principal wants to know how many cars are needed to drive to a football game. She could solve the problem if she also knew:

    1) 36 people are going to the game.
    2) 24 children and 15 adults are going to the game.
    3) 18 adult drivers are going to the game.
    4) 48 children are going to the game.

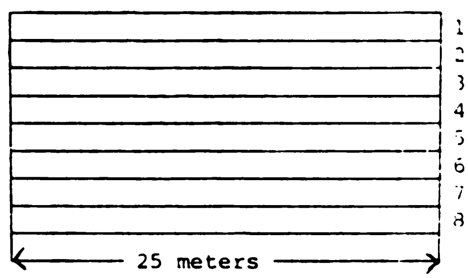
27. The price of a calculator was $12.99. Julius wanted to find out how much the calculator was reduced during a sale. What else would Julius need to know?

    1) It was an SR-18 calculator.
    2) It was a 5 function calculator.
    3) A 9-volt battery is included in the price.
    4) The sale price was $7.83.

28. Phil bought 2 pounds of peanuts for 98¢ a pound and 1 pound of lemon drops for 79¢ a pound. To find the total cost, Phil multiplied 2 times 98¢ and got $1.96. He then added $1.96 + $.79 and got $2.75. Which problem below can be solved using exactly the same steps?

    1) I sold an Old Superman comic book for 79¢ and 2 Batman comic books for 98¢ each. How much money did I get altogether?
    2) I sold one Superman comic book for 79¢. How much more money do I need to buy 2 comic books at 98¢ each?
    3) I paid 98¢ for 2 comic books and sold them for 79¢ each. How much profit did I make on the sale?
    4) I sold 2 Superman comic books for 79¢ each and a Batman comic book for 98¢. How much money did I get altogether?

29. City Swimming Pool



The life guard at City Swimming Pool wants to find the width of the pool. She could find the width if she knew:

1) The pool is 25 meters long.
2) The water in the pool is 6 inches from the top.
3) The pool is 8 feet deep at one end.
4) There are 8 lanes each 7 feet wide.

30.

The distance from A to B is 4 cm. About how far is it from B to C?

1) 5 cm.   3) 2 cm.
2) 1 cm.   4) [illegible] cm.

562

IPSP PROBLEM SOLVING TEST

Harold L. Schoen

Theresa M. Oehmke

Name ____

Last First

Use the following information from a teacher's record book to answer items 1 - 5.

Name	Test					
	I	II	III	IV	V	VI
Adams, Jerry	82	75	90	57	72	86
Betts, John	95	98	89	72	95	92
Brumm, Joyce	91	96	93	72	84	92
Kemper, Ed	64	65	72	58	61	74

1. On which test did Jerry Adams receive the highest score?

   1) I 3) IV
   2) III 4) VI

2. On test V, which student received the highest score?

   1) Joyce Brumm
   2) John Betts
   3) Jerry Adams
   4) Ed Kemper

3. On which test were the scores the lowest?

   1) I 3) IV
   2) II 4) V

4. If 70 or less is a failing score which student failed the most tests?

   1) Jerry Adams
   2) John Betts
   3) Joyce Brumm
   4) Ed Kemper

5. If 92 or more is a grade of A which student made the most A's?

   1) Jerry Adams
   2) John Betts
   3) Joyce Brumm
   4) Ed Kemper

---

6. Everyday Steve tries to throw a baseball from his house to his barn. The barn is 58 meters from the house. Yesterday Steve's best throw bounced 12 meters short of the barn. To find the length of his throw Steve subtracted 12 meters from 58 meters and got 46 meters. Which problem below can be solved using exactly the same steps?

   1) Jill had \$58. She earned \$12 more. How much money does she have now?
   2) Jill had \$58. She spent \$12. How much money does she have now?
   3) Jill had \$58. She earned \$46 more. How much money does she have now?
   4) Jill had \$58. She spent \$46. How much money does she have now?

7. Bill is 4 cm taller than Ethan and Ethan is 2 cm taller than David. Which question below could be answered using this information?

   1) How tall is Bill?
   2) How tall is Ethan?
   3) How much taller is Bill than David?
   4) How tall is David?

8. For breakfast on the day of a basketball game 15 players will drink a total of 240 ounces of milk and 90 ounces of juice. Which question below could be answered using this information?

   1) How much milk does the star player drink?
   2) How much orange juice does the star player drink?
   3) How much milk does the manager drink?
   4) How many 8 ounce milk cartons should the team manager order?

SNACK PROBLEM

I bought a snack at a restaurant. This was my order.

Hot Dog	30¢
Fries	25¢
Coke	20¢
Total	75¢

Use the above problem to answer items 9 - 11.

9. In the Snack Problem, suppose a hot dog cost only 20¢ today. How could the total cost be found?
   1) Subtract 20¢ from 75¢
   2) Subtract 10¢ from 75¢
   3) Add 10¢ to 75¢
   4) Add 20¢ to 75¢

10. In the Snack Problem, suppose the fries were free today. How could the total cost be found?
    1) Subtract 50¢ from 75¢
    2) Subtract 30¢ from 75¢
    3) Subtract 25¢ from 75¢
    4) Subtract 20¢ from 75¢

11. In the Snack Problem, I cancelled one of the items in my order. The cost of my order was then 45¢. Which item did I cancel?
    1) Hot Dog
    2) Fries
    3) Coke
    4) None of these

---

12. The distance around a rectangular swimming pool is 76 meters. The lifeguard wanted to know the length of the pool. Which of these would he need to know?
    1) The pool is filled to within 20 cm of the top.
    2) The pool is 3 m deep at one end.
    3) The pool is 13 m wide.
    4) The pool is divided into 8 swimming lanes.

13. Debbie has 40 baseball cards and Wayne has 26. To find the number of cards they had together they added 40 + 26 and got 66. Which problem below can be solved using exactly the same steps?
    1) Pat has 40 marbles. Sean won 26 marbles from Pat in a game. How many marbles does Pat have left?
    2) Pat had 40 marbles. Sean lost 26 marbles to Pat in a game. How many marbles does Pat have now?
    3) Pat won 40 marbles and Sean won 26 marbles. How many more marbles did Pat win than Sean?
    4) Pat and Sean had 40 marbles. They gave 26 marbles away. They each took half of the remaining marbles. How many does each have left?

14. It takes Jenny 8 minutes to get to and from school each day. She wondered how many minutes she spends going to and from school in an entire school year. Jenny could solve the problem if she also knew:
    1) There are 60 minutes in an hour.
    2) There are 180 school days in a year.
    3) The school is half a mile from Jenny's house.
    4) Jenny is 9 years old.

15. Together you and I had $6.00. We spent a total of $3.20 for a record and some ice cream. We each took half of the money that was left. Which question below could be answered using this information?
    1) How much did the ice cream cost?
    2) How much did the record cost?
    3) Could we buy another record at the same price?
    4) How much money did each of us have left?

Picnic Problem

At a school picnic the children drank 48 cokes. A six-pack of cokes cost $1.09. To find the cost of all 48 cokes, the principal found that 8 six-packs were used. She then multiplied $1.09 x 8 and got $8.72.

Use the above information to answer items 16 - 18.

16. In the picnic problem, suppose the children drank twice as many cokes. What would be the total cost of the cokes?

1) $1.09 x 6	3) $8.72 x 2
2) $1.09 x 48	4) $8.72 x 8

17. In the picnic problem, suppose the cokes came in eight-packs which cost $1.09. What would be the total cost of the cokes?

1) $1.09 x 6	3) $1.09 x 48
2) $1.09 x 8	4) $8.72 x 6

18. In the picnic problem, suppose a six-pack of cokes costs $1.28 instead of $1.09. What would be the total cost of the cokes?

1) $8.72 + $.19	3) $1.09 x 6
2) $1.28 x 6	4) $1.28 x 8

---

19. Two of the cash drawers in a store contain a total of $140. You shift $15 from the first cash drawer to the second. The two drawers then contain equal amounts.

Which question below could be answered using this information?

1) How much money is in each drawer?
2) Which cash drawer is bigger?
3) How much money was in the first cash drawer yesterday?
4) How many cash drawers are there in the store?

20. Tina has saved 25¢ a week for 8 weeks. She wants to know how much more money she needs to buy a calculator. Tina could solve the problem if she also knew:

1) There are 4 weeks in a month.
2) Batteries are not included with the calculator.
3) The calculator costs $8.95.
4) There is a "10% off" sale on the calculators.

21.

$$H = 15 - \frac{A}{2}$$

H = number of hours of sleep needed.
A = age of the person in years.

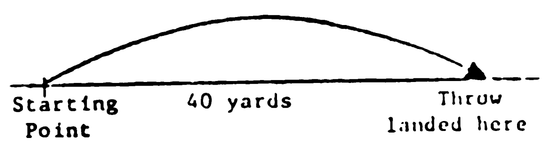
Using this formula, how many hours of sleep does a 6-year-old need?

1) 8	3) 12
2) 9	4) 15

22. The number of cars plus the number of motorcycles in the school parking lot is 11. Altogether there are 34 wheels on these cars and motorcycles. The principal wanted to know how many cars are in the lot. Which choice below would he need to know?

1) Each parking space is 1.7 m wide.
2) Each car has 4 wheels.
3) Each parking space is 5 m long.
4) The lot has 42 parking spaces for cars.

23.



I threw a football 40 yards. The picture above shows the path that the football followed. At its highest point, about how high was the throw above the ground?

1) 50 yards	3) 30 yards
2) 10 yards	4) 5 yards

Use the following information to answer items 24 and 25.

The formula for finding the distance in miles is

distance = rate x time

where rate is the average speed in miles per hour and time is in hours.

---

24. How far will you travel in 5 hours at an average rate of 40 miles per hour?

    1) 8 miles
    2) 20 miles
    3) 45 miles
    4) 200 miles

25. On a bicycle trip you went 45 miles in 5 hours. What was your average rate?

    1) 7 m.p.h.
    2) 9 m.p.h.
    3) 40 m.p.h.
    4) 225 m.p.h.

---

26. A farmer has 8 more hens than dogs. The total number of dogs and hens is 128. To find the number of each divide 128 ÷ 2 = 64. Then add 64 + 4 = 68 hens and 64 - 4 = 60 dogs. Which problem below could be solved using exactly the same steps?

    1) Boris earns $8 more per week than Lon. If Boris earns $128 per week, how much does Lon earn?
    2) Boris earns $8 more per week than Lon. If Lon earns $128 per week, how much does Boris earn?
    3) Boris earns $8 more per week than Lon. Together they earn $128. How much does each earn per week?
    4) Boris earns $8 more per week than Lon. Together they earn $128. How much less does Lon earn than Boris?

27. Tim has saved $.25 a week for the past 8 weeks for a calculator that costs $8.95. He wants to know the total amount he has saved in the 8 weeks. Which choice below would answer Tim's question?

    1) Multiply $.25 by 8.
    2) Subtract $.25 from $8.95 and multiply the answer by 8.
    3) Multiply $.25 by 8 and subtract that amount from $8.95.
    4) Add 8 and 25 and subtract the answer from $8.95.

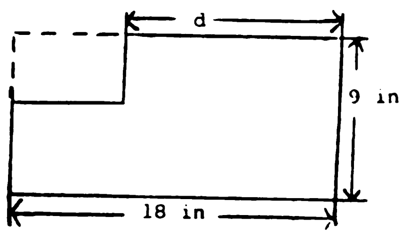
28. Paul is 1 decimeter taller than Jim, who is 15 decimeters tall. To find Paul's height the boys added 15 + 1 and got 16 decimeters. Which problem below can be solved using exactly the same step?

    1) My brother is 1 year younger than I am. I am 15 years old. How old is my brother?
    2) I have 15 times as much money as George. George has $1. How much money do I have?
    3) My score in darts was 15. I made 1 more point. What is my score now?
    4) Patty's and Sara's ages add to 15 years. Sara is 1 year old. How old is Patty?

29. Joe bought 4 reflectors at $.50 each, a headlight for $2.98, a battery for $.35, and a roll of tape for $1.50. The clerk wanted to find the total cost. Which choice below would he need to know?

    1) Joe had a free gift coupon for the battery.
    2) The tape was a 2-inch roll.
    3) The battery was a #3.
    4) Joe paid with a credit card.

30.



The small rectangle was cut from the corner of the larger rectangle. About how long is d?

    1) 5 in
    2) 6 in
    3) 9 in
    4) 12 in

781

I P S P P R O B L E M S O L V I N G T E S T

Harold L. Schoen
Theresa M. Oehmke

Name ____

Last **First**

Use this information to answer items 1 - 3.

In football a touchdown is worth 6 points, the point after touchdown is 1 point and a field goal counts 3 points.

1. North High scored 2 touchdowns and one field goal in a game with East High, while East High scored one touchdown, a point after touchdown and 2 field goals. What was the final score?
   1) East High won 15 - 13.
   2) North High won 15 - 12.
   3) It was a 13 - 13 tie.
   4) North High won 15 - 13.

2. The Vikings scored 8 points by scoring a touchdown and a safety. How many points are given for a safety?
   1) 1   3) 5
   2) 2   4) 8

3. The Bears scored 3 touchdowns, 3 points after touchdown and some field goals. They scored a total of 30 points. How many field goals did they score?
   1) 2   3) 9
   2) 3   4) 10

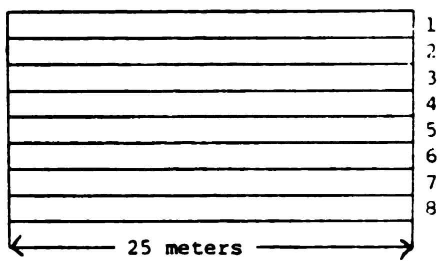
---

4. A car can carry 6 children or 5 adults. The school principal wants to know how many cars are needed to drive to a football game. She could solve the problem if she also knew:
   1) 36 people are going to the game.
   2) 24 children and 15 adults are going to the game.
   3) 18 adult drivers are going to the game.
   4) 48 children are going to the game.

5. The price of a calculator was $12.99. Julius wanted to find out how much the calculator was reduced during a sale. What else would Julius need to know?
   1) It was an SR-18 calculator.
   2) It was a 5 function calculator.
   3) A 9-volt battery is included in the price.
   4) The sale price was $7.83.

6. Phil bought 2 pounds of peanuts for 98¢ a pound and 1 pound of lemon drops for 79¢ a pound. To find the total cost, Phil multiplied 2 times 98¢ and got $1.96. He then added $1.96 + $.79 and got $2.75. Which problem below can be solved using exactly the same steps?
   1) I sold an Old Superman comic book for 79¢ and 2 Batman comic books for 98¢ each. How much money did I get altogether?
   2) I sold one Superman comic book for 79¢. How much more money do I need to buy 2 comic books at 98¢ each?
   3) I paid 98¢ for 2 comic books and sold them for 79¢ each. How much profit did I make on the sale?
   4) I sold 2 Superman comic books for 79¢ each and a Batman comic book for 98¢. How much money did I get altogether?

7. City Swimming Pool



The life guard at City Swimming Pool wants to find the width of the pool. She could find the width if she knew:
   1) The pool is 25 meters long.
   2) The water in the pool is 6 inches from the top.
   3) The pool is 8 feet deep at one end.
   4) There are 8 lanes each 7 feet wide.

8. 

The distance from A to B is 4 cm. About how far is it from B to C?
   1) ½ cm.   3) 2 cm.
   2) 1 cm.   4) 3 cm.

Library Problem

Trevor checked out 8 books from the library. He returned them 2 days after they were due. The library charged him 5¢ per day for each book. The bill looked like this.

8 books x 5¢ per book x 2 days late

Cost: 80¢

Use the above problem to answer items 9 - 11.

9. In the Library Problem, suppose Trevor had checked out only 6 books instead of 8. What could be done to find the cost?
   1) Multiply 8 x 6¢ x 2.
   2) Multiply 6 x 80¢.
   3) Multiply 6 x 5¢ x 2.
   4) Subtract 6 from 80.

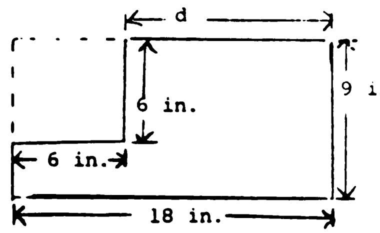
10. In the Library Problem, suppose Trevor had returned the 8 books just 1 day late. What could be done to find the cost?
    1) Divide 8 by 2.
    2) Multiply 8 x 5¢ x 1.
    3) Multiply 8 x 5¢ x 4.
    4) Multiply 2 x 80¢.

11. In the Library Problem, suppose the library charged 10¢ per day for each book. What could be done to find the cost?
    1) Multiply 2 x 80¢.
    2) Multiply 8 x 10¢ x 1.
    3) Add 10¢ to 80¢.
    4) Multiply 10 x 80¢.

---

12. The school cafeteria had 230 kg of milk to be shared by 46 children. The cook wanted to know how many glasses of milk each child could have. The cook could solve the problem if he also knew:
    1) There are 1000 grams in a kilogram.
    2) Each glass holds 0.2 kg of milk.
    3) The children all like milk.
    4) Each glass is 8 cm high.

13.



A 6 inch square was cut from the corner of the above rectangle. How long is d?

1) 3 in.
2) 6 in.
3) 12 in.
4) 15 in.

14. A farmer wishes to plant a row of trees 982 yards long for a windbreak. He will start at the old family tree and plant a tree every 2 feet. To find the number of trees he will need to plant he multiplied 982 yards by 3 and got 2946 feet. He then divided 2946 by 2, getting 1473 trees. Which problem below could be solved using exactly the same steps?
    1) The length of your step is 2 feet. How many yards will you walk in 982 steps?
    2) If the length of your step is 2 feet, how many steps must you take to walk 982 yards?
    3) You walk 982 yards in 2 minutes. On the average, how many yards do you walk each second?
    4) If the length of a very tall man's step is 2 yards, how many steps must he take to walk 982 feet?

15. Andy has a one-dollar bill and several coins. Tim has a 5 dollar bill and 31 cents in coins. The boys want to find out how much they have together. What else do they need to know?
    1) Andy has 43¢ in coins.
    2) Tim has a quarter, a nickel and a penny.
    3) Andy has exactly 7 coins.
    4) Together Tim and Andy have less than $10.

Use the Railroad Problem for items 16 - 17.

> Railroad Problem
>
> A school reserves a railroad car for students to attend a state championship basketball game. If 80 students attend, the fare is $12 each. For each additional student the fare is reduced by $1.00 each. If 82 students attend the fare is
>
> $12 - $2 = $10 per student

16. In the railroad problem, 85 students take the train. What is the fare per student?

    1) Subtract $3 from $10.
    2) Subtract $5 from $12.
    3) Subtract $3 from $12.
    4) Subtract $5 from $10.

17. In the railroad problem a student fare was $9. How many students attended?

    1) 3 3) 83
    2) 77 4) 90

---

18. Joyce bought a bicycle priced at $90. She had an 8% discount because she worked at the bicycle shop. To find the price she had to pay she multiplied .08 x $90 and got $7.20. She then subtracted $90 - $7.20 and got $82.80. Which problem below could be solved using exactly the same steps?

    1) Tom earned $90. For doing an excellent job he was given an 8% tip. With the tip how much did Tom earn?
    2) Tom earned $90. For doing an excellent job he was given an 8% tip. How much was his tip in dollars?
    3) Tom earned $90. He paid his brother 8% of his earnings. How much did Tom pay his brother?
    4) Tom earned $90. He paid his brother 8% of his earnings. How much did Tom have left after paying his brother?

19. The peak of Mount Everest is about 29,000 feet above sea level. Mr. Smith asked the class to find how many miles this would be. Which choice below would answer Mr. Smith's question? (5,280 ft. = 1 mile)

    1) Divide 29,000 by 5,280.
    2) Multiply 5,280 by 29,000.
    3) Add 5,280 and 29,000.
    4) Subtract 5,280 from 29,000.

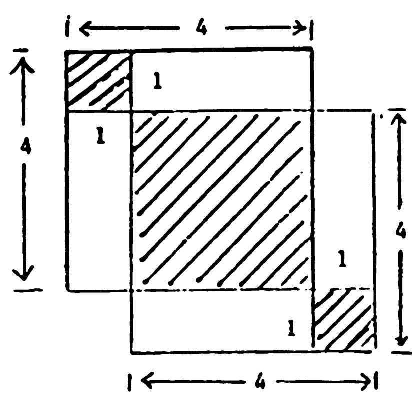
20. Long Distance Rates

Minutes Talked	1	5	7	10
Cost	33¢	$1.35	$1.89	$2.58

Suppose you made 2 calls each lasting 5 minutes. How would this cost compare with the cost of one 10-minute call?

1) Two 5-minute calls cost more than one 10-minute call.
2) Two 5-minute calls cost less than one 10-minute call.
3) Two 5-minute calls cost the same as one 10-minute call.
4) Not enough information is given.

21. What is the area of the shaded portion of this figure? All angles are right angles and lengths are in inches.

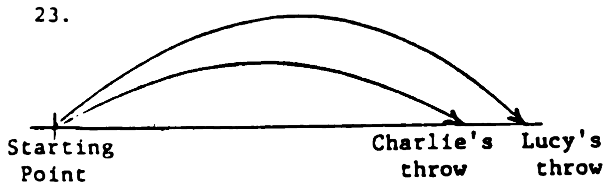


1) 11 square inches.
2) 18 square inches.
3) 9 square inches.
4) 16 square inches.

22. There were 36 passengers on a bus. One-fourth of them got off at a bus stop. To find the number of passengers left on the bus, take ¼ x 36 which is 9. Then there are 36 - 9 or 27. Which problem below could be solved using exactly the same steps?

    1) Earl has 36 cousins. One-fourth of them are male. How many of them are female?
    2) Earl has 36 cousins. One-fourth of them are male. How many of them are male?
    3) One-fourth of Earl's cousins are male. If Earl has 36 cousins who are female, how many cousins does he have altogether?
    4) One-fourth of Earl's cousins are male. If Earl has 36 cousins who are male, how many cousins does he have altogether?

23.



Charlie threw a baseball 38 meters. About how long was Lucy's throw?

1) 30 m.	3) 50 m.
2) 39 m.	4) 70 m.

24. During a recent drought, each person in northern California was limited to 50 gallons of water per day. Mr. Tucker used 30 gallons for drinking and bathing. He wanted to use the remainder of his limit to water his lawn, but he wasn't sure how long he could run the water. Mr. Tucker could answer the question if he also knew:

    1) The rate at which the water comes out of the hose.
    2) The time of day he began watering the lawn.
    3) The amount of water other members of his family used.
    4) The size of his lawn.

25. Tickets for a movie cost $1.00 for children under 12. Mr. Jones bought tickets for two adults and two children. He gave the clerk a $10 bill. Mr. Jones wanted to know how much change he should get. What else would he have to know to solve the problem?

    1) A party of at least 6 children gets in free.
    2) Only 200 of the 300 seats in the theater were filled.
    3) Mr. Jones' change consisted of bills only.
    4) Adult tickets are $2.50 each.

26. In baseball the distance from the pitcher's mound to home plate is 60 feet and 6 inches. To find that distant in inches, multiply 60 x 12 to get 720 inches. Then add 720 + 6 to get 726 inches. Which problem below could be solved using exactly the same steps?

    1) There are 60 minutes in an hour. How many minutes are there in 12 hours and 6 minutes?
    2) There are 60 minutes in an hour. How many minutes are there in 6 hours and 12 minutes?
    3) There are 60 minutes in an hour. How many hours is 12 hours and 6 minutes?
    4) There are 60 minutes in an hour. How many hours are in 726 minutes?

27. Eva knew that Babe Ruth hit 714 home runs in his major league baseball career. She wanted to know how many home runs he averaged per year. Which choice below would she also need to know about Babe Ruth?

    1) He hit 60 home runs in 1927.
    2) He played for 20 years.
    3) He died in 1948.
    4) He was a pitcher for 3 years.

28. A bicycle trip from Moline to Iowa City took 8 hours, but the return trip took 6 hours.

    Which question below could be answered using this information?

    1) How many miles from Moline to Iowa City?
    2) How long did the round trip take?
    3) What was the average speed for the entire trip?
    4) What was the average speed on the return trip?

29. Which of the following would you use to find out how many 8 oz. glasses of milk each person gets if 46 people share equally 756 ounces?

    1) 756 ÷ 46, then divide by 8.
    2) 756 ÷ 46, then multiply by 8.
    3) 756 - 46, then divide by 8.
    4) 756 - 46, then multiply by 8.

30. It is estimated that 7 percent of tennis balls made by a machine are defective. The machine produces 30 tennis balls each hour. The head of the tennis ball company wanted to find the amount of money lost on the defective balls each hour. She could solve the problem if she also knew:

    1) It cost 50¢ to manufacture each tennis ball.
    2) The machine produces one tennis ball every 2 minutes.
    3) The tennis balls are sold 3 in a can.
    4) The machine operates 16 hours a day.

782

IPSP PROBLEM SOLVING TEST

Name ____
Last First

Picnic Problem

At a school picnic the children drank 48 cokes. A six-pack of cokes cost $1.09. To find the cost of all 48 cokes, the principal found that 8 six-packs were used. She then multiplied $1.09 x 8 and got $8.72.

Use the above information to answer items 1 - 3.

1. In the picnic problem, suppose the children drank twice as many cokes. What would be the total cost of the cokes?

   1) $1.09 x 6   3) $8.72 x 2
   2) $1.09 x 48   4) $8.72 x 8

2. In the picnic problem, suppose the cokes came in eight-packs which cost $1.09. What would be the total cost of the cokes?

   1) $1.09 x 6   3) $1.09 x 48
   2) $1.09 x 8   4) $8.72 x 6

3. In the picnic problem, suppose a six-pack of cokes costs $1.28 instead of $1.09. What would be the total cost of the cokes?

   1) $8.72 + $.19   3) $1.09 x 6
   2) $1.28 x 6   4) $1.28 x 8

---

4. Two of the cash drawers in a store contain a total of $140. You shift $15 from the first cash drawer to the second. The two drawers then contain equal amounts.

   Which question below could be answered using this information?

   1) How much money is in each drawer?
   2) Which cash drawer is bigger?
   3) How much money was in the first cash drawer yesterday?
   4) How many cash drawers are there in the store?

5. Tina has saved 25¢ a week for 8 weeks. She wants to know how much more money she needs to buy a calculator. Tina could solve the problem if she also knew:

   1) There are 4 weeks in a month.
   2) Batteries are not included with the calculator.
   3) The calculator costs $8.95.
   4) There is a "10% off" sale on the calculators.

6. $$H = 15 - \frac{A}{2}$$

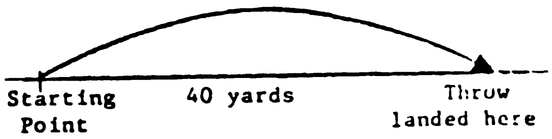
   H = number of hours of sleep needed.
   A = age of the person in years.

   Using this formula, how many hours of sleep does a 6-year-old need?

   1) 8   3) 12
   2) 9   4) 15

7. The number of cars plus the number of motorcycles in the school parking lot is 11. Altogether there are 34 wheels on these cars and motorcycles. The principal wanted to know how many cars are in the lot. Which choice below would he need to know?

   1) Each parking space is 1.7 m wide.
   2) Each car has 4 wheels.
   3) Each parking space is 5 m long.
   4) The lot has 42 parking spaces for cars.

8. 

   I threw a football 40 yards. The picture above shows the path that the football followed. At its highest point, about how high was the throw above the ground?

   1) 50 yards   3) 30 yards
   2) 10 yards   4) 5 yards

Use the following information to answer items 9 and 10.

The formula for finding the distance in miles is

distance = rate x time

where rate is the average speed in miles per hour and time is in hours.

---

9. How far will you travel in 5 hours at an average rate of 40 miles per hour?

   1) 8 miles 3) 45 miles
   2) 20 miles 4) 200 miles

10. On a bicycle trip you went 45 miles in 5 hours. What was your average rate?

    1) 7 m.p.h. 3) 40 m.p.h.
    2) 9 m.p.h. 4) 225 m.p.h.

---

11. A farmer has 8 more hens than dogs. The total number of dogs and hens is 128. To find the number of each divide 128 ÷ 2 = 64. Then add 64 + 4 = 68 hens and 64 - 4 = 60 dogs. Which problem below could be solved using exactly the same steps?

    1) Boris earns $8 more per week than Lon. If Boris earns $128 per week, how much does Lon earn?
    2) Boris earns $8 more per week than Lon. If Lon earns $128 per week, how much does Boris earn?
    3) Boris earns $8 more per week than Lon. Together they earn $128. How much does each earn per week?
    4) Boris earns $8 more per week than Lon. Together they earn $128. How much less does Lon earn than Boris?

12. Tim has saved $.25 a week for the past 8 weeks for a calculator that costs $8.95. He wants to know the total amount he has saved in the 8 weeks. Which choice below would answer Tim's question?

    1) Multiply $.25 by 8.
    2) Subtract $.25 from $8.95 and multiply the answer by 8.
    3) Multiply $.25 by 8 and subtract that amount from $8.95.
    4) Add 8 and 25 and subtract the answer from $8.95.

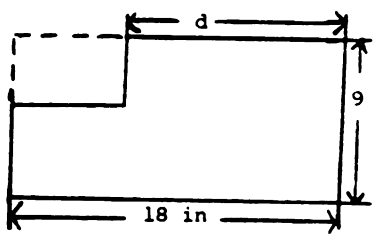
13. Paul is 1 decimeter taller than Jim, who is 15 decimeters tall. To find Paul's height the boys added 15 + 1 and got 16 decimeters. Which problem below can be solved using exactly the same step?

    1) My brother is 1 year younger than I am. I am 15 years old. How old is my brother?
    2) I have 15 times as much money as George. George has $1. How much money do I have?
    3) My score in darts was 15. I made 1 more point. What is my score now?
    4) Patty's and Sara's ages add to 15 years. Sara is 1 year old. How old is Patty?

14. Joe bought 4 reflectors at $.50 each, a headlight for $2.98, a battery for $.35, and a roll of tape for $1.50. The clerk wanted to find the total cost. Which choice below would he need to know?

    1) Joe had a free gift coupon for the battery.
    2) The tape was a 2-inch roll.
    3) The battery was a #3.
    4) Joe paid with a credit card.

15.



The small rectangle was cut from the corner of the larger rectangle. About how long is d?

1) 5 in 3) 9 in
2) 6 in 4) 12 in

Use the following information for items 16 - 18.

CLASSIFIED AD RATES	
To figure cost multiply the number of words (including address and/or phone number) times the appropriate rate given below. Cost equals (number of words) x (rate per word). Minimum ad 10 words, $2.80.	
1 - 3 days	28¢ per word
5 days	31.5¢ per word
10 days	40¢ per word
30 days	84¢ per word

16. What is the least amount (or minimum) an ad would cost?

    1) 10¢ 3) 84¢
    2) 28¢ 4) $2.80

17. Boys' black Schwin bike, five speed, basket, light, good condition, call 338-1432.

    How much would it cost to run this ad for 2 days?

    1) $.56 3) $3.78
    2) $3.36 4) $6.72

18. To find the cost of running an ad for 5 days you would:

    1) Multiply 5 x 31.5¢.
    2) Multiply the number of words by 5.
    3) Multiply the number of words by 31.5¢
    4) Multiply the number of words by 5 x 31.5¢.

---

19. The distance around Jay's garden is 200 meters. The length of one side of the garden is twice that of another side. He wants to know the number of square meters in the garden. Jay could find the answer if he also knew:

    1) The garden contains 10 rows of green beans.
    2) The garden is rectangular.
    3) The garden is enclosed by a fence.
    4) The distance around the garden is [illegible].

20. Janet had read the first 246 pages in a 390 page book. To find the number of pages she had left to read Janet subtracted 390 - 246 and got 144 pages. Which problem below could be solved using exactly the same steps?

    1) The Smiths are taking two trips. One is 390 kilometers and the other is 246 kilometers long. How many kilometers will they travel in all?
    2) The Smiths are taking two trips. The first is 246 kilometers and the second is 144 kilometers. How many kilometers longer is the first trip than the second?
    3) The Smiths are taking a 246 kilometer trip. So far they have gone 144 kilometers. How many kilometers farther must they travel?
    4) The Smiths are taking a 390 kilometer trip. So far they have gone 246 kilometers. How many kilometers farther must they travel?

21. Tina saves 25¢ a week. She needs $1.95 more to buy a calculator for $8.95. She has forgotten how many weeks she has been saving but she would like to know. Which choice below would answer Tina's question?

    1) Subtract $1.95 from $8.95 and divide 25 into the answer.
    2) Divide 25 into $8.95 and add $1.95 to the answer.
    3) Divide 25 into $1.95 and subtract the answer from $8.95.
    4) Multiply 25 times $1.95 and divide the answer into $8.95.

Use the following information for items 22 and 23.

> Pet Problem
>
> A pet shop needs 210 pounds of vitamins each month to feed the animals. The vitamins come in 30-pound bags which cost $10 each. To find the monthly cost, the owner divided 210 pounds by 30 and got 7 bags. He then multiplied 7 x $10 and got $70, the cost of the vitamins each month.

22. In the Pet Problem, the next month the cost of the vitamins went up to $12 per 30-pound bag. How could the monthly cost be computed?

    1) Multiply 7 x $12.
    2) Multiply 30 x $12.
    3) Multiply 30 x $2.
    4) Multiply 7 x $2.

23. In the Pet Problem, several large pets were sold. The pet shop owner found he then only needed 150 pounds of vitamins a month. How could the monthly cost be computed?

    1) Multiply 60 x $10. Subtract the answer from $70.
    2) Divide 150 by 30. Multiply that answer by $10.
    3) Subtract 150 from 210. Multiply that answer by $10.
    4) Divide 150 by 30. Multiply that answer by $70.

---

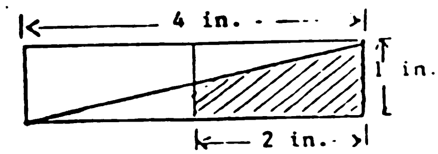
24. A motorist made a trip from Iowa City to Marshalltown in 3 hours. Because of car problems it took her 4 hours to make the return trip. Which question below could be answered using this information?

    1) How long did the round trip take?
    2) What was the motorist's average speed from Marshalltown to Iowa City?
    3) How far is Iowa City from Marshalltown?
    4) What was the motorist's average speed for the round trip?

25. The distance around a farm is 140 rods. The length of one side is twice that of another side. What else must the farmer know to find the length of the farm?

    1) The farm yields 100 bushels of wheat per acre.
    2) The farm is rectangular in shape.
    3) The farm is entirely enclosed by a fence.
    4) The farm has an area of 30 acres.

26.



Find the area of the shaded region.

1) 0.5 sq. in.
2) 1 sq. in.
3) 1.5 sq. in.
4) 2 sq. in.

27. Shelley has 75 marbles which is 11 more than twice as many as Karen has. To find how many marbles Karen has, Shelley added 75 + 11 and got 86. She then said Karen has 43 marbles. Is Shelley right?

    1) Yes.
    2) No. She should have multiplied 86 x 2 and got 172.
    3) No. She should have subtracted 75 - 11 = 64. Then 32 is the right answer.
    4) No. She should have multiplied 11 x 2 = 22. Then 75 - 22 = 53 is the right answer.

28. Rose bought 12 cartons of soda pop. There were 6 bottles in each carton. To find the number of bottles in all Rose multiplied 12 times 6 and got 72 bottles. Which problem below can be solved using exactly the same steps?

    1) Arnold bought 12 lollipops. He gave 6 of them to friends. How many does he have left?
    2) Arnold bought 6 lollipops. His mother gave him 12 more for his birthday. How many does he have in all?
    3) Arnold had 12 lollipops to share equally with 6 friends. How many lollipops does each friend get?
    4) Arnold bought 6 lollipops that cost 12¢ each. How much do the lollipops cost in all?

29. Eight layers of blocks are stacked in a box. Rick wanted to know the total number of blocks in the box. Which choice below would he need to know?

    1) Each block is 10 cm high.
    2) The box is only half full.
    3) Each layer is 6 blocks long and 5 blocks wide.
    4) Exactly 20 blocks are red.

30. Joan earned some money babysitting. She bought a record and a coke with half of the money. She saved the rest but she forgot how much it was. She could find out how much she saved if she knew:

    1) The cost of the record.
    2) The cost of the coke.
    3) Her hourly wages for babysitting.
    4) The cost of the record and the cost of the coke.

KEYS

IPSP Test

Item	561	562	781	782
1	4	2	4	3
2	2	2	2	1
3	1	3	2	4
4	3	4	2	1
5	1	2	4	3
6	4	2	1	3
7	1	3	4	2
8	2	4	2	2
9	4	2	3	4
10	3	3	2	2
11	1	1	1	3
12	4	3	2	1
13	1	2	3	3
14	1	2	2	1
15	1	4	1	4
16	3	3	2	4
17	2	1	3	2
18	1	4	4	3
19	2	1	1	2
20	3	3	1	4
21	2	3	1	1
22	1	2	1	1
23	4	2	3	2
24	2	4	1	1
25	2	2	4	2
26	2	3	1	3
27	4	1	2	3
28	1	3	2	4
29	4	1	1	3
30	2	4	1	4

APPENDIX K

MATHEMATICAL TERMS AND PHRASES FOUND IN THE IPSP PROBLEM SOLVING TEST - FORMS 561 AND 562

APPENDIX K

MATHEMATICAL TERMS AND PHRASES FOUND IN THE IPSP

PROBLEM SOLVING TEST - FORMS 561 AND 562

Form 561

Problem Number	Term or Phrase
#1-5	actual weight exactly less than more than
#6-9	farther meters feet yards together using exactly the same steps half the "remaining money" miles per gallon
#10-15	total total score plus including how many . . . altogether a bag . . . contains
#16-18	find the . . . cost
#19-22	kg = kilogram square rectangle yards long multiplied divided length

Problem Number	Term or Phrase
	average how much do they have together
#23-25	final score scored a total of . . .
#26-30	altogether reduced--the price was reduced wide width 25 meters . . . long using exactly . . . total cost 8 feet . . . deep

Form 562

Problem Number	Term or Phrase
#1-5	highest score were . . . lowest failed the most tests 70 or less most
#6-8	using exactly the same steps meters cm = centimeter 12 meters short length a total of subtracted earned $12.00 more spent $12.00
#9-11	total cost fries were free cancelled total
#12-15	rectangular m = meter wide exactly the same . . . steps to get to and from together entire have left how many more remaining a total of half the money that . . . was left have left
#16-18	twice as many total cost instead of
#19-23	equal amounts a total of how much more formula

Problem Number	Term or Phrase
	"10% off" sale plus altogether how high highest point starting point above
#24-25	distance = rate x time average rate
#26-30	exactly the same steps more total amount total number more per week decimeter total cost rectangle 15 times as much larger

APPENDIX L

MATHEMATICAL TERMS AND PHRASES FOUND IN THE

HEATH MATHEMATICS (1981) FIFTH GRADE TEXTBOOK

APPENDIX L

MATHEMATICAL TERMS AND PHRASES FOUND IN

HEATH MATHEMATICS (1981) FIFTH GRADE TEXTBOOK

Page Number	Term or Phrase
Chapters I-II - Place Value and Addition and Subtraction	
7	longest
	shortest
	kilometer
9	greatest . . . seating capacity
	least
11	greatest area
	third largest
	average
	depth greater than . . .
18	less than
	greater than
22	give each sum
29	total price
31	total score
33	total price, total attendance
39	kilometer, how much more money does she need
43	increase
	total population
47	total score
54a	how many fewer . . . boys
Chapter III - Multiplication	
65	round trips
69	find the product
73	averaged
77	round trips
	total amount
78	averaged

Page Number	Term or Phrase
Chapter IV - Division	
100	average
	higher average
	lower average
105	total price
107	average gift
110	total cost
112	average . . . test score
	above the average
	below the average
Chapter V - Geometry	
130	congruent figures
134	line of symmetry
135	horizontal
	vertical
138	number pair
141	difference in height
146	average price
Chapter VI - Fractions--Addition and Subtraction	
147d	how much farther
151	ratio of girls to boys
152	possible outcomes--probability
163	how many hours in all
	how much all together
169	how much farther
173	total . . . rainfall
180	how much farther
184a	how far did she run in all
	how much less
Chapter VII - Fractions--Multiplication and Division	
206a	how many cups of flour in all
Chapter VIII - Decimals--Addition and Subtraction	
213	order the averages--least to greatest
217	total weight
	total cost

Page Number	Term or Phrase
219	total weight--total cost
221	how much more
222	how much faster
224	how much change
226	total weight
	total cost
230a	total time
	how much faster
Chapter IX - Measurement	
237-238	the length of
	the width of
	your height
	distance around your waist
	the distance between
241	measure the length and width
	estimate the perimeter
	measure the circumference
	rectangular
	square
	perimeter
243	compute the area
245	compute its volume
249	what is its perimeter
253	long and wide
	square inches
	square feet
	cubic foot--cubic yard
	length is twice its width
255	the combined weight
257	how many square feet
	what is the volume
	total cost
Chapter X - Consumer Mathematics	
265	how much change did he get back
267	total price
271	what is the sale price
273	total price
	total cost
275	how much money did she have left

Page Number	Term or Phrase
277	total price
	total cost
	how much was his refund
278	total cost
	total price
	how much will the discount be
	what will be the sale price
280	what is the discount
	sale price
	total price
Chapter XI - Mixed Numbers--Addition and Subtraction	
283c	how much meat in all
	how much more in the large box
287	how much more flour is needed
289	how many miles . . . altogether
292	how much farther
294-295	total price
	find the price
Chapter XII - Decimals--Multiplication and Division	
301c	the average distance
	the area of a floor
305	area of a rectangular garden
	volume of a rectangular box
309	price per kilogram
	total cost
	how many kilometers per hour did he average
316	what is the area
	how many kilometers did it average each hour
320a	average distance traveled
342	total number of . . . calories
344	round trip
Extra Problem Solving	
345	how much did she spend in all
	how much did he spend
347	how many . . . tickets short of the goal

Page Number	Term or Phrase
348	how much will the difference be
	total cost
352	total cost
353	average per player
	average per game
355	total value
357	average spent per player
	average amount spent
362	average price per yard
363	round your answer . . . to the nearest ounce
365	total time
	difference in times
369	miles per gallon
370	how far is the entire route
	round your answer . . . to the nearest whole number
	total cost
371	how many . . . miles per hour did they average
	how many miles did they average per month
373	round your answer up . . . to the next cent

APPENDIX M

MATHEMATICAL TERMS AND PHRASES THAT ARE FOUND IN THE HEATH MATHEMATICS (1981) FIFTH GRADE TEXTBOOK AND IN THE IPSP PROBLEM SOLVING TEST (1979) (FORMS 561 AND 562)

APPENDIX M

MATHEMATICAL TERMS AND PHRASES THAT ARE FOUND IN THE HEATH MATHEMATICS (1981) FIFTH GRADE TEXTBOOK AND IN THE IPSP PROBLEM SOLVING TEST (1979) (FORMS 561 AND 562)

Form 561	Form 562
farther	total
miles per gallon	total cost
total	rectangular
total score	wide
how many altogether	twice as many
find the cost	average rate
square	rectangle
average	total amount
total cost	altogether
less than	how much more
wide	length
altogether	
rectangle	
length	
width	

APPENDIX N

VOCABULARY TEST -

MATCHING AND FILL IN THE BLANK

APPENDIX N

VOCABULARY TEST - MATCHING AND FILL IN THE BLANK

Part I. Matching

Directions: Match each statement to the mathematical term or phrase it describes.

1. How many miles a car can travel on a certain number of gallons of gas. _____
2. Divide the total score by the number of games played. _____
3. Add together the cost of two or more purchases. _____
4. Drive 3 hours and travel a distance of 120 miles. Your car travels at 40 miles per hour. _____

A. Find the cost

B. Average rate

C. Miles per gallon

D. Average

Part II. Matching

5. To find the price of several items purchased, add the prices together._____
6. Jeff has 6 tickets, Sarah has 11 tickets, and Marty has 9 tickets. Together, Jeff, Sarah, and Bill have 26 tickets. _____
7. Four equal sides and four right angles. _____
8. The greater distance someone throws a ball, compared to a shorter throw. _____
9. Adding together the scores of 2 or more events. _____

E. Farther

F. Total score

G. Total cost

H. Square

I. Total

Part III. Fill in the Blank

Directions: Select a term or phrase from the following to complete each sentence: square, total score, total, altogether, farther, total cost.

1. During a basketball game Robyn scored 5 points, Laura scored 3 points, Andy scored 4 points, Amy scored 6 points, and Julie scored 7 points. ________ ________, the team scored 25 points. The 25 points the team scored was the team's ____________________ for the game.

2. Jack threw a baseball 200 feet. Jim threw a baseball 150 feet. Jack threw the baseball 50 feet ____________________ than Jim.

3. A __________________ has four equal sides and four right angles.

4. Bill has 6 marbles, Kay has 7 marbles, and Danny has 5 marbles. Together, they have a ______________ of 18 marbles.

5. David purchased the following items at the grocery store:
   Eggs: $ .90 per dozen
   Bread: $1.10 per loaf
   Bacon: $1.79 per pound.
   He paid the clerk $3.79 for the items he purchased. The price he paid for the groceries was the ______________ of his purchases.

Part IV. Fill in the blank

Directions: Select a term or phrase from the following to complete each sentence: find the cost, miles per gallon, average rate, average.

6. Julie drove her car 300 miles and used 10 gallons of gas. She averaged 30 __________________________ on her trip.

7. Jim bowled three games. His scores were 110, 118, and 105. Jim's total score for the three games was 333. His three game __________________________ was 111 pins per game.

8. Tony was shopping for some diving equipment. He bought a diving mask for $15.98 and some ear plugs for $4.98. For Tony to ________________________ of his diving equipment he would add $15.98 and $4.98 together.

9. Sarah was on a trip in her automobile for 6 hours and traveled a distance of 300 miles. Her _________ ________________ for the trip was 50 miles per hour.

BIBLIOGRAPHY

BIBLIOGRAPHY

Aiken Jr., Lewis R. "Mathematics as a Creative Language." The Arithmetic Teacher. Vol. 24, March 1977. Pp. 251-255.

Ballew, Hunter, and Cunningham, James W. "Diagnosing Strengths and Weaknesses of Sixth-Grade Students in Solving Word Problems." Journal for Research in Mathematics Education. Vol. 13, May 1982. Pp. 202-210.

Bell, Frederick H. "Posing and Solving Verbal Problems." Mathematics Teacher. Vol. 73, December 1980. Pp. 652-656.

Block, Alex Ben. "This is a War." Forbes. Vol. 135, March 11, 1985. Pp. 90-91.

Campbell, Donald T. , and Stanley, Julian C. Experimental and Quasi-Experimental Designs for Research. Boston, Massachusetts. Houghton-Mifflin Company, 1966.

Charles, Randall, and Lester, Frank. Teaching Problem Solving--What, Why, and How. Palo Alto, California. Dale Seymour Publications, 1982.

Cheves, Deborah, and Parks, Terry. "Making Problem Solving Real." Educational Leadership. Vol. 41, December 1983/January 1984. Pp. 54-57.

Chiodo, John J., and Klausmeier, Robert L. Jr. "'V.T.'--The Extra Step in Classroom Roleplaying." The Social Studies. Vol. 75, May/June 1984. Pp. 122-123.

DiPillo, Peter. "Videotape in the Classroom." Audiovisual Instruction. Vol. 23, April 1978. Pp. 42-42.

Dunlap, William P., and McKnight, Martha Brown. "Vocabulary Translations for Conceptualizing Math Word Problems." The Reading Teacher, Vol. 32, November 1978. Pp. 183-189.

Earle, Richard A. Teaching Reading and Mathematics. Newark, Delaware. Internal Reading Association, 1976.

Earp, N. Wesley, and Tanner, Fred W. "Mathematics and Language." Arithmetic Teacher. Vol. 28, December 1980. Pp. 32-34.

Fry, Edward, and Sakiey, Elizabeth. "Common Words Not Taught in Basal Readers." The Reading Teacher. Vol. 39, January 1986. Pp. 395-398.

Gibbons, J.H. (Director). Office of Technology Assessment. Informational Technology and Its Impact on American Education. Washington D.C. November 1982. Pp. 37-47.

Gibney, Thomas C., and Meiring, Steven P. "Problem Solving: A Success Story." School Science and Mathematics. Vol. 83, March 1983. Pp. 194-203.

Gilman, Hank. "Home-Computer Buyers Find Incentives in Sinking Prices and Innovative Software." The Wall Street Journal, 5 August 1986, p. 33.

Grossnickel, Foster E., and Brueckner, Leo J. Discovering Meaning in Arithmetic. Philelphia. The John C. Winston Company, 1959. P. 308.

Grouws, Douglas A., and Thomas, William E. "Problem Solving: A Panoramic Approach." School Science and Mathetics. Vol. 81, April 1981. Pp. 307-314.

Hayes, Jeanne. Microcomputer and VCR Usage in Schools 1985-86. Denver, Col. Quality Education Data, Inc., 1986.

Herber-Nelson, Joan. "Expanding and Refining Vocabulary in Content Areas." Journal of Reading. Vol. 29, April 1986. Pp. 626-633.

Hollander, Sheila K. Reading the Special Language of Mathematics. ED 137726. Arlington, Virginia. ERIC Document Reproduction Service, 1977.

House, Peggy A., Wallace, Martha L., and Johnson, Mary A. "Problem Solving as a Focus? How? When? Whose Responsibility?" The Agenda in Action. National Council of Teachers of Mathematics. Reston, Virginia, 1983. Chapter 1.

Houtz, John C., and Denmark, Robert M. "Student Perceptions of Cognitive Classroom Structure and Development of Creative Thinking and Problem Solving Skills." Educational Research Quarterly. Vol. 8, Fall 1983. Pp. 20-26.

Johnson, Harry C. "The Effect of Instruction in Mathematical Vocabulary Upon Problem Solving in Arithmetic." Journal of Educational Research. Vol. 38, October 1944. Pp. 97-110.

Johnson, J.T. "On the Nature of Problem-Solving in Arithmetic." Journal of Educational Research. Vol. 43, October 1949. Pp. 110-115.

Kahanec, Frank A. "Video Mathematics." Mathematics Teacher. April 1985. Pp. 260-262.

Kaplan, Don. "Making Scene with Video." Instructor. Vol. 95, January 1986. Pp. 56-58.

________. Video in the Classroom. White Plains, New York. Knowledge Industry Publications, Inc., 1980.

Krulik, Stephen. "To Read or Not to Read, "That is the Question." Mathematics Teacher. April 1980. Pp. 248-252.

Krulik, Stephen, and Reys, Robert. Problem Solving in School Mathematics. The National Council of Teachers of Mthematics, Inc. Reston, Virginia, 1980.

Krulik, Stephen, and Rudnick, Jesse A. Problem Solving --A Handbook for Teachers. Boston, Massachusetts. Allyn and Bacon, Inc., 1980.

________. "Suggestions for Teaching Problem Solving--A Baker's Dozen." School Science and Mathematics. Vol. 81, January 1981. Pp. 37-41.

Lester, Frank K. Jr. "Issues in Teaching Mathematical Problem Solving in the Elementary Grades." School Science and Mathematics. Vol. 81, February 1982. Pp. 93-98.

Lyda, W.J., and Duncan, Frances M. "Quantitative Vocabulary and Problem Solving." The Arithmetic Teacher. Vol. 14, April 1967. Pp. 289-291.

Malsam, Margaret. "New Vistas: Videotaped Art Instruction." School Arts. Vol. 79, December 1979. Pp. 24, 33-34.

Mayhew, Harry, and Whitfield, Edie L. "Capturing Science on Videotape." Science and Children. Vol. 20, November/December 1982. P. 13.

McGee, Lea. "A Study of Third Graders' Comprehension of a Selected Story Following Listening, Viewing Television, and Reading." Paper presented at the National Reading Conference, St. Petersburg, Florida, December 1978.

Morton, Robert L. "The Place of Arithmetic in Various Types of Elementary-School Curriculums." Arithmetic 1949 (Supplementary Educational Monographs, No. 70). Chicago. University of Chicago Press, 1949. P. 7.

Muth, K. Denise. "Solving Arithmetic Word Problems: Role of Reading and Computational Skills." Journal of Educational Psychology. Vol. 76, April 1984. Pp. 205-210.

Muth, K. Denise, and Glynn, Shawn M. "Integrating Reading and Computational Skills." Journal of Instructional Psychology. Vol. 12, March 1985. Pp. 34-38.

National Assessment of Educational Progress 1981-1982. The Third National Assessment of Mathematics. Denver, Colorado. Educational Commission of the States.

National Council of Teachers of Mathematics. An Agenda for Action: Recommendations for School Mathematics of the 1980s. Reston, Virginia. The Council, 1980.

Oehmke, Theresa M. "The Development and Validation of a Testing Instrument to Measure Problem Solving Skills of Children in Grades Five Through Eight." Unpublished Ph.D. dissertation, University of Iowa, 1979.

Polya, George. How to Solve It (Second Edition). Garden City, New York. Doubleday, 1957.

________. Mathematical Discovery. New York. John Wiley and Sons, Inc., 1962. P. v.

Reider, William L. "Videocassette Technology in Education: A Quiet Revolution in Progress." Educational Technology. Vol. 24, October 1984. Pp. 12-15.

Reutzel, D. Ray. "C^6: A Reading Model for Teaching Arithmetic Story Problems." The Reading Teacher. October 1983. Pp. 28-34.

Riley, James D., and Pachtman, Andrew B. "Reading Mathematical Word Problems: Telling Them What to Do Is Not Telling Them How to Do It." Journal of Reading. March 1978. Pp. 531-534.

Robinson, H.A. Teaching Reading and Study Strategies: The Content Areas. Boston, Massachusetts. Allyn and Bacon, 1975.

Rucker, Walter E., and Dilley, Clyde A. Heath Mathematics. Lexington, Massachusetts. D.C. Heath and Company, 1981.

Sakiey, Elizabeth, and Fry, Edward. 3000 Instant Words. Providence, Rhode Island. Jamestown Publishers, 1984.

Shaftel, Fannie, and Shaftel, George. Role Playing for Social Values: Decision Making in Social Studies. Englewood Cliffs, New Jersey. Prentice-Hall, Inc., 1967.

Shufelt, Gwen. The Agenda in Action. Reston, Virginia. The National Council of Teachers of Mathematics, Inc., 1983.

Skrypa, Aldona. "Effects of Mathematical Vocabulary Training on Problem Solving Ability of Third- and Fourth-Graders." Ph.D. dissertation, Rutgers University, The State University of New Jersey, 1979. New Brunswick, New Jersey. ERIC 172 169.

Stauffer, Russell G. "A Vocabulary Study Comparing Reading, Arithmetic, Health, and Science Texts." The Reading Teacher. Vol. 20, November 1966. Pp. 141-147.

Stover, Georgia. "Rewording Arithmetic Word Problems for Sixth and Eighth Graders to Minimize Reading Difficulties." Reading Improvement. Vol. 17, Spring 1980. Pp. 26-35.

Threadgill-Sowder, Judith. "Question Placement in Mathematical Word Problems." School Science and Mathematics. Vol. 83(2), February 1983. Pp. 107-111.

VanderLinde, Louis F. "Does the Study of Quantitative Vocabulary Improve Problem Solving." The Elementary School Journal. Vol. 65, December 1964. Pp. 143-152.

________. "An Experimental Study of the Effect of the Direct Study of Quantitative Vocabulary on the Arithmetic Problem Solving Ability of Fifth Grade Pupils." Ph.D. dissertation, Michigan State University, East Lansing, Michigan, 1962.

"Video Cassette Recorders." Consumer Reports. Vol. 50, September 1985. Pp. 524-531.

Wildt, Albert R., and Ahtola, Olli. Analysis of Covariance. Beverly Hills, California. Sage Publications, Inc., 1978.